Evaluating methods of obtaining total catch estimates for individual Victorian bay and inlet recreational fisheries

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State Government Victoria Department of Primary Industries

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NON-TECHNICAL SUMMARY

2003/047 Evaluating methods of obtaining total catch estimates for individual Victorian bay and inlet recreational fisheries

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Objectives:

1. Review survey methods used to estimate total annual catches of key species in Victorian bay and inlet recreational fisheries.
2. From the results of past surveys, statistically assess the costs and sampling requirements of different survey methods for providing unbiased estimates of total recreational catch and effort, with acceptable precision.
3. Conduct a workshop to evaluate alternative angler survey methods.
4. Develop a cost-effective survey design to provide annual estimates of recreational catch for main recreational fisheries.
5. Trial the recommended design.
6. Review the success of the pilot survey at a second workshop and recommend a final survey design.

OUTCOMES ACHIEVED TO DATE

The most suitable method for monitoring the total recreational catch from Victoria's recreational fisheries is a phone-diary survey complemented with a boat-ramp survey. This approach provides reliable and cost-effective estimates of the total recreational catch of finfish for individual bays and inlets. The design uses a database of anglers that purchased a Recreational Fishing Licence. The methodology was tested on the western Victorian snapper stock.

Implementation of this design provides information required for:

1. Assessments of annual catch estimates of the recreational fishery.
   Estimates of total recreational catch from this survey will be used to determine the status of finfish stocks in Victorian bay and inlet fisheries. This information will also be used for development, implementation and review of fishery management plans, and resource allocation.
2. Matching the spatial resolution of recreational fishing data to the spatial scale at which fisheries are managed.
   Victoria's marine and estuarine recreational fisheries are characterised by the presence large well-defined and protected waterways in which the majority of fishing activities occur. The method developed by this project enables the collection of fishery data on a spatial scale that is appropriate for management. Management frameworks are more likely to be adopted when informed by data collected at the spatial scale at which the fishery is administered.

The survey design developed in this project provides total recreational catch estimates of particular species for stock assessment models. In addition, data collected using this methodology assists in establishing and monitoring specific resource sharing/allocation targets for particular fisheries/stocks.

NON-TECHNICAL SUMMARY

Estimates of total catch are fundamental for understanding the impact of fishing activity on fish populations. All licensed commercial fishers in Victoria record their daily catch and effort data in logbooks. These data provide a continuous time-series census of the total commercial catch and valuable information on the dynamics of fish populations and fishing activity. Estimates of catches by recreational fishers are more difficult and expensive to obtain and annual estimates of total catch from the recreational sector have not been routinely obtained.

The state-wide total recreational catch of snapper (332 tonnes), King George whiting (215 t), and flathead (599 t) in 2000/01 of were all greater than the annual commercial catches of 84 t, 137 t and 110 t, respectively. Such comparisons are important when determining the sustainability of the stocks and the allocation of fishing effort, and can only be made from monitoring the recreational fishery.

This project follows the National Recreational and Indigenous Fishing Survey (NRIFS) where a phone-diary survey method was used to obtain data on recreational fisheries at state-wide levels. The NRIFS was effective for large scale assessment, but has limitations for estimating catch at smaller spatial scales; it is unlikely to be repeated regularly in Victoria because of the expense and time involved. The aim of this Fisheries Research and Development Corporation (FRDC) and Fisheries Victoria funded project was to identify a cost-effective survey method to estimate total recreational catch of key recreational species that would complement data obtained routinely from the commercial sector.

The management of finfish fisheries in Victoria is based on water bodies. Most recreational fishing in Victorian marine waters is conducted in Port Phillip Bay (PPB). In 2000/01, 88% of the catch from Victorian bays and inlets was taken in PPB, where 95% of the catch was taken by boat-based anglers. The western snapper stock includes PPB, Western Port and coastal waters west of Wilsons Promontory, and is of particular interest to fisheries managers. Previous research indicates PPB is the most important nursery area for snapper, as juveniles spawned in PPB replenish the entire western stock. Snapper is an important recreational species and was chosen as the key species for this project. Survey methods were tested and refined in PPB.

A phone-diary survey was identified as the preferred method to provide cost-effective, annual estimates of total catch for key recreational fisheries in Victoria. A survey to assess the recreational catch from the western Victoria snapper stock, with particular emphasis on catches from PPB and Western Port, was used to test the method. The survey was comprised of the following components:

- a screening survey primarily to recruit diarists (May/June 2006);
- a subsequent 12 month phone-diary survey to obtain catch and effort data, where diarists were provided with a diary card and species identification guide, and regularly contacted throughout the period (1 July 2006 to 30 June 2007);
- a wash-up survey to assess diarist attitudes and opinions (July/August 2007);
- a calibration survey primarily to provide benchmarking information for the phone-diary survey (July/August 2007);
- boat-ramp surveys to provide assessments of anglers not covered by the phone-diary survey (principally exempt fishers and unlisted RFL holders) and also to collect size/frequency data for snapper (November 2006 to April 2007).

Unlike the NRIFS, where a household-based White Pages sampling frame was used, these surveys sampled the Recreational Fishing Licence (RFL) database in Victoria. In 2000/01, licensable anglers were estimated to account for 93% of the recreational catch of snapper in Victoria; RFL holders were assumed to dominate the current snapper harvest in the current survey.

High response rates (≥ 90%) were achieved across all survey components. Such high response rates reduce the potential for non-response bias, provide increased confidence in data quality and are an important performance indicator for surveys of this kind. The rates observed in this survey were attributed to careful survey design, interviewer skill, and high levels of interest and co-operation by anglers.

Data from the phone-diary survey were adjusted according to the calibration survey to provide expanded population estimates for 1 and 3 year RFL holders resident in coastal statistical divisions of Victoria (135,214 licences, including interstate and short-term licences). An estimated 55,582 RFL holders

harvested 612,202 (± 79,586 SE) snapper in 2006/07. The estimated total recreational catch was 244,542 (± 21,742 SE) snapper in PPB and 152,162 (± 18,588 SE) in Western Port. The precision of snapper harvest estimates obtained in this survey was consistently lower than those obtained in the NRIFS. This was attributed to sampling more avid anglers. These anglers account for the majority of the annual harvest.

Results from the 2006/07 boat-ramp survey indicated 86% of snapper harvest was taken by RFL holders residing in coastal statistical divisions. The remaining snapper harvest was taken by exempt anglers (12%) and RFL holders from inland statistical divisions (2%).

No attempt was made to quantify the snapper harvest from exempt fishers (the population of the exempt fishers was unknown). The likely magnitude of snapper harvest by exempt anglers is around 14%, which approximates one standard error (13%) for the expanded harvest estimate for RFL holders, residing in coastal statistical divisions.

Avidity profiles of respondents in the boat-ramp survey were assessed to determine any behavioural differences between RFL holders with a White Pages listing and unlisted RFL holders and exempt fishers. The majority of fishers (78%) that reported a harvest of snapper were identified as avid fishers (> 15 days annual fishing by recall). Avid anglers represented 77% of all listed RFL holders, 84% of unlisted fishers and 77% of the exempt group. It was assumed that listed RFL holders were representative of their unlisted counterparts.

This project has demonstrated that the RFL database provides an extremely cost-effective sampling frame for surveys of this kind. Areas for improvement of the database have been identified, including: routine collection of contact details (especially telephone numbers) for all RFL holders; profiling of avidity and identification of preferred target species; and regular data entry to ensure that the database is up-to-date. Extension of the RFL database to include all fishers (i.e. no exemptions) is also suggested as this would provide a substantial benefit to future monitoring of recreational catch.

Development of future surveys using the RFL database would need to consider study objectives in terms of fishery-specific factors (such as the size of the fishery and number of access points) and selection of appropriate temporal and spatial scales. Such research could range from relatively brief single-contact surveys to assess opinions or awareness of fishers, through more detailed catch and effort assessments for specific fisheries (as in the present survey), to state-wide assessments using a dual-frame sample. The use of the RFL database and skilled interviewers were important in achieving study objectives.

Keywords

Recreational fishery assessment, recreational fishing licence, phone-diary survey, recall bias, snapper, Port Phillip Bay, Western Port

Acknowledgments

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1 Introduction

1.1 Background

1.1.1 Methods used to Estimate Catch in Recreational Fisheries

A variety of methods are available for surveys of recreational fisheries. Different approaches have their own inherent strengths and weaknesses, and are more or less appropriate according to the scale and objectives of the surveys (Pollock *et al.* 1994, Table 1). Off-site methods (phone, mail and door-to-door interviews, and diaries) obtain data from anglers after fishing activity has occurred. On-site or intercept surveys (aerial, access and roving surveys) obtain data from anglers, during or immediately after fishing, at locations near the fishing activity. On-site surveys using spatial and temporal sampling frames can be especially efficient when anglers are easily located in a fishery with limited access points (such as a small number of fishing or boat-launching sites). The phone interview approach was used in the National Recreational and Indigenous Fishing Survey (NRIFS) to obtain data on recreational fisheries at state-wide levels. This approach was well suited to providing broad scale assessments of angling activity within numerous, diffuse access points using lists of telephone numbers as a sampling frame.

While diary, access and roving surveys are equally suited for collecting current fishing data using short questionnaires, they differ in the method of data collection. This difference influences the potential for errors (Table 2). In access and roving surveys, interviewers collect fishing data at the time of fishing activity; there is a lower potential for sampling, response and non-response errors (Pollock *et al.* 1994; Pollock *et al.* 1997). Data from phone-diary surveys is reported by the angler after fishing activity; there are potentially higher rates of sampling errors (from improper selection, under-coverage and avidity bias), response errors (from prestige and rounding bias, question misinterpretation and species misidentification) and non-response errors (from refusals).

The method of estimating catch also varies for different survey methods. For example, total catch can be estimated from a phone-diary survey by multiplying the total catch for each household with an expansion factor according to the proportion of the total population that each household represents; the total fishing effort does not need to be calculated. Total catch is calculated similarly for bus-route and creel surveys by multiplying the daily-retained catch rate with the total annual effort (angler hours). The total annual effort in a bus-route survey is estimated from the number of boat trailers (in a boat-based fishery) and the amount of time they are observed at each ramp, whereas a creel survey alone cannot provide an estimate of total annual effort. A creel survey may be complemented by an aerial survey, where the total annual effort is estimated from the number of boats engaged in fishing and the average number of anglers per boat. The total catch (in weight) is calculated by multiplying the total catch (in numbers) with an appropriate weight conversion factor.

The diversity of approaches exemplifies the need to tailor surveys to the characteristics of particular fisheries and survey objectives in Australia. Phone-diary surveys have been used in Queensland (Higgs 1999; Higgs 2001) and the NRIFS (Henry and Lyle 2003), but there were important design differences between these surveys. Bus-route surveys have been used for recreational fisheries in South Australia (McGlennon and Kinloch 1997b) and Western Australia (Sumner and Williamson 1999). Several studies have focussed on developing and applying new techniques for surveying anglers in Australia (Steffe *et al.* 1996; Kinloch *et al.* 1997; McGlennon and Kinloch 1997a; McGlennon and Kinloch 1997b).

A large range of methods has been used in the past to collect information on Victorian marine and estuarine recreational fisheries. This previous work has been undertaken with funding from State

Governments or VRFish using diverse staffing arrangements in efforts to reduce costs and maximise the efficiency of surveys. A combination of on-site surveys and angler diaries are currently used in Victoria to obtain data on catch rates and length frequency composition of the catch for selected recreational fisheries and for selected species within these fisheries. Methods have been developed to allow the data collected by these surveys to be incorporated into formal stock assessment models (Conron 2004), and age-structured models for key fisheries are under development. Such data provide no estimate of total catch and have been shown in at least some fisheries to have limitations as indicators of stock status. Bus-route surveys have been conducted (Conron and Coutin 1995a; Conron and Coutin 1995b; Conron and Coutin 1998), but their cost was found to preclude their routine use even for the major Victorian bays and inlets. The presence of a significant night time component in some fisheries, such as the Port Phillip Bay (PPB) snapper fishery, creates an additional demand on the selection of an appropriate sampling method. Consequently, data on total catch have seldom been obtained, and are not obtained on an annual basis for any Victorian, or Australian, recreational fishery.

1.1.2 Bay and Inlet Recreational Fisheries in Victoria

The Victorian coastline is more than 2,000 km in length with more than 30 bays, inlets and estuaries covering more than 3,700 km^2. The bays and inlets are ecologically distinct, brackish or marine environments that are influenced by inputs from catchment tributaries and tidal exchanges with coastal waters. Most of these bays and inlets have been increasingly influenced by human activities yet continue to provide a sustainable fish harvest. Recreational fishing occurs wherever there is suitable access to boat ramps, piers or access to the shoreline. The main recreational fisheries are located in PPB (Gunthorpe *et al.* 1997; Coutin 2000b), Western Port (Gunthorpe and Hamer 2000b), Corner Inlet (MacDonald 1997a; Gunthorpe and Hamer 2000a) and the Gippsland Lakes (Gunthorpe 1997; MacDonald 1997b) (Figure 1). Smaller recreational fisheries occur in Mallacoota Inlet, Lakes Tyers, Shallow Inlet, Anderson Inlet, Tamboon Inlet, Sydenham Inlet, Wingan Inlet, the Snowy River estuary, and the Barwon River estuary.

Victoria's marine and estuarine recreational fisheries are naturally stratified by the presence of a few large well-defined and protected waterways in which the majority of fishing activity occurs. Important commercial fisheries are also licensed according to these geographic regions. This makes it feasible and desirable to consider surveys of recreational fishing on this spatial scale, even though the fish stocks are seldom restricted to individual bays and inlets.

Natural climatic factors and a range of human 'development' activities other than fishing influence the fish habitat and environmental conditions in Victorian bays and inlets. Variations in total catch and species catch composition that occur between each bay or inlet and over time within a bay or inlet are thought to reflect the impact of fishing and the variable habitat and environmental conditions affecting fish reproduction and survival.

Commercial and recreational fishers have recorded more than 100 fish species in Victorian bays and inlets, but only about a dozen species are usually targeted by recreational fishers. The three main species of interest to recreational fishers are snapper (*Pagrus auratus*) (Coutin 1997; Coutin and Conron 1997; Gunthorpe 1997; MacDonald 1997b; Coutin 2000c), King George whiting (*Sillaginodes punctata*) (Smith and MacDonald 1997) and black bream (*Acanthopagrus butcheri*) (Coutin *et al.* 1997; MacDonald 1997b; Cashmore *et al.* 2000; Coutin 2000a). Other species of interest are Australian salmon (*Arripis trutta*), calamary (*Sepioteuthis australis*), garfish (Family Hemiramphidae) and flathead (Family Platycephalidae).

The majority of recreational angling in Victorian bays and inlets occurs in PPB. In 2000/01, 88% of the total recreational catch from Victorian bays and inlets was taken from PPB. The total recreational catch for snapper (211 t), King George whiting (93 t) and flathead (395 t) in PPB during 2000/01 exceeded reported commercial catches for these species of 53, 85 and 23 t, respectively, for the same period.

Snapper is an important recreational species and the western stock (which includes PPB, Western Port and coastal waters west of Wilsons Promontory) is of particular interest to fisheries managers. Previous research indicates PPB is the most important nursery area for snapper with juveniles spawned in PPB replenishing the entire western stock (Hamer and Jenkins 2007). Spawning and recruitment are largely driven by habitat and environmental conditions.

1.2 Need

Estimates of total catch are fundamental for understanding the impact of fishing activity. All licensed Victorian commercial fishers record their daily catch and effort in logbooks, which are submitted to the Catch and Effort Unit (DPI, Queenscliff). These data provide a census of the total commercial catch and valuable information on the dynamics of fished populations and fishing activity. Estimates of angler catches are difficult and expensive to obtain and annual estimates of total catch from the recreational sector in individual Victorian bays and inlets have not been obtained routinely.

An estimate of the total recreational catch of important fish stocks is required for:

- regular monitoring of recreational fishing activity
- assessment of fisheries where the recreational component is significant
- fisheries that require decisions concerning resource allocation between commercial and recreational sectors
- development, implementation and review of fishery management plans.

Additionally, it is desirable for the spatial resolution of recreational fishing monitoring to be matched to the spatial scale at which fisheries are managed.

Allocation of available fish resources between the commercial and recreational fishing sectors is becoming increasingly important for fisheries managers (Lal *et al.* 1992; MacDonald 1995; McGlennon and Kinloch 1997b; Kearney 2001). A formal resource allocation process for Victoria's bay and inlet fisheries is being initiated, with snapper, King George whiting, black bream, calamary and southern sea garfish identified as key species. Methods of providing comparable estimates of the value of commercial and recreational sectors are being developed. This process will require data on the total catch by each fishing sector. Resource allocation decisions would clearly be better informed and more defensible if the total catch from both sectors is known (Kearney 2001).

In some instances, the total catch taken by the recreational sector from Victorian waters can exceed that by the commercial sector. For example, the estimated retained catches of snapper (179 t), King George whiting (163 t), and flathead (334 t) by recreational anglers in Victoria during 2000/01 (Henry and Lyle 2003) were all greater than the annual commercial catches of 84, 137 and 110 t, respectively (DPI 2004). Such comparisons cannot be made without regular monitoring of the catch taken from recreational fishing. The provision of estimates of total catch by the recreational sector has an important management context and the development of suitable methods of obtaining these data will allow for more objective assessment of fisheries and resource allocation decisions.

Fishery management plans are likely to be more effective and have greater stakeholder acceptance when they are based on current estimates of the relative impact of each sector (Kearney 2001). Understanding the extent and dynamics of the recreational sector is important in the development, implementation and review of these management plans. The need for such data is frequently identified in fishery and stock assessments for Victorian bay and inlet fisheries.

The NRIFS provided useful state-wide overviews of fishing activity (Henry and Lyle 2003). The breadth and complexity of the NRIFS required an extended time period for analysis and reporting. This delay makes any estimates of recreational catch less applicable for stock assessment purposes where frequent, preferably annual, estimates are desirable. Some of the delay in reporting was attributable to the development of methods and future surveys likely to be quicker to analyse and report. The phone-diary survey method developed for the NRIFS indicates a phone-diary survey is potentially very useful, although its applicability to smaller spatial scales, and as a regular survey technique, remains to be tested.

Management decisions are most likely to meet their objectives when they have been informed by data collected regularly at the spatial scale at which the fishery is administered. The assessment and management of fisheries in Victoria is undertaken at a finer spatial scale than that provided by the NRIFS. Methods need to be developed that allow data to be collected from Victoria's recreational fisheries on an annual (or regular) basis, in a cost-effective manner and at an appropriate spatial scale.

1.3 Aims and objectives

This Fisheries and Research Development Corporation (FRDC) and Fisheries Victoria funded project aims to recommend cost-effective methods to estimate the annual catch of key, large recreational fisheries for complementing data obtained routinely from the commercial sector. The implementation of regular, reliable and cost-effective angler surveys will provide data that will allow more realistic and rigorous assessments of bay and inlet recreational fisheries.

There are six project objectives:

1. Review survey methods used in the past to estimate total annual catches of key species in Victorian bay and inlet recreational fisheries.
2. From the results of past surveys, statistically assess the costs and sampling requirements of different survey methods for providing unbiased estimates of total recreational catch and effort, with acceptable precision.
3. Conduct a workshop to evaluate alternative angler survey methods.
4. Develop a cost-effective survey design that would, if possible, provide annual estimates of recreational catch for main recreational fisheries.
5. Trial the recommended design.
6. Review the success of the pilot survey at a second workshop and recommend a final survey design.

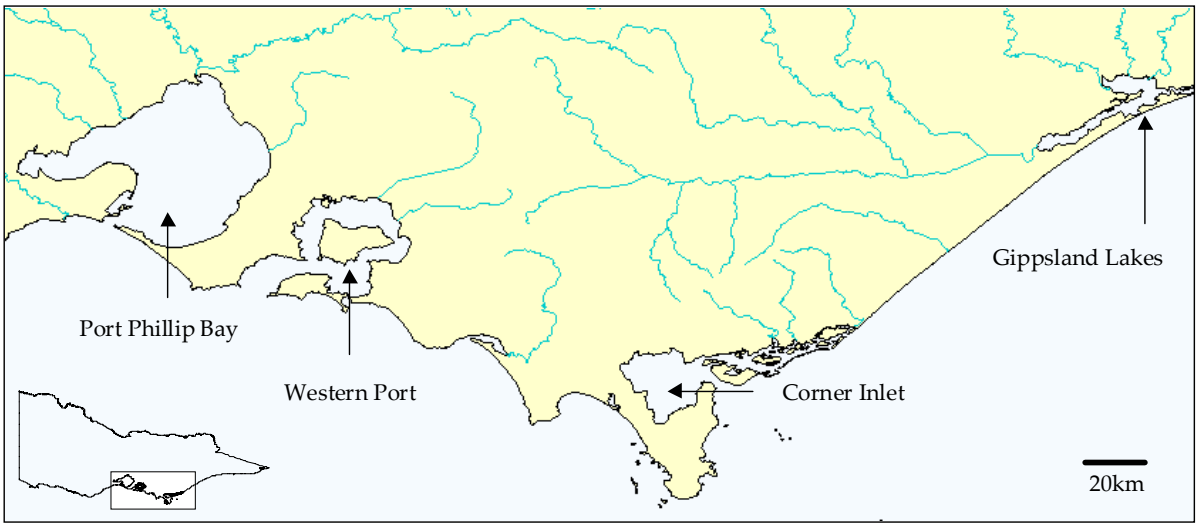

Figure 1: Map of Victorian coastline showing major bays and inlets.

Table 1: Features of angler surveys that best characterise the choice of survey method.

Attribute	Off-site methods					On-site methods		
	Mail	Phone, list or directory	Phone, random	Door-to-door	Diary	Access	Roving	Aerial
Information context	Provides data from past				Provides current data			
Time to conduct past surveys	Long	Short			na			
Questionnaire length	Long				Short			na
Data collection	Reported by angler					Observed by survey agent		
Sampling frame for survey	List of people to contact, either general (e.g. phone lists) or specific (e.g. list of anglers)			List or area frame	Variable	Classification of fishing area into spatial (e.g. zones) or temporal (e.g. season or day type) groups		
Access points to fishery	Undefined or diffuse access points to fishery					Defined	Undefined or diffuse	
Total number of anglers in fishery	High	Low	High		Low	High	Low	High
Geographical area of fishing	Large					[1]	Small	Large
Cost to conduct survey	Low			High	Low	Medium		

Table adapted from Essig and Holliday 1991 in (Pollock *et al.* 1994); na = non applicable

[1] Traditional access survey for small areas and the bus-route access survey for large areas with many access points

Table 2: Potential occurrence for errors in different recreational fishing surveys.

Error type	Off-site methods					On-site methods		
	Mail	Phone list or directory	Phone, random	Door-to-door	Diary	Access	Roving	Aerial
Sampling Errors								
Improper selection	L	L	L	L	H	L	L	L
Undercoverage	M	M	L	L[1]	H	M[2]	L	M[3]
Avidity bias	M	M	L	L	H	H	H	0
Length-of-stay bias	0	0	0	0	0	0	M	0
Response errors								
Recall bias	H	M	M	M	L	L	L	0
Prestige bias	H	H	H	H	H	L	L	0
Rounding bias	H	H	H	H	H	L	L	0
Lies	M	M	M	M	M	L	L	0
Question misinterpretation	H	M	M	L	H	L	L	0
Species misidentification	H	H	H	H	H	L	L	0
Incorrect length, weights	H	H	H	H	H	L	L	0
Non-response errors								
Refusals	H	M	M	L	H	L	L	0
Unavailables	L	M	M	M	L	L	L	0
Impediments (language, literacy)	M	L	L	L	M	L	L	0

Table adapted from Essig and Holliday 1991 in (Pollock *et al.* 1994)

* H = high probability of occurrence, M = medium, L = low and 0 = not applicable

[1] Low for area frames, medium for list frames

[2] Medium because sometimes access points are missing from the frame list; this is dependent on the fishery

[3] Anglers or boats may not always be visible from the air even though the area frame is complete

2 Review of previous survey methods

This section presents the methods and results for addressing the first project objective: review survey methods used in the past to estimate total annual catches of key species in Victorian marine and estuarine recreational fisheries.

2.1 Methods

2.1.1 Review of Publications

A list of previous publications on recreational fishing in Victorian bays and inlets was compiled. The DPI library catalogue was used to search for publications with the keywords 'Victoria', 'recreational' and 'fishing'. The reference lists of these publications were also searched, in addition to departmental publication lists on the DPI website. Studies investigating recreational fishing in inland Victoria were excluded; only studies investigating recreational fishing in Victorian bays and inlets were included. Additionally, only publications reporting original results were included. Publications that were presenting previously published results to a different audience (such as conference proceedings) were not included (Walker 1978; Coutin and Conron 1997).

Publications were reviewed and evaluated according to specific criteria to provide formal assessment of the research priority, sampling methods, recreational fishing participation, effort and catch. Data gathered for the sampling methods included survey type, angler contact method, sampling frame, sampling design, sample size, sample selection, preparation required for data collection, sampling effort, survey dates, time of survey, and potential data constraints. These details provide valuable information for comparisons of different survey methods.

2.1.2 Review of Databases

Databases reviewed for this report include

- RECFISH databases from 1997 to 2004 for PPB, Western Port and Gippsland Lakes
- NRIFS databases (including the screening survey and phone-diary survey)
- aerial survey data collected in 1983 and from 1990 to 1993

All databases were converted to SAS for analysis.

RECFISH DATABASES

Data collected from surveys on recreational fishing in Victorian bays and inlets conducted between 1995 and 2004 have been entered and stored on departmental computers at Queenscliff using ACCESS databases. There were six databases of interest to this project. Three were for boat-ramp surveys conducted in the Gippsland Lakes (Gippsland2004), PPB (PPB2004) and Western Port (Westernport2004). These databases were formatted similarly and contain data from several projects.

The Gippsland2004 database provided the cleanest data and the PPB2004 database needed further validation (Natalie Bridge, pers. comm.). Preliminary validation of the PPB database, by checking outliers and original data sheets, was undertaken before analysis of the data. The tables of interest to this project were the data entry tables (coversheet, questionnaire and catch) and the reference tables (species and geographic locations). The species of interest for this project include snapper (also called pinkies), King George whiting (whiting) and black bream.

NRIFS DATABASE

Data from the NRIFS used for this report included avidity data from the screening survey (held as an ACCESS table) and the NRIFS catch and effort tables (stored in EXCEL). Some checks for outliers and inconsistencies were performed and it was otherwise assumed that the data were clean.

OTHER DATABASES

Data from the aerial surveys in 1983 and the early 1990s were available as CSV files. Some data from recreational fishing surveys conducted prior to 1997 (Hall and MacDonald 1985a; Hall and MacDonald 1985b; Hall *et al.* 1985; Hall and MacDonald 1986; MacDonald and Hall 1987) were not available.

2.2 Results

2.2.1 Review of Publications

There were 19 publications of original research included in the publication review (Appendix 3). These publications were generally location specific, with only five publications investigating recreational catch at a state-wide level (Beinssen 1978; Hobday *et al.* 1996; Conron and Kirwin 2000; Henry and Lyle 2003; Conron and Bridge 2004). There were six publications on recreational fishing in PPB (MacDonald and Hall 1987; Dragun 1991; Conron and Coutin 1995a; Coutin *et al.* 1995; Conron and Coutin 1998), including one on the Melbourne Docklands (Knuckey *et al.* 1997). There were five publications on the recreational catch in Gippsland Lakes (Hall and MacDonald 1985b; Conron and Coutin 1995c; Conron and Walker 1997; Conron and Bills 2000), including Lake Tyers (Hall and MacDonald 1985a), and two at Nooramunga and Corner Inlet (Hall and MacDonald 1986; Conron and Coutin 1995b). Other publications were specific for Western Port (Dragun 1991) and Mallacoota Inlet (Hall *et al.* 1985). Six publications were prioritised by species: snapper (Conron and Coutin 1995a; Conron and Coutin 1998), black bream (Conron and Bills 2000), snapper, King George whiting and black bream (Conron and Bridge 2004), rock lobster (Hobday *et al.* 1996), and all recreational species (Henry and Lyle 2003).

A number of different survey types and angler contact methods have been used to collect information on Victorian bay and inlet recreational fisheries. Off-site surveys have included interviews by mail, telephone or door-to-door interviews (Beinssen 1978; MacDonald and Hall 1987; Dragun 1991; Henry and Lyle 2003) and angler diaries (Conron and Kirwin 2000; Conron and Bridge 2004). On-site surveys have included aerial surveys (Beinssen 1978; MacDonald and Hall 1987; Conron and Coutin 1995c; Coutin *et al.* 1995), bus-route surveys (Conron and Coutin 1995a; Conron and Coutin 1995b; Conron and Coutin 1998) and roving creel surveys (Beinssen 1978; Hall and MacDonald 1985a; Hall and MacDonald 1985b; Hall *et al.* 1985; Hall and MacDonald 1986; MacDonald and Hall 1987; Conron and Coutin 1995c; Coutin *et al.* 1995; Knuckey *et al.* 1997; Conron and Bills 2000). Many surveys have used more than one method, such as an opinion poll, an aerial survey and a roving creel survey.

2.2.2 Off-Site Surveys

Off-site interviews have been conducted by door to door, telephone, mail and phone-diary surveys (Beinssen 1978; MacDonald and Hall 1987; Dragun 1991; Henry and Lyle 2003). A summary of survey methods used for off-site interviews on recreational fishing in Victorian bays and inlets is given in Table 3. The confidential nature of these surveys generally allows interviewers to ask questions enabling respondent profiles to be established and matched with ABS population profiles. The results can be described in terms of population profiles, which can influence estimates of effort and catch. For example, differences in the minimum age of respondents can influence the estimated effort and catch in the population.

Most off-site surveys conducted in Victorian bays and inlets have aimed to provide a broad assessment of recreational fishing, although a few have aimed to provide detailed information for specific locations or fisheries and while some provide estimates of total catch, most only provide data on fishing participation.

Off-site surveys have used a variety of angler contact methods and sampling frames. These sampling frames generally required a reasonable level of effort to obtain. For example, an initial screening survey was required to obtain a list of households for the NRIFS phone-diary survey. Initial telephone screening surveys have also been used to obtain lists of anglers and clubs.

Although one method (the Angler Fishing Diary Program) obtains samples from a selective group of experienced anglers, most off-site surveys obtain random samples from a stratified, random sampling design. For example, a survey to estimate the recreational catch of southern rock lobster involved distributing 20 to 30 questionnaires to 12 dive clubs that were randomly selected each month according to groupings based on population, location and value. Other off-site surveys aimed at establishing state-wide estimates of recreational catch have been stratified according to ABS regions with a representative number of households randomly selected within each region.

The sample selection for two major surveys of state-wide recreational fishing activity were similar in 1982/83 and 2000/01, potentially providing comparisons in fishing participation and demographic information. The number of primary samples was similar for these surveys with 7,000 households surveyed in 1982/83 and 9,055 households in 2000/01. Different sampling protocols were followed in these surveys and only the NRIFS had a follow up survey. Surveys using a list of angling or dive clubs had relatively smaller sample sizes, such as 269 angling clubs and 132 dive clubs sampled, but these probably represent a large proportion of such clubs.

The number of secondary samples which form the basis of each interview for each primary sample can be much larger than the number of primary samples according to the number of fishing events. For example, in the Angler Fishing Diary Program, 201 anglers (primary sample) collectively recorded 8,269 fishing trips (secondary sample) detailing captures of 95,477 fish and measurements for 54,827 fish over six years.

The simplest approach to data collection in off-site surveys involves asking a few additional questions with an ongoing Roy Morgan Omnibus Survey that is surveying a wide range of population issues. Data collection can involve recruiting and training interviewers for a self contained survey, conducting an initial telephone screening survey to obtain a sampling frame, and ongoing liaison with angling and dive clubs, Fisheries and Wildlife Officers and anglers.

Surveys may have no specific survey times, such as the Angler Fishing Diary Program, where diaries are returned by mail when completed by the angler. The survey times for the NRIFS were selected by interviewers and diarists to provide the most convenient time for respondents. Other surveys have been conducted on weekday, day-time hours (initially outside business hours) and these can have high non-response rates, while conducting surveys on weekends can minimise non-responses rates.

The preparation for data collection, time of survey and survey constraints can potentially bias the data, particularly for off-site surveys, which have medium to high response and non-response errors compared with on-site surveys. Data constraints can bias the data according to age restrictions (e.g. minimum ages of 5, 14 or 15) or toward a particular group of fishers (such as avid or occasional anglers).

NRIFS

The methods developed for the NRIFS comprised of a series of telephone interviews with interviewers maintaining contact with the same group of anglers over the duration of the survey. The frequency of interviews was determined by the frequency of angling events. Methods to correct for potential sources of errors such as non-representativeness of sample frame, non-response bias, recall bias, prestige bias and behavioural shifts, were incorporated into the design. A diary assisted the memory recall of respondents and data was collected by interviewers to reduce demands on respondents.

The sampling frame for the NRIFS was a list of households stratified within geographic regions of different population densities corresponding with Australian Bureau of Statistics (ABS) statistical divisions (Henry and Lyle 2003). The numbers of replicate samples were proportional to the population of households in each region. Four of the eight Victorian regions used in the NRIFS were coastal regions. The Gippsland region had the largest coastline (including Corner Inlet, Gippsland Lakes and Mallacoota). The Victorian population is concentrated in the Melbourne region (with 71% of households), which includes Western Port and the majority of PPB. The south west of PPB (including Geelong) was allocated to the Barwon region. The differences in numbers of private dwellings by regions determined the sample size for the survey, for example, 2,935 household samples in the Melbourne region, 960 in Barwon, 810 in Gippsland and 810 in the Western District.

The NRIFS provided national, state-wide and regional estimates of the demographic profile of recreational fisher, the type, frequency and location of their fishing activities, target species and their catch and how much they spent on fishing. The survey provided a nation-wide estimate of total recreational catch with 94% of respondents completing the 12-month survey.

2.2.3 On-Site Surveys

The on-site surveys in Victorian bays and inlets have included aerial, bus-route and creel surveys to provide a detailed picture of fishing activity, generally for a specific location or species. All the on-site surveys conducted in Victorian bays and inlets have used an area and time sampling frame and similar

stratified, random sampling designs. Aerial surveys only provide an estimate of total effort to complement a creel survey, and bus-route surveys only provide estimates of catch and effort from boat-based fishing, while creel surveys can provide estimates of catch and effort for both boat and shore-based angling. Additionally, there is no direct angler contact for aerial surveys, while the angler contact method for bus-route and creel surveys is angler interviews.

AERIAL SURVEYS

Four aerial surveys of recreational fishing activity have been conducted in Victorian bays and inlets. These were in the Gippsland Lakes from January to April 1995 (Conron and Coutin 1995c) and PPB from January to May 1977 (Beinssen 1978), October 1982 to September 1983 (MacDonald and Hall 1987), and January 1989 to April 1994 (Coutin *et al.* 1995). A summary of the survey methodology used for these aerial surveys is given in Table 4.

Aerial surveys provide a count of boats or anglers that can be expanded to daily totals. The location of boats and anglers can be marked onto maps allowing calculation of area weightings. The sampling frame for these surveys included stratification by time (season, day type and time of day) and area (estuaries or zones within an estuary). Aerial surveys have used stratified, random sampling designs with strata defined by zones, month, day type and/or day-time periods. Day types were either weekday or weekends, which usually included public holidays or busy summer periods. The primary sample unit (in these aerial surveys) was sample day with number of flights the secondary sampling unit. For example, the most recent aerial survey in PPB covered 240 sample days with 326 flights (Coutin *et al.* 1995).

Flights were made with a single-engine Cessna 172, requiring a pilot and one or two observers at a height of at least 150 m above sea level. Allocation of flights for different strata, flight direction (clockwise or anti) and starting point were randomly chosen to avoid potential bias. Aerial surveys are especially useful for large fishing areas with many anglers. These surveys are limited in that flights could be cancelled when wind speed exceeded 30 knots and they can only be used to estimate fishing effort. Estimates of total effort from aerial surveys in PPB have been used to complement creel surveys.

BUS-ROUTE SURVEYS

Bus-route surveys have been conducted in Corner Inlet from January to April 1995 (Conron and Coutin 1995b) and in PPB from December to May 1995 (Conron and Coutin 1995a) and from January to April 1995 (Conron and Coutin 1998). A summary of the survey methods used for these surveys is given in Table 5.

These surveys required a survey agent to visit a series of boat ramps along a survey route with predetermined waiting times at each ramp. The starting location of pre-ordered boat ramps was determined randomly and all boat ramps were visited on each sample day. In the surveys conducted in PPB there were two sections (west and east) with separate routes on each. In addition to providing an estimate of the catch rate from interviews of anglers at each boat ramp, a bus-route survey can provide an estimate of the number of boats at each ramp. The numbers of boats entering and leaving the water were counted at each ramp and interviews were conducted with all boat parties that are encountered. The total catch for each trip is identified, measured and counted by the interviewer. The fishing effort data included the number of fishers, time spent fishing and a count of the number of trailers at each boat ramp (including launches and retrievals from recreational trailers). The total catch was estimated by multiplying the average catch rate (estimated from catch and time spent fishing) with an estimate of the total fishing effort (angler hours).

The primary sample for bus-route surveys was sample day and the secondary sample was boat party. The number of secondary samples can be much larger than the number of primary samples. For example, in the most recently published bus-route survey of PPB there were 39 sample days with 234 boat parties interviewed (Conron and Coutin 1998). Bus-route surveys in PPB can have up to three routes that need to be completed concurrently. A single route can be up to eight ramps that can be completed by one person in approximately 7 hours. If a survey required three staff on a single day, each completing a single route, then this was considered three sample days.

Additionally, bus-route surveys required a feasibility study to determine ramps and waiting times. Considerations to survey design include restrictions on the age of anglers that are interviewed, exclusion of fishing from boats with fixed moorings or fishing activity outside survey times, and potential

cancellation of designated sample days in rough weather. Automatic traffic counters have been used at some ramps to validate data. Adjustments are required for recreational boats that were not fishing, and fishing activity outside survey times.

ROVING CREEL SURVEYS

Ten roving creel surveys on recreational fishing in Victorian bays and inlets have been reported. Most surveys have been conducted in the Gippsland Lakes and PPB. Surveys in the Gippsland Lakes were conducted from January to May 1977 (Beinssen 1978), from April 1979–February 1983 (Hall and MacDonald 1985a), from January to April 1995 (Conron and Coutin 1995c), and in 1995 and 1996 (Conron and Bills 2000). Surveys in PPB were conducted from January–May 1977 (Beinssen 1978), October 1982–September 1983 (MacDonald and Hall 1987), 1989–94 (Coutin *et al.* 1995) and November 1996–January 1997 (Knuckey *et al.* 1997). Other roving creel surveys have been conducted in Corner Inlet from October 1983–March 1984 (Hall and MacDonald 1986), Lake Tyers from July 1984 to June 1985 (Hall and MacDonald 1985a), Mallacoota from December 1981 to June 1984 (Hall *et al.* 1985) and Western Port from January to May 1977 (Beinssen 1978). A summary of the survey methodology used in these surveys is given in Table 6.

These surveys required a survey agent to move around a given location in a pre-determined direction, counting the number of anglers or boats or both and interviewing either all the anglers encountered or a random sample of the anglers. Creel surveys have stratified random sampling design with strata defined by spatial zones, day type (weekdays or weekends) and/or day-time periods. Random sampling was made by randomly assigning sample days to each stratum, or randomly allocating the starting zone, time and sequence in each zone or rotating the starting zone, time and sequence between sample days. The total catch for each fishing party was identified, measured and counted by the interviewer. The fishing effort data includes the number of anglers and time spent fishing. The total catch was estimated by multiplying the average catch rate (estimated from catch and time spent fishing) with an estimate of total fishing effort (hours).

A single interview with an angler can take approximately 5 minutes and a sample day can be between 5–7 hours. The number of secondary samples was larger than that the number of primary samples; rom 769 sample days in the PPB creel survey from 1990–93 there were 12,302 angler interviews including 3,485 boat and 8,817 shore interviews (Coutin *et al.* 1995).

Stratification of creel surveys may be determined from a pilot study or prior knowledge of anglers, managers and researchers. Creel surveys have similar considerations to bus-route surveys: potential age constraints on interviews, fishing activity outside survey times is not known and designated sample days may be cancelled in rough weather.

Table 3: Summary of off-site surveys on recreational fishing in Victorian bays and inlets.

Attribute↓ Reference →	Beinssen 1978	MacDonald and Hall 1987	Dragun 1991	Dragun 1991
Survey scope	State-wide	PPB	PPB and Western Port	PPB and Western Port
Angler contact method	Door to door interview	Door to door interview	Telephone	Mail
Sampling frame	List of households	List of households	List of households and locations	List of anglers and angling clubs
Sampling design	Stratified random	Stratified random	Stratified random	Selective
Primary sample	320 households	approx. 7,000 households	1,573 in general recreation survey & 340 in recreational fishing	65 fishers & 269 angling clubs
Secondary sample	2 interview questions asked at 320 households per weekend over 2 consecutive weekends	2 interview questions asked at 575–666 households per month over 12-months	12 interview questions in the general recreation survey & 25 in the recreational fishing survey	25 interview questions
Sample selection	10 households randomly selected from 30 districts of similar population size each weekend	Stratified for different population densities	Country component stratified throughout non-metropolitan regions according to ABS population	120 willing anglers identified from phone-diary survey
Requirements and/or resources	Conducted with Roy Morgan Omnibus Survey*	Conducted with Roy Morgan Omnibus Survey*	Recruitment and training of interviewers	Telephone screening survey to obtain list of anglers and clubs
Survey dates	late Feb 1977	Oct 1982 to Sep 1983	1991	1991
Time of survey	Weekend daytime		Day-time hours (initially outside business hours)	
Data constraints	Victorians over 14	Victorians over 14	Victorians over 15	Victorians over 15

* Retrieval of data from Roy Morgan likely to cost more than $10,000

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Table 3: Summary of off-site surveys on recreational fishing in Victorian bays and inlets. CONTINUED

Attribute↓ Reference →	Hobday *et al.* 1996	Conron and Kirwin 2000	Henry and Lyle 2003	Conron and Bridge 2005
Survey scope	Southern Rock Lobster and Abalone	Variety of species/locations	State-wide	Variety of species/locations
Angler contact method	Questionnaire completed at Dive shops with SCUBA air refills	Angler Diary Logbook	Telephone interview	Angler Diary Logbook
Sampling frame	List of SCUBA Dive Clubs	List of volunteer anglers	List of households and geographic regions	List of volunteer anglers
Sampling design	Stratified random	Selective	Stratified random	Selective
Primary sample	132 dive clubs	70 anglers	9,055 household phone numbers	201 anglers
Secondary sample	351 questionnaires returned by mail during 11 months	1,417 fishing trips detailing capture of 22,031 fish and measurements for 8,593 fish (43% retained & 57% released)	Number of fishing trips per household	8,269 fishing trips detailing capture of 95,477 fish and measurements for 54,827 fish
Sample selection	20–30 questionnaires distributed to 12 dive clubs randomly selected each month according to groupings based on population, location and value	Experienced anglers volunteer for the diary program	Households randomly selected from 8 regions of different population size	Experienced anglers volunteer for the diary program
Requirements and/or resources	Recruit and liase with Dive shops	Recruitment and liaison with anglers	Recruitment and training of interviewers	Recruitment and liaison with anglers
Survey dates	Sep 1995 to Aug 1996	2 year program from Spring 1998 to Jun 2000	May 2000 to Apr 2001	6 year program from Jul 1997 to Jun 2003
Time of survey	Monthly from Nov to Aug	No specific survey time	Selected by interviewers and diarists	No specific survey time
Data constraints	Biased toward divers using dive shops	Survey not appropriate to estimate total catch	All fishers over 5 in the household were included	Survey not appropriate to estimate total catch

Table 4: Summary of on-site, aerial surveys on recreational fishing in Victorian bays and inlets.

Attribute↓ Reference →	Beinssen 1978	MacDonald and Hall 1987	Conron and Coutin 1995c	Coutin *et al.* 1995
Survey scope	PPB	PPB	Gippsland Lakes	PPB
Angler contact method	Aerial counts of boats with no direct angler contact	Aerial counts of boat with no direct angler contact	Aerial counts of boat with no direct angler contact	Aerial counts of boat with no direct angler contact
Sampling frame	Area & Time	Area & Time	Area & Time	Area & Time
Sampling design	Stratified random; estuary subdivided into 3 areas, day type (weekdays or weekends[1]) & day-time periods (6–10 & 10–14 and 14–18)	Stratified random with 5 zones, day type (weekdays or weekends[1]) and day-time (morning and afternoon/evening)	Stratified random; with 8 spatial zones with 2–3 sub areas[2] in each zone, day type (weekdays or weekends[1]) & day-time periods (6–10 & 10–14 and 14–18)	Stratified random with 5 zones, season, day type (weekdays or weekends[1]) and day-time (morning and afternoon)
Primary sample	40 sample days	24 sample days	30 sample days	240 sample days
Secondary sample	18 flights recording anglers on shore & jetties, stationary boats, & number of anglers on stationary boats (from sub sample of boats)	48 flights recording anglers on shore & jetties, stationary boats, & number of anglers on stationary boats (from sub sample of boats)	33 flights recording number of anglers on small and large boats	326 flights recording anglers on shore & jetties, stationary boats, & number of anglers on stationary boats (from sub sample of boats)
Sample selection	2 flights randomly assigned to each estuary (n = 3) & day type (n = 2) to cover all daytime periods within each 40 day period	2 flights each on a randomly chosen weekday and weekend day (or public holiday) per month for 12-months, flight direction (clockwise or anti) was randomly chosen	1 flight randomly assigned to each zone (n = 8), sub area (n = 2–3) & day-time period (n = 3) on 20 randomly assigned weekend days (66% flights) & 10 randomly assigned week days (33% flights)	Flights randomly assigned to day-time period (n = 2), greater sampling intensity in summer (Oct to Mar) (2 weekdays & 2 weekends) & winter (Apr to Sep) (1 weekday & 1 weekend), random flight start and direction (clockwise or anti)
Requirements and/or resources	Single engine Cessna 172 with pilot and one observer	Single engine Cessna 172 with pilot and one observer	Single engine Cessna 172 with pilot and two observers	Single engine Cessna 172 with pilot and two observers
Survey dates	29 Jan to 30 May 1977	Oct 1982 to Sep 1983	Jan to Apr 1995	Jan 1989 to Apr 1994
Time of survey	6–10, 10–14 and 14–18 (hrs)		6–10, 10–14 and 14–18 (hrs)	
Data constraints	One plane at 60 m & second at 450 m about 6.5 km offshore	One plane at 250 m		One plane at 500 m about 3 km from shore

[1] weekends include public holidays & all of January, [2] two subareas in Lake Wellington were excluded

Table 5: Summary of on-site, bus-route surveys on recreational fishing in Victorian bays and inlets.

Attribute↓ Reference →	Conron and Coutin 1995a	Conron and Coutin 1995b	Conron and Coutin 1998
Survey scope	PPB	Nooramunga & Corner Inlet	PPB
Angler contact method	Interview with 8 questions & counts of boat trailers	Interview with 8 questions & counts of boat trailers	Interview with 8 questions & counts of boat trailers
Sampling frame	17 boat ramps (8 on West & 9 on East) with waiting time 3.25 hr W & 3.5 hr E, travelling time 3.75 hr W & 3.5 hr E, distance 250 km W & 200 km E	7 boat ramps with waiting time 2.5 hr, travelling time 4.5 hr	17 boat ramps (8 on West & 9 on East) with waiting time 3.25 hr W & 3.5 hr E, travelling time 3.75 hr & 3.5 hr E, distance 250 km W & 200 km E
Sampling design	All boat ramps visited on each sample day with sampling at dawn & dusk	All boat ramps visited on each sample day with sampling at dawn & dusk	All boat ramps visited on each sample day with sampling at dawn & dusk
Primary sample	39 sample nights	39 sample nights	39 sample nights
Secondary sample	174 boats	320 boats	234 boats & 553 angler trips
Sample selection	Waiting times at boat ramps estimated by feasibility study and starting location of pre ordered boat ramps was determined randomly	Starting location of pre ordered boat ramps was determined randomly	Waiting times at boat ramps estimated by feasibility study and starting location of pre ordered boat ramps was determined randomly
Requirements and/or resources	Survey requires two survey agents for 3 days a week (each working 1 side of PPB) sampling 2 weekdays & 1 weekend, each day requires 7 hours to complete survey, automatic traffic counter used at 2 boat ramps	Survey requires one survey agent for 3 days a week sampling 2 weekends & 1 weekday, each day requires 7 hours to complete survey, automatic traffic counter used at 2 boat ramps & interviews at sea by F&WO	Survey requires two survey agents for 3 days a week (each working 1 side of PPB) sampling 2 weekdays & 1 weekend, each day requires 7 hours to complete survey
Survey dates	mid Dec 1994 to May 1995	Dec to May 1995	Jan to Apr 1995
Time of survey	3–10 and 18–1	6–13 and 13–20 pm	7 hr period from dusk to dawn
Data constraints	Boats with fixed moorings not included		

Table 6: Summary of on-site, roving creel surveys on recreational fishing in Victorian bays and inlets.

Attribute↓ Reference →	Beinssen 1978	Conron and Bills 2000	Conron and Coutin 1995c	Coutin *et al.* 1995	Knuckey *et al.* 1997
Survey scope	PPB, Western Port & Gippsland Lakes	Gippsland Lakes	Gippsland Lakes	PPB	Melbourne Docklands
Angler contact method	1 interview with 26 questions	1 interview with 9 questions (& fish measurement) & count of anglers or parked cars (if anglers not visible)	Interview	Interview, fish measurement & count of anglers	Interview, fish measurement & count of anglers
Sampling frame	Area & Time	Area & Time	Area & Time	Area & Time	Area & Time
Sampling design	Stratified random	Stratified random with region (Mitchell, Tambo & Lakes Entrance)	Stratified random with zones[1] (n = 6), day type (weekdays or weekends[2]) & day-time (n = 3)	Stratified random with zones (n = 5), day type (weekdays or weekends[2]) & day-time (n = 2)	Stratified random with regions (n = 7), day type (weekdays or weekends[2]) & day-time (n = 2)
Primary sample	sample days	132 sample days	sample days	769 sample days (195 boat sample days & 361 shore)	27 sample days
Secondary sample	644 angler interviews (270 at PPB, 163 WP & 211 GL)	2,435 interviews of 5,249 anglers; 4,132 black bream measured	264 angler interviews (131 boat anglers & 133 shoreline anglers)	12,302 angler interviews (3,485 boat interviews &8,817 shore)	104 angler interviews
Sample selection	Survey one week after aerial survey on corresponding week day & day-time (where possible), interviews coded by fishing group & individual angler	Sample days randomly allocated from 5 weekdays & 5 weekends per month, 3 regions per day & 3 day-time period	60 sample days randomly allocated from weekdays & weekends, with 6 zones & 3 day-time periods	Sample days randomly allocated for each month & zone (3 weekday & 2 weekend for boat survey & 4 weekday & 4 weekend for shore), starting time and sequence varied in each zone	Equal weight to day type and day-time
Requirements and/or resources	Number of interviews determined by observed ratio of anglers on boat, shore & jetties from aerial survey	Land-based surveys of shoreline anglers during peak fishing season	Interviews of shore & boat-based angling requiring 1 staff (shoreline survey) & 2 staff (boat survey)	Interviews requiring 1 staff (shoreline) & 2 staff (boat) with 6 hrs to complete survey	Single survey agent travelled through each region over a 6 hr period
Survey dates	29 Jan to 30 May 1977	May to Nov in 1995 & 1996	Jan to Apr 1995	1989 to 1994	Nov 1996 to Jan 1997
Time of survey	6–10, 10–14 and 14–18 (hrs)	Early, middle & late	Morning, midday & evening	8–14 and 14–20 (hrs)	8–14 and 14–20 (hrs)
Data constraints	Interviews of anglers > 10yrs		Automatic traffic counter at 2 boat ramps		

[1] two zones in the Gippsland Lakes were excluded and two weighted higher, [2] weekends include public holidays & all of January: F&WO = Fisheries and Wildlife Officer

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Table 6: Summary of on-site, roving creel surveys on recreational fishing in Victorian bays and inlets. CONTINUED.

Attribute↓ Reference →	Hall and MacDonald 1985a	Hall and MacDonald 1985b	Hall and MacDonald 1986	MacDonald and Hall 1987	Hall *et al*. 1985
Survey scope	Gippsland Lakes	Lake Tyers	Nooramunga & Corner Inlet	PPB	Mallacoota Inlet
Angler contact method	Angler interview and counts of anglers	Angler interview and counts of anglers	Angler interview and counts of anglers	Angler interviews of shore & boat-based angling and counts of anglers	Angler interview and counts of anglers
Sampling frame	Area & Time	Area & Time	Area & Time	Area & time	Area & Time
Sampling design	Stratified random with zones (n = 8) & day type (weekdays or weekends[2])	Stratified random with zones (n = 2) & day type (weekdays or weekends[2])	Stratified random with zones (n = 3) & day type (weekdays or weekends[2])	Stratified random with zones (n = 5) & day type (weekdays or weekends[2])	Stratified random with zones (n = 2) & day type (weekdays or weekends[2])
Primary sample	41 sample days	22 sample days	18 sample days (6 surveys each requiring 3 days to complete)	Sample days	26 sample days
Secondary sample	~400 interviews (~200 boat interviews & ~200 shore)	68 interviews (98 boat interviews & 103 shore)	144 interviews (majority from boat interviews)	1,766 interviews (613 boat interviews & 1,153 shore)	1,766 interviews
Sample selection	Survey agents counted shore anglers, number of boats, then conducted 10 random interviews with 5 boat anglers & 5 shore anglers	Survey agents counted shore anglers, number of boats, then conducted random interviews, sampling on 1st & 2nd days of each month, each zone required ½ day to sample, starting zone was rotated between surveys	Sample days occurred on 3 consecutive days across the last weekend each month, weekend and weekdays rotated between zones	6 consecutive days (incl 2 weekend days) for boat survey and 4 consecutive days (incl 2 weekend days)	Survey agents counted shore anglers, number of boats, then conducted random interviews, sampling on 1st & 2nd days of each month, each zone required ½ day to sample, starting zone was rotated between surveys
Requirements and/or resources	Interviews required 2 F&WO staff & boat	Interviews required 2 F&WO staff & boat	Interviews required 2 F&WO staff & boat, 1 sample day to complete each zone	Interviews requiring 1 staff (shoreline survey) & 2 staff (boat survey), 6 hours to complete sample day	Interviews required 2 F&WO staff & boat
Survey dates	Apr 1979 to Feb 1983	Jul 1984 to Jun 1985	Oct 1983 to Mar 1984	Oct 1982 to Sep 1983	Dec 1981 to Jun 1984
Time of survey	Daytime	Daytime	Daytime	Daytime	Daytime
Data constraints	No night time surveys	No night time surveys	No night time surveys	No night time surveys	No night time surveys

[2] weekends include public holidays & all of January

3 Analysis of survey methods

This section presents the methods and results for objective 2: from the results of past surveys, statistically assess the costs and sampling requirements of different survey methods for providing unbiased estimates of total recreational catch and effort, with acceptable precision. The survey methods were evaluated only for their ability to estimate the retained catch. Findings from this section were presented at the Australian Society for Fish Biology Annual Workshop in 2005, and published in the Workshop Proceedings (Ryan *et al.* 2006, Appendix 4).

3.1 Methods

The Aquatic Sciences and Fisheries Abstracts database was used to search for studies with keywords 'precision', 'catch' and 'estimate'. Studies investigating the precision of topics other than catch sampling were excluded; only studies investigating catch sampling were included. Additional searches were made on the reference lists of these publications and departmental publication lists on the DPI website. The resulting list included scientific papers and grey literature (Jones *et al.* 1990; Lockwood 1997; Bradford and Francis 1999; Brown 1999; Bradford 2000; Hoyle and Cameron 2003). There were several particularly relevant departmental publications on designing cost-effective sampling regimes to estimate catch using local expertise and software (Smith *et al.* 1997; Knuckey and Gason 2001; Knuckey *et al.* 2001). This literature provides background for analysing and evaluating the success of past Victorian angler surveys.

3.1.1 Surveys of Recreational Boat Anglers in PPB

PPB was chosen as an appropriate bay for comparing survey methodologies for estimating total recreational catch; 47% of the retained recreational catch in Victoria is taken from PPB, with 95% of the catch in PPB taken by boat-based anglers (Henry and Lyle 2003). Three different survey methods have been used to estimate the total recreational catch from boat-based anglers in PPB: an off-site phone-diary survey (2000/01), an on-site bus-route survey (1995–1997) and an on-site roving creel survey (mid 80s, 90s and 2002–present).

The sample frames and units were different for these three survey methods. The bus-route and creel surveys use an area and time sampling frame, while the sampling frame for the NRIFS survey was a list of anglers obtained through a screening survey. The primary sample, which can be altered within a sample design, was sample day for the bus-route or creel surveys and household for the phone-diary survey. The sample size for each survey is based on the primary sample, which could be optimally determined before a survey commences. The precision and number of samples for the primary sample could be predicted for different survey methods allowing determination of the optimal number of primary samples for different levels of precision.

The secondary sample is the basis for each angler interview. The secondary sample units were the number of fishing events per household in the phone-diary survey, or the number of fishing parties per sample day for the bus-route and creel surveys. Catch data were collected from the secondary sample and the number of anglers varies within each secondary sample. The tertiary sample was the number of individuals in the household that fished in the NRIFS or the number of anglers for the bus-route and creel surveys. The catch from the secondary sample is divided by the number of anglers (tertiary sample) to allow comparison of catches.

The total effort for the boat-based fishery for snapper in PPB has been estimated from the NRIFS, bus-route survey and an aerial survey (to complement the creel survey). The primary samples for measuring effort have been household (NRIFS), sample day (bus-route survey) and flights (aerial survey). The secondary sample for reporting effort was an expansion factor (based on ABS population data) for each household in the NRIFS, number of trailers per ramp in the bus-route survey and number of boats per flight in the aerial survey.

Analysis of the distribution of catch involved a two step process that firstly determined the probability of a catch according to the binary response of zero and non-zero catches, followed by fitting the non-zero catches to the negative binomial distribution. This procedure has been used for the analysis of

recreational catch data in Queensland (O'Neill and Faddy 2003) and commercial fisheries in New Zealand and Victoria. The Shapiro-Wilk statistic (W) was used to test the null hypothesis of normality for each distribution and a chi square test was used to test the negative binomial distribution.

The analysis of catch was performed by a generalised linear model with maximum likelihood estimation of parameters using PROC GENMOD in SAS. A GENMOD procedure was used firstly to compare the binary response of zero or non-zero catches to compare the probability of catching a fish for different factors, and then to fit the distribution of retained catch to a negative binomial distribution (after excluding zero catches) to compare the non-zero catches for different factors. The analysis was performed separately for snapper, King George whiting and flathead using catch data from all three surveys. While anglers specifically target certain species (particularly snapper and King George whiting), not all will catch their target species, and catches of non-target species were included in the analyses.

Factors that could potentially influence the probability of a catch, and the amount caught, were included in the analysis. These were survey method (NRIFS, bus-route and creel), season (spring, summer and autumn), day type (weekday and weekend), avidity (avid, regular and occasional) and region (Bellarine, Melbourne and Mornington). Fishing time was used as a covariate. Significant factors could be incorporated into simulations of different sampling methods, and used as appropriate stratification in future survey designs to reduce random errors and improve the precision of catch estimates.

3.1.2 Simulations of Different Sampling Methods

Monte Carlo simulations were conducted to obtain estimates of total catch and precision using an off-site phone-diary survey and on-site bus-route and creel (supported by an aerial) surveys. Estimated probabilities and distributions from previous recreational fishing surveys aimed at determining the total recreational catch for three key species from the boat-based fishery in PPB were used to provide input for the simulations. The simulations repeatedly calculated the total annual catch for sample sizes ranging from 50–650 (with increments of 100) for each primary sample, indicating the number of households for a phone-diary survey, or sample days for bus-route and creel surveys.

There were four steps in the simulations:

1. Estimate the catch rates as catch per angler in household in the phone-diary survey, catch per boat engaged in fishing in the bus-route survey and catch per fishing event in the creel survey
    a. allocate sample size for simulation
    b. predict number of primary samples from estimated distributions of
        i. fishing trips per household in the NRIFS
        ii. boat parties per sample day in the bus-route survey
        iii. fishing events per sample day in the creel survey
    c. predict number of secondary samples from estimated distributions of
        i. anglers per fishing trip in the NRIFS
        ii. anglers per fishing party in the bus-route survey
        iii. anglers per fishing event in the creel survey
    d. determine probability of a catch from estimated probability of a non-zero catch (Pr>0)
    e. predict daily catch rate from estimated distribution of non-zero catch per angler
2. Estimate total annual catch in numbers by multiplying the daily catch rate with estimated
        i. distribution of weighting per household person in the NRIFS
        ii. distribution of number of trailers at each ramp in the bus-route survey
        iii. distribution of number of boats per flight in the aerial survey
        iv. total annual effort (1,600,000 angler hours) for all survey methods
3. Estimate the total catch in weight by multiplying the total annual catch in numbers with the mean weights: 0.700 kg for snapper, 0.220 kg for King George whiting and 0.180 kg for flathead (Henry and Lyle 2003).
4. Simulations were repeated 1,000 times for each primary sample and the total annual catch (and a range of summary statistics) estimated for each repeat; a plot of the mean (of the mean catch) and the coefficient of variation (of the mean catch) was made for different sample sizes to compare the accuracy and precision for different numbers of each primary sample.

The cost to conduct a survey was estimated for each survey method by reviewing previous project budgets (adjusted by CPI). These costs included cost per household for a phone-diary survey, cost per sample day for the bus-route and creel surveys, and cost per flight for the aerial survey. These costs were compared with the sample sizes and precision to provide assessment of the cost-effectiveness for different levels of precision.

ASSUMPTIONS

The simulations aimed to provide a broad overview of three survey methods to compare the precision and cost-effectiveness for estimating the recreational catch in PPB. Methods were compared on the basis of changing the primary sampling units, such as number of households in a phone-diary survey, sample days in a bus-route or creel survey. This broad approach required several assumptions.

The sampling frames were considered the same as the original surveys conducted in PPB. The ramps and waiting times for the bus-route survey were originally determined from estimates of the number of boats using each ramp. The list of anglers for the NRIFS was obtained from a screening survey, but assuming a list is available for the simulations allows the results to be applicable whether the list of anglers was obtained from a screening survey or database of RFL holders.

Stratification from results of the GENMOD analysis improves precision of the estimate of total catch. Differences in the probability of a catch and the distribution of (non-zero) catches for different levels of avidity, region, day type and season will be factored into a pilot survey design to reduce the random variation. By excluding any differences in probability and catch in the simulations the random variation would be increased, but this would be equally applied to all survey methods and is not likely to affect the outcome of the comparisons between survey methods.

Anglers in the simulations were assumed to be harvesting the same population where the probability of a non-zero catch and distribution of non-zero catches was considered the same for all surveys. The distribution of (non-zero) catches were standardised to catch per angler, and there was no need to vary the number of anglers within each secondary sample.

Sampling was not conducted during winter in both the bus-route and creel surveys and only a few winter fishing events were recorded in the NRIFS. Prediction of catches for winter was not included in the simulations. The winter catch of snapper in PPB was considerably lower than at other times of the year. Similarly, the shore-based catch of snapper in PPB was considerably lower than that taken from boats and was not estimated in the bus-route survey. Only boat-based fishing of snapper in PPB was simulated.

3.2 Results

3.2.1 Surveys of Recreational Boat Anglers in PPB

SAMPLE UNITS FOR ESTIMATING CATCH

The primary sample for the three different survey methods used to estimate the catch from the boat-based fishery for snapper in PPB was the basis for conducting angler interviews. There were 112 households interviewed in the NRIFS during 2000/01 that retained fished in PPB (compared with approximately 1,000 households that retained and/or released fish throughout Victoria); 319 sample days in the bus-route surveys conducted from 1995–1997; and 176 sample days in creel surveys conducted from 1999–2005.

The secondary sample (fishing event in the NRIFS, fishing party in the bus-route survey and fishing event in the creel survey) formed the basis of each interview for reporting catch. The frequency distributions of fishing trips for the NRIFS ($W = 0.534$, $p = < 0.001$), the number of fishing parties for the bus-route survey ($W = 0.907$, $p = < 0.001$) and fishing events for the creel survey ($W = 0.944$, $p = < 0.001$) were all not normally distributed (see Figure 3, Appendix 4). There were 394 recorded events in the NRIFS, 3,247 fishing parties interviewed in the bus-route survey, 3,157 fishing events in the creel surveys. The number of fishing parties per sample day in the bus-route survey ranged from 1–38. Smaller fishing parties were most common, 8 or less fishing parties were observed on 52% of sample days, and the number of fishing parties observed decreased with increasing party size. There was a general, but

uneven, decline in the frequency of fishing events per sample day with increasing number of events in the creel survey.

The secondary sample for the bus-route and creel surveys were independent, but those for the phone-diary survey were not independent as the number of fishing trips were influenced by the fishing activity in each household. Of the 112 households that fished in PPB in the NRIFS, the majority of these households (89%) reported 8 or less fishing trips per household for boat-based fishing in PPB (in fact 45% recorded only 1 fishing trip), while the remaining 11% of households reported between 9–42 fishing trips.

The distributions of the tertiary sample (number of anglers) were not normal for the NRIFS ($W = 0.231$, $p = < 0.001$), bus-route survey ($W = 0.296$, $p = 0.01$) and creel survey ($W = 0.299$, $p = 0.01$) (Figure 2). The number of anglers varied between the three survey methods, from one diarist for each recorded fishing event in the NRIFS, to the number of anglers in each fishing party or fishing event in the bus-route and creel surveys. Consequently, the bus-route and creel surveys had a large range in the number of anglers for each secondary sample with more than 50% of fishing parties and fishing events having 2 anglers, compared with the NRIFS where 94% of households had only one angler per recorded event.

SAMPLE UNITS FOR ESTIMATING EFFORT

Of the households surveyed in the NRIFS that fished in PPB, 58% were from statistical divisions in country locations and 42% were from the Melbourne statistical division (Table 7). Person diary weights in country locations were all below 700 and catches from these households contributed less toward the estimated total state-wide catch. Person diary weights in city locations ranged from 700–2,100 and catches from these households contributed more toward the estimated total catch.

Retained catches of snapper in PPB from boat-based anglers were reported from households in five country statistical divisions: Barwon, Western Districts, Central Highlands, Loddon-Campaspe and Goulburn/Ovens Murray (Table 7). These catches represented 33% of the unweighted total number of snapper taken in PPB, but expanded to represent 7% of the estimated total recreational catch of snapper in PPB (Henry and Lyle 2003). By comparison, households in the Melbourne statistical division reported 67% of the unweighted total number of snapper in PPB, but contributed to 93% of the estimated total recreational catch of snapper in PPB.

Higher person diary weights were allocated to anglers in city households because they represent a larger proportion of the total population. The wide range in person diary weights for city locations, and their importance to the estimate of total catch, has implications for using a distribution of person diary weights in the simulations and using the phone-diary survey method on a small spatial scale.

There were 13,408 trailers counted for 1,138 ramps during the bus-route surveys. The average number of trailers per ramp was 11.78 (SE = 0.58), although the number of trailers ranged from 0–267. The distribution was not normal (Figure 3).

There were boats counted for 275 flights during the aerial surveys. The number of boats per flight ranged from 0–250 and the distribution was not normal. The average number of anglers per boat was 2.05, which was consistent with numerous past surveys (Figure 3).

PROBABILITY OF A CATCH

Although there were differences in the probability of non-zero catches of the seven most common species caught by boat anglers in PPB from the three different survey methods (see Figure 4, Appendix 4). These differences may be due to the surveys being conducted over different time periods, but the underlying trends in probability of a non-zero catch were the same for the three survey methods. The fish most likely to be caught in PPB by boat anglers, irrespective of survey method or when the survey was conducted, was flathead with a probability of a non-zero catch (for all surveys combined) of 0.485, followed by King George whiting (0.217) and snapper (0.130) (Figure 4). The probabilities of non-zero catches were lowest for calamary (0.092), barracouta (0.052), garfish (0.039) and Australian salmon (0.017).

There were 1,140 non-zero catches of snapper (including effort targeting snapper and other species). Survey, season, day type, avidity, ramp and fishing time were all significant ($p = < 0.001$) in determining the probability of catching snapper (Table 8). Avid anglers were more likely to catch snapper. Anglers were more also likely to catch snapper in the creel surveys and NRIFS than in the bus-route survey.

Anglers were also more likely to catch snapper in spring, on weekdays, from Melbourne and Mornington, and if a longer time was spent fishing (Table 8, Figure 5).

There were 1,322 non-zero catches of King George whiting (including effort targeting KGW and other species). Survey, season, avidity, ramp and fishing time were all significant ($p = < 0.001$) in determining the probability of catching King George whiting (Table 8). Day type ($p = 0.008$) was considered not significant. Avid and regular anglers were more likely to catch King George whiting. Anglers were more also likely to catch King George whiting in the NRIFS than in the bus-route and creel surveys. The probability of catching King George whiting was also higher in autumn, in Bellarine, and when a longer time was spent fishing (Table 8, Figure 5).

There were 3,381 non-zero catches of flathead (including effort targeting flathead and other species). Survey, season, day type, avidity, ramp and fishing time were all significant ($p = < 0.001$) in determining the probability of catching snapper (Table 8). Avid and occasional anglers were more likely to catch flathead. Anglers were more also likely to catch flathead in the bus-route and creel surveys than in the NRIFS. Higher probabilities were also observed in summer and autumn, weekends, fishing from Bellarine and Mornington, and over a longer fishing time (Table 8, Figure 5).

The probability of catching snapper was highest in the creel survey (22%) compared with the NRIFS (18%) and bus-route survey (11%) (Figure 5). The probability of catching King George whiting was highest in the NRIFS (27%) compared with the bus-route (20%) and creel (17%) surveys. The probability of catching flathead was lowest in the NRIFS (43%) compared with the bus-route (49%) and creel (48%) surveys.

Snapper was more likely to be caught in spring (24%) than summer (16%) and autumn (13%), while King George whiting was less likely to be caught in spring (7%) than summer (19%) and autumn (26%). Flathead was only slightly less likely to be caught in spring (43%) than in summer (49%) and autumn (48%) (Figure 5).

The probability of catching snapper was higher on weekdays (21%) compared with weekends (15%), but was lower for flathead on weekdays (39%) compared with weekends (49%); there was no difference in day type on the probability of catching King George whiting (10% on weekdays and weekends) (Figure 5).

The probability of catching snapper was higher for avid anglers (23%) compared with regular (14%) and occasional (11%) anglers. Avid (21%) and regular (21%) anglers were more likely to catch King George whiting than occasional (15%) anglers. The probability of catching flathead was slightly lower for avid anglers (46%) than regular (48%) or occasional (48%) anglers (Figure 5).

Snapper was more likely to be caught in Mornington (20%) and Melbourne (18%) compared with Bellarine (10%). King George whiting was more likely to be caught in Bellarine (36%) than in Melbourne (17%) and Mornington (6%). The probability of catching flathead was similar for Bellarine (47%), Mornington (46%) and Melbourne (46%) (Figure 5).

MEAN NON-ZERO CATCH

The distributions of non-zero catch rates per angler for snapper ($W = 0.652$, $p = < 0.001$), King George whiting ($W = 0.779$, $p = < 0.001$) and flathead ($W = 0.245$, $p = 0.01$) were not normally distributed (see Figure 5, Appendix 4). Snapper were mostly caught in small numbers, with 61% of anglers only caught a single snapper. Anglers caught more King George whiting; while 31% of anglers only caught one King George whiting, 35% of anglers caught 2–5. Flathead were caught in larger numbers than both snapper and King George whiting. Most anglers (30%) only caught one flathead, but catches of 2–10 flathead were made by 58% of anglers.

The range in catch reflects the maximum bag limit for most species, where the current maximum bag limit for snapper is 10, King George whiting is 20 and flathead is 30 (except dusky flathead which is 5). The catch may exceed the bag limits if there where changes in previous years, or more than one angler (although these catches were standardised to catch per angler).

There were 556 non-zero catches of snapper in PPB. Survey ($p = 0.007$), season ($p= < 0.001$), day type ($p = < 0.001$), avidity ($p = 0.003$), ramp ($p = 0.016$) were all significant in determining the catch of snapper (Table 9). Fishing time ($p = 0.454$) was not significant. There was an increased retained catch of snapper

by occasional anglers, on weekdays, from Melbourne and Mornington, and in summer and autumn (Table 9, Figure 6). The mean non-zero catch was highest for snapper in the NRIFS.

There were 934 non-zero catches of King George whiting in PPB. Season (p = < 0.001), day type (p = 0.002), avidity (p = < 0.001), ramp (p = < 0.001) and fishing time (p = 0.005) were all significant in determining the probability of catching King George whiting (Table 9). Survey (p = 0.539) was not significant. There was an increased retained catch of King George whiting by avid anglers, on weekdays, from Bellarine and Mornington, in autumn, and if a longer time was spent fishing (Table 9, Figure 6). The mean non-zero catch was highest for King George whiting in the NRIFS.

There were 2,239 non-zero catches of flathead in PPB. Season (p = 0.0111), ramp (p = < 0.0001) and fishing time (p = < 0.0001) were all significant in determining the probability of catching flathead (Table 9). Survey (p = 0.4219), day type (p = 0.6446) and avidity (p = 0.9285) were not significant. There was an increased retained catch of flathead from Mornington, in summer and autumn, and if a longer time was spent fishing (Table 9, Figure 6). The mean non-zero catch was highest for flathead in the NRIFS.

The mean non-zero catch for snapper was highest in the NRIFS (3.739) compared with the bus-route (1.525) and creel (1.692) surveys. Similarly, the mean non-zero catch of King George whiting (7.015) and flathead (12.286) in the NRIFS were higher than catches observed from other surveys. The mean non-zero catch of King George whiting was not different between the bus-route (5.280) and creel surveys (4.495). The mean non-zero catch of flathead was also the same for the bus-route (4.345) and creel surveys (4.181) (Figure 6).

The mean non-zero catch of snapper increases from spring (1.339) to summer (1.872) to autumn (2.159), while the mean non-zero catch of King George whiting decreases from spring (4.196) to summer (4.756) to autumn (5.745). The mean non-zero catch of flathead was relatively similar in spring (4.599), summer (4.738) and autumn (4.899) (Figure 6).

The mean non-zero catch of snapper and King George Whiting were higher on weekdays (2.333 and 6.712 respectively) compared with weekends (1.619 and 4.743 respectively). Catches of flathead were also higher on weekdays (5.197) than weekends (4.688), but this difference was not significant (Figure 6).

The mean non-zero catch of King George Whiting by avid anglers (6.026) was higher than for regular (4.304) and occasional (4.833) anglers. The mean non-zero catch of snapper by occasional anglers (2.427) was higher than that observed for avid (1.807) and regular (1.470) anglers. Similarly for flathead, the mean non-zero catch by occasional anglers (5.810) was higher than avid (4.332) and regular (4.501) anglers (Figure 6).

The mean non-zero catch of snapper was highest in Melbourne (1.794) compared with Bellarine (1.602) and Mornington (1.512). The mean non-zero catch of King George whiting was highest in Bellarine (5.049) and Melbourne (5.552) compared with Mornington (2.661), while the mean non-zero catch of flathead was highest in Mornington (4.777) and Melbourne (4.197) compared with Bellarine (3.714) (Figure 6).

3.2.2 Simulations of Different Sampling Methods

The numbers of secondary samples were allocated according to the analysis of effort distributions for the Monte Carlo simulations. A random number from a Poisson distribution with a mean of 9.94 was used to allocate the number of boat parties in the simulations for the bus-route survey. A random number between 1 and 42 was used to allocate the number of fishing events in the simulations for the creel survey (excluding an extreme number of 58 fishing events observed for one sample day). The number of recorded events per household was allocated in the simulations by firstly selecting a random number to assign a probability then indicating a different outcome based on the probability. Where the probability was less than 15%, a random number between 10 and 42 was selected. For the larger probability (85%), a random number from a Poisson distribution with a mean of 2.17 was allocated.

The allocation of a catch for each secondary sample was the same for each survey method according to the parameters estimated in the analysis of probability of a catch and proportion of non-zero catches in the previous section (Table 10). The catch for each secondary sample was allocated by firstly selecting a random number to assign a probability of a non-zero catch. These probabilities were 0.130 for snapper, 0.217 for King George whiting and 0.515 for flathead. If the outcome indicated a non-zero catch, then a

catch was allocated from the exponential distribution with a mean of 1.73 for snapper (standard deviation = 1.99), 5.98 for King George whiting (sd = 10.38) and 5.12 for flathead (sd = 8.57).

A comparison of the probability of non-zero catch and mean (non-zero) catch based on observations from the raw data for snapper, King George whiting and flathead in PPB is given in Table 11. These estimates provide the values used in the Monte Carlo simulations.

The mean catch rate provides a comparison of the accuracy for a range of primary sample units (see Figure 6, Appendix 4). The mean catch rates remained constant with increasing sample size indicating the accuracy of the estimated catch rates did not change. But the range in maximum and minimum mean catches is larger for smaller samples indicating lower sample sizes were less likely to accurately estimate catch. These ranges were also different between survey methods, but it should be noted that the primary sample unit is not comparable between survey methods; one sample day is not the same as one household. What this does suggest is that the accuracy of the bus-route and creel surveys increases rapidly between 50 and 150 sample days and accuracy of the phone-diary survey improves more gradually between 150 and 250 households.

The standard error of the mean catch provides a comparison of the precision for different primary sample units (see Figure 6, Appendix 4). The standard error of the mean catch decreased as the number of samples increased. Higher samples had lower standard error and higher precision. The ranges between the lowest and highest standard error of the mean catch also decreased with increasing sample size. This is related to the nature of the survey method where eight or fewer recorded events were observed in 85% of households in the phone-diary survey, but eight or fewer fishing parties were observed in 50% of sample days in the bus-route and creel surveys.

A cost model for the different survey methods, based on expenditure from previous recreational fishing surveys, was developed that was linear (costs increased with sample size), continuous and deterministic (there were no stochastic properties) (see Figure 7, Appendix 4). Costs were calculated as a combination of fixed and variable costs. The fixed costs for a phone-diary survey ($130,000) were much higher than for bus-route and creel surveys (both $50,000), reflecting the work required to establish a good sampling frame for a phone-diary survey. The phone-diary survey had much lower variable costs for collecting samples. These were estimated to be about $100 per household, compared with $700 for a sample day in the bus-route and $900 for a sample day in the creel survey.

The standard error and cost for the three survey methods were compared with assess the sampling errors relative to the costs of collecting and processing the data (see Figure 7, Appendix 4). The initial high curve for a phone-diary survey reflects the high fixed costs and low precision of small sample sizes, but the lower variable costs of a phone-diary survey allow the precision and cost to become comparable with bus-route and creel surveys. For example, at $190,000, there is a similar precision between 380 households for a phone-diary survey or 190 sample days from a bus-route survey. At $240,000, there is a similar precision between 750 households for a phone-diary survey and 190 sample days from a creel survey. The cost-effectiveness reaches a point at about $300,000 where the cost of taking additional samples produces minimal further decreases in standard error and has limited potential to increase precision for all survey methods.

Similar results were observed for snapper (which had a low probability of a catch and a low non-zero catch), King George whiting (low probability of a catch and a high non-zero catch) and flathead (high probability of a catch and a high non-zero catch).

3.3 Discussion

The recreational fishery in PPB was suitable for assessing the use of bus-route, creel and phone-diary surveys to estimate recreational catch within a small spatial scale. The GENMOD analyses indicate that significant differences (α = 0.05) exist in the probability of a catch and non-zero catch distribution for different levels of avidity, region, day type and season for each species. These differences can be factored into a survey design with appropriate stratification to improve precision of the total estimate. Spatial strata, such as zones or regions, and temporal strata, such as day type and season, have been used in recreational fishing surveys in Victoria. The angler variable, avidity, has rarely been incorporated into a survey design, although anglers were asked their level of avidity during interviews.

A higher catch was expected for avid anglers, possibly because of longer periods of fishing and better knowledge of the resource. This does not always equate to higher catches, particularly for snapper, and previous surveys have indicated the importance of non-catch related motives for fishing. There were often different interpretations for regular and occasional anglers by both interviewers and anglers themselves. This may explain some of the inconsistencies in the estimated probabilities and catches for the two groups.

It was assumed that there was no interaction between the survey method and the level of avidity, region, day type or season. By not including these variations in the simulations, the random variation was increased, but remained the same for all survey methods. Differences in the probability of a catch and the non-zero catch distribution for different levels of avidity, region, day type and season for each species could be factored into the simulations to reduce the random variation. This will not affect the outcome of the comparisons between survey methods.

The simulations do not incorporate sampling errors associated with estimating annual effort. These are possibly higher for an aerial survey compared with the expansion procedure of the phone-diary survey. The creel survey provided lower standard errors for the estimates of catch rate than the bus-route survey at all levels of expenditure. The phone-diary survey produced the most rapid decreases in standard error with increasing expenditure (but from a higher starting level) and produced the lowest standard errors at higher expenditure levels.

The preferred survey method for estimating the recreational catch may depend on the ability and costs to achieve precise estimates, objectives of the survey and available funds. If the survey objectives were purely to estimate catch by numbers, then a phone-diary survey is most likely to provide this information at the lowest cost for precision, particularly if the costs incurred with establishing a sampling frame can be reduced, for example, by using a database of fishing participants. Changes in the cost structures may influence outcome and choice of the preferred method.

Survey errors and survey costs are reflections of each other (increasing expenditure reduces uncertainty for all survey methods) and in planning a survey, effort should be directed toward both reducing the errors and producing the greatest usefulness with the funds available.

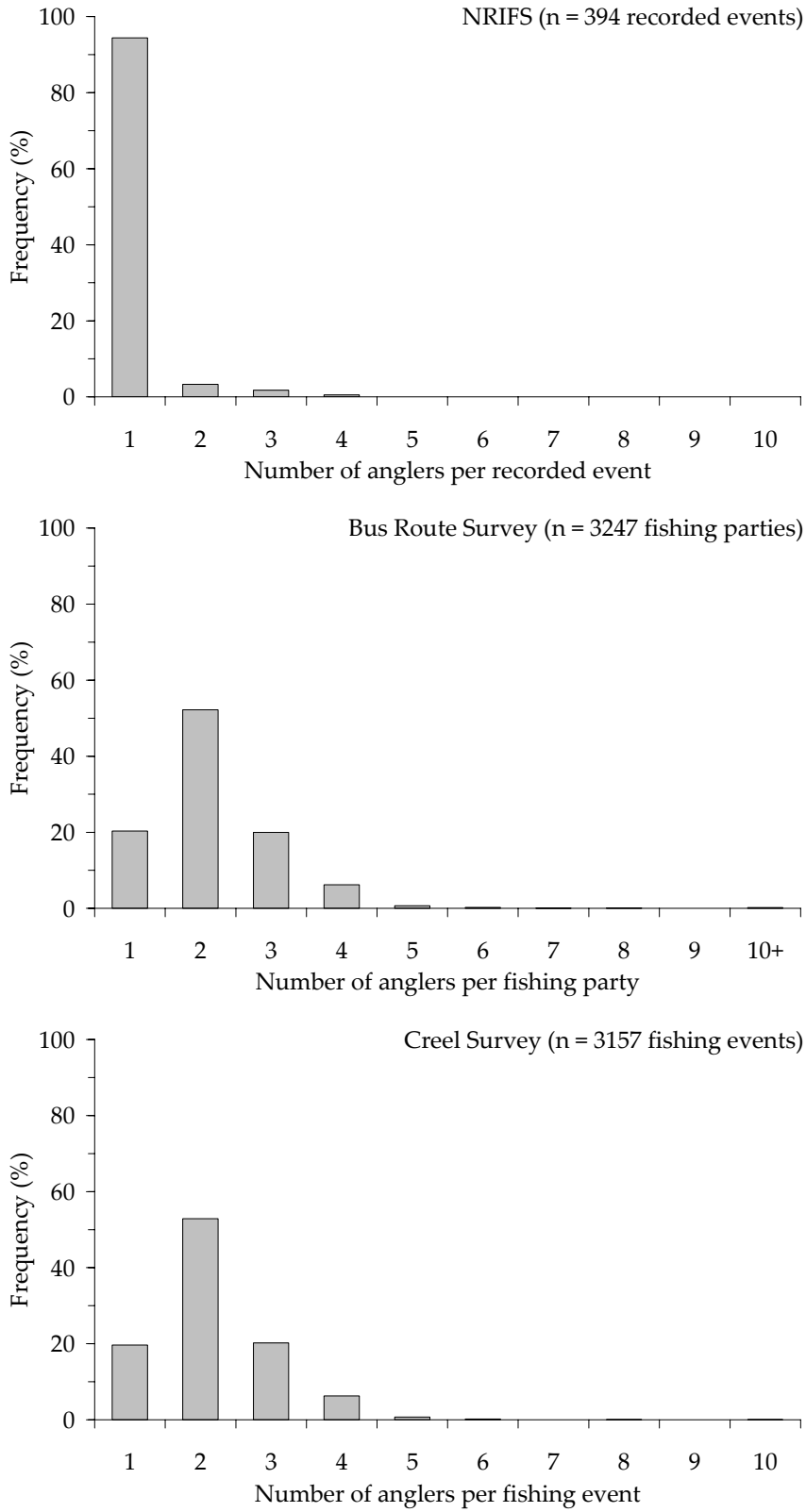

Figure 2: Distribution of tertiary sample from three survey methods used to estimate the total catch of boat-based fishing for snapper in PPB.

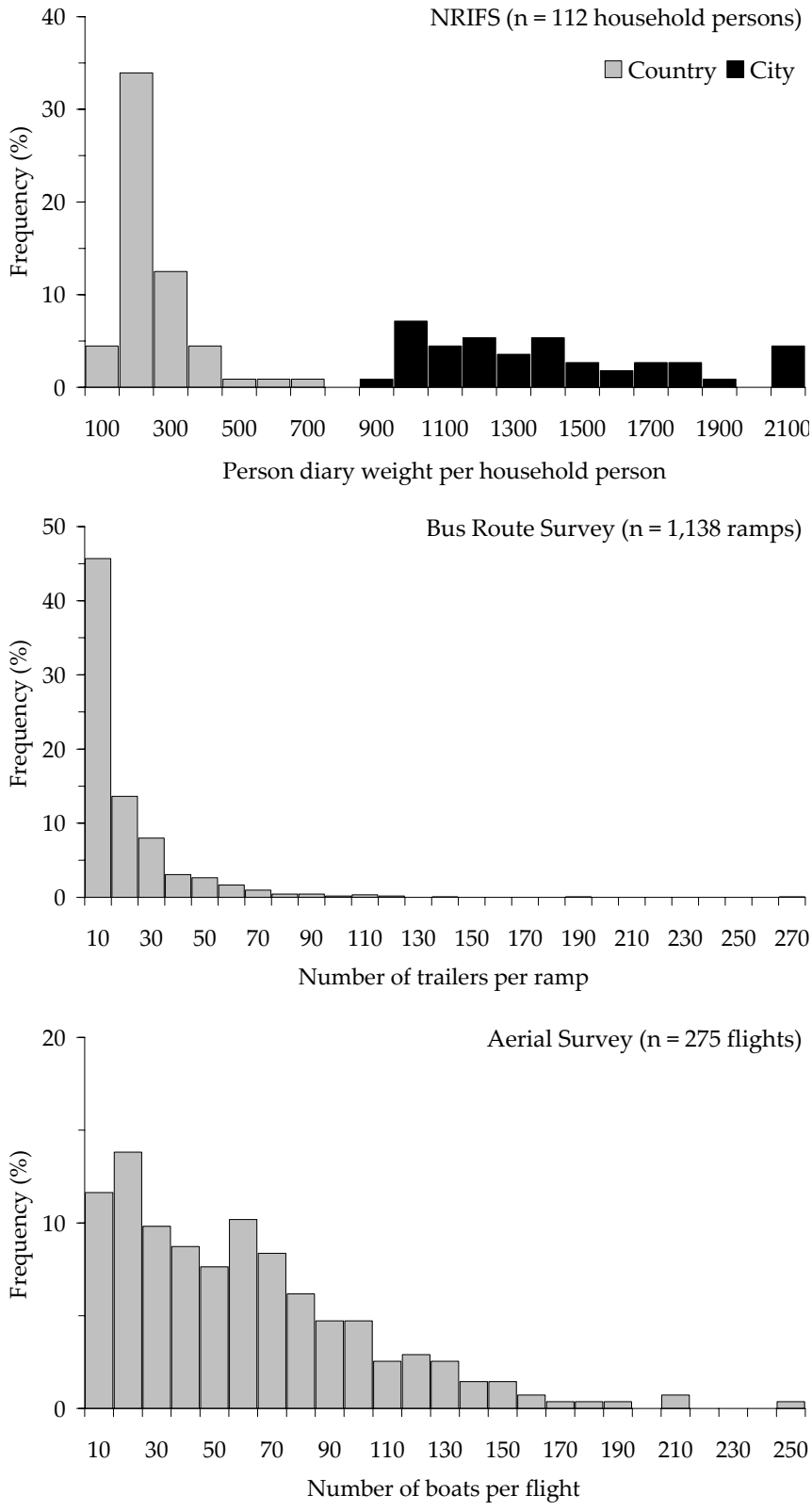

Figure 3: Distribution of secondary sample from three survey methods used to estimate the total effort of boat-based fishing for snapper in PPB.

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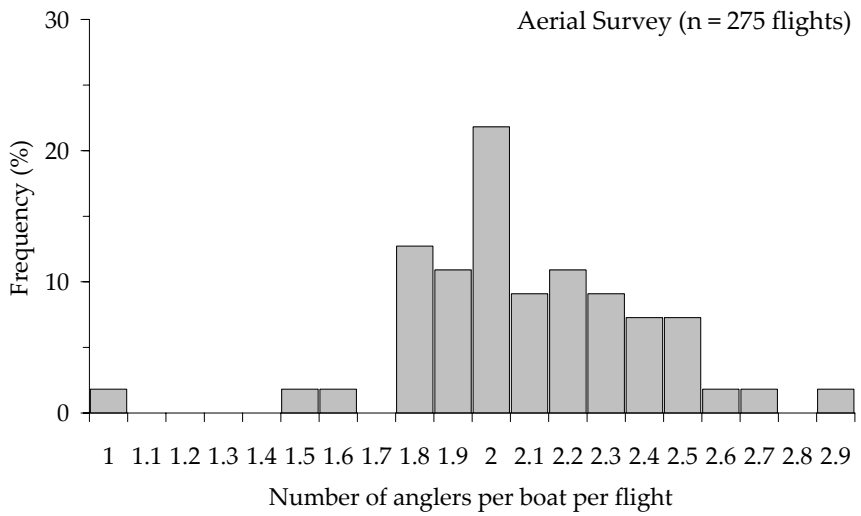

Figure 3: Distribution of secondary sample from three survey methods used to estimate the total effort of boat-based fishing for snapper in PPB.

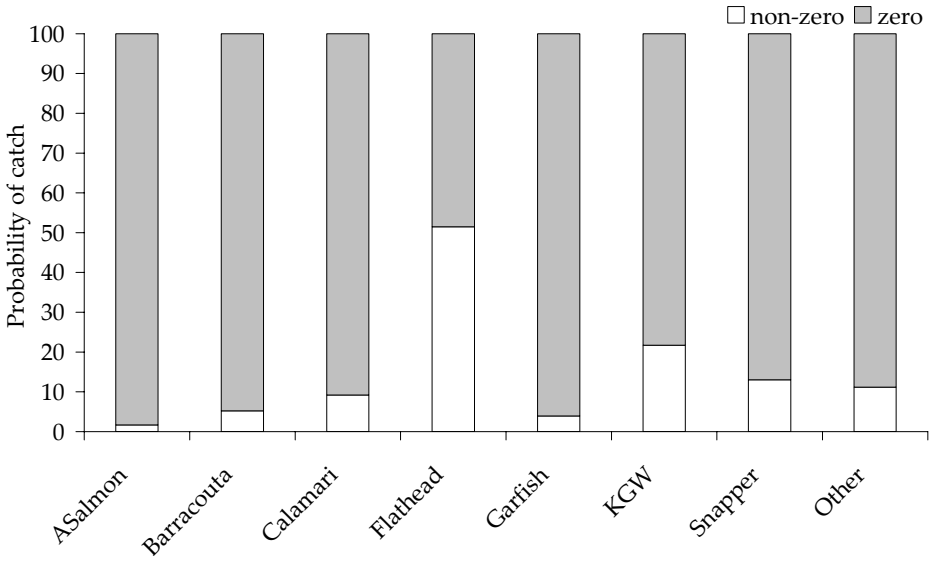

Figure 4: Probability of zero and non-zero catches for major species groups for all surveys combined by boat-based anglers in PPB.

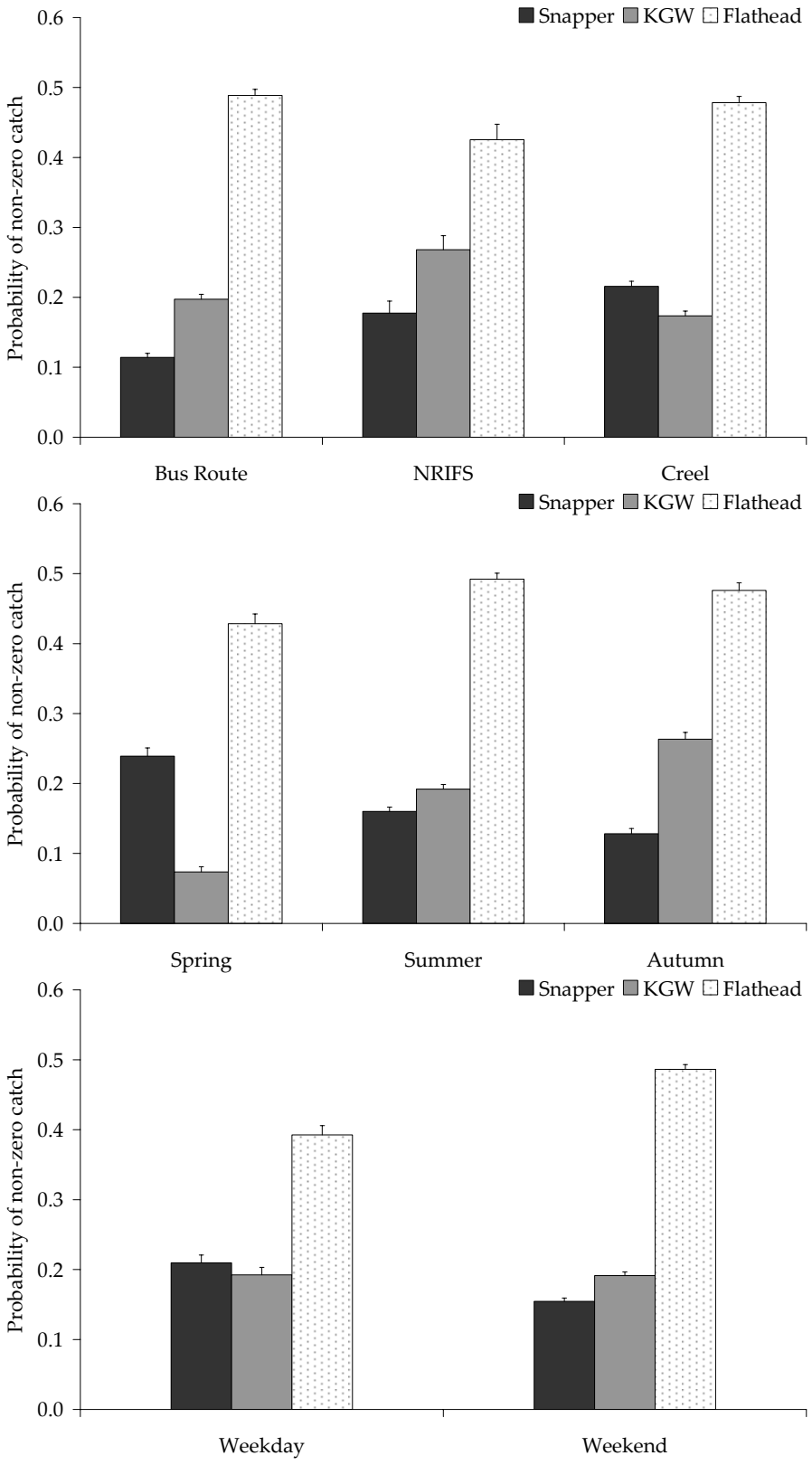

Figure 5: Probability of non-zero catch (and standard error) for snapper, King George whiting and flathead for survey, season, day type, avidity and ramp.

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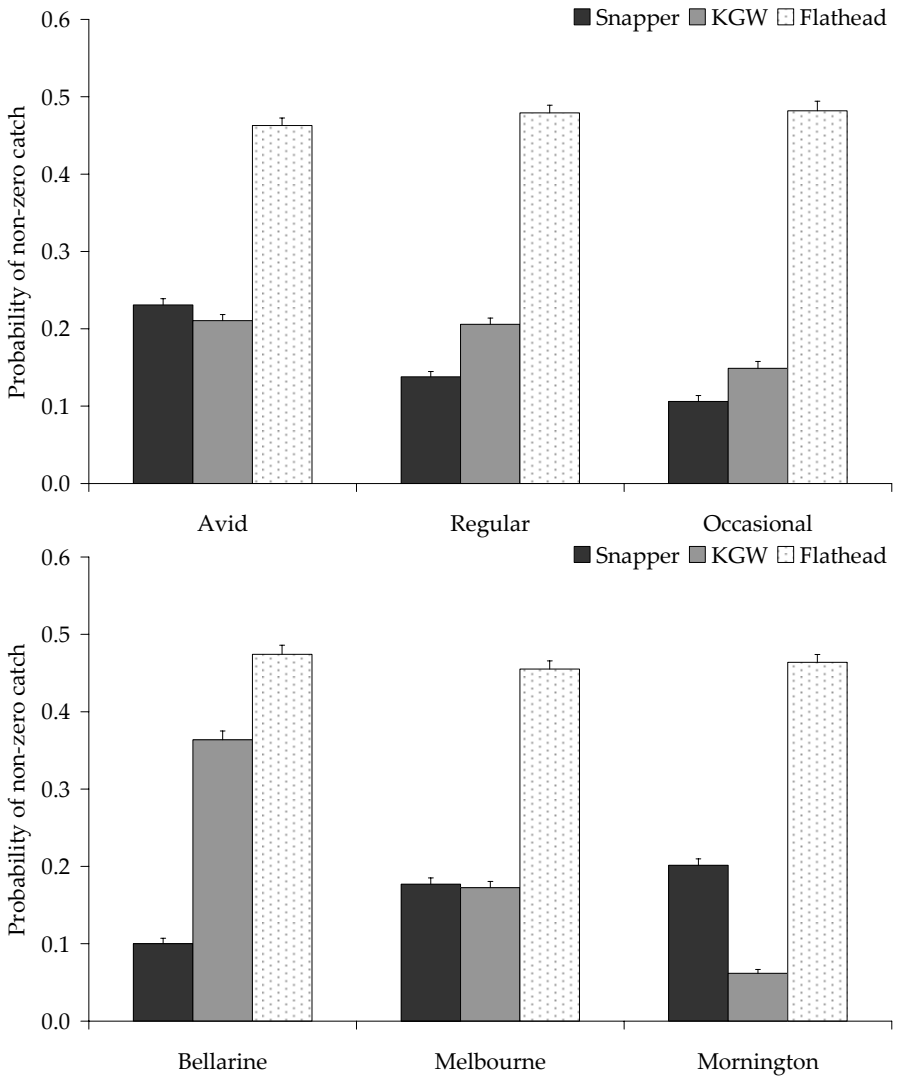

Figure 5: Probability of non-zero catch (and standard error) for snapper, King George whiting and flathead for survey, season, day type, avidity and ramp.

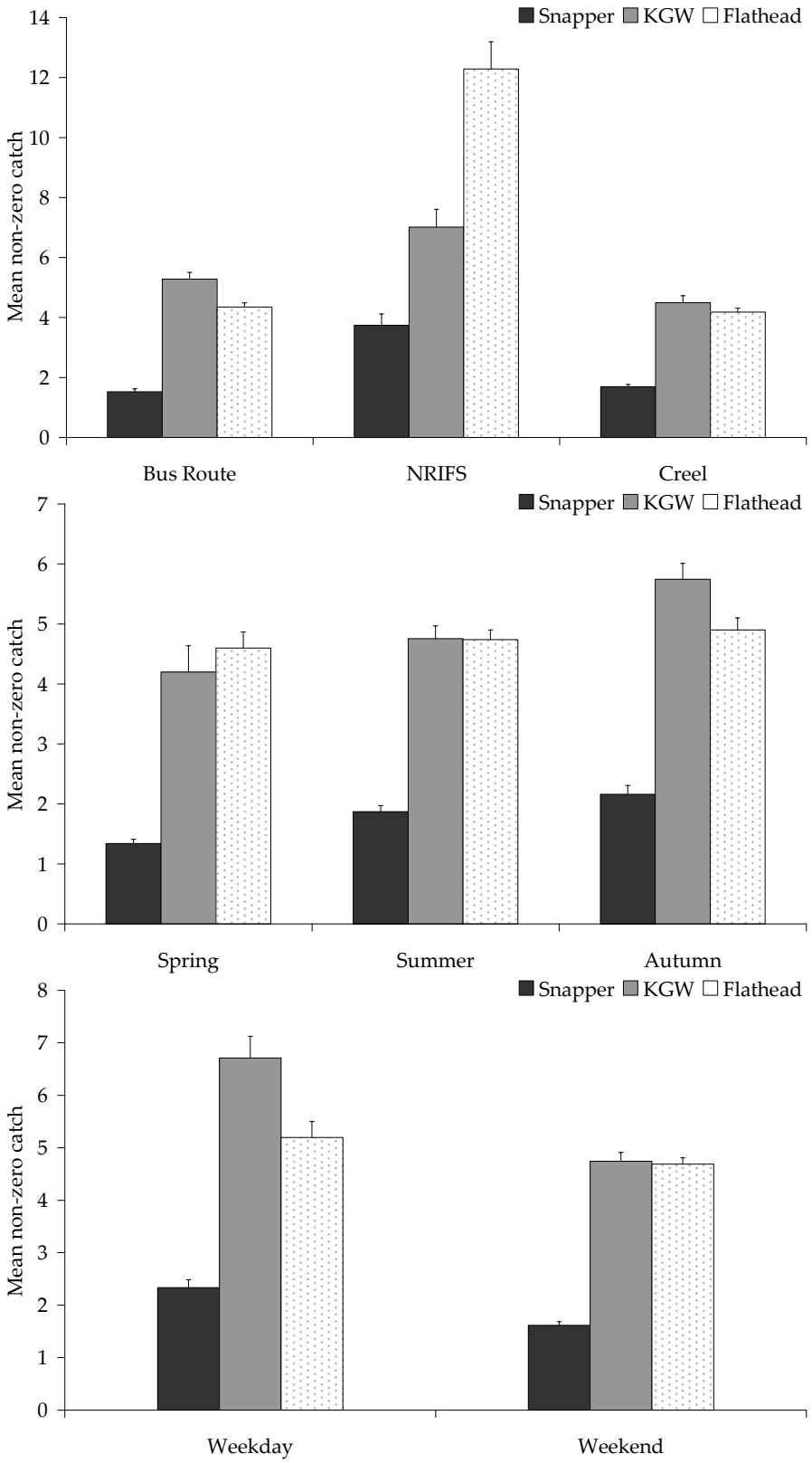

Figure 6: Mean non-zero catch (and standard error) for snapper, King George whiting and flathead for survey, season, day type, avidity and ramp.

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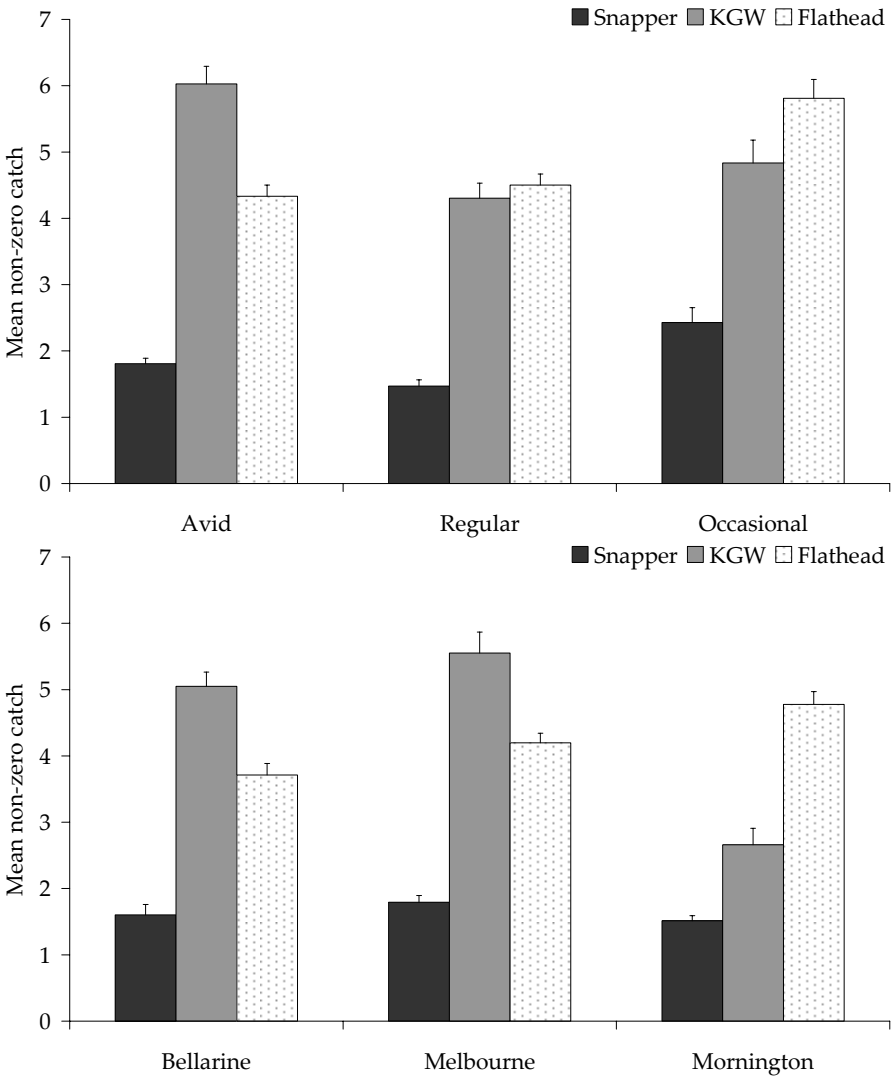


Figure 6: Mean non-zero catch (and standard error) for snapper, King George whiting and flathead for avidity, ramp, day type, season and survey.

Table 7: Estimated number of snapper taken by boat-based anglers in PPB by statistical division.

statistical division	% households in statistical division	Expanded estimated total number of snapper	%
City	58	292,751	93
Barwon	27	20,379	6
Western District	1	217	< 0.5%
Central Highlands	2	1,195	< 0.5%
Loddon/Campaspe	1	743	< 0.5%
Goulburn/Ovens Murray	1	243	< 0.5%

Table 8: GENMOD analysis on the probability of retaining snapper, King George whiting and Flathead in PPB.

Parameter			Snapper		KGW		Flathead	
Source		DF	Chi Square	Pr > ChiSq	Chi Square	Pr > ChiSq	Chi Square	Pr > ChiSq
Survey		1	227.1049	< 0.0001	22.0211	< 0.0001	25.0125	< 0.0001
Season		2	20.5026	< 0.0001	255.6074	< 0.0001	31.5957	< 0.0001
Day type		1	40.0250	< 0.0001	3.0271	0.0819	36.6139	< 0.0001
Avidity		3	132.7777	< 0.0001	63.1636	< 0.0001	94.2029	< 0.0001
Ramp		2	80.3082	< 0.0001	645.9531	< 0.0001	29.2519	< 0.0001
Fishing time		1	204.5477	< 0.0001	35.3655	< 0.0001	110.5855	< 0.0001
Parameter			Snapper	SE	KGW	SE	Flathead	SE
Intercept			-2.5796	0.1264	-3.8008	0.1438	-0.4830	0.0849
Survey	Bus-route		-1.1369	0.0782	0.3450	0.0738	0.2661	0.0533
	NRIFS		-0.3524	0.1461	2.2550	0.1523	-0.0950	0.1101
	Creel		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Seas	Autumn		-0.1626	0.0840	0.5064	0.0708	0.1776	0.0567
	Spring		0.2910	0.0890	-1.2816	0.1217	-0.2416	0.0696
	Summer		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Day type	Weekday		0.5682	0.0884	0.1570	0.0898	-0.4029	0.0669
	Weekend		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Avidity			0.2910	0.3427	-0.8438	0.3662	-1.6200	0.2322
	Avid		1.0616	0.1075	0.6687	0.1005	-0.4278	0.0699
	Regular		0.3898	0.1101	0.3790	0.0986	-0.1396	0.0688
	Occasional		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ramp			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Bellarine		-0.8398	0.0986	2.2798	0.1021	0.0543	0.0647
	Melbourne		-0.1771	0.0812	1.1570	0.1045	0.3144	0.0612
	Mornington		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing time			0.1905	0.0135	0.0841	0.0139	0.1154	0.0113
Scale			1.0000	0.0000	1.0000	0.0000	1.0000	0.0000

Summary includes criteria for assessing goodness of fit statistics for Type III analysis and parameter estimates (with standard errors).

Table 9: GENMOD analysis (excluding zero catches) fitting the negative binomial distribution to retained catch of snapper, King George whiting and flathead in PPB*.

			Snapper		KGW		Flathead	
Source		DF	Chi Square	Pr > ChiSq	Chi Square	Pr > ChiSq	Chi Square	Pr > ChiSq
Survey		1	7.3842	0.0066	0.3772	0.5391	0.6451	0.4219
Season		2	41.2023	< 0.0001	30.5922	< 0.0001	8.9959	0.0111
Day type		1	18.7773	< 0.0001	9.5049	0.0020	0.2128	0.6446
Avidity		3	14.0922	0.0028	57.9325	< 0.0001	0.4556	0.9285
Ramp		2	8.2699	0.0160	58.5840	< 0.0001	28.2153	< 0.0001
Fishing time		1	0.5609	0.4539	7.7487	0.0054	34.9385	< 0.0001
Parameter			Snapper	SE	KGW	SE	Flathead	SE
Intercept			0.5769	0.1007	0.3474	0.1333	1.3834	0.0572
Survey	Bus-route		-0.1538	0.0568	0.0347	0.0565	0.0283	0.0352
	NRIFS		0.6412	0.1026	1.2467	0.1363	0.9085	0.0716
	Creel		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Season	Autumn		0.1298	0.0590	0.2210	0.0555	0.0541	0.0369
	Spring		-0.3242	0.0650	-0.2963	0.1080	-0.1013	0.0485
	Summer		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Day type	Weekday		0.2569	0.0587	0.2153	0.0703	0.0216	0.0468
	Weekend		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Avidity			0.1496	0.2496	0.2621	0.3193	0.0762	0.1938
	Avid		0.1491	0.0854	0.5370	0.0889	-0.0183	0.0462
	Regular		-0.0663	0.0892	0.1553	0.0873	0.0008	0.0443
	Occasional		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ramp			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ramp	Bellarine		0.0496	0.0765	0.6878	0.0917	-0.2296	0.0446
Ramp	Melbourne		0.1655	0.0581	0.7307	0.0969	-0.1438	0.0406
Ramp	Mornington		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing time			-0.0070	0.0093	0.0347	0.0126	0.0438	0.0076
Dispersion			0.1747	0.0224	0.6465	0.0314	0.6903	0.0204

Summary includes criteria for assessing goodness of fit statistics for Type III analysis and parameter estimates (with standard errors).

Table 10: Parameter estimates used in Monte Carlo simulations.

Species	Probability of non-zero catch	Pr(>0)	Mean non-zero catch	Catch	Weight conversion factor	Weight
Snapper	0.130	Low	1.73	Low	0.70	High
KGW	0.217	Low	5.98	High	0.22	Low
Flathead	0.515	High	5.12	High	0.18	Low

Table 11: Comparison of proportion of observations, probability of non-zero catch and mean catch for snapper, King George whiting and flathead in PPB.

Variable	Level	Proportion	Pr (> 0)	SE Pr (> 0)	Mean catch	SE catch
Snapper						
Avidity	Avid	3.7	0.231	0.008	1.81	0.083
	Regular	2.1	0.138	0.007	1.47	0.095
	Occasional	1	0.106	0.008	2.43	0.227
Region	Bellarine	1	0.100	0.007	1.60	0.157
	Melbourne	2.2	0.177	0.008	1.79	0.100
	Mornington	2.6	0.201	0.008	1.51	0.078
Day type	Weekday	1	0.210	0.011	2.33	0.153
	Weekend	3.0	0.154	0.005	1.62	0.067
Season	Spring	1.1	0.239	0.012	1.34	0.069
	Summer	2.1	0.160	0.006	1.87	0.099
	Autumn	1	0.128	0.007	2.16	0.147
Survey	Bus-route	4.2	0.114	0.006	1.52	0.096
	NRIFS	1	0.177	0.017	3.74	0.379
	Creel	7.7	0.216	0.007	1.69	0.073
King George whiting						
Avidity	Avid	2.4	0.211	0.008	6.03	0.266
Avidity	Regular	2.2	0.206	0.008	4.30	0.227
Avidity	Occasional	1	0.149	0.009	4.83	0.346
Region	Bellarine	5	0.364	0.011	5.05	0.215
	Melbourne	2.6	0.172	0.008	5.55	0.316
	Mornington	1.0	0.062	0.005	2.66	0.246
Day type	Weekday	1	0.193	0.011	6.71	0.412
	Weekend	4.1	0.191	0.005	4.74	0.167
Season	Spring	1.0	0.074	0.007	4.20	0.440
	Summer	7.1	0.192	0.007	4.76	0.211
	Autumn	6	0.263	0.010	5.75	0.264
Survey	Bus-route	4.8	0.197	0.007	5.28	0.224
	NRIFS	1	0.268	0.020	7.02	0.591
	Creel	4.1	0.174	0.007	4.49	0.232
Flathead						
Avidity	Avid	1.5	0.463	0.010	4.33	0.168
	Regular	1.6	0.479	0.010	4.50	0.167
	Occasional	1	0.482	0.013	5.81	0.286
Region	Bellarine	1	0.474	0.012	3.71	0.173
	Melbourne	1.4	0.455	0.011	4.20	0.145
	Mornington	1.3	0.464	0.010	4.78	0.192
Day type	Weekday	1	0.393	0.013	5.20	0.303
	Weekend	5.4	0.486	0.007	4.69	0.122
Season	Spring	1.0	0.429	0.014	4.60	0.267
	Summer	3.1	0.492	0.008	4.74	0.161
	Autumn	2	0.476	0.011	4.90	0.200
Survey	Bus-route	7.9	0.489	0.009	4.35	0.142
	NRIFS	1	0.425	0.022	12.29	0.911
	Creel	7.1	0.478	0.009	4.18	0.136

4 Proposed survey design to estimate boat-based recreational catch

4.1 Introduction

This section of the report addresses the fourth objective of the project: to develop a cost-effective survey design that would, if possible, provide annual estimates of recreational catch for the main recreational fisheries in Victoria. This section documents the proposal submitted to Fisheries Victoria and FRDC for approval to conduct a pilot survey using the phone-diary survey method to estimate the total recreational catch of snapper in PPB. This objective constituted the mid-cycle project review to determine if objectives 5 (trial the recommended design) and 6 (conduct a final project workshop) would be completed.

The proposed pilot survey was designed from the results of a review of previous recreational fishing surveys, Monte Carlo simulations, assessment of cost-effectiveness and a project workshop. The phone-diary survey method was determined to be a cost-effective method of collecting large numbers of samples for determining the total recreational catch from boat-based anglers in PPB and Western Port, where the key species are snapper, King George whiting and flathead.

The proposed sampling method utilises outputs from the NRIFS, including survey documentation, interviewer guidelines, questionnaires, and data management and statistical tools, which were developed by a team of specialist consultants. The proposed survey design has two options: a 4–6 month period that would include November and December (when larger adult snapper are targeted) and January to April (when juvenile snapper are targeted), and a full 12-month survey that would provide estimates of annual total catch for a range of species including snapper and King George whiting. A 12-month period was offered as alternative because maintaining the extra months sampling would incur a minor additional cost for a phone-diary survey. The specific objectives of the pilot survey design were to: determine the number of participants, profile the demographic characteristics of recreational fishers, and quantify the total catch of key fish species by boat-based recreational anglers in PPB, and possibly Western Port.

4.2 Proposed Survey Design

4.2.1 Sampling Frame

The most important considerations in a recreational fishing survey design are determining the information that needs to be collected and the most appropriate method of contacting anglers to collect this information (Malvestuto 1996). There are several methods of establishing a suitable sampling frame for a phone-diary survey, with varying costs and ease of obtaining, and varying inherent biases that affect the completeness of the list of anglers and accuracy of the data collected.

Establishing a sampling frame can be an expensive component of a phone-diary survey, but once established the costs for conducting the survey, and maintaining regular phone contact with each angler, are minimal. One of the most expensive components of the NRIFS was the screening survey used to find households with active anglers willing to participate in the survey. The cost of the data per fisher year was estimated as $40, of which $10 was spent on the initial screening process to recruit diarists (Henry and Lyle 2003). The method used to establish the sampling frame needs to be calibrated to calculate response rates (to ensure data are not affected by non-response bias) and samples need to be portioned into appropriate sample fractions (to ensure appropriate samples are taken within each stratum).

A suitable sampling frame for estimating the total recreational catch from boat-based anglers in PPB and Western Port could be obtained from a screening survey, or a list of anglers from a database of recreational fishing participants, such as the RFL or Vessel Registration database.

i. SCREENING SURVEY

Telephone screening surveys uses methods that are well established and widely used, particularly by marketing organisations. Households chosen by randomly allocated phone numbers are sampled from telephone directory listings (preferably electronic versions) with households allocated into regions

consistent within Australian Bureau of Statistics (ABS) statistical divisions. The number of samples within each stratum can be allocated according to the population size and participation rates in each stratum and telephone numbers randomly selected to ensure equal probability of sampling households within each stratum. Telephone numbers should not be substituted for other numbers where data are unavailable.

The screening survey in the NRIFS used a single-stage cluster sampling with private household as the primary sampling unit. A cluster design is useful when a list of survey participants is either unavailable or expensive to obtain. Cluster sampling also allows estimation of appropriate expansion factors using ABS estimated resident population for private dwelling households. The survey questionnaire was structured to establish: demographic profile (such as age and gender), socio-economic profile (such as employment, education and ethnicity), and participation in recreational fishing in the previous 12-months (number of days fished), club membership, fishing licence status and vessel ownership. Respondents intending to fish in the next 12-months were invited to participate in the phone-diary survey. The proposed survey design would use a much smaller set of questions than those in the NRIFS.

The screening survey in the NRIFS sampled 43,945 Australian telephone numbers (including 9,055 Victorian telephone numbers), from which 9,122 Australian households (including 1,345 Victorian households) progressed to the phone-diary survey. The aims of the NRIFS were broader than those required for the proposed survey. A survey to primarily estimate total recreational catch only needs to identify anglers for the main household phone-diary survey.

ii. VESSEL REGISTRATION DATABASE

Another potential sampling frame for phone-diary surveys of boat-based recreational fishing is the Recreational Boat Registration database, as owners of recreational vessels with a motor that can be used for propulsion are required to register with VicRoads on behalf of Marine Safety Victoria. Limitations of the VRD includes the inclusion of boats not used for fishing, and registered vessel owners may not be the only people to use vessel for recreational fishing. This database potentially provides a complete and available sampling frame that would facilitate efficient extraction of an unbiased sample of boat-based fishers, but approaches to Marine Safety Victoria failed to secure access due to privacy issues.

iii. RECREATIONAL FISHING LICENCE

A population screening survey to locate fishers may not be needed if there is a suitable database of fishing participants, such as the RFL database. The RFL in Victoria provides a database of current active anglers that could potentially remove the need for a large screening survey. The Victorian RFL can be purchased for periods of 48 hours ($5.50), 28 days ($11) and 1 year ($22) from selected DPI offices, retail businesses (including fishing tackle stores), Shell Touch outlets (48 hour and 28 day licences only) and online.

An estimated 549,804 Victorian residents fished in the year from June 1999 to May 2000, representing 12.7% of the state population. Most fishers were in the 30–44 age bracket (159,804 fishers), although participation rates were also high in the 5–14 (117,715 fishers), 15–29 (127,086 fishers) and 45–59 age groups (104,851 fishers). Participation rates by age in Victoria from the NRIFS indicated 18.5% of participants were 5–14 years of age, and 2.3% were 75 years of age or more. Approximately 75% of fishing participants between 18 and 70 are potential holders of a RFL (Figure 7).

The NRIFS estimated approximately 225,000 Victorian residents held a RFL in the 12-months prior to May 2000 (Henry and Lyle 2003), which was the highest level of licence ownership (41.4% of fishers) of any state. It was suggested that the number of RFL holders was likely to be higher than indicated in the NRIFS because the RFL was introduced during to the 12-month survey period and many fishers had not obtained the licence at the time of the initial screening survey. An average of 230,000 RFL's are sold each year with 245,408 recreational fishing licence holders issued in 2004/05 (John Vaytauer, Fisheries Victoria, pers. comm.), with a possibility that some licence holders purchase more than one 28 day or 2 day licences throughout the year. This was much less than 50% of the estimated 549,804 Victorian residents that fished in the year from June 1999 to May 2000 (Henry and Lyle 2003).

The one year licence accounted for 78% of licences sold in 2002/03 (Fishing Lines, October 2003), 75% in 2003/04 (Fishing Lines, April 2004) and 73% in 2004/05 (John Vaytauer, Fisheries Victoria). The two day licence accounted for 16% of licences in 2002/03, 18% in 2003/04 and 20% in 2004/05. The 28 day licence accounted for only 6% of licence sales in 2002/03, and 7% in both 2003/04 and 2004/05. There is a strong

seasonal trend in RFL sales with most licenses (45%) sold during summer and a minor peak in sales during Easter (Figure 8).

There were three considerations for use of the RFL database as a sampling frame:

i. EXEMPTIONS

A RFL is not required by individuals under 18 years of age or individuals 70 years or older; or individuals with state or commonwealth concession cards. A list of RFL holders is an incomplete sampling frame and the angling activities of those on the database may not be representative of the total angling population. There is potential for using the RFL database for sampling recreational fisheries, accurately estimating the total catch of the recreational fishing population, if a suitable protocol for accounting for exemptions can be developed using data from the NRIFS. This protocol should estimate the proportion of people exempt from obtaining a RFL and their associated catch and effort. This allows the extent of bias from exemptions to be accurately assessed and indicate the extent to which adjustments would be needed. Although results from the NRIFS will become increasingly outdated and potentially more biased over time, an assumption that there is no shift in the relative levels of effort and catch between licensed and exempt anglers is probably of less concern than other uncertainties in the stock assessments.

ii. DATA AVAILABILITY

The licence information requested for on-line purchases includes licence type (1 year, 28 day or 2 day) and the date and time that the licence is to be valid. The personal details required for a RFL are given name, family name, email address (a copy of the RFL is emailed to licence holders), street, suburb, state, postcode and date of birth. The absence of a telephone contact number in the RFL database is another limitation. Telephone numbers can be sourced from telephone registries, but silent numbers and mobile numbers would not be available. Phone numbers would also be unavailable for RFL holders without a phone, where RFL holders had changed numbers, and where data recorded in the RFL database were insufficient to generate a match on the telephone register. The full details of the RFL database for 2004/05 have been entered onto a database by Fisheries Victoria.

iii. NON COMPLIANCE

Non-compliance with RFL requirements may be another source of bias in the database. Compliance activities are part of proactive approach to ensure sustainable fishing in PPB by the state Government. A survey by Fisheries Victoria Officers in 2004 found a 98% compliance rate with fisheries recreational licences and catch requirements for the 1,094 anglers and 5 recreational charter vessels encountered in PPB (Fisheries Victoria Fish-e-Fax Issue 132, 11 November 2004), indicating anglers were aware of both licence requirements and catch limits. This estimate of compliance may be an over-estimate of the proportion of anglers that comply with the RFL requirements, as the sample was obtained from anglers actively engaged in fishing activity, who are more likely to be avid anglers. The larger proportions of regular or occasional anglers were less likely to be fishing during the sampling period.

4.2.2 Stratification

The proposed survey design incorporates stratified random sampling with samples divided into homogenous units to reduce sampling variance (Cochran 1977, Pollock *et al.* 1994). The number of samples within each stratum is determined by the characteristics of each stratum. For example, more samples are usually taken where fishing effort is greater and catch rates are more variable.

Stratification is best determined from analysis of data collected from previous bus-route, creel and phone-diary surveys, particularly where the probability of a non-zero catch and the mean non-zero catch were found to be significantly different. Postcodes will be assigned to statistical divisions from the Australian Bureau of Statistics National Localities Index with samples in the proposed survey apportioned according to the proportion of anglers from each statistical division observed the NRIFS and previous surveys in PPB and Western Port. Samples will also be apportioned according to the avidity of anglers (based on number of fishing events recalled by anglers for the previous year) to ensure appropriate representation of avid and non-avid anglers in the survey.

Collection of data will also allow for appropriate spatial and temporal factors to be considered during data analysis, such as regions (Bellarine, Melbourne and Mornington in PPB), day type (weekday and weekend), time of day (pre-dawn, morning, afternoon, evening) and season.

4.2.3 Data collection/Questionnaires

Participants are selected randomly from the sampling frame. Participant information (age, gender, and postcode) will be gathered at the commencement of the survey to allow for demographic benchmarking and to ensure the data from the sample can be accurately expanded to provide estimates for the total angling population. Participants will also be asked how many times they fished in the previous year to estimate angler avidity. The survey requirements will be explained to respondents during the initial telephone interview.

Participants will be asked questions relating to their fishing activities during the previous month, such as the number of fishing events and the water body (PPB or Western Port), location, method, platform (boat or shore), target species, start and finish times, and species identification and number of fish caught and released for each fishing event during the previous month. Following the procedure used in the NRIFS, an appointment for the next telephone interview will be arranged at the end of each monthly contact to follow soon after the next intended fishing event or the end of the month, whichever is sooner.

Other procedures used in the NRIFS would be adopted to reduce potential response errors. All participants will be provided with a species identification sheet to reduce misidentification and a recall diary to allow for efficient collection of post-trip data and to reduce recall, prestige and rounding biases. Data collection is the responsibility of the survey interviewer during telephone interviews when participants can be asked to explain information that is unclear to reduce errors from question misinterpretation. Frequent, minimum monthly phone contact will be maintained with all participants to ensure any activity not recorded in the diary can be collected with reduced recall bias.

4.2.4 Database

A relational database incorporating range, logic and sequence checks was developed in Microsoft Access for the NRIFS. MAFFRI was responsible for maintaining the Victorian component during data collection, entry and editing. Data quality for the proposed survey will be maximised through appropriate training and management of survey interviewers and completion of data collection, entry and validation in-house with incomplete or ambiguous data referred to survey interviewers for follow-up with participants. The utilisation of the database structure developed for the NRIFS provides significant savings to the proposed survey.

4.2.5 Data Expansion

The participation numbers (frequency of fishing in the survey sample) and catch rates (catch per angler hour in the survey sample) will be determined for each stratum. Formulae for calculations will be those used in the NRIFS.

Data imputation can be used to provide missing demographic data, allowing the sample to be retained for analyses. Although data imputation was required for 0.2% of individuals in the NRFIS, it may not be necessary in the proposed survey, particularly if the RFL database is used as a sampling frame and the primary sample unit is RFL holder and adequate sample coverage is made within each stratum according to age, gender and avidity.

The expansion of participation numbers and catch rates from the survey sample to the total population is based on the demographic profiles of fishing participants in the survey sample and demographic profiles from the ABS Estimated Resident Population (ERP). Demographic benchmarking between the sample and population profiles will be used to assess sample representation and provide weighting for expanded population estimates. Age and gender benchmarks will be developed for each stratum and comparisons between sample and population benchmarks within stratum.

Weighting allows expansion of sample data to population estimates. Simple weights can be obtained by dividing population benchmarks with the number of samples in each stratum. Integrated weighting as used in the NRIFS, is more appropriate for cluster sampling as it allows adjustment for sample representation within each stratum using characteristics such as age and gender (Lemaitre and Dufour 1987). Consideration will also be given according to the coverage of the sampling frame, particularly anglers without a telephone or those with an unlisted or mobile number, which were not available in telephone directory listings.

Confidence limits associated with estimates of total catch will be based on formulae described in the NRFIS, which utilise variance associated with the catch rates and weighting factors.

4.2.6 Validation surveys

Response errors, such as recall, prestige and rounding biases and question misinterpretation, were minimised by using a recall diary and species identification sheet for participants, and by using a survey interviewer to collect data and maintain frequent phone contact with participants. Sampling and non-response errors may need to be evaluated with additional surveys that potentially enhance data quality. An on-site creel survey can assess sampling errors from improper selection, inadequate sample coverage, avidity bias, species misidentification and obtain estimates of the length and weight relationship for key species. A non-response survey can assess non-response errors from unavailable samples and refusals.

ON-SITE SURVEY

Participants in the phone-diary survey are only required to report catch (in numbers) for individual species. The mean length and weight for key recreational species from previous creel surveys may be used to allow conversion of catch numbers to catch weights. On-site surveys can also be used to validate species identification, determine size structure of key recreational species, substantiate recreational fishing activities and assess the degree on non-coverage in the sampling frame.

MAFFRI conducts representative creel surveys, with samples collected from sites and periods of highest recreational fishing, in PPB and Western Port throughout December to April and an Angler Diary Logbook Program, with samples collected from avid anglers. These surveys were not designed to provide catch and catch rate data that was representative of all recreational anglers, but may be used to provide data (such as species identification, composition and size structure) to complement the proposed survey that is collected within the same time period. Creel surveys also provide an opportunity to validate the demographic profile of anglers, which is necessary when the sampling frame is incomplete. Representative creel surveys are more likely to encounter avid anglers, which potentially provide a biased sample of the angling population that over-estimates catch.

NON-RESPONSE SURVEY

Demographic representations of samples within each stratum were produced by integrated weighting, but this may not be truly representative if fishing participation was different between non-response and response groups. Non-response includes sample loss, non-contact and refusals.

The number of anglers recruited to the phone-diary survey can be influenced by sample loss, such as anglers listed in the RFL database that do not have a telephone number in directory listings. For example, the number is unlisted or a mobile number or they do not have a residential telephone. Further samples were lost when the telephone is not answered ('non-contact') or is answered but participation in the survey is declined ('refusals').

Non-response can be addressed from a random sample from sample loss, non-contact, and refusals. After confirming the telephone number is the same as the initial contact, the interviewer will endeavour to collect information on the age, gender and number of fishing events in the previous 12-months. If the RFL database is used as the sampling frame, then the age and gender will be known. This allows the non-response group to be characterised in terms of fishing participation, age, gender and avidity. No further information is required from the non-response survey.

Correction factors can be applied to the integrated weights if non-responding samples affect fishing participation. Non-response data can be collected from a one-off follow-up survey that is weighted according to the number of samples in each stratum. Non-response data were aggregated by strata to characterise the non-response group in terms of fishing participation and avidity, then compared with aggregated fishing participation and avidity data in the response group.

Participation and avidity correction factors were calculated from the ratio of participation numbers by age and gender and the ratio of proportions in different avidity classes, respectively, in the non-response and response groups. These correction factors were responsive to the degree of non-response within each stratum and provide adjustments to the integrated weights to more accurately reflect participation numbers according to age, gender and avidity with benchmark populations.

Consideration may also be given to unexpected fishing, fishers that 'drop-in' or 'drop-out' of the fishery. The NRIFS found that the numbers of participants in the phone-diary survey that did not fish ('drop-outs') were similar to the number of people that initially thought they would not fish but did ('drop-ins') (Henry and Lyle 2003). In a fishing population that is not changing rapidly during the survey period, the number of anglers leaving the fishery can be assumed to balance the number of anglers entering the fishery. This equilibrium approach to fishing participation has been previously applied to recreational fisheries (Bradford 1998, Higgs 1999, Higgs 2001). Any adjustments to participation numbers based on unexpected fishing may be difficult to estimate precisely because of small sample sizes (Henry and Lyle 2003).

4.2.7 Project Staff

Management, implementation, analysis and reporting of the proposed survey remain 'in-house' to maintain data quality and consistency. The survey would be facilitated by a project manager to assume responsibility for: data validation, tabulation and expansion; analysis and reporting of the survey results; recruitment, training and management of survey staff; and various administrative and reporting tasks. Interview staff will collect data through monthly telephone contact with diarists. Interviews would usually occur out of office hours, so interviewers may work from home-based offices. They would be recruited locally in accordance with specific criteria and receive formal training in all facets of the survey work. They are expected to assume responsibility for data entry and liaise with the project manager on a regular basis. Data entry, validation and management can be managed on-site in Queenscliff.

4.3 Discussion

The innovative approach used in the NRIFS provides a model for future recreational surveys with the potential to provide accurate and precise annual estimates of total catch for key species in Victorian bay and inlet recreational fisheries. The phone-diary approach could provide sufficiently precise data for specific fisheries without the need for interviewers to meet large numbers of anglers. The number of diarists needed to obtain an acceptably precise estimate of total catch for the key species in the major bays and inlets may be prohibitively large.

The proposed pilot survey focuses on boat-based angling in PPB and Western Port, where the key species are snapper, King George whiting and flathead, and was originally intended to be conducted over a 4–6 month period to include the main summer to Easter fishing period for snapper. Approval of the pilot survey design is to be requested from Fisheries Victoria and the Fisheries Research and Development Corporation. The budget required to conduct the pilot survey will depend on the details of the survey design and the period over which the survey is conducted. Some modifications to the pilot survey design would be considered to reduce slightly higher than expected costs. If the funds required to conduct the pilot survey greatly exceed those available, then the cost of obtaining annual estimates of catch from recreational fisheries is most likely to exceed ongoing available funds and the feasibility of this objective would need to be reviewed.

The proposed survey will be implemented according to the preferred design if approval to continue the project is granted. At the completion of the pilot survey, the results will be analysed and reviewed at a final project workshop. Evaluation of the project design with consideration of how it might be improved is necessary for developing a final design for a full angler survey of recreational fishing in Victorian bays and inlets. Options for the implementation of an ongoing recreational angler survey program would then be presented to Fisheries Victoria for approval and possible ongoing funding.

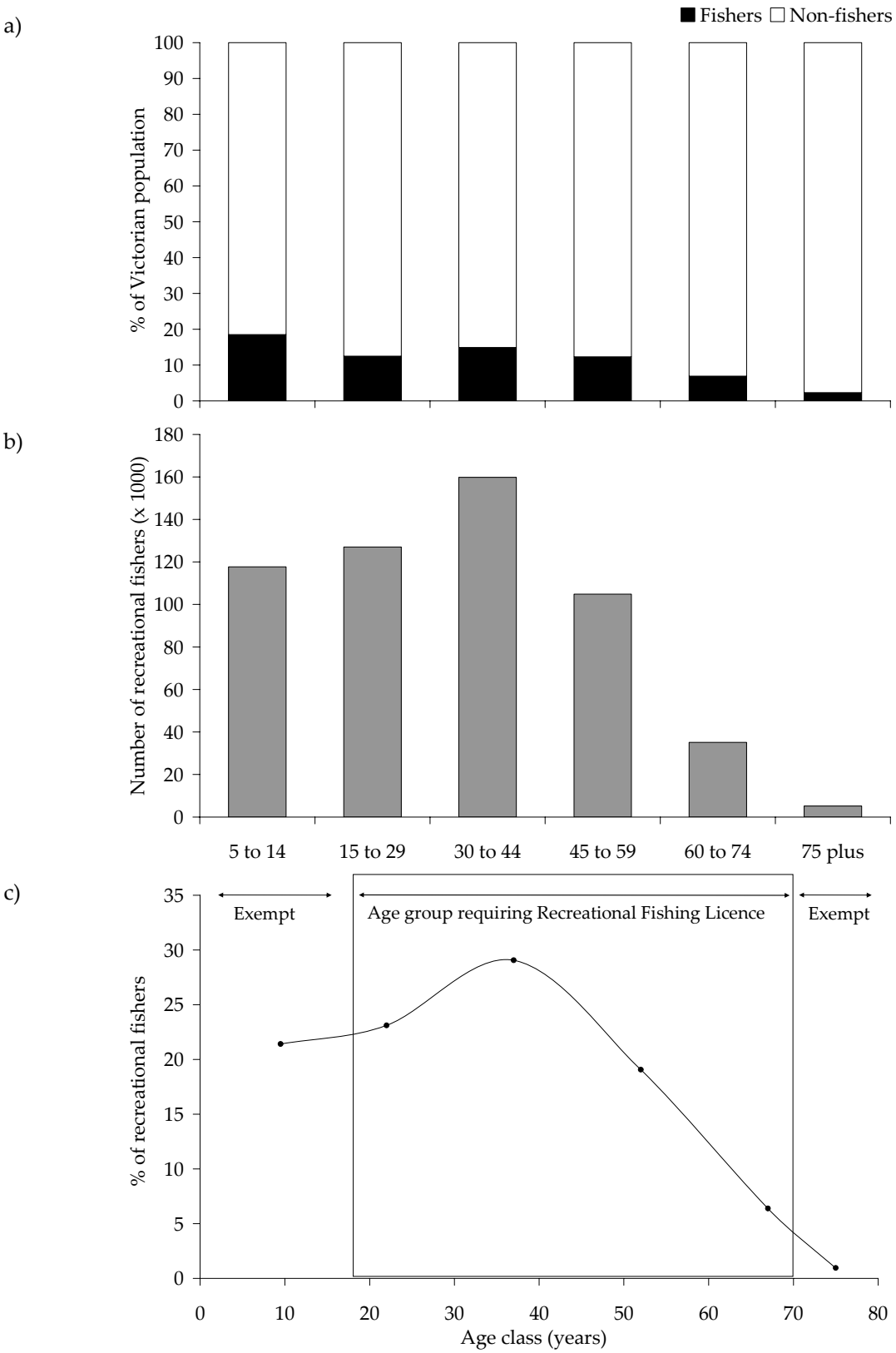


Figure 7: Fishing participation in Victoria during June 1999 to May 2000 by age: (a) proportion of fishers and non fishers, (b) total number of fishers and (c) proportion of fishers.

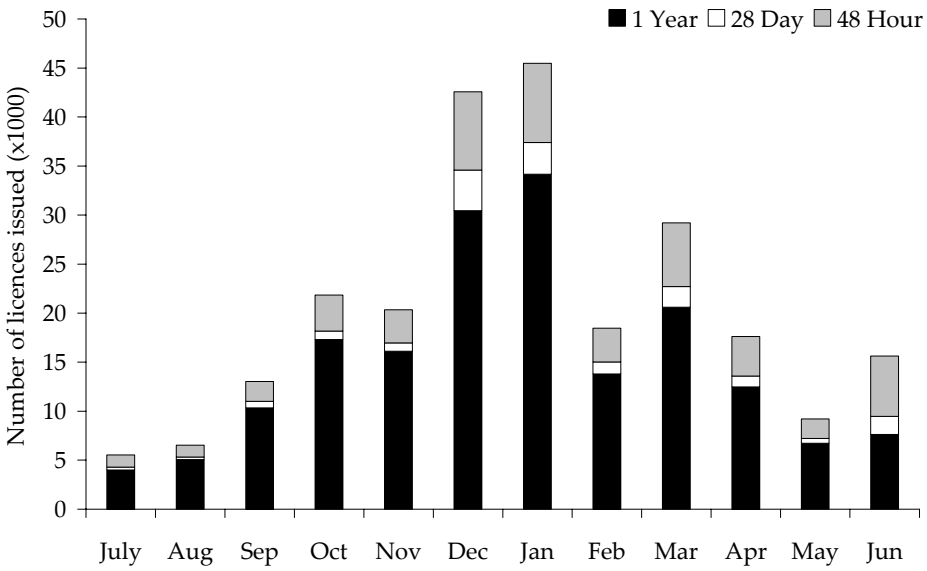


Figure 8: RFL sales in 2004/05 financial year by month and licence type.

Table 12: Potential sampling frames for estimating boat-based recreational catch in PPB.

Attribute	Screening survey	RFL database	Vessel registration database
Estimated Cost	High	Medium	Low
Telephone contact	White Pages directory listing	Match RFL database with White Pages directory listing	Phone contact required for vessel registration licence
Benefits	Methodology developed in NRIFS	RFL database of anglers for 2004/2005 available	Same primary sample unit as, and directly comparable with, bus-route surveys
			Complete (for boat-based angling)
Limitations	Incomplete	Incomplete	Includes boats not used for fishing
	Some households unavailable cannot contact unlisted (silent or mobile) numbers or households without telephone	Some anglers exempt from RFL and some RFL holders unavailable cannot contact unlisted (silent or mobile) numbers or anglers without telephone	Registered names not necessarily the only people to use vessel for recreational fishing
	Electronic White Pages directory no longer available		

5 Development of survey design

5.1 Background

The implementation of regular, reliable and cost-effective angler surveys could provide data that would allow realistic and rigorous assessments of Victorian bay and inlet fisheries that are exploited by both recreational and commercial fisheries. Phone, bus-route and creel survey methods were compared for their ability to obtain annual catch estimates for Victorian recreational fisheries, which could complement data obtained from the commercial sector. The phone-diary survey method was identified as the preferred method and a cost-effective pilot survey design from the results of a review of previous recreational fishing surveys, Monte Carlo simulations, assessment of cost-effectiveness and a project workshop. This section of the report addresses the fifth objective of the project: trial the recommended design. This section documents the development of the survey methodology using indicative data from the NRIFS, RFL database and RSE models, and a 12 month phone-diary survey of recreational fishing in coastal Victoria. This trial follows a mid-project review by FRDC and FV.

A phone-diary survey is appropriate for collecting data on recreational fishing. Previous phone-diary surveys of recreational fishing have proven to be highly successful without being biased by fisher avidity. Other benefits of phone-diary surveys include the ability to implement within a short time frame, good response rates (particularly if the target population is defined by a list of respondents) and potentially predictable call costs. Phone-diary surveys are increasingly being seen as a cost-effective alternative of collecting fishing data for large recreational fisheries in Queensland (Higgs 1999, Higgs 2001), Tasmania (Lyle and Smith 1998, Lyle 1999, Lyle 2000, Forward and Lyle 2002, Lyle and Morton 2004), and nationally (Henry and Lyle 2003).

The National Recreational Fishing Survey (NRIFS), in particular, developed a phone-diary survey method for obtaining data on recreational fisheries at regional and state-wide levels (Henry and Lyle 2003). The sample for the phone-diary survey was obtained from a screening survey of households randomly selected from White Pages telephone listings. Expansion of participation numbers and catch rates from the sample to the total population were based on demographic profiles of participants in the sample and demographic profiles from the Australian Bureau of Statistics (ABS) Estimated Resident Population.

Response errors were minimised by providing recall diaries and species identification sheets for respondents, and by using interviewers to collect data and maintaining frequent phone contact with respondents. There was potential for sampling errors from improper selection and non-representation, and these were evaluated by comparing results with data from on-site creel surveys. Non-response errors were considered with an additional survey of unavailable samples and refusals. The innovative approach of the NRIFS provides a model for future recreational fishing surveys.

A phone-diary survey of recreational fishing in coastal Victoria in 2006/07 was proposed to provide estimates of key recreational species from boat-based anglers in some of the larger bays and inlets in coastal Victoria. This also provides an opportunity to test the methodology developed by the NRIFS for providing recreational catch data for smaller spatial scales, and for utilising the outputs from the NRIFS, including survey documentation, interviewer guidelines, questionnaires, and data management and statistical tools.

A trial of the phone-diary survey to investigate recreational fishing on a spatial scale smaller than that conducted in the NRIFS was approved by FRDC and Fisheries Victoria. The objectives of the phone-diary survey were to: determine the number of RFL holders participating in recreational fishing in coastal Victoria, profile the demographic characteristics of these recreational fishers, and quantify the total catch of key fish species by boat-based recreational anglers in PPB, and possibly Western Port. This chapter addresses the development of the survey methodology required to implement the recommended design.

This survey was essentially the same as the NRIFS, but three major differences: (i) the geographic scope with samples stratified by residency (city or country), (ii) the primary sample unit for the NRIFS was household, but it was person based (RFL holder) in this survey, and (iii) samples were allocated into two

sample types: sample A where invitation to participate in the phone-diary survey is given to avid and non-avid anglers and sample B where only avid anglers were invited to participate in the phone-diary survey.

The objectives of this chapter are to:

i. develop the output specifications, sampling design and questionnaires and other survey instruments using indicative data from the NRIFS, RFL database and RSE models
ii. conduct a pilot test of the screening survey on a small sample of RFL holders
iii. provide documentation for the development of a phone-diary survey of recreational fishing coastal Victoria

5.2 Methods

A pilot survey was conducted to test the potential of a database of RFL holders as a sampling frame, determine the proportion of RFL holders from the 2004/05 database that intended to fish in saltwater in 2006/07 and to test the questionnaire design for the screening survey. This was a small scale survey of 210 RFL holders to ensure the screening survey would identify sufficient snapper fishers that could be enlisted as diarists for the 12 month phone-diary survey.

Participants were randomly selected from the sampling frame. Participant information (age, gender, and postcode) will be gathered at the commencement of the survey to allow for demographic benchmarking and to ensure the data from the sample can be accurately expanded to provide estimates for the total angling population. Participants were asked how many times they had fished in the previous year to provide an estimate of angler avidity. The survey requirements will be explained to respondents during the initial telephone interview.

Participants will be asked questions relating to their fishing activities during the previous month, such as the number of fishing events and the water body (PPB or Western Port), location, method, platform (boat or shore), target species, start and finish times, and species identification and number of fish caught and released for each fishing event during the previous month. Following the procedure used in the NRIFS, an appointment for the next telephone interview will be arranged at the end of each monthly contact to follow soon after the next intended fishing event or the end of the month, whichever is sooner.

Other procedures used in the NRIFS will also be adopted to reduce potential response errors. All participants will be provided with a species identification sheet to reduce misidentification and a recall diary to allow for efficient collection of post-trip data and to reduce recall, prestige and rounding biases. Data collection is the responsibility of the survey interviewer during telephone interviews when participants can be asked to explain information that is unclear to reduce errors from question misinterpretation. Frequent, minimum monthly phone contact will be maintained with all participants to ensure any activity not recorded in the diary can be collected with reduced recall bias.

5.2.1 National Recreational Fishing Survey

Catch and effort data from the phone-diary survey, and profiling data from the wash-up survey of the National Recreational Fishing Survey (NRIFS) were used to assess the proportion of total participation, effort and catch that the proposed survey was likely to provide. Tabular data summaries included raw and expanded data, with percentages for each (unless otherwise stated) and row/column totals for all (as appropriate.), for all recreational fishing, all saltwater recreational fishing, any harvest, snapper, KGW and flathead. For example, for raw catch estimates were the number of fish harvested from individual fishing events and expanded catch estimates were the total number of fish harvested from the fishing population. Summary data excluded totals for Victorian residents that only fished interstate. These data summaries provided the information to assist in the design of the phone-diary survey of recreational fishing in Victorian bays and inlets.

Summaries were made by statistical division (SD), residence, RFL status and avidity. Statistical divisions were based on those used in the NRIFS, according to the ABS Australian Standard Geographical Classification (Figure 9).

Variables were constructed for the analyses from the results of the Wash-up Survey in the NRIFS, where age, senior card and pension information was recorded for all Victorian fishers, consequently the RFL

status is only known for Victorian residents as age or pension data were unavailable for interstate fishers. These variables included:

i. Residence: If the state of residence was Victoria, then Residence was coded "Victoria", else Residence was coded "Interstate"
ii. Licensable: If fishers' age was between 18 and 70, and there was no senior card or pension, then they were licensable, otherwise they were exempt
iii. RFL: If Licensable = 'L' then RFL = 'L'; else if Licensable = 'Unknown' then RFL =' Unknown'; else RFL =' E'
iv. Exemption category: this variable was created for Victorian residents only; coding was 'E_18' (less than 18 years of age), 'E_70' (greater than 70 years of age), 'E_S' (holder of senior card), 'E_D' (holder of disability pension) and 'L' (licensable)
v. Avidity: expressed either as three groupings (1–4 days, 5–14 days and 15 days or more) from the variable 'avidity class', or as five groupings (Less than 5 days, 5 to 9 days, 10 to 14 days, 15 to 19 days and 20 or more days) from the variable 'How many days'. Avid anglers were those that fished 15 days or more

5.2.2 Recreational Fishing Licence

The RFL database was analysed to understand fishing effort in the broad sense of license purchases (frequency of sales by license type and month of purchase) and to provide a sampling frame for the phone-diary survey. Data were transferred into excel spreadsheets and imported into SAS for analysis and sample selection. The variables in the sample frame were agent identification, surname, given name, address, town, postcode, date of birth, issue date, licence number and licence type. Initial checks on the data included duplicate checks, taking with care where RFL holders held more than one 2 day or 1 month RFL's in a financial year, and checks on upper/lower case and spelling of suburbs and if correct postcodes were assigned to suburbs. Statistical divisions were assigned according to the National Localities Index for the Australian Standard Geographical Classification (ABS 2002) using postcodes and suburb entered in the RFL database. On rare occasions postcodes (particularly in country areas) were assigned more than one statistical division.

There were approximately 220,000 observations for 2004/05. Only Victorian residents from coastal statistical divisions were 'in-scope' for this survey. RFL holders with interstate addresses, or Victorian addresses in the Mallee/Wimmera, Central Highlands, Goulburn/Ovens-Murray and Loddon statistical divisions were excluded from the sampling frame. Data without a surname or town, where issue dates were not within the range of July 2004 to June 2005, where birthdates indicated ages less than 18 or greater than 70, and with addresses for PO boxes or RMB were also omitted. These losses to the sampling frame yielded a useable RFL database of approximately 160,000 Victorian RFL holders from the Western District, Barwon, Melbourne and Gippsland/East Gippsland statistical divisions. There were about 30,000 of these 160,000 observations where the entered data indicated the issue month and year to be 01/1900. The cell formats (e.g. dd"02/2005", dd"03/2005" etc) over-rided the entered data (e.g. 15/01/1900) to display what was assumed to be the correct issue date. These date formats were subsequently corrected in the data.

Samples were selected from the RFL database using PROC SURVEYSELECT (SAS 2004) according to ABS statistical divisions. The selected samples accounted for loss of data from unmatched entries and potential non-response. The sample size assumed approximately 50% of RFL records could be matched with a phone number. This was based on a sample of 50 city and 50 country RFL holders that were manually entered in the on-line White Pages yielding a loss of 50% that could not be matched unmatched with a phone number. Reasonably high contact and uptake rates could be assumed for the matched data, based on previous research, so it was assumed the sample would achieve a non-response rate of 20%. The selected sample was sent to SENSIS for matching telephone numbers.

A sample of 1,300 RFL holders was randomly selected for the pilot survey, which included RFL holders from the Melbourne statistical division and three coastal, country statistical divisions (Western District, Barwon and Gippsland/East Gippsland). A sample of 10,000 RFL holders was randomly selected for the screening survey with samples taken proportionally for all license holders from the 2004/05 database. For the calibration survey, a sample of 10,000 was randomly selected from RFL holders that held one and three year licences in the 2006/07 database.

5.2.3 Pilot Survey

A database of RFL holders has been identified as a suitable sampling frame for contacting recreational fishers for a phone-diary survey of recreational fishers to estimate the total recreational catch of snapper in coastal Victoria will be conducted in 2006/07. The most complete data were available for the 2004/05 financial year. As the screening survey was to be conducted in May 2006, the data in the RFL database could be anywhere from 9 to 21 months out of date. There are 10,000 changes to the telephone listings each day (SENSIS0059 2005) and the available RFL database may include listings that were unavailable because of relocations or previous RFL holders that no longer fish or hold a RFL. A pilot survey was planned to provide a small-scale survey to ensure the screening survey will identify sufficient fishers.

The aims of the pilot survey were

i. To provide an initial test of 210 RFL holders
ii. To ensure the screening survey will identify sufficient snapper fishers for diaries
iii. Fine tune the costs (pay rates, call rates) of the screening survey
iv. Determine the frequency of fishing events by licence holders in the previous year
v. Estimate the number of licence holders that intend to renew their RFL in the next year
vi. Determine the number of licence holders that intend to fish in saltwater in the next year
vii. Estimate the species that RFL intend to target in the next year

The target population included RFL holders who were Victorian residents with a White Pages phone listing that resided in one of four coastal statistical divisions, and who line fished from the shore or a boat. The pilot survey will not provide information on recreational fishing from; anglers exempt from obtaining a RFL, RFL holders with unlisted, silent or mobile numbers, new RFL holders and anglers from other statistical divisions. Preliminary analyses indicate recreational fishing from these 'out-of-scope' groups was minimal.

The RFL database provides a sampling frame that suits the target population. There were approximately 220,000 records in the sampling frame for the 2004/05 year. The PROC SURVEYSELECT program (SAS 2004) was used to take a simple random sample from four coastal statistical divisions, where the majority of coastal recreational anglers that fish for snapper reside. To obtain a sample of 210 RFL holders, with an estimated 20% non contacts, a sample of 252 phone numbers was obtained from the RFL database.

There were several issues with the sampling frame:

i. The sampling frame was obtained from a database of fishers who purchased a RFL in 2004/05. While the majority of recreational fishers purchase a full year RFL and most of these are renewed annually, the aim of this pilot survey was to determine if the available sampling frame is adequate for a survey to be conducted in 2006.
ii. A small sample taken from a large sampling frame may not be representative. A stratified, random sample of RFL holders was selected randomly from mutually exclusive strata (ABS statistical divisions) to ensure representative samples.
iii. Recreational fishers were not required to provide telephone numbers when purchasing a RFL. Phone numbers for the selected sample were obtained using MACROMATCH (SENSIS0059 June05), a service provided by SENSIS, a subsidiary of Telstra.

A two page questionnaire was developed around the survey objectives. The questionnaires were trialled on a sample of 140 RFL holders (70 city residents and 70 country residents) by three interviewers, each with the aim of completing a minimum of 35 questionnaires for city RFL holders and 35 questionnaires for country RFL holders. The questionnaires included contact details for individual RFL holders, call details, response report, introduction and 10 questions/sequence guides (see West and Ryan 2009). Both the questionnaire and interviewing conventions and procedures were similar to those in the National Recreational Fishing Survey (NRIFS) (Henry and Lyle 2003).

Interviewers were instructed to record all telephone calls (whether successful or otherwise) in the call details section and to make a minimum of 10 effective calls over a variety of times and day types before classifying a respondent as a non-contact. The response report was completed after finalising the survey questionnaire to assist in identifying sample loss and non response.

Interviewers were also given Workload Control Sheets (to keep track of calls), a timesheet (to calculate the 'through-put' rates for the screening survey) and an Interviewer Feedback Sheet (to assist with survey debriefing, identify items that respondents had difficulty answering and evaluate the questionnaire). Questions in the Interviewer Feedback Sheet were based on recommendations for reviewing questionnaires by Foddy (1993).

5.2.4 Relative Standard Error

The relative standard error (RSE) is a preferred measure of variability (precision) that accounts for differences in the magnitude of the total catch estimates. A large RSE is considered unreliable, while a lower RSE is considered more precise. A model of the error structure was based on the RSE model developed for the NRIFS on an EXCEL spreadsheet. This model predicted the RSE for total catch estimates before the survey and then estimated the RSE achieved at the completion of the survey. This RSE model was adjusted for the survey design of recreational fishing in coastal Victoria to determine appropriate sample sizes to achieve the desired RSE. This required making a reasonable assumption that snapper represent 5% of the total harvest, and estimates of recreational fishing participation rate (intention to fish/re-licence (from the pilot survey), and estimates of the mean effort (hrs/angler/day) and mean CPUE (fish kept/angler/hr) for each strata in the survey design. The values for effort and CPUE were calculated from the actual mean effort and mean CPUE for line fishing in marine waters from the NRIFS data.

5.3 Results

5.3.1 National Recreational Fishing Survey

The total harvest for all marine species in the NRIFS is given in Table 13. The most commonly harvested species was flathead (44%), followed by King George whiting (13%), Australian salmon (7%), black bream (6.75%) and snapper (6.33%). Five species of interest for resource allocation in coastal Victoria include snapper, black bream, King George whiting, garfish (3.4%) and southern calamary/squid (2.65%). These seven represent 83.5% of the total state-wide marine harvest.

The majority of participants that fished either state-wide or in coastal regions only (including offshore, inshore and river/estuaries) were Victorian residents; with only 7% of fishing in Victoria from inter-state fishers (Table 14a). Fishers from the Melbourne statistical division dominated participation both state-wide (54%, Table 14b) and in coastal regions (60%, Table 14c).

Participation was also higher for licensable fishers, both state-wide (Table 14d) and in coastal regions (Table 14e), almost 70% of recreational fishing participants were licensable. Victorian residents participating in recreational fishing state-wide were more likely to be avid fishers, recalling fishing on 5 to 14 days (36%) or 15 or more days (25%, Table 14d) conducted during the screening survey in 2000. Similarly, Victorian residents participating in recreational fishing in coastal regions recalled fishing on 5 to 14 days (37%) or 15 or more days (28%, Table 14e) conducted during the screening survey in 2000.

The tendency for most recreational fishers to be residents from Melbourne and avid anglers was reflected in comparisons of total participation between statistical divisions and angler avidity (Table 15, Figure 10) and harvests for all marine finfish, snapper, King George whiting and flathead (Table 16, Figure 11).

The proposed survey design using the database of RFL holders as a sampling includes only fishers with a RFL with only residents from coastal statistical divisions chosen for the sampling frame. This group of fishers were 'in-scope' for selection into the sample. Fishers that were 'out-of-scope' from the sampling frame, and cannot be selected for the sample include: interstate residents, Victorian residents that were exempt from the RFL and licensable Victorian residents from inland statistical divisions. A final analysis of the NRIFS data were compare to explore the participation and harvests of key marine species by 'in-scope' and 'out-of-scope' fishers.

Licensable Victorian residents from the four coastal statistical divisions (the 'in-scope' group for the current survey) account for the largest proportions of the total number of fishers and the total harvest of marine finfish compared with the 'out-of-scope' groups (Table 17, Figure 12). For example, 79.6% of the harvest of all marine finfish, 93.2% of the snapper harvest, 81.8% of the King George whiting harvest and 82.7% of the flathead harvest was taken by licensable Victorian residents from coastal statistical divisions (Figure 12).

The 'out-of-scope' group for the current survey harvested 20.4% of all marine finfish with 0.6% from interstate residents, 17.8% from exempt Victorian residents and 2.0% from licensable Victorian residents of inland statistical divisions. The harvest attributed to the 'out-of-scope' group was lower for harvests of some of the more commonly caught species. For example, the 'out-of-scope' group was responsible for 18.2% of the King George whiting and 17.3% of the flathead harvest. Exempt Victorian residents were responsible for the largest portion of this catch (16.4% for King George whiting and 15.1% for flathead). The 'out-of-scope' group harvested only 6.8% of the total state-wide snapper harvest with 0.2% from interstate residents, 4.6% from exempt Victorian residents and 2.0% from licensable Victorian residents in inland statistical divisions.

This data suggests the implications of using the RFL database as a sampling frame were that a sample drawn from 58.5% of all saltwater fishers, would account for approximately 80% of all harvest (including King George whiting and flathead), and over 90% of the snapper harvest.

5.3.2 Recreational Fishing Licence

A similar number of licenses were sold each year during the 8 year period from 1999/00 to 2006/07, with similar proportions of 48 hour, 28 days and 1 year licenses (Figure 13). The introduction of the 3 year license in 2005/06 slightly altered proportions of different license categories, with a reduction in the proportion of 1 year licenses and an increase in the proportion of 48 hour licenses, and it is likely that uptake of the 3 year license will increase further after 2006/07. There was also a strong seasonality in license sales by month; the majority licenses were sold during the summer holiday period. The average monthly RFL sales were highest for all license categories during December and January (Figure 13).

The sampling frame for the pilot and screening surveys was a list of RFL holders from 2004/05. The sampling frame for the calibration survey (conducted at the completion of the 12 month phone-diary survey) was a list of RFL holders from 2006/07. The RFL data for 2006/07 was incomplete for 48 hour and 28 day licenses, as postcodes were excluded from the minimum entry fields. Consequently statistical divisions could not be assigned to RFL holders that purchased 48 hour or 28 day licences in 2006/07.

The ability to match phone numbers with RFL holder details from random samples for the pilot, screening and calibration surveys is summarised in Table 18. SENSIS Macromatch© provided phone numbers for 518 (40%) RFL holders from a sample of 1,300 RFL holders for the pilot survey; only 7% were an exact match and 15% were a match with some variation in the initials of the RFL holder (Table 18). The calibration survey had a higher percentage of matches (53%) because the data were more recent and there were no 48 hour or 28 day RFL holders in the sample.

5.3.3 Pilot Survey

The interviewer's experience with the questionnaire and the respondent's answers to the questions were used to evaluate the questionnaire (Table 19). There were several changes made to the questionnaire following the data collection to improve clarity and structure. The response report was expanded to include additional categories for moved house and number disconnected and two questions (8a and 10a) were considered unnecessary and were omitted from the screening survey questionnaire.

The five key details required to confirm the correct identity of the RFL holder (name, birth date, postcode, telephone number and licence type) were considered too numerous, and only name, birth year and postcode were deemed necessary to confirm the correct identity of the RFL holder in the screening survey. Birth date, in particular, was considered too personal to ask at the beginning of the questionnaire with interviewers having had no opportunity to develop a rapport with the respondents.

Similarly, many respondents did not appreciate the interrogation at the beginning of the questionnaire regarding licensing behaviour. These questions were also considered unnecessary as interest lies in respondents intention to renew their RFL (to verify completeness of the sampling frame) and go recreational fishing during the survey period (the prerequisite for invitation to participate in the phone-diary survey). Consequently, question 3 and sequence guides 2 and 4 were not included in the screening survey questionnaire.

Questions 6d and 8b were altered to pre-coded questions where respondents were offered the list of species from the code frame established in this survey to limit the range of response options. An 'other' category was not included as the list of species of interest were considered exhaustive for the purpose of

the screening survey and interviewer feedback indicated respondents, especially avid (and non-avid but hopeful) fishers, would list many 'other' species that were of low interest and importance. Finally, the questionnaire for the screening survey was also altered to include details inviting suitable RFL holders (intending saltwater line fishers) to participate in the 12 month phone-diary survey.

Questionnaires were edited before data entry by observing for incomplete or missing responses, patterns of responses that may have indicated instructions were misunderstood (such as interviewers not conforming to sequence guides). Editing involved checking that sequence guides were followed, checking all relevant questions were answered, dealing with incomplete questionnaires, reviewing data entry procedures and dealing with irregularities in questionnaires.

A set of decisions as to how to correct mistakes was made before proceeding with data entry. These decisions varied from re-contacting the interviewer to verify information, best-guessing the most likely responses, such as future intentions for where fishing would occur, what species would be targeted and what type of licence would next purchased could be based on previous behaviour. Respondents were generally very happy to discuss their fishing practices and intentions with 83% fully responding and only 3% that refused to answer any questions (Table 20). The number of calls required to contact respondents ranged from one to four, although 10 effective calls were deemed necessary before classifying a respondent as a full non-contact.

Of the 217 fully responding RFL holders in the survey, 42 did not intend to fish in the next 12 months, but the remaining 175 did intend to fish. The proportion of RFL holders that did intend to fish in saltwater was calculated by dividing the combined number that indicated they would fish either in saltwater or both (saltwater and freshwater) in Question 7b with RFL holders that intended to fish in the next 12 months. The proportion of RFL holders from a simple random sample of 175 RFL holders intending to fish in saltwater in the next 12 months was 0.90. The 95% confidence intervals without the finite population correction were 0.90 ± 0.04. We can be 95% confident the proportion of intending saltwater fishers was between 0.862 and 0.938. The FPC was not included in the calculations as the ratio of the sample size to the target population was less than 0.10%.

A code frame from the responses to the open response question 8b was created by reviewing and hand tabulating individual responses as if they were multiple responses with each respondent able to specify a number of different species they intended to target in the next year. There were 14 species suggested for future targeting. The most common were black bream, garfish, King George whiting, snapper and calamary. Less common species were; abalone, Australian salmon, elephant fish, gummy shark, leatherjacket, lobster, mullet and trevally. Another consideration in developing a code frame was to include all species identified as key species for resource allocation issues by Fisheries Victoria (namely black bream, flathead, garfish, King George whiting, snapper, calamary and rock lobster). A code list for common or resource allocation species was developed and less common or resource allocation species were included in an 'other' category. Individual columns were established in the data entry table to correspond with positive responses for each response on the code list.

A frequency distribution of the intended targeting preferences of RFL holders (Figure 14) indicates the most common species for future targeting was flathead (n = 121), followed by snapper (113) and King George whiting (110). Less common species for future targeting were black bream (n = 69), calamary (60), garfish (46) and 'other' (61). Lobster targeting was only indicated by 14 RFL holders, which was not surprising considering the specialised nature of recreational fishing for lobster and previous estimates of the number of recreational fishers that harvest lobster.

Another important issue relevant to the phone-diary survey is angler avidity (determined by the recalled number of days fished in the previous 12 months by each RFL holder) and 55 RFL holders (30%) indicated they had fished 15 days or more in the previous year (Figure 14). This group were defined as avid anglers and previous research suggests licensed, avid anglers contribute 80% of the total catch of snapper in Victorian bays and inlets. The data from this survey suggests the ratio of avid to non-avid anglers was 30 to 70%, but consideration in the development of the phone-diary survey will be given to determine the best ratio of avid to non-avid anglers in the sample to decrease the error associated with catch estimates of avid anglers.

The time period between obtaining the sampling frame and collecting the data is another relevant issue, as the fishing activity of the sample needs to reflect current fishing, but the sampling frame was obtained

from the 2004/05 financial year. RFL holders were asked to estimate their intention to renew their RFL; 156 RFL holders (72%) indicated they intended to renew their licence. Those that did not intend to renew their licence (61) were either moving interstate or overseas or unable to fish for medical or other personal reasons (such as having young families). Comparisons could also be made between the previous licence held and licence type likely to purchased when their current licence expired (Figure 14). The majority (145) of RFL holders in the survey purchase, and intend to renew with, full year licences.

The pilot survey suggested the 2004/05 RFL database was a suitable sampling frame for a phone-diary survey to estimate the recreational catch of snapper in coastal Victoria as 72% of RFL holders in our sample intend to renew their fishing licence, 90% (± 3.8, 95% CI) were likely to fish in saltwater and 65% intend to fish for snapper. Consequently, this sampling frame will identify a representative sample of snapper fishers for monitoring over a 12 month phone-diary survey. The pilot survey also indicated 30% of RFL holders were avid fishers according to frequency of fishing events in the previous year. Previous research has shown that avid fishers catch the majority of snapper in coastal Victoria, in addition to fishing more often and, as they generally possess a greater knowledge of where and when, they also fish more efficiently.

There were several changes implemented to improve data collection, questionnaire design and analysis for the screening survey as a result of the pilot survey. Changes to the questionnaire design included; adding an additional 2 response codes, reducing the key details required to assess respondent identity, pre-coding questions 6d and 8b, omitting questions 3, 8a and 10a, omitting sequence guides 2 and 4, and including details to invite suitable RFL holders (intending saltwater line fishers) to participate in the 12 month phone-diary survey.

The sample design optimised the number of avid diarists in the phone-diary survey by splitting the sample with one sample inviting all intending saltwater line fishers into the phone-diary survey (30% avid and 70% non-avid) and a second sample inviting only avid anglers to participate.

A cost of $4 per questionnaire for the screening survey was determined from the average number of calls required to contact RFL holders, timesheets completed by the interviewers and the hourly award wage for experienced telephone interviewers (ABS Salary Rates 2006, NUW and AMSRO Market Research Industry Agreement 2005–2008).

5.3.4 Relative Standard Error

An EXCEL model accounting for avidity and ABS strata was used to predict the relative standard error (RSE) for total catch estimates for a range of sample sizes. Data from the NRIFS (effort and CPUE) and the pilot survey (intention to fish/re-licence) were calculated for each stratum in the survey design. For example, data in the RSE model included a mean effort in the Barwon (3.43 ± 0.07 SE hrs/angler/day), Gippsland (4.20 ± 0.10), Melbourne (4.31 ± 0.09) and Western District (3.84 ± 0.09) statistical divisions.

A relative standard error (RSE) of 0.21 was achieved for the state-wide estimate of snapper in the NFRS, indicating the estimate of total recreational catch had low variability, albeit at a spatial scale inappropriate for management. The estimated RSE for the total catch of snapper by licensable anglers in PPB was much less precise (0.66) and was considered unreliable for meaningful estimates of total recreational catch at the smaller geographic scale. The phone-diary survey is yet to be tested to achieve a lower RSE at smaller spatial scales, which are more appropriate for management. The sample size was chosen to provide a RSE for the total recreational catch of snapper in PPB that could be comparable to the RSE achieved state-wide in the NRIFS.

5.4 Discussion

Large-scale, off-site surveys of recreational fishing require cost-effective and representative sampling of the target population. This requires a sampling frame, a list of members of the target population to provide an unbiased and representative sample. Such a frame needs to be up-to-date, complete, contain no duplicates or redundant members, contain accurate identification/contact details, correspond to the unit of study and be easy to use. This is often achieved by sampling households from White Pages telephone listings. In Victoria, where there are 2 million households, approximately 6 households need to be contacted to find a single fishing household. This represents a substantial cost. Members of the target

population that were not represented in this sampling frame were fishing households that do not have a phone listing.

In Victoria, there are 5 million residents and approximately 10% of these residents participate in recreational fishing. The RFL allows the 90% of population that do not fish to be excluded from the screening survey, just about every call will contact a fisher and this would be a substantial cost saving. There were other benefits of using a RFL in terms of response rates, stratification and precision that will be discussed today. There is potential bias if the sampling frame does not represent the entire fishing population. Members of the target population that were not represented in this sampling frame were RFL holders that do not have a White Pages phone listing and fishers that were exempt from a RFL.

Although around 60% of recreational fishers in Victoria were exempt, RFL holders can be major participants in key recreational fisheries. In 2000/01, licensable anglers were estimated to have caught 95% of the recreational catch of snapper. Most snapper anglers reside in Melbourne or coastal statistical divisions and highly avid anglers dominated the snapper harvest. Even though the RFL database is primarily an administrative tool and does not completely cover the target population, it is reasonable to assume the RFL database potentially covers the majority of fishers that harvest snapper. For the PPB snapper fishery, the database of RFL holders was identified as a cost-effective sampling frame for a screening survey and subsequent 12 month phone-diary survey to estimate total recreational catch of snapper and other key marine species. Such a survey could focus on a smaller geographic scope than the NRIFS to cover coastal fishing only (primarily PPB and Western Port). As avid fishers catch more snapper it is appropriate and effective to stratify sampling by avidity and the survey could be designed to allow more avid anglers into the sample. Additional stratification from ABS statistical division would also be effective for providing demographic to allow comparability with the NRIFS and on-site surveys in PPB.

There is potential bias from non–representation of fishers from inland statistical divisions, unlisted RFL holders and recreational fishers with an RFL exemption in the sampling frame, particularly if these fishers catch more or less than those represented in the sample. This potential bias was addressed with some modifications to the on-going on-site surveys in PPB, to randomly interview an angler during boat party interviews and collect person based catch and demographic data including license eligibility and phone listing.

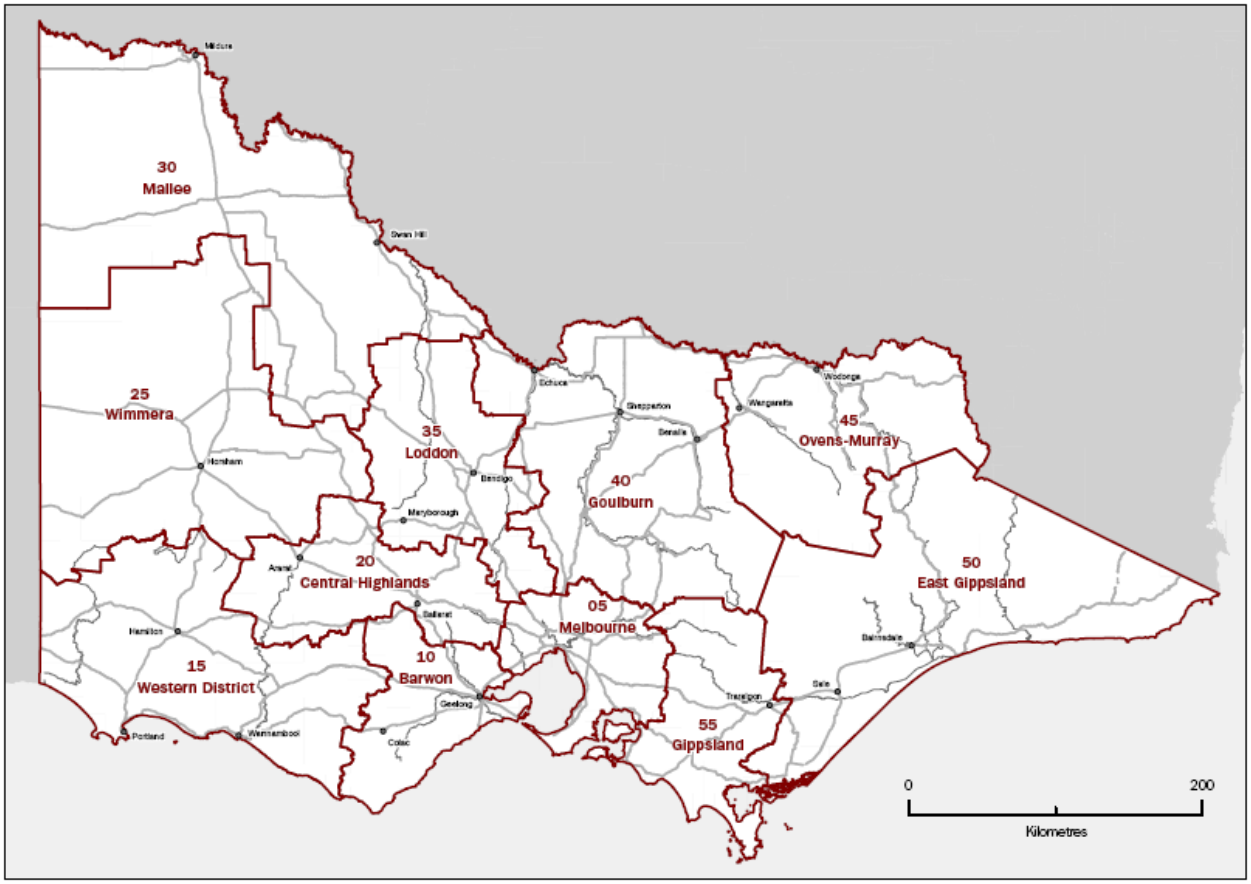
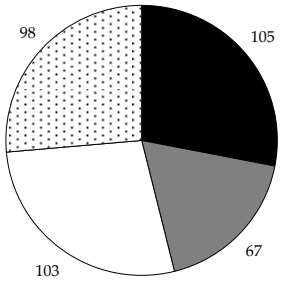


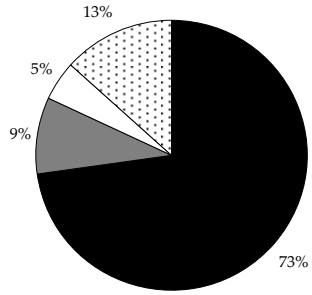
Figure 9: ABS statistical divisions.

Source (ABS 2006)

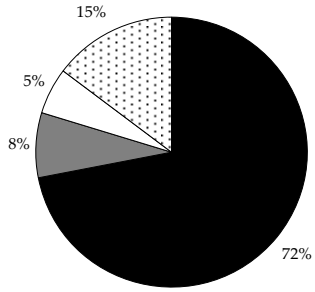
(a) Number of diarists



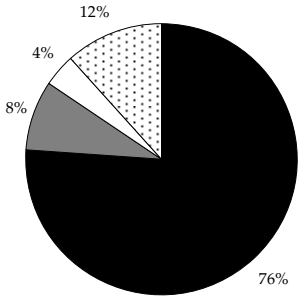
(b) Total participation



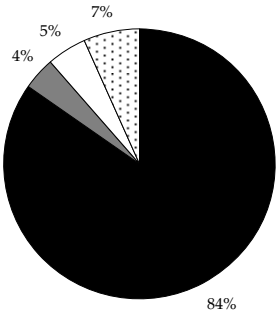
(c) Total effort (hours fished)



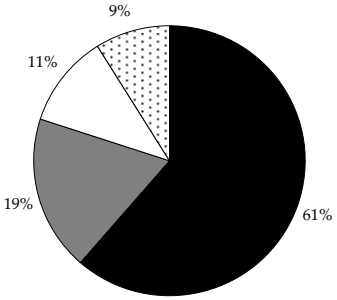
(d) Harvest of all marine finfish



(e) Harvest of snapper



(f) Harvest of King George whiting



(g) Harvest of flathead

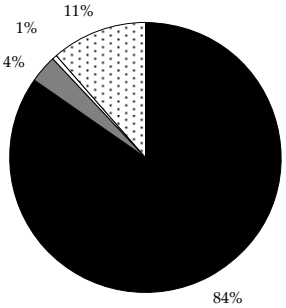
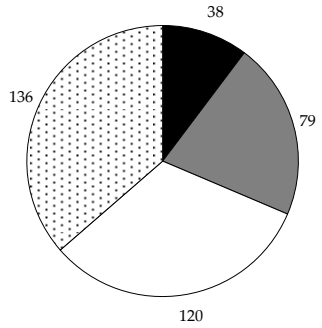


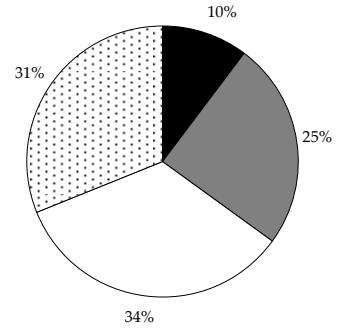
Figure 10: Fishing effort and harvest from coastal Victoria in 2000/01 by statistical division.

ABS statistical divisions: Melbourne (black), Barwon (grey), Western District (white) and Gippsland (stippled).

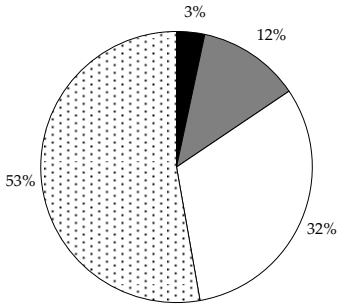
(a) Number of diarists



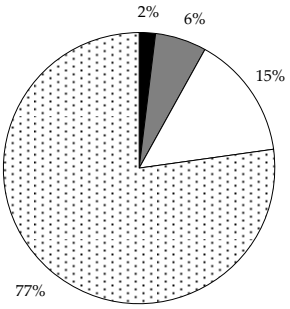
(b) Total participation



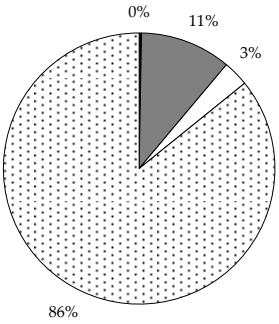
(c) Total effort (hours fished)



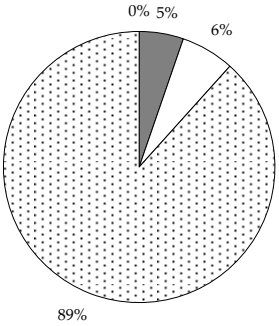
(d) Harvest of all marine finfish



(e) Harvest of snapper



(f) Harvest of King George whiting



(g) Harvest of flathead

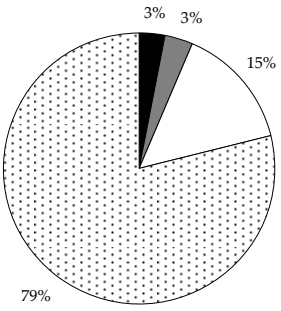
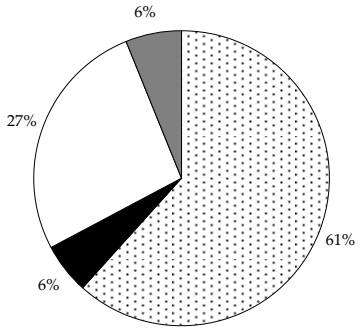


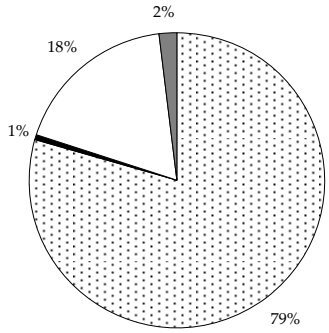
Figure 11: Fishing effort and harvest from coastal Victoria in 2000/01 by avidity.

Recalled number of days fished in the previous year: did not fish (black), 1–4 days (grey), 5–14 days (white) and ≥15 days (stippled).

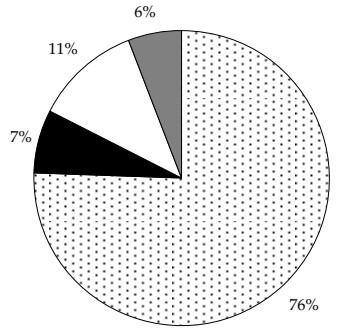
(a) Number of fishers that caught marine finfish



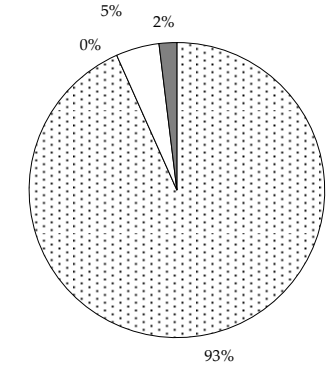
(e) Harvest of all marine finfish



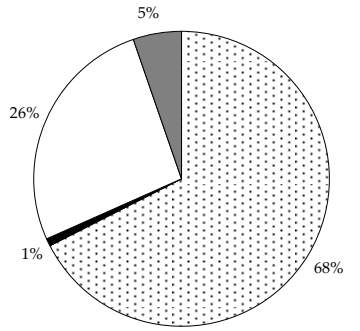
(b) Number of fishers that caught snapper



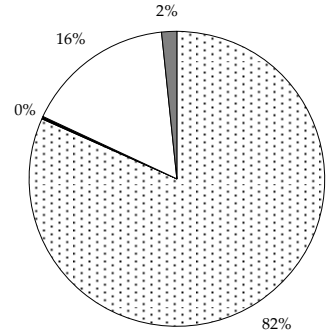
(f) Harvest of snapper



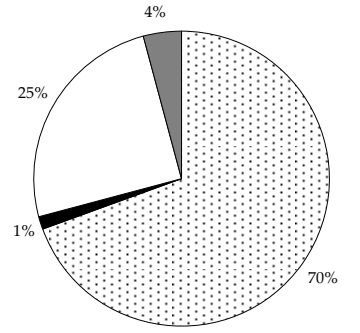
(c) Number of fishers that caught KGW



(g) Harvest of KGW



(d) Number of fishers that caught flathead



(h) Harvest of flathead

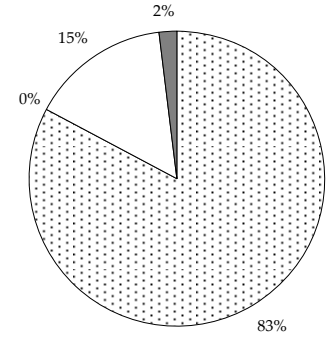


Figure 12: Percentage of fishers participating in recreational fishing and harvest of all marine finfish, snapper, King George whiting and flathead in coastal Victoria in 2000/01.

'In-scope' group (stippled) includes all licensable Victorian residents from coastal statistical divisions. 'Out-of-scope' group includes interstate residents (black), Victorian residents with RFL exemption (white) and licensable Victorian residents from inland statistical divisions (grey).

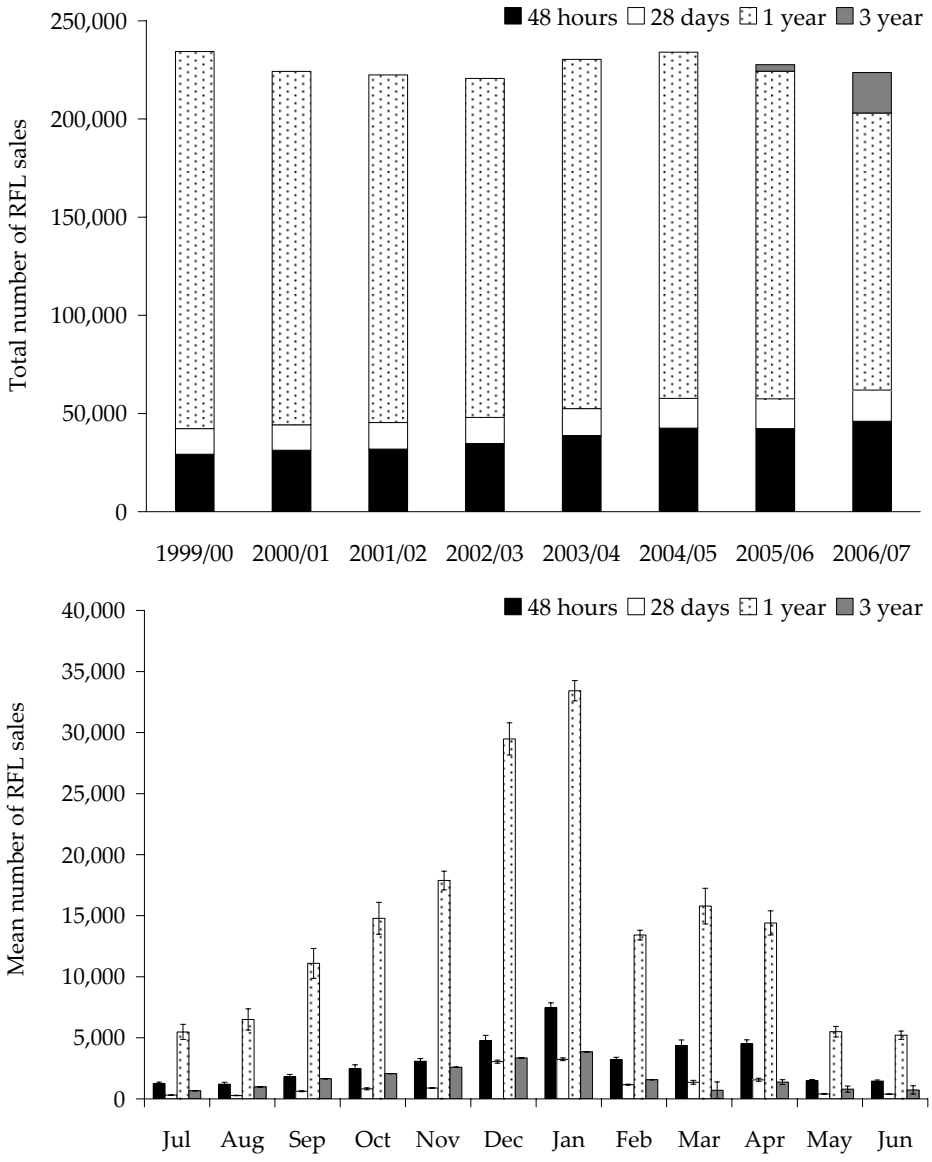


Figure 13: Annual RFL sales and average monthly RFL sales (with associated standard error) by licence type from 1999/00 to 2006/07.

Number of 48 hour (black), 28 day (white), 1 year (stippled) and 3 year (grey) RFL sales.

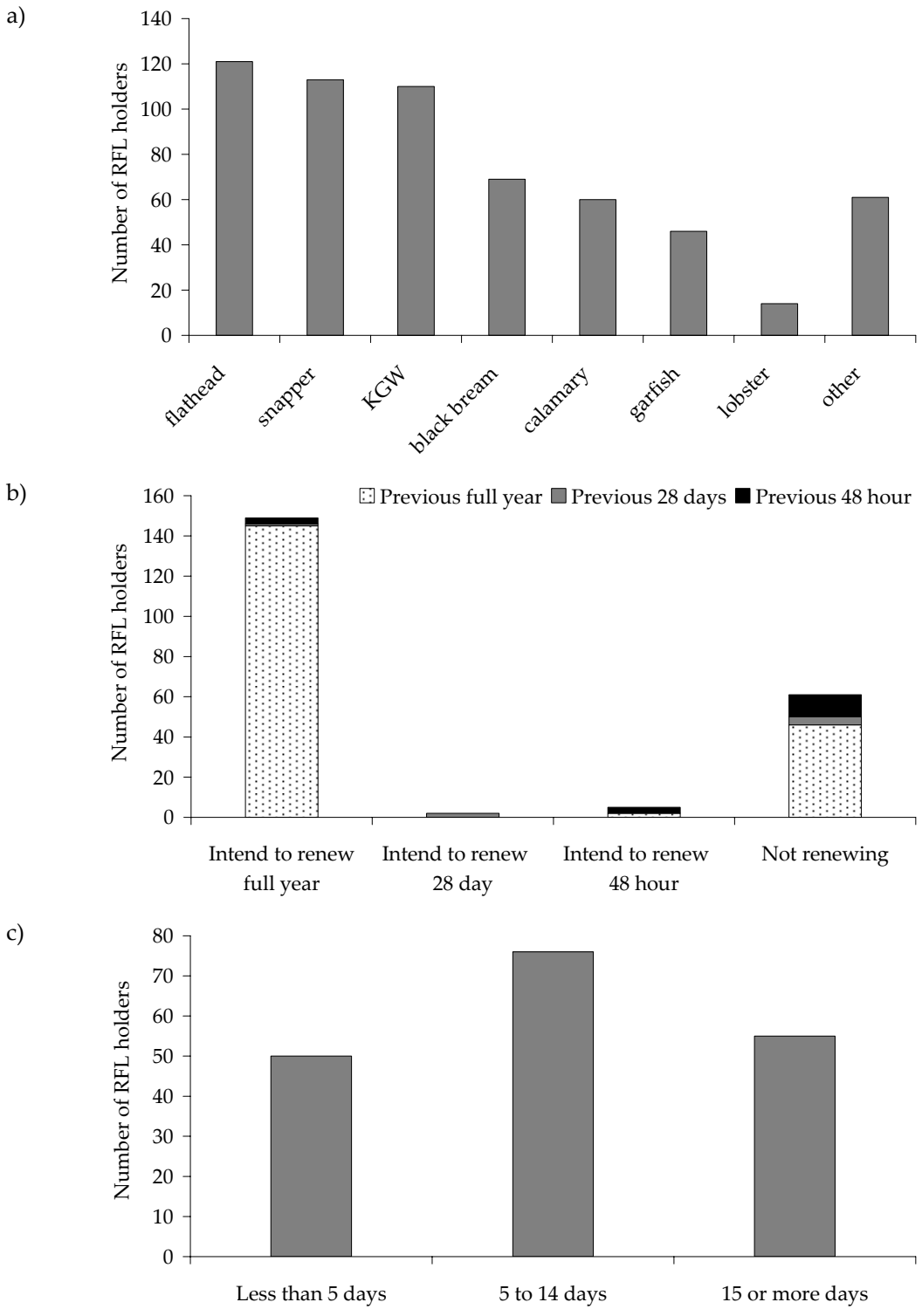


Figure 14: Pilot survey of recreational fishing in coastal Victoria during May 2006: (a) intention of RFL holders to target different species in the next 12 months, (b) intention to renew RFL by licence type and previous licence and (c) recalled number of days fished.

Table 13: State-wide total harvest by species or species groups (NRIFS).

Species/species group	Total Harvest	SE	RSE	%
Australian herring	11,354	6,458		0.15%
Australian salmon	541,852	85,492		7.22%
Black bream	506,704	95,468		6.75%
Blue mackerel	7,057	5,144		0.09%
Cod (various)	12,158	3,569		0.16%
Flatfish	37,572	37,357		0.50%
Flathead	3,316,071	658,108		44.17%
Garfish	255,199	75,558		3.40%
King George whiting	975,349	173,254		12.99%
Kingfish/Samson fish	375			0.00%
Leatherjacket	166,378	53,187		2.22%
Luderick	33,273	7,179		0.44%
Morwong	4,688			0.06%
Mullet	301,848	78,893		4.02%
Pike	257,795	82,758		3.43%
Sharks/rays	89,423	20,585		1.19%
Snapper	474,879	103,762		6.33%
Squid/cuttlefish	199,202	63,342		2.65%
Sweep	26,324	12,958		0.35%
Tailor	57,428	17,821		0.76%
Trevally	107,241	26,361		1.43%
Whiting	4,997	2,532		0.07%
Wrasse	120,689	33,958		1.61%
Total Harvest by numbers	7,507,856			100.00%

* Finfish totals include squid/cuttlefish

Table 14: Number of people that fished recreationally state-wide and in coastal (offshore, inshore and river/estuary) Victoria in 2000/01.

a. Participation by licensable and state of residence

	Victorian resident		Interstate resident		Total participation	
RFL status	State-wide	Coastal	State-wide	Coastal	State-wide	Coastal
Exempt	146,592	97,846			146,592	97,846
	31.60%	*30.70%*			*29.40%*	*28.47%*
Licensable	317,244	220,880			317,244	220,880
	68.40%	*69.30%*			*63.62%*	*64.27%*
Unknown			34,811	24,937	34,811	24,937
			100.00%	*100.00%*	*6.98%*	*7.26%*
Total	463,835	318,725	34,811	24,937	498,647	343,663

b. State-wide participation for Victorian residents by licensable and statistical division

RFL status	Melbourne	Barwon	Western District	Central Highlands	Mallee Wimmera	Loddon Campaspe	Goulburn /Murray	Gippsland	Total
Exempt	78,296	11,143	6,824	6,755	6,709	6,498	13,289	17,078	146,592
	29.02%	*35.19%*	*38.31%*	*39.68%*	*35.66%*	*29.23%*	*33.45%*	*36.53%*	*31.60%*
Licensable	191,509	20,527	10,988	10,267	12,106	15,732	26,444	29,669	317,244
	70.98%	*64.81%*	*61.69%*	*60.32%*	*64.34%*	*70.77%*	*66.55%*	*63.47%*	*68.40%*
Total	269,805	31,670	17,813	17,023	18,815	22,229	39,733	46,748	463,835

c. Participation in coastal fishing for Victorian residents by licensable and statistical division

RFL status	Melbourne	Barwon	Western District	Central Highlands	Mallee Wimmera	Loddon Campaspe	Goulburn /Murray	Gippsland	Total
Exempt	58,899	10,182	5,022	3,429	1,709	1,402	1,837	15,365	97,846
	28.72%	*35.25%*	*35.21%*	*33.29%*	*37.85%*	*23.66%*	*24.70%*	*36.33%*	*30.70%*
Licensable	146,208	18,702	9,240	6,871	2,806	4,523	5,600	26,929	220,880
	71.28%	*64.75%*	*64.79%*	*66.71%*	*62.15%*	*76.34%*	*75.30%*	*63.67%*	*69.30%*
Total	205,107	28,884	14,263	10,299	4,516	5,925	7,437	42,294	318,725

d. State-wide participation for Victorian residents by licensable and avidity (from screening survey)

RFL status	Did not fish	1 to 4 days	5 to 14 days	15 or more days	Total
Exempt	13,835	47,857	54,908	29,992	146,592
	28.07%	*36.32%*	*33.35%*	*25.38%*	*31.60%*
Licensable	35,454	83,925	109,709	88,157	317,244
	71.93%	*63.68%*	*66.65%*	*74.62%*	*68.40%*
Total	49,289	131,781	164,616	118,149	463,835

e. Participation in coastal fishing by Victorians by licensable and avidity (from screening survey)

RFL status	RFL status	Did not fish	1 to 4 days	5 to 14 days	15 or more days
Exempt	Exempt	13,835	47,857	54,908	29,992
		28.07%	*36.32%*	*33.35%*	*25.38%*
Licensable	Licensable	35,454	83,925	109,709	88,157
		71.93%	*63.68%*	*66.65%*	*74.62%*
Total	Total	49,289	131,781	164,616	118,149

Table 15: Number of diarists, total participation and total hours fished by statistical division and angler avidity for coastal Victoria in 2000/01.

Number of diarists

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0	8	7	12	11	38
	8%	*10%*	*12%*	*11%*	*10%*
1 to 4 days	22	13	23	21	79
	21%	*19%*	*22%*	*21%*	*21%*
5 to 14 days	38	18	34	30	120
	36%	*27%*	*33%*	*31%*	*32%*
15 or more days	37	29	34	36	136
	35%	*43%*	*33%*	*37%*	*36%*
TOTAL	105	67	103	98	373

Total Participation

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0	13,541	2,803	1,127	2,973	20,444
	9%	*15%*	*12%*	*11%*	*10%*
1 to 4 days	37,700	5,098	1,610	5,290	49,699
	26%	*27%*	*17%*	*20%*	*25%*
5 to 14 days	50,443	5,042	3,533	9,578	68,595
	35%	*27%*	*38%*	*36%*	*34%*
15 or more days	44,525	5,759	2,972	9,088	62,343
	30%	*31%*	*32%*	*34%*	*31%*
TOTAL	146,208	18,702	9,240	26,929	201,080

Effort (Total Hrs Fished)

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0	93,073	18,147	25,949	21,885	159,054
	3%	*5%*	*10%*	*3%*	*3%*
1 to 4 days	405,124	87,886	12,546	79,339	584,894
	12%	*23%*	*5%*	*11%*	*12%*
5 to 14 days	1,154,041	67,684	75,984	213,027	1,510,736
	34%	*18%*	*30%*	*30%*	*32%*
15 or more days	1,787,676	202,154	141,232	392,480	2,523,542
	52%	*54%*	*55%*	*56%*	*53%*
TOTAL	3,439,913	375,872	255,712	706,730	4,778,226

Table 16: Harvest of all marine finfish, snapper, King George whiting and flathead by statistical division and angler avidity from coastal Victoria in 2000/01.

All marine finfish

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0	84,643	16,222	5,114	16,813	122,793
	2%	*3%*	*2%*	*2%*	*2%*
1 to 4 days	253,038	53,574	6,656	62,155	375,424
	5%	*11%*	*3%*	*9%*	*6%*
5 to 14 days	600,177	35,539	35,479	220,949	892,143
	13%	*7%*	*14%*	*31%*	*15%*
15 or more days	3,706,715	390,986	201,652	403,722	4,703,075
	80%	*79%*	*81%*	*57%*	*77%*
TOTAL	4,644,573	496,321	248,901	703,639	6,093,434

Snapper

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0			1,043		1,043
			5%		*< 1%*
1 to 4 days	44,133	2,282	1,012	775	48,202
	12%	*13%*	*5%*	*3%*	*11%*
5 to 14 days	4,258	2,250	1,996	4,864	13,367
	1%	*13%*	*10%*	*16%*	*3%*
15 or more days	326,464	12,765	16,452	24,470	380,150
	87%	*74%*	*80%*	*81%*	*86%*
TOTAL	374,855	17,297	20,502	30,109	442,763

King George whiting

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0			346		346
			< 1%		*< 1%*
1 to 4 days	21,413	10,098	2,207	8,352	42,070
	4%	*7%*	*3%*	*12%*	*5%*
5 to 14 days	34,761	5,322	1,434	8,430	49,947
	7%	*4%*	*2%*	*12%*	*6%*
15 or more days	432,485	134,923	83,371	54,326	705,105
	89%	*90%*	*95%*	*76%*	*88%*
TOTAL	488,659	150,344	87,358	71,107	797,468

Flathead

Avidity	Melbourne	Barwon	Western District	Gippsland	TOTAL
0	84,643		232	1,416	86,290
	4%		*1%*	*< 1%*	*3%*
1 to 4 days	40,659	9,171	923	37,723	88,476
	2%	*10%*	*6%*	*12%*	*3%*
5 to 14 days	279,615	10,057	1,079	112,510	403,261
	12%	*11%*	*6%*	*37%*	*15%*
15 or more days	1,905,222	76,309	14,458	155,596	2,151,585
	82%	*80%*	*87%*	*51%*	*79%*
TOTAL	2,310,139	95,537	16,692	307,245	2,729,613

Table 17: Number of fishers and harvest of all marine finfish, snapper, King George whiting and flathead in coastal Victoria in 2000/01.

	No. of Fishers (expanded)				Harvest (No. x spp.-expanded)			
	Marine finfish harvest	Snapper harvest	KGW harvest	Flathead harvest	All marine finfish	Snapper	KGW	Flathead
'In-scope'								
Licensable Vic coastal SD	160,547	41,027	43,280	95,282	6,137,566	442,763	797,468	2,741,640
	61.6%	*75.6%*	*67.6%*	*69.5%*	*79.6%*	*93.2%*	*81.8%*	*82.7%*
'Out-of-scope'								
Interstate residents	14,816	3,788	530	2,032	43,523	839	1,634	4,424
	5.7%	*7.0%*	*0.8%*	*1.5%*	*0.6%*	*0.2%*	*0.2%*	*0.1%*
Exempt Vic resident	69,356	6,240	16,811	34,251	1,376,559	21,620	159,838	501,366
	26.6%	*11.5%*	*26.2%*	*25.0%*	*17.8%*	*4.6%*	*16.4%*	*15.1%*
Licensable Vic inland SD	16012	3,242	3,440	5,566	157,301	9,657	16,410	68,641
	6.1%	*6.0%*	*5.4%*	*4.1%*	*2.0%*	*2.0%*	*1.7%*	*2.1%*
Sub-total 'Out-of-scope'	100,184	13,270	20,781	41,849	1,577,384	32,117	177,881	574,431
	38.4%	*24.4%*	*32.4%*	*30.5%*	*20.4%*	*6.8%*	*18.2%*	*17.3%*
Total	260,731	54,297	64,062	137,131	7,714,950	474,879	975,349	3,316,071
	100%	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

Table 18: Proportion of matched and unmatched phone numbers for samples of RFL holders in the pilot, screening and calibration surveys using SENSIS Macromatch.

Match Type	Pilot		Screening		Calibration	
EXACT MATCH - An exact match is the highest level of match confidence. All of the elements of the customer contact records provided exactly match records in the White Pages®.	93	7%	884	9%	32	<1%
INITIALS VARIANCE - Initials vary slightly from those in the White Pages®.	194	15%	1660	17%	3,098	31%
STREET NUMBER VARIANCE - Street number varies slightly from those in the White Pages®. This can be the result of a transposition error "26" keyed as "62" or "Unit 1/16" entered as 16A".	7	1%	17	<1%	0	0%
INITIALS NOT USED - When customer initials are not considered in the match process, a match is made on all other fields.	119	9%	1188	12%	1,334	13%
SURNAME & INITIALS VARIANCE - Customer surname and initials are slightly different to those in the White Pages®. There may be a transposition error such as "Gn" instead of "Ng" or incorrectly typed names such as "James" instead of "Jones". This indicates variations between the surname and initials provided and White Pages®.	29	2%	217	2%	293	3%
STREET NUMBER VARIANCE & INITIALS NOT USED Customer street number slightly different to those in the White Pages® with customer initials ignored for the matching process (similar to #3.). There is an exact match to Business Name/customer surname, Street name and Postcode.	9	1%	71	1%	232	2%
STREET NAME VARIANCE - Customer street name and customer initials are slightly different to those in the White Pages®. There is an exact match on business/customer name and Postcode.	31	2%	182	2%	98	1%
STREET NAME VARIANCE & STREET NUMBER NOT USED - Customer street name and customer initials are slightly different to those in the White Pages® - street number is ignored. There is an exact match on business/customer name and Postcode	36	3%	297	3%	221	2%
NAME AND NUMBER – Exact match (residential)	0	0%	0	0%	0	0%
NAME AND NUMBER – Match on business name only	0	0%	0	0%	0	0%
Total Matched Records	518	40%	4516	45%	5,308	53%
Unmatched Records - Match Type						
Too Many Matches - Not enough uniqueness within the record to match.	4	1%	27	1%	31	<1%
Not Matched - No entry in the White Pages for this contact. This could be due to silent numbers, relocations that haven't been notified, mistakes in the data file submitted etc.	773	59%	5428	54%	4,326	43%
Errors within the Data File - This is where data is missing in required fields, or a field might be missing or some other computer detectable error in that record that prevents a check being made.	5	<1%	29	<1%	335	3%
Total Unmatched Records	782	60%	5484	55%	4,692	47%

Table 19: Evaluation of survey questionnaires and reaction of RFL holders to individual questions.

Question	Interviewer Feedback
Were there any questions that made the respondent uncomfortable?	Many respondents were uncomfortable with the details check (date of birth, licence expiry etc). If respondents were hesitant, some interviewers would go to Q5 to help respondents relax and feel comfortable, before referring back to licence questions. Q3a/b Telling respondents their licence had expired and asking if they'd got another one made some interviewers feel like they were policing respondents and they had to reassure them they weren't. Asking if respondents had taken out more than 1 licence was confusing as most purchase a 1 year licence and were unaware of the other types.
Were there any questions that had to be repeated?	Q10a seemed like a repeat of an earlier question that confused some respondents; Some respondents had taken out a licence but were unsure when it expired ("really that long ago" or " is it that time already").
Were there any questions that appeared to be misinterpreted?	3b The majority of people get a 1 yr licence and could not understand why interviewers would ask if they got more than one licence. This question should be asked only if respondents did not get a full year licence. Respondents tended to go into a lot of detail on all the "other" species.
Were there any questions that were difficult to read?	No
Were there any questions that that you came to particularly dislike?	Q3b Q8a; Some interviewers would initially skip the licence expiry questions, and return to them after respondents were comfortable with them ("Later rather than sooner").
Were there any questions that dragged?	Q8b
Were there any questions where the respondent seemed to want to say more?	Q6d Q5b Q8b; Many respondents wished to report illegal fishing actions, and requested more detailed explanations/application of results from this survey.

Table 20: Response report from a pilot survey of 260 RFL holders.

Response report	Response code	Number of respondents	% of respondents
Fully responding	1	217	83%
Full refusal	2	8	3%
Part refusal	3	2	1%
Full non-contact	4	2	1%
Part non-contact	5	3	1%
Other non-response (specify)	6	2	1%
Wrong number (refer to office)	7	16	6%
Other (specify)–fax/disconnected	9	10	4%
Total		260	

6 Survey of Recreational Fishing in coastal Victoria 2006/07

6.1 Introduction

Phone-diary, bus route and other creel surveys can provide similar accuracy for total recreational catch within current or slightly retrospective timeframes, but the spatial scale and number of access points are major factors in terms of cost-effectiveness. Potential advantages and biases that may influence the accuracy of total catch estimates were qualitatively compared, in addition to simulations comparing precision and development of a cost model for each survey method. The phone-diary survey was identified as the preferred method and a cost-effective survey design to provide annual estimates of recreational catch for the main recreational fisheries in Victoria was developed and tested.

The preferred survey was designed to assess the recreational catch of snapper by RFL holders in coastal Victoria, with particular emphasis on PPB and Western Port. Indicative information was also required in terms catch by fishers exempt from the RFL. This survey also provided an opportunity to test the methodology developed by the NRIFS in assessing recreational catch data for smaller spatial scales. As for the NRIFS, response errors were minimised by providing respondents with diary cards and species identification guides and by using trained interviewers to collect data and maintain frequent phone contact with respondents.

The survey methodology was essentially the same as the NRIFS, but with several key differences in sampling. The geographic scope was confined to coastal marine waters, with specific emphasis on PPB and Western Port. The primary sample unit was person-based and only coastal residents and RFL holders with a White Pages listing were included. Data from the NRIFS, showed that most snapper anglers resided in Melbourne (79%) or coastal statistical divisions (14%) and highly avid anglers (>15 days fishing annually) dominated the snapper harvest (81%). Statistical division and avidity were considered appropriate strata for the present survey. ABS statistical division was classified from suburb/postcode information in the RFL database and avidity was based on questioning in the screening survey in terms of the number of days fished by recall for the previous 12 months.

For the snapper fishery, the database of RFL holders was identified as a cost-effective sampling frame for a screening survey and subsequent 12 month phone-diary survey to estimate catch and effort. There are 2 million households in Victoria and approximately six households need to be contacted to find an angler. Similarly, there are 5 million residents and approximately 10% of these fish. The RFL allowed the 90% of population that do not fish to be excluded from the screening survey and this was a substantial cost saving. Although around 60% of recreational fishers in Victoria are exempt, RFL holders are major participants in key recreational fisheries. For example, in 2000/01, licensable anglers were estimated to have caught 93% of the recreational catch of snapper. It was reasonable to assume that the RFL database potentially represented the majority of fishers that harvest snapper.

Potential bias existed through non–representation of fishers from inland statistical divisions, unlisted RFL holders and recreational fishers with an RFL exemption, particularly if these fishers harvest more or less than those represented in the sample. Such behavioural differences were evaluated through annual on-site surveys conducted by MAFFRI in PPB and Western Port and particularly, for the period of the phone-diary survey. An angler was randomly selected during boat party interviews to collect person-based catch and demographic data, including license eligibility, phone listing and avidity profiles.

The survey was implemented with five components (Figure 15:

i. screening survey (May/June 2006)
ii. phone-diary survey (1 July 2006 to 30 June 2007)
iii. wash-up survey (July/August 2007)
iv. calibration survey (July/August 2007)
v. on-site survey (November 2006 to April 2007)

6.2 Methods

6.2.1 Output Specifications

Prior to final development of the survey instrument, detailed output specifications were prepared, for each survey component including objectives and various scope/study criteria in terms of temporal, spatial, respondent and fishing activity coverage.

6.2.2 Screening Survey

The screening survey was conducted by telephone interview during May/June 2006 to identify RFL holders that intended to fish in Victorian marine waters during 2006/07. Activities in scope for the screening survey included all recreational fishing methods, predominantly line fishing, but also other fishing methods, such as diving, nets, traps and spears. The screening survey investigated mainly saltwater fishing activity in Victorian coastal waters, but included some questions about freshwater fishing. Species in scope for the screening survey included any aquatic (animal) species, with specific questions on previous catches and future targeting of: flathead, snapper, King George whiting, black bream, garfish, Australian salmon, calamary/squid, rock lobster and abalone. The sampling frame for the screening survey was obtained from a database of anglers who purchased a Victorian RFL in 2004/05. All 1 and 3 year licence holders were included. The relatively small numbers of 48 hour and 28 day licences were excluded due to the absence of address/contact details in the database. An age criterion of 18–69 years applied as younger and older individuals were exempt from a RFL. No substitution of RFL holders occurred during the study. Two screening samples were randomly selected; the first to provide a sample to invite all anglers (avid and non-avid) into the phone-diary survey, and a second sample to invite only avid anglers into the phone-diary survey. General eligibility for the phone-diary survey was based on an intention to do any line fishing in Victorian marine waters in the coming 12 months.

6.2.3 Phone-Diary Survey

The phone-diary survey was conducted from 1 July 2006 to 30 June 2007 to quantify recreational fishing effort (hours and days fished) and catch levels (numbers by species, both harvested and released) for a full 12 month period. Other information was also obtained in terms of fishing region, target species, fishing method and platform. All diarists were provided with a species identification guide (showing clear colour images of the common marine species) and a simple diary card, which served more as a 'memory jogger' than a traditional fishing logbook. The phone-diary survey was confined to recreational line fishing in Victorian marine waters and all other fishing methods were excluded (such as diving, nets, traps and spears), as was any freshwater fishing activity. Fishing activity was classified in terms of 10 ‘sea’ and 17 ‘river’ fishing regions as defined in the NRIFS. Species in scope for the phone-diary survey included all aquatic species actually caught by line fishing (including calamary/squid). Any other catches, such as rock lobster or abalone were not recorded.

6.2.4 Wash-Up Survey

The wash-up survey was conducted during July/August 2007 during the final telephone contact with each diarist to assess attitudinal information for a range of fisheries-related issues. At the time, Fisheries Victoria had issued a discussion paper on proposed snapper management options and specific questions were included to assess angler awareness and opinions of the proposed management options. Other questioning was included to assess diarists' perceptions as to whether they fished "more, less or about the same" amount of time in the 12 month diary period, compared with the prior 12 months. This information was important to avidity profiling of diarists and the ultimate expansion/calibration process.

6.2.5 Calibration Survey

The calibration survey was conducted during July/August 2007 to provide benchmark information on the numbers of 1 and 3 year RFL holders that fished during the period July 2006 to June 2007. The survey amounted to a 'back-end' screening survey, where participation and profiling information for the diary period was used to ‘calibrate’ the results from the phone-diary survey. Activities and species in scope for the calibration survey were identical to the original screening survey. As an integral part of the calibration process, specific questioning was included to assess recalled personal harvest (yes or no) in the phone-diary period of any of the following species: flathead, snapper, King George whiting, black

bream, garfish, Australian salmon, calamary/squid, rock lobster and abalone. The opinions of respondents were also sought in relation to various fishing-related issues, including the discussion paper on snapper management options.

The calibration survey was stratified by residency (city or country) with a person-based (RFL holder) sampling unit. The sampling frame was obtained from a list of RFL holders in 2006/07. Postcodes were excluded from the minimum entry fields for 48 hour and 28 day licenses in the RFL database for 2006/07. Consequently, statistical divisions could not be assigned to RFL holders that purchased 48 hour or 28 day licences in 2006/07 and the sample for the calibration survey was confined to RFL holders with a valid one year licence (that was purchased in 2006/07) or three year licence (that was purchased in 2006/07, 2005/06 or 2004/05).

6.2.6 On-Site Surveys

MAFFRI conducted creel surveys at boat ramps in PPB and Western Port during peak fishing months of the phone-diary survey period. Sampling was allocated to the following strata: regions within PPB (Bellarine, Melbourne and Mornington) and Western Port (Western and Eastern parts); day type (weekend/weekday); time of day (am/pm); and season (October–December and January–April). Sample days were also confined to daylight hours only and were not designed to estimate total catch and effort. Rather, representative information was obtained in terms of size/frequency data for key recreational species. This enables mean weights to be determined for conversion of the harvest numbers obtained through the phone-diary survey to harvest weights. This allows for direct comparison of the recreational harvest to commercial fishery information which is routinely recorded as weights.

The species identification skills of anglers were also routinely assessed in the on-site surveys to validate phone-diary survey reporting. Additionally, the catch, effort and catch rate data were compared between the on-site and phone-diary surveys. An important role of the on-site surveys related to assessment of the extent and behavioural differences of anglers not covered by the phone-diary survey, principally exempt and unlisted RFL holders and RFL holders from inland statistical divisions or interstate. Further to this, avidity profiles of anglers were assessed to discriminate between the behavioural differences between the various angler groups covered (or not) by the phone-diary survey.

6.2.7 Data Expansion, Weighting and Analysis

For the various telephone survey components of the study, the primary sampling unit was the RFL holder (person-based). Detailed catch and effort data obtained through the phone-diary survey from RFL holders with a White Pages listing were expanded to the total population of 1 and 3 year RFL holders residing in the coastal statistical divisions of Victoria, as determined from the RFL Database. Data from the on-site surveys was used to test the assumption that listed RFL holders were representative of their unlisted counterparts.

The number of fishers within this population was determined by stratum through the calibration survey and 'counterpart' anglers in the phone-diary survey were identified by relevant profiling information (statistical division and avidity). Accordingly, eight cells were used to weight samples: statistical division (Melbourne, Barwon, Western District, Gippsland) and fisher avidity (15 days or more fishing in the previous year by recall) and non-avid (less than 15 days fishing in the previous year). For more accurate estimation of snapper harvest, additional variables were included from the calibration survey in terms of any reported snapper harvest (or not) and fishing locations in the phone-diary survey period.

The sample weight (or expansion factor) for a given subsample was determined by the inverse of the fraction it represented in the population, according to the following equation, where a_{hi} = weight for RFL holder i in stratum h, N_h = total number of RFL holders in stratum h, n_h = number of RFL holders sampled in stratum h

$$a_{hi} = \frac{N_h}{n_h}$$

The total catch of species in each stratum over the phone-diary period was calculated by multiplying the weighted catch for all diarists in each stratum with the number of RFL holders in each stratum. The variability of total catch can be measured by the variance, which accounts for the weighted catch for all

diarists in each stratum and the number of RFL holders in each stratum. It is difficult to compare the variances between samples that have different sample sizes (more samples usually have lower variance) or between samples that have different total estimates (lower totals usually have lower variance). The standard error (SE) was another measurement of variability that accounts for differences in the number of samples, but the relative standard error (RSE) was the preferred measure of variability as this accounts for differences in the magnitude of the total estimate between samples, allowing comparison of precision of different estimates. A large RSE is considered unreliable. Formulae for calculating total catch and measures of variability are detailed in Henry and Lyle (2003).

Data from the on-site surveys of PPB and Western Port did not require adjustment or expansion of this kind and were used for indicative/comparative purposes.

6.2.8 Survey Documentation

Development of the NRIFS resulted in a substantial set of survey materials, including questionnaires and interviewer manuals, to facilitate and simplify the collection/recording of survey data (Survey Development Working Group 2000). These were produced following an extensive design and testing program. Highly structured questionnaires were developed, where question wording, instructions to interviewers and pre-coded answer categories were included in accordance with a range of standardised interviewing conventions.

An equivalent approach was employed for all telephone survey components of the present study, including thorough training and monitoring of interviewers and development of a comprehensive interviewer manual. The manual includes detailed questionnaire conventions, definitions and procedures for the survey and also provides an important role in ongoing analysis of the survey database. A copy of the manual is provided in West and Ryan (2009), along with similar information for the on-site survey. Other survey documentation includes questionnaires and workload control sheets (see Appendix 5; attachments in West and Ryan 2009).

6.3 Results

The survey of recreational fishing in coastal Victoria 2006/07 was evaluated according to several criteria, including: response profiles for the screening, phone-diary and calibration surveys; the number of fishing events and cumulative catch for diarists in the phone-diary survey; the estimated total catch of snapper by RFL holders and precision associated with the catch estimates; and potential bias due to coverage limitations in the sampling.

6.3.1 Response Profiles

The initial screening survey conducted prior to the phone-diary survey was based on a sample of 2,965 RFL holders, of which 91.7% were fully responding (Table 21). Similarly, 89.9% RFL holders fully responded from a sample of 2,800 for the calibration survey at the end of the phone-diary survey. These response rates are significantly higher than those obtained for Victoria in 2000/01 (76%), where a gross sample of 9,055 households was required to adequately screen the population, consistent with sampling a low participation fishery from the broader (White Pages) population (Table 21).

Refusal rates were extremely low for both the screening (3.0%) and calibration surveys (4.5%). This was attributable to the use of experienced interviewers and the fact that relevance of the subject matter strongly correlates with response propensity (i.e. an 'interest' in fishing). Despite at least 10 effective calls over the survey period, 5% non-contact was observed in both the screening and calibration surveys.

The vast majority (94%) of eligible RFL holders identified in the screening survey agreed to participate in the phone-diary survey (650 initial diarists) and 639 respondents completed the survey, representing a response rate of 98% for the diary-uptake group. The response rates for the various components of the survey provide considerable confidence in overall data quality and minimise the impact of non-response bias.

6.3.2 Target Preference

Respondents in the screening and calibration surveys were questioned on their target preferences; the three most common target species were snapper, King George whiting and flathead (Figure 16). These

three species are generally more available throughout longer periods during the year. These fisheries are predominantly only accessible to anglers that can access a boat. Fisheries in PPB and Western Port are close to Melbourne, which reduces travel times and limits costs to some extent. Other species identified as being targeted less frequently were garfish, calamary, rock lobster and abalone. These low participation recreational fisheries are potentially restricted by seasonal availability (particularly for garfish and calamary) or spatial availability (particularly rock lobster and abalone where recreational fisheries are generally less accessible).

6.3.3 Number of Fishing Events

The survey design was effective in increasing the number of fishing events in the larger bays, and achieved substantially more fishing events at regional scales compared with those obtained in 2000/01. For example, the number of fishing events reported in PPB in 2006/07 (1,480) was almost double those obtained in 2000/01 (813), and the number of fishing events reported in Western Port in 2006/07 (668) was three times greater than those obtained in 2000/01 (183) (Table 21). This was primarily attributable to over-sampling of avid anglers, who naturally have higher annual fishing effort levels.

6.3.4 Number of Diarists and Cumulative Catch

Over-sampling of avid fishers in the phone-diary survey was also effective in achieving a higher cumulative catch of snapper, King George whiting and flathead from more diarists compared with the NRIFS (Figure 17). For example, 24 'licensable' diarists caught 302 snapper in the NRIFS with 50% of cumulative catch caught by 2 diarists and 7 diarists reporting 10 or more snapper over the 12 months. These results increased in the 2006/07 survey, where 135 diarists caught 1,127 snapper with 50% of cumulative catch caught by 15 diarists and 32 diarists reporting 10 or more snapper over the 12 months.

Similarly, in the NRIFS, 22 'licensable' diarists caught 878 King George whiting with 50% of cumulative catch caught by 3 diarists and 14 diarists reporting 10 or more whiting over the 12 months. The samples in 2006/07 indicated 83 diarists caught 1,604 whiting with 50% of cumulative catch caught by 7 diarists and 31 diarists reporting 10 or more whiting over the 12 months. For flathead, 46 'licensable' diarists caught 1,790 flathead with 50% of cumulative catch caught by 3 diarists and 24 diarists reporting 10 or more in the NRIFS. In 2006/07, 168 diarists caught 3,905 flathead with 50% of cumulative catch caught by 15 diarists and 85 diarists reporting 10 or more flathead over the 12 months.

6.3.5 Behaviour Change Assessment from the Wash-Up and Calibration Surveys

Fishing behaviour was explored in both the wash-up and calibration surveys, in terms of any reported fishing activity in the phone-diary survey period (2006/07) and the previous 12 months (2005/06). Respondents reporting fishing in both years were then asked whether they fished "more, less or about the same number of days" in the diary period, compared with the prior 12 months. A comparison of the respective results for the wash-up and calibration surveys is provided in Figure 18.

The survey samples were drawn from licence databases for different years and consistency in these survey results cannot be expected. The calibration survey (the more recent database) necessarily provides more appropriate representation for the phone-diary survey period and related 'symmetry' in terms of behaviour change assessment. Small proportions of respondents in the calibration survey reported fishing in neither year (7%), 2005/06 (3%) and 2006/07 (6%), with 84% reporting fishing in both years (Figure 18). For respondents that fished in both years, 50% reported fishing about the same number of days, and similar proportions reporting fishing more and less fishing activity in the diary period (24% and 26%, respectively). By contrast, 76% of respondents in the wash-up survey reported fishing in both years, but only 28% reported the same level of activity, 11% reported fishing more and the majority (61%) reported fishing less in the diary period (Figure 18). These differences highlight the importance of the calibration survey in benchmarking and correction of the phone-diary survey data.

In both the wash-up and calibration surveys, respondents reporting any change in fishing activity/level between the two years were assessed in terms of the main (and other) reasons for this change. Responses were classified according to a pre-determined code-frame. In both surveys, the ranking of major reasons for such change were similar, with work/business related factors the predominant reason (e.g. more/less busy with work, changes in shifts etc.). Other factors in descending order of importance were: home/family related (e.g. renovating, new baby); social related (e.g. friend fished more/less or

started/stopped); location related (e.g. moved to different area); other 'access' related (e.g. bought/sold boat); fishing quality/catch rates (e.g. better/worse); and different kinds of fishing/targeting. Other factors emerged at minority levels: personal preference (e.g. new sport/ recreation); personal health/fitness; cost (e.g. licence and fuel prices); and environmental factors (e.g. water quality/levels).

6.3.6 Estimates of total catch of snapper by 1 and 3 year RFL holders

Two approaches were used to expand data from the phone-diary survey. The first approach used sample weights for the numbers of 1 and 3 year RFL holders in each coastal statistical division and the proportions of avid and non-avid anglers determined from the calibration survey (Table 22), to estimate participation and fishing effort. When used to estimate harvest, this approach produced consistently lower estimates than comparable results for 2000/01 (Table 22), mainly because the process did not take account of harvest profiles or fishing location information from the calibration survey. The harvest estimates for key species using simple expansion have been provided for illustrative purposes only.

The second expansion approach utilised additional data from the calibration survey, in terms of whether respondents reported a personal snapper harvest or not, and whether they fished in PPB, Western Port and elsewhere. This was considered the most appropriate and sensitive expansion method for snapper. Assessment of harvest estimates for other key species should employ this approach in later analysis work. Using this alternative approach, benchmark calibrations correctly accounted for 135,214 RFL holders (Table 22). Adjustment for species and fishing location had an upward effect on the estimated total harvest of snapper from 365,662 using the first approach to 612,202 using the more detailed expansion method (Table 23).

The estimated total harvest of snapper across the 4 coastal regions in Victoria in 2006/07 was comparable with the estimated total harvest by licensable anglers in 2000/01 (Figure 19, Table 23). Total harvest estimates of snapper by licensable anglers in PPB were comparable in 2000/01 (285,793 ± 188,603 SE) and 2006/07 (244,542 ± 21,742 SE); in coastal west in 2000/01 (123,355 ± 31,726 SE) and 2006/07 (129,299 ± 18,180 SE). An increase in the total harvest of snapper was observed in Western Port from (2,776) in 2000/01 to (152,162 ± 2 18,558 SE) in 2006/07, which was consistent with increasing availability, catches and catch rates of snapper observed from annual on-site surveys, along with anecdotal information.

Standard errors provide an indication of variability of each estimate (Figure 19). Relative standard error (RSE) accounts for differences in the magnitude of the total estimate and is a preferred measure of variability. The estimated RSE for the total catch of snapper by licensable anglers in PPB in 2000/01 was 0.66 (Table 25), which was less precise than the estimated RSE of 0.16 in 2006/07. The survey design in 2006/07 using a RFL sampling frame with over-sampling of avid anglers also produced a more precise estimate at the regional level compared with that obtained state-wide during 2000/01. In 2000/01 there were insufficient samples to estimate a RSE for Western Port, but the survey in 2006/07 obtained a RSE of 0.23. The estimated RSE in coastal west was 0.25 in 2000/01 to 0.24 in 2006/07. The precision levels obtained at a regional scale for the western snapper stock in 2006/07 were comparable to, or better than that, those obtained state-wide for snapper (0.218) during 2000/01.

The number of 1 and 3 year RFL holders from coastal statistical divisions that harvested snapper in 2006/07 (55,582) was comparable with the estimate of 41,027 for licensable anglers in 2000/01 (Table 24). In 2006/07, an estimated 32,351 licensed anglers harvested snapper in PPB, 17,864 in Western Port and 18,483 in other coastal areas. The majority of licensed anglers that harvested snapper (42%) were avid anglers residing in the Melbourne statistical division (Figure 19). The high proportion of snapper harvested by avid anglers from all coastal statistical divisions (71%) and Melbourne residents (58%) was consistent with results from the NRIFS.

6.3.7 Potential Bias due to Coverage Limitations

The parallel on-site survey program provided important information in terms of coverage bias, through interviews with some 1,536 'randomly-selected' fishers, to provide individual catch, demographic and profiling data. From these interviews, 344 anglers reported a total of 895 retained snapper. None of the snapper retained in the on-site surveys was caught by anglers from interstate and only a small harvest (was taken by inland residents (2%). Anglers with RFL exemption accounted for 12% of the retained snapper (Table 26), with 11% in PPB and 15% in Western Port (Figure 20).

The remaining 86% of retained snapper referred to 'licensable' anglers who were residents of coastal statistical divisions and this was similar to the proportion assessed for the 2000/01 survey. The majority of retained snapper (65%) in the on-site survey was harvested by RFL holders reporting a White Pages listed telephone number, with unlisted RFL holders accounting for 21% (Table 26). Similar patterns emerged for listed RFL holders in PPB (63%) and Western Port (67%) (Figure 20).

In attempting to assess the extent of behavioural bias for anglers not covered by the phone-diary and calibration surveys, comparisons were made in catch rates (CPUE) of snapper from the on-site survey for the various angler groups (listed RFL holders vs. unlisted RFL holders and the exempt group). No significant differences were detected in this analysis (Figure 21) and not surprisingly, due to the inherent insensitivity of daily or hourly catch rate data.

Avid anglers comprise only a minority of all fishers, but they consistently account for the majority of total recreational harvest. This is more a function of their higher annual effort as opposed to catch rates (per hour or day). In the following analysis, anglers interviewed in the on-site survey were classified as avid (15 days or more fishing in the previous 12 months, by recall) or non-avid (less than 15 days), with consistent proportions of avid anglers observed across the various 'scope' groups and at several levels. The majority of interviews were with avid anglers (67%), with identical proportions for listed and unlisted RFL holders (67%) and the relatively small exempt group (65%) (Table 27). A similar proportion (69%) of avid fishers reported a personal harvest of any species (n = 887), with 69% for listed RFL holders, 73% for unlisted RFL holders and 65% for the exempt group. A higher proportion (78%) of avid fishers reported a personal snapper harvest, with 77% for listed RFL holders, 84% for unlisted RFL holders and 77% for the exempt group. When expressed as a proportion of all retained snapper, a similar majority (80%) emerged for avid anglers, with 79% for listed RFL holders, 89% for unlisted RFL holders and 75% for the exempt group.

The catch rates of snapper (measured in fish per angler hour) in PPB for RFL holders with a phone listing (0.51 ± 0.08 SE) were not significantly different to those for unlisted RFL (0.51 ± 0.08 SE) and RFL exempt (0.48 ± 0.08 SE) anglers (Figure 21). Similarly, in Western Port, the catch rates of snapper for avid RFL holders with a phone listing (0.58 ± 0.07 SE) were not significantly different to those for unlisted RFL (0.69 ± 0.12 SE) and RFL exempt (0.76 ± 0.22 SE) anglers (Figure 21). This provides further evidence that the fishing behaviour of unlisted RFL holders was not different to listed RFL holders, and additional support for the assumption that listed RFL holders were representative of their unlisted counterparts.

The results from the phone-diary survey have been expanded in this report to estimate total harvest of snapper for all 1 and 3 year RFL holders (listed and unlisted) in the coastal statistical divisions, where the populations were known from licence database counts. Clearly, the estimated harvest of 612,202 snapper by these fishers comprises the vast majority of the total recreational harvest.

The population of exempt fishers was unknown, the on-site survey results also confirm that they comprise a small minority of total snapper harvest (as for the 2000/01 survey), along with RFL holders from interstate or inland statistical divisions, and those with 48 hour or 28 day licences (due to the impacts of naturally lower avidity). Whilst no attempt has been made to quantify the snapper harvest for these fishers, the minority proportion observed in the on-site survey (around 14%) was considered a reasonable indicator. As a comparison, the likely magnitude of this component approximates one standard error for the expanded estimate for RFL holders (RSE = 0.13, Table 28).

Although harvest weights have not been estimated in this report, the size/frequency data from the on-site survey should be carefully considered in any such analysis. For example, the total length distributions of snapper ranged from 26–88 cm in PPB and 23–81 cm in Western Port (Figure 22). Also, seasonal shifts were observed, with larger individuals more common from October to December and smaller 'pinkies' more common from January to April.

6.4 Discussion

The requirement for appropriate estimates of recreational harvest has been identified for key recreational species throughout Australia. Estimates of total recreational catch have been used for assessments of snapper stocks in Queensland (Allen *et al.* 2006), New South Wales (Scandol 2004, Stewart and Hughes 2008), South Australia (Fowler *et al.* 2007), and Western Australia (Moran and Kangas 2003). State-wide

off-site surveys have been recently repeated in South Australia, Tasmania and the Northern Territory, with Queensland likely to repeat the state-wide survey in 2010/11.

The most suitable method for monitoring total catch from Victoria's recreational fisheries needs to provide reliable estimates of catch for the defined spatial and temporal scales, yet not be too expensive to implement. This survey has developed methods to conduct cost-effective targeted phone-diary surveys to estimate recreational catch for specific recreational fisheries/stocks (namely the western Victorian snapper stock). This methodology could be adopted by Fisheries Victoria if there was a clearly identified need for recreational catch estimates of particular species for stock assessment models, or to assist establishing and monitoring compliance with specific resource sharing/allocation targets for particular fisheries/stocks.

This survey demonstrated that precise estimates for the vast majority of total recreational catch can be achieved at smaller spatial scales. The precisions obtained at regional levels for the western snapper stock in 2006/07 were comparable to, or less than, those obtained state-wide for snapper during 2000/01. The benefits of screening from a RFL sampling frame were evident in: reduced costs, high response rates, an increased number of fishing events and increased precision. Disproportionate stratification (over-sampling of avid anglers) was viable using a RFL sampling frame where avid anglers could be contacted cost-effectively. This survey also addressed accuracy by using a single frame survey with an on-site survey to assess non-represented fishing. The coverage of any future surveys using this approach could be improved by routine collection of contact details for all RFL holders (including phone number). Other potential approaches include a dual-frame survey using both White Pages and RFL listings, where exempt fishers might account for larger proportions of the total harvest of the relevant species (e.g. black bream) or a single frame where an exhaustive RFL listing was available, as for licence database surveys in Tasmania, South Australia and Western Australia.

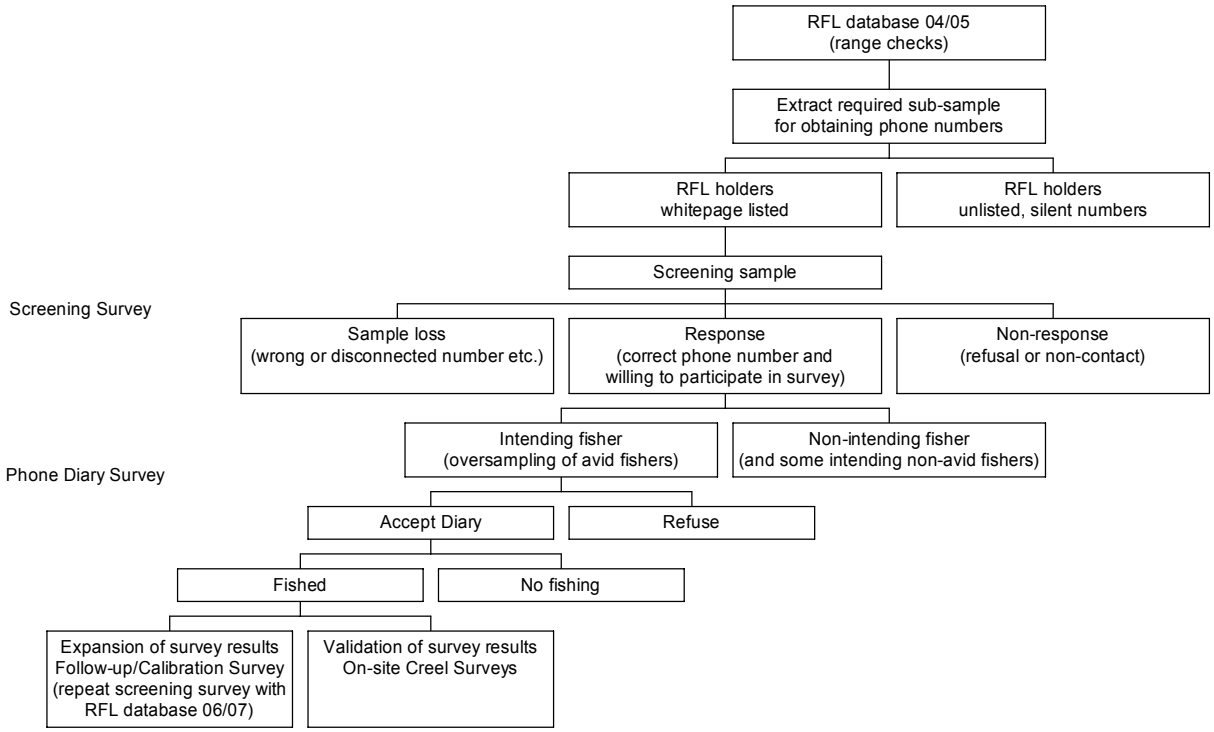


Figure 15: Flow chart of survey components.

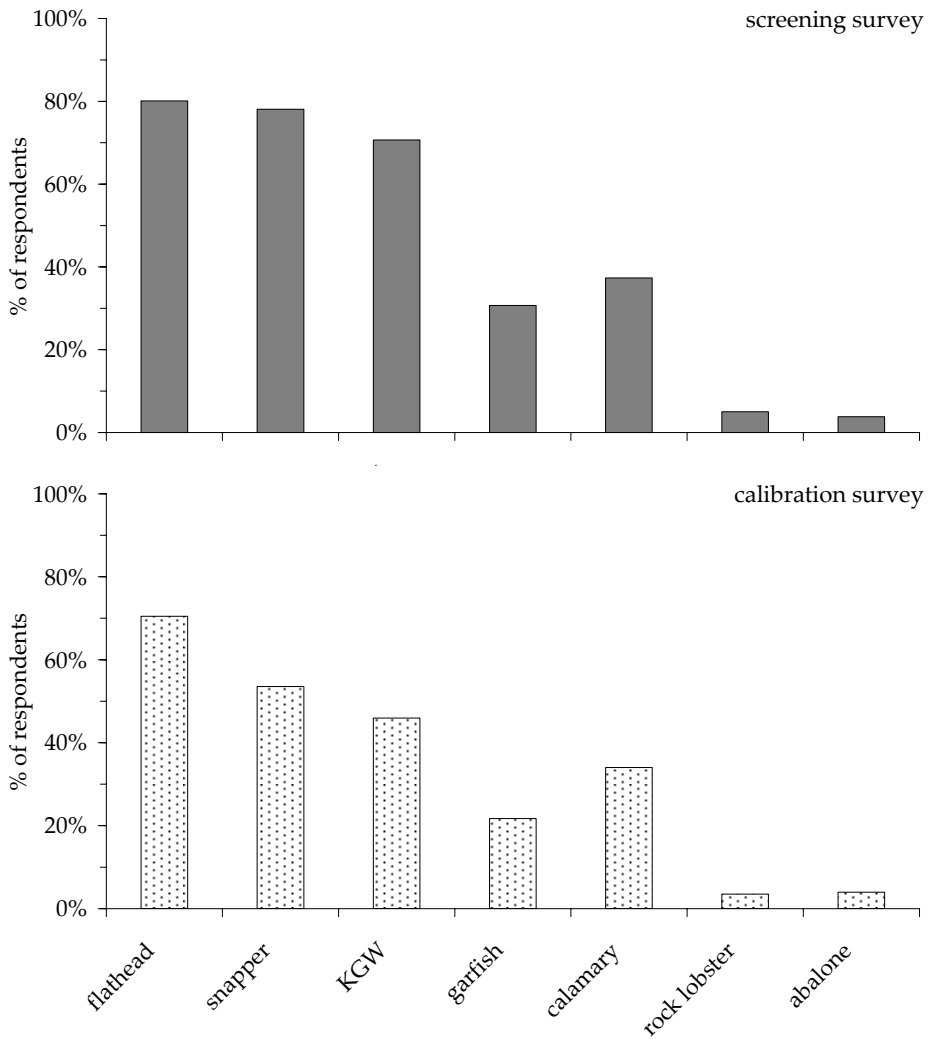


Figure 16: Target preference of respondents in the screening and calibration surveys.

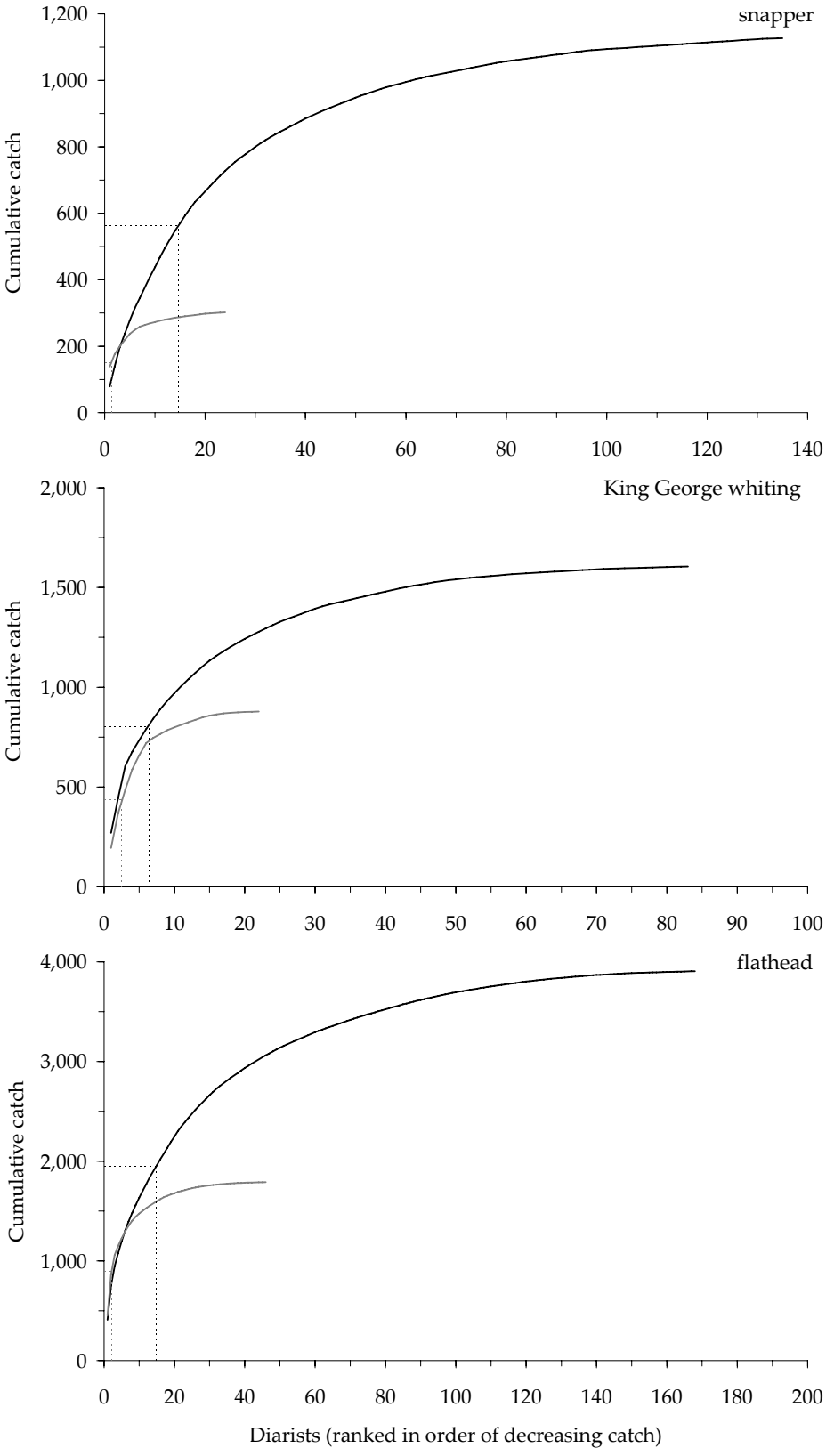


Figure 17: Number of diarists and cumulative catch for snapper, King George whiting and flathead in 2006/07 (black line) and 2000/01 (grey line).

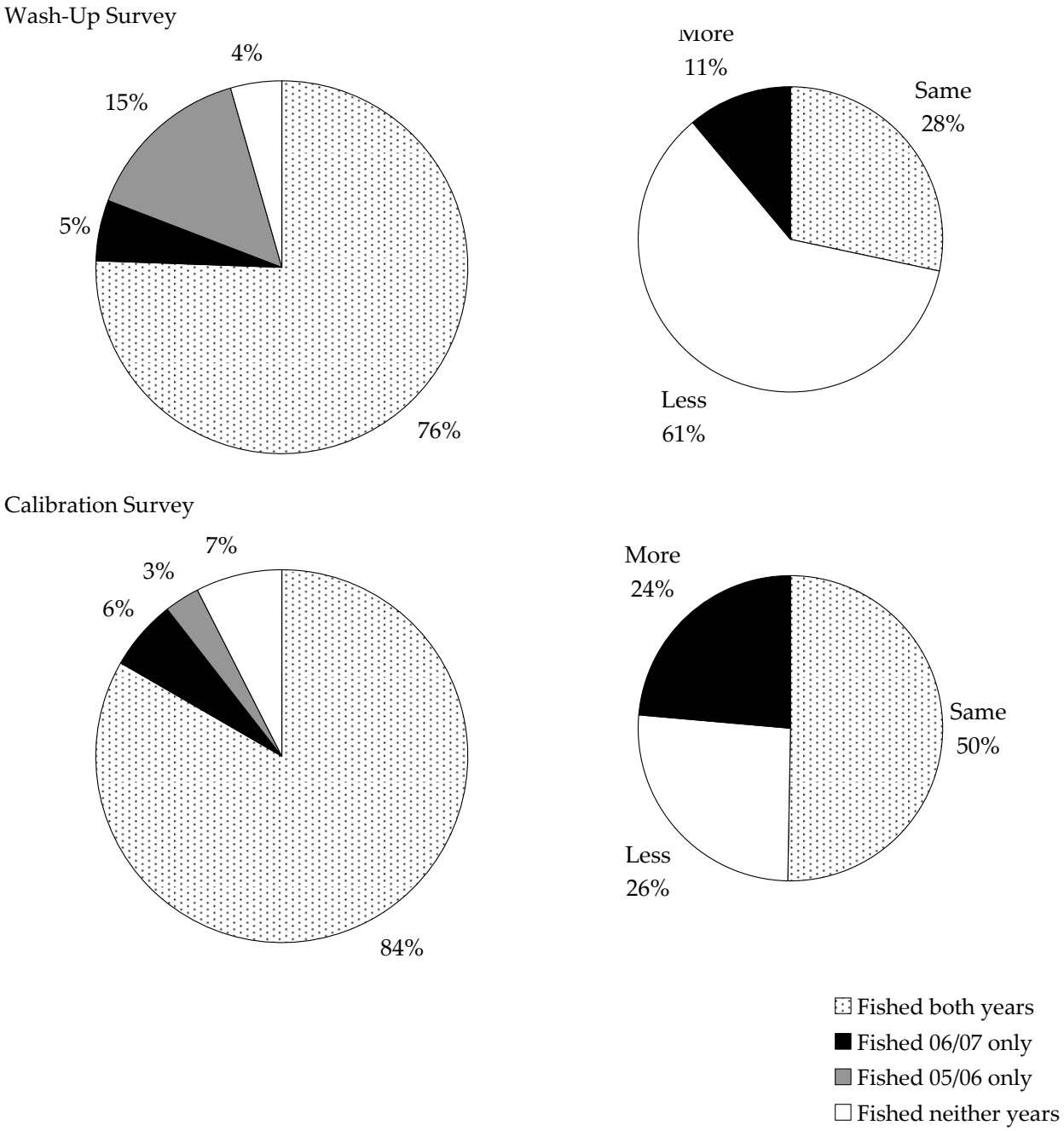


Figure 18: Perceived behaviour change of respondents in the wash-up and calibration surveys.

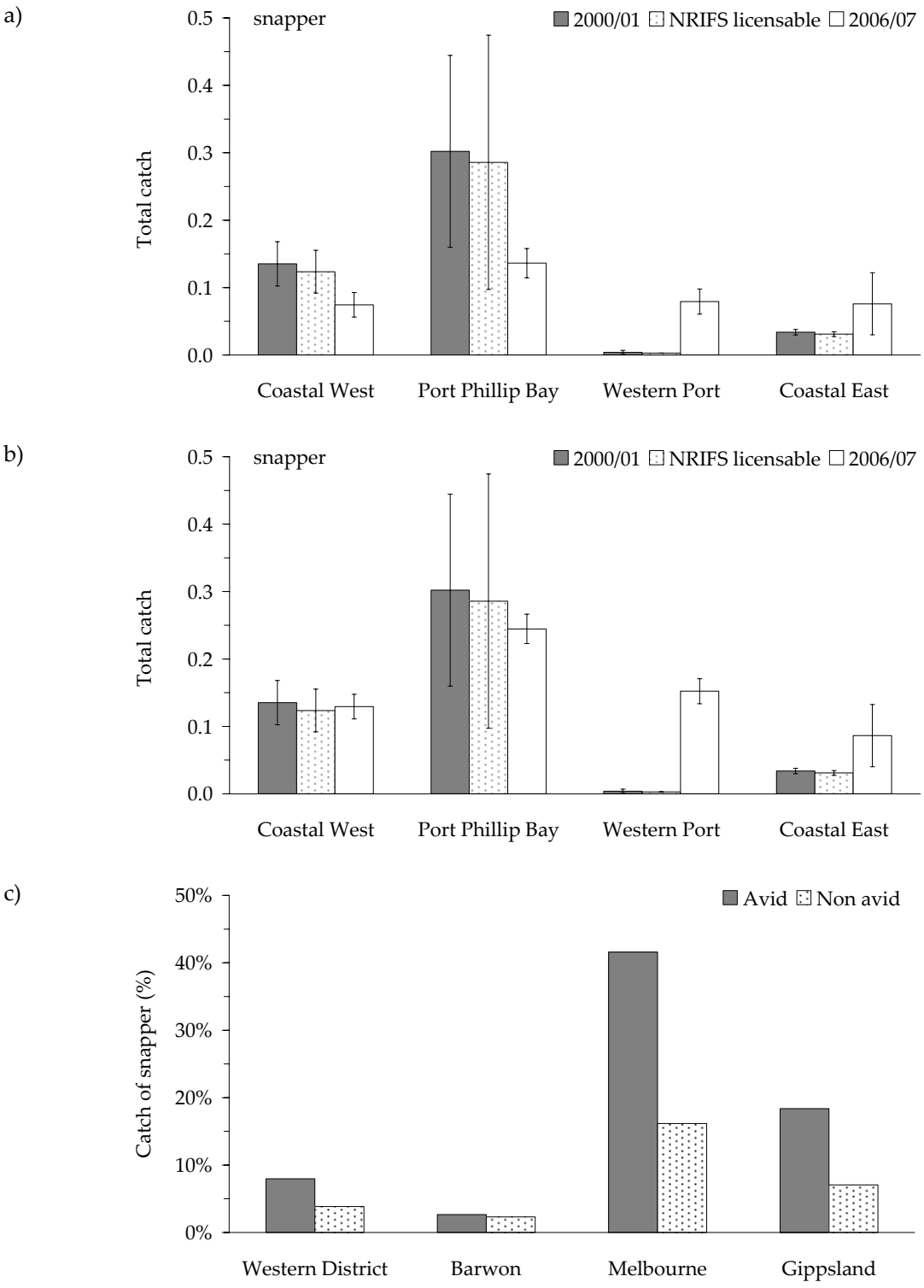


Figure 19: Estimated total recreational catch of snapper (number x 10^6) from coastal Victoria in 2000/01 and 2006/07 by: (a) fishing region with adjustment from simple expansion, (b) fishing region with adjustment from calibration survey and (c) 2006/07 statistical division and avidity.

a) and b) NRIFS licensed (stippled) and 2006/07 (white bar)
c) avid (grey) and non-avid (stippled bar)

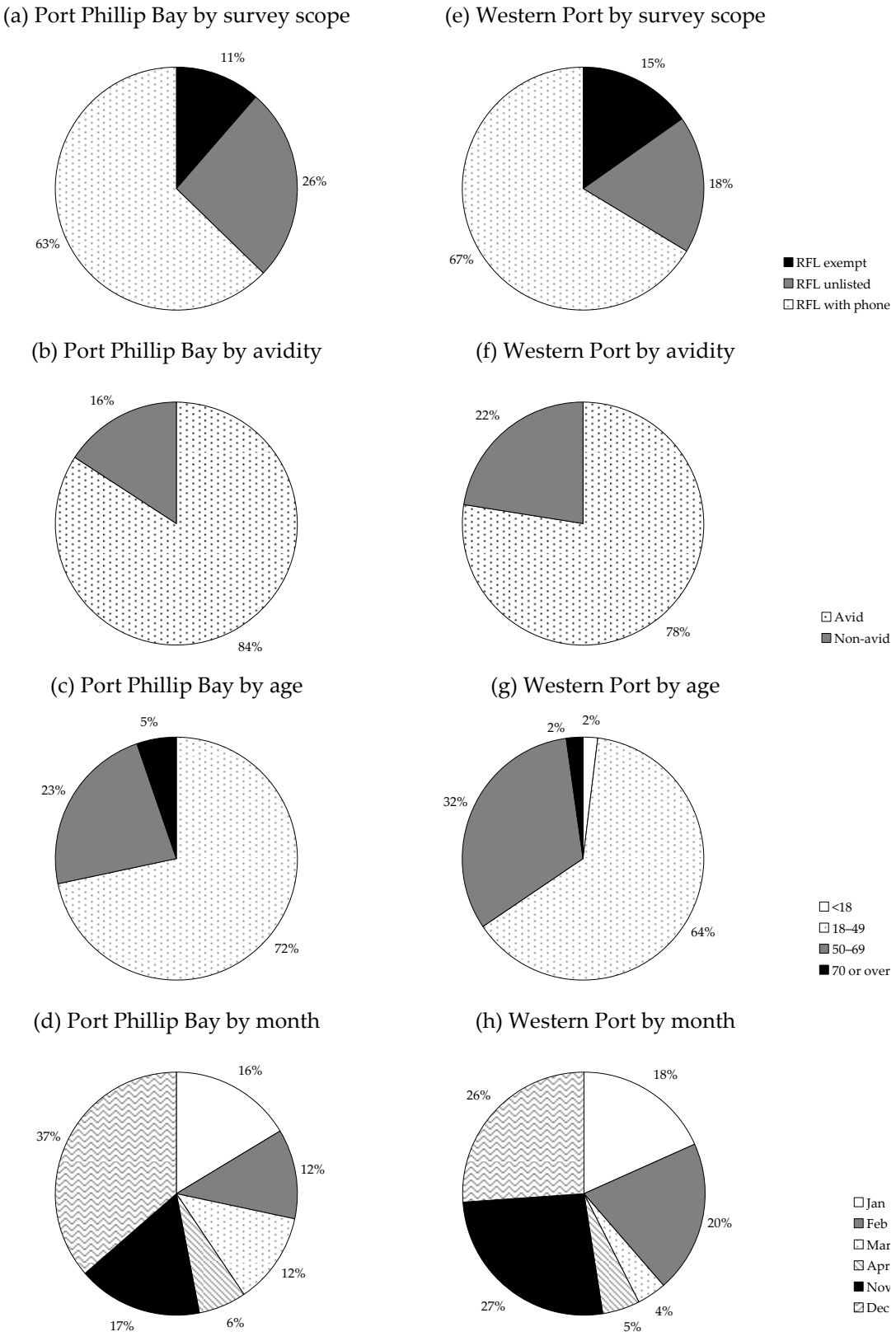


Figure 20: Proportion of snapper retained by survey scope, avidity, age and month from on-site surveys in PPB and Western Port in 2006/07.

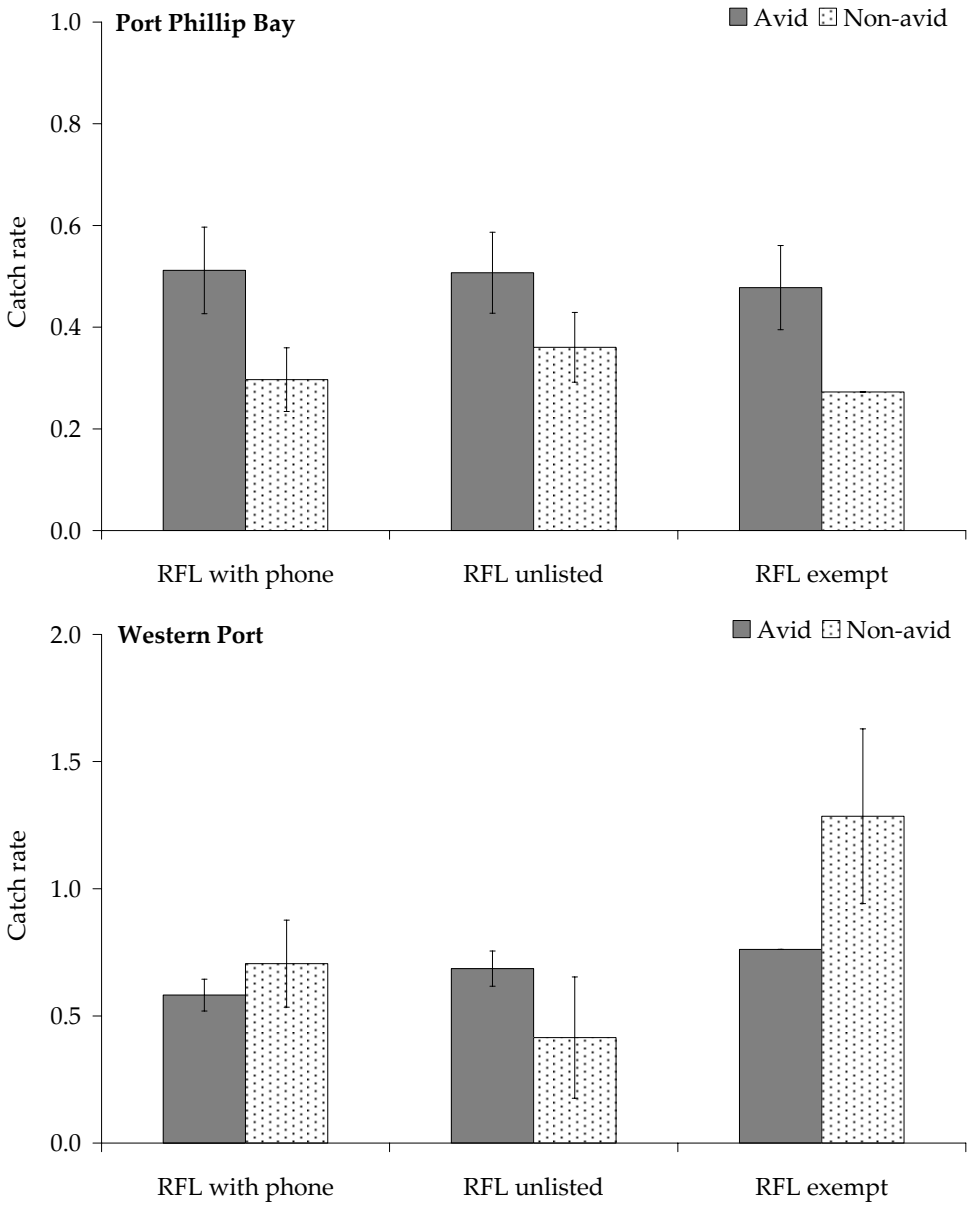


Figure 21: Comparison of snapper catch rate (fish per angler hour) by location, avidity and scope from on-site survey.

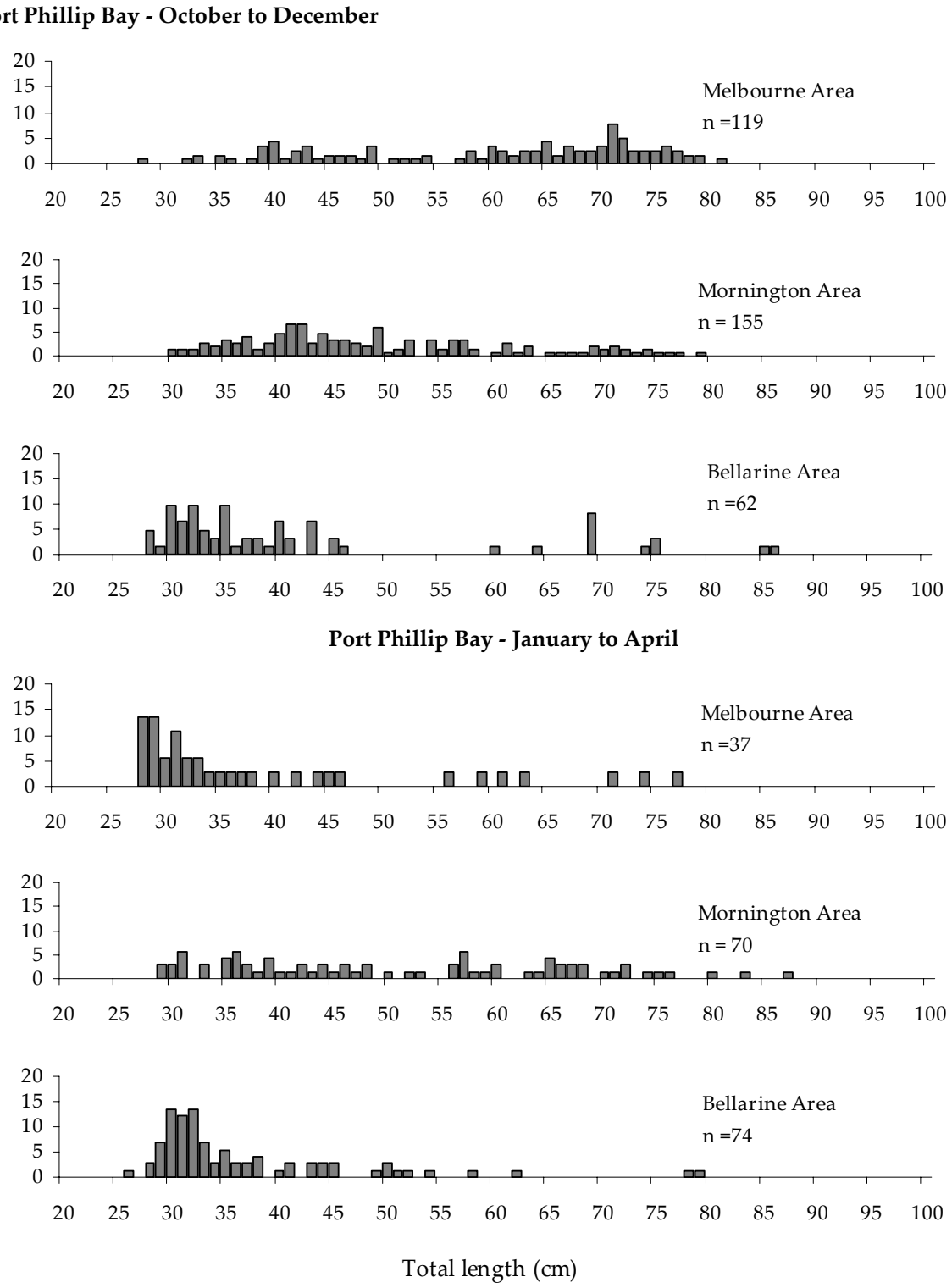


Figure 22: Size composition of snapper caught (retained and released) by anglers fishing at boat ramps in PPB and Western Port (2006/07, n = number of fish measured).

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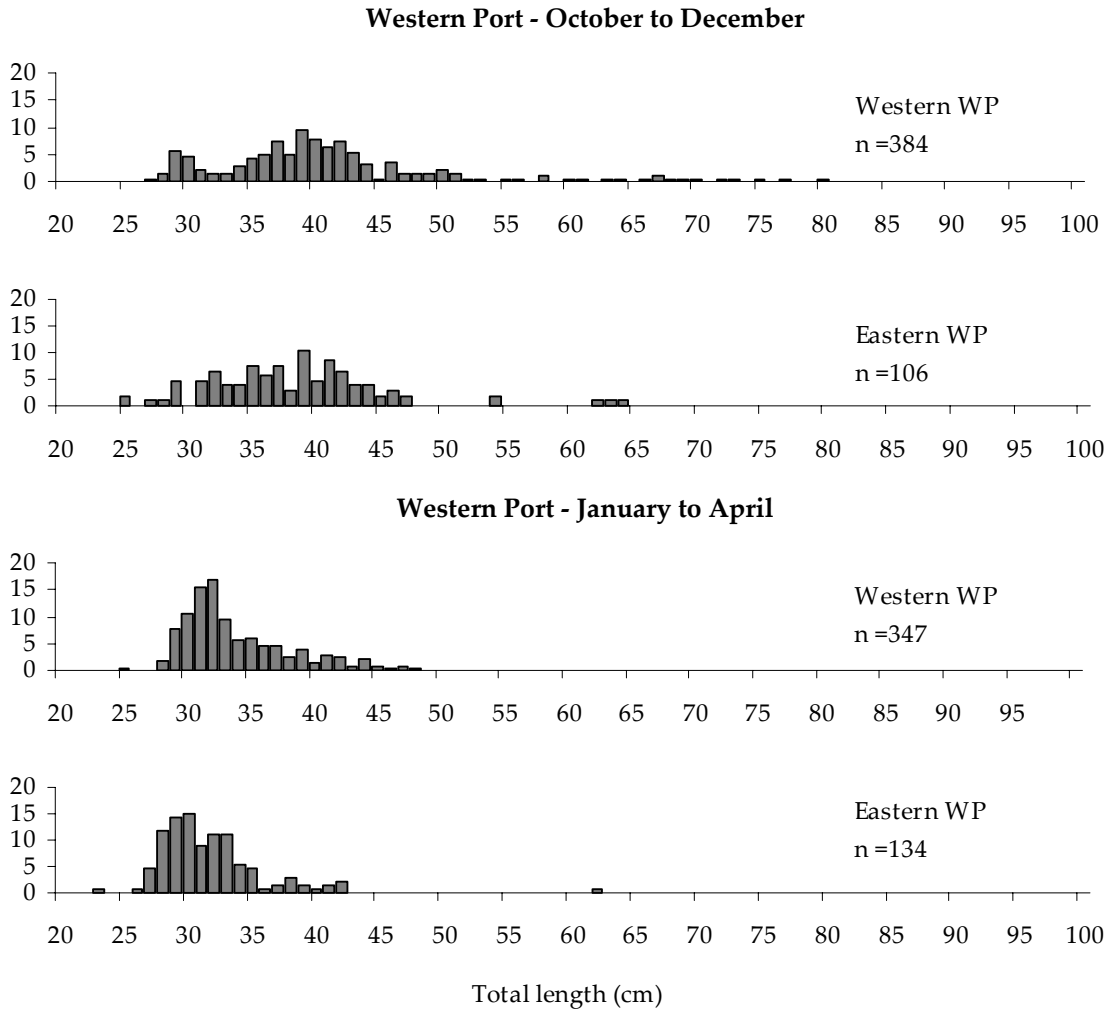

Figure 22: Size composition of snapper caught (retained and released) by anglers fishing at boat ramps in PPB and Western Port (2006/07, n = number of fish measured).

Table 21: Response report and number of fishing events.

Response Report

	NRIFS 00/01	Screening 06	Calibration 07
Gross sample	9,055	2,965	2,800
Sample loss	1,098	383	214
Net sample	7,957	2,582	2,586
Fully responding	76%	91.7%	89.9%
Refusal	19%	3.0%	4.5%
Non-contact	5%	5.1%	5.3%
Other		0.2%	0.2%

Number of fishing events

Fishing region	NRIFS 00/01	Phone-Diary 06/07
PPB	813	1,480
Western Port	183	668
Coastal (west and east)	3,101	2,218
State-wide	4,097	4,366

Percentage catch of snapper

Survey scope	NRIFS 00/01	On-site survey 06/07
RFL holder	94%	88%
RFL exempt	5%	10%
Inland	1%	2%
Interstate	< 0.01%	0%

Avidity of respondents

Avidity category	NRIFS 00/01	Screening 06	Phone-Diary 06/07	Calibration 07
Less than 5 days	32%	36%	13%	29%
5 to 14 days	40%	31%	18%	36%
15 or more days	28%	33%	69%	35%

Table 22: Expansion of sample weights and sampling fractions for RFL holders using (a) simple expansion by statistical division and avidity and (b) Detailed expansion by statistical division and fishing activity and benchmark calculations.

(a) Simple expansion by statistical division and avidity

Statistical Division	Number of 1 & 3 year RFL holders	Avidity	% from calibration survey	Number in phone-diary sample	Number in population (06/07 RFL)	Sample weight	Sampling fraction
Melbourne	98,106	Avid	27%	278	26,631	95.80	1.04
		Non avid	73%	117	71,475	610.89	0.16
Western District	6,842	Avid	40%	21	2,737	130.32	0.77
		Non avid	60%	17	4,105	241.48	0.41
Barwon	12,972	Avid	30%	52	3,940	75.76	1.32
		Non avid	70%	31	9,032	291.37	0.34
Gippsland	17,294	Avid	35%	50	6,113	122.27	0.82
		Non avid	65%	31	11,181	360.66	0.28
Total	135,214			597	135,214		

(b) Detailed expansion by statistical division and fishing activity and benchmark calculations

	Melbourne	Western District	Barwon	Gippsland	Total
RFL holders 2006/07 (1 and 3 yrs)	98,106	6,842	12,972	17,294	135,214
Gross sample	1,540	196	434	630	2,800
Sampling Fraction	0.016	0.029	0.033	0.036	0.021
Fully responding	1244	169	373	529	2315
Sample take rate	80.8%	86.2%	85.9%	84.0%	82.7%
Sampling Fraction	0.013	0.025	0.029	0.031	0.017
Expansion Factor (inverse of above)	78.863	40.485	34.777	32.692	58.408
Respondents that fished in 06/07 (raw)	1,134	159	342	493	2,128
Respondents that fished in 06/07 (expanded)	89,431	6,437	11,894	16,117	123,879
% Fished	91%	94%	92%	93%	92%
Respondents that did not fish in 06/07 (raw)	110	10	31	36	187
Respondents that did not fish in 06/07 (expanded)	8,675	405	1,078	1,177	11,335
Total RFL holders	98,106	6,842	12,972	17,294	135,214

Table 23: Total catch (number by species).

Species/species group	2000/01 NRIFS	2000/01 NRIFS licensable	2006/07 phone-diary number harvested (raw)	%	2006/07 simple expansion*	2006/07 detailed expansion*
Flathead	3,316,071	2,741,640	7,190	33%	1,219,895	n/a
KG whiting	975,349	797,468	4,915	23%	621,006	n/a
Snapper	474,879	442,763	2,802	13%	365,662	612,202
Aust salmon	541,852	412,475	1,192	6%	149,657	n/a
Garfish	255,199	202,978	1,116	5%	181,415	n/a
Calamary	199,202	135,057	1,090	5%	132,114	n/a
Black bream	506,704	258,679	832	4%	122,897	n/a
Mullet	301,848	175,563	375	2%	53,309	n/a
Sharks/rays	89,423	86,671	295	1%	39,393	n/a

* Harvest estimates based on the simple expansion are considered under-estimates and have been provided for illustrative purposes only. Appropriate estimates using the detailed expansion for species other than snapper are the subject of later analysis

Table 24: Expansion of snapper harvest and number of fishers by region and statistical division.

Snapper harvest

Region	Melbourne	Western District	Barwon	Gippsland	Total
Port Phillip Bay	227,545	0	16,649	349	244,542
Western Port	141,576	0	1,752	8,834	152,162
Other	37,342	69,273	11,206	97,677	215,498
Total	406,463	69,273	29,607	106,859	612,202
NRIFS*	374,855	20,502	17,297	30,109	442,763

Number of fishers

Region	Melbourne	Western District	Barwon	Gippsland	Total
Port Phillip Bay	28,233	0	3,876	422	32,531
Western Port	15,731	0	219	1,914	17,864
Other	7,886	3,603	2,678	4,315	18,483
Total**	na	na	na	na	55,582
NRIFS[1]	28,374	2,599	4,198	5,856	41,027
NRIFS[2]	20	29	18	19	86

*NRIFS expanded estimate for snapper harvested by licensable, Victorian residents

** regional estimates may not add to totals, due to anglers fishing in more than one region

[1] NRIFS number of licensable, Victorian residents (expanded) that harvested snapper

[2] NRIFS number of licensable, Victorian residents (raw data) that harvested snapper

Table 25 Comparison of precision associated with total harvest estimates for snapper by fishing region.

	NRIFS		NRIFS licensed		2006/07	
Snapper	n	RSE	n	RSE	n	RSE
Coastal West	128	0.24	94	0.25	140	0.24
PPB	100	0.47	80	0.66	375	0.16
Western Port	5	0.76	2		140	0.23
Coastal East	21	0.13	16	0.13	84	0.61
Total	254	0.21	192	0.29	739	0.13

* NRIFS state-wide RSE estimate for snapper was 0.218

Table 26: Proportion of snapper harvested by randomly selected anglers during on-site surveys.

Bay	Avidity	RFL with phone	RFL unlisted	RFL exempt	Total
PPB	avid	130	53	27	210
		18%	*7%*	*4%*	*29%*
	non-avid	26	11	1	38
		4%	*2%*	*0%*	*5%*
WPB	avid	249	84	44	377
		34%	*12%*	*6%*	*52%*
	non-avid	67	4	29	100
		9%	*1%*	*4%*	*14%*
Total		472	152	101	725
		65%	*21%*	*14%*	*100%*

* percentages are for total snapper retained

Table 27: Number of interviews (with or without a harvest, with harvest of any species and with harvest of snapper) and proportion of snapper harvested by randomly selected anglers during on-site surveys.

Count of all interviews

avidity	RFL exempt	RFL unlisted	RFL with phone	Total
avid	117	193	720	1030
	65%	67%	67%	67%
non-avid	64	95	347	506
	35%	33%	33%	33%
Total	181	288	1067	1536
	100%	100%	100%	100%

Count of all interviews with a harvest of any species

avidity	RFL exempt	RFL unlisted	RFL with phone	Total
avid	73	111	432	616
	65%	73%	69%	69%
non-avid	39	42	190	271
	35%	27%	31%	31%
Total	112	153	622	887
	100%	100%	100%	100%

Count of all interviews with a harvest of snapper

avidity	RFL exempt	RFL unlisted	RFL with phone	Total
avid	30	52	186	268
	77%	84%	77%	78%
non-avid	9	10	57	76
	23%	16%	23%	22%
Total	39	62	243	344
	100%	100%	100%	100%

Sum of snapper harvested

avidity	RFL exempt	RFL unlisted	RFL with phone	Total
avid	93	141	482	716
	75%	89%	79%	80%
non-avid	31	17	131	179
	25%	11%	21%	20%
Total	124	158	613	895
	100%	100%	100%	100%

7 Discussion

7.1 Benefits and adoption

The most suitable method for monitoring Victoria's recreational fisheries needs to provide reliable estimates of catch and effort, yet not be too expensive to implement. This survey has developed methods to conduct targeted phone-diary surveys to estimate harvest for key recreational species (namely the western Victorian snapper stock) in a cost-effective manner. The use of the RFL database as a sampling frame provided a substantial cost-saving in this survey. Investments to improve the database as a sampling frame (at least routine collection of contact details, including phone numbers) would facilitate further research for a range of recreational fishing issues.

Subject to future needs and funding availability, various options exist for targeted surveys of this kind (for particular species and spatial scales) as well as ongoing surveys to provide year-to-year comparisons of recreational fisheries. Consideration should be given to a dual-frame sampling approach (White Pages and RFL database) for any repeat of the 2000/01 state-wide survey in Victoria, where substantial cost savings could be achieved in the screening survey component.

For any such research, the present survey has demonstrated the importance of thorough development and 'mining' of various datasets to optimise coverage and data utility. In this regard, further analysis of the current database would provide valuable information for other marine species.

On-site surveys were also shown to have a complementary role to off-site surveys, in validating species identification, mean lengths and length-weight relationships for key recreational species, and in assessment of proportions of 'out-of-scope' groups in the off-site survey.

7.2 Further Development

The choice of sampling frame influences the accuracy of the total catch estimate. For the present survey, licence exemptions and the routine absence of telephone numbers in the RFL database limited the ability to randomly sample all fishers in the population. Suburb/postcode information was available for 1 and 3 year RFL holders and enabled phone numbers to be obtained for most licensees through White Pages/Sensis searches. The absence of any address/contact details for all short-term RFL holders (48 hour and 28 day licences) meant that the activities of these fishers could not be assessed (even broadly in the calibration survey).

The inclusion of exempt anglers in a phone-diary survey would be desirable for those species where a high proportion of catch is attributable to these fishers, such as black bream in the Gippsland Lakes. In such cases, a dual-frame sample could be employed, by firstly sampling fishers from the RFL database and then screening 'out-of-scope' fishers from White Pages telephone listings. Respondents already present on the RFL sampling frame would be excluded from the second frame.

The impact of non-representation could be effectively eliminated by extending the RFL to include all recreational fishers and by providing up-to-date contact details (including phone numbers). Although the various policy implications have not been addressed here, the benefit of such an approach lies in providing cost-effective research.

Routine inclusion of contact details (especially phone numbers) and key profiling information on RFL applications can provide additional benefits. For example, avidity profiling provides efficiency in stratification of screening surveys and reduces survey costs. Similarly, identification of target species or broad fishery participation (such as freshwater, marine or both) assists in providing sampling frames for individual fisheries and is particularly useful for low participation fisheries, such as rock lobster or abalone. Recreational fishing license databases without any exemption categories are routinely used in sample surveys to estimate the total recreational catch for low participation fisheries. For example, surveys of rock lobster and abalone in Tasmania (Lyle 2008); scallops in Tasmania (Tracey and Lyle 2008); rock lobster in South Australia (Currie *et al.* 2006); and rock lobster in Western Australia (Melville-Smith and Anderton 2000).

An ideal sampling frame is, by definition: up-to-date and complete; contains accurate identification and contact details for all entries, has no duplicates; corresponds to the primary sample unit for the study; and is easy to use. An ideal RFL database would include contact details, avidity profiles and target preference (endorsements) for all fishers and is regularly up-dated to enhance sampling and benchmarking for future surveys. These improvements would enable the dynamics of the fishery to be monitored, including routine assessment of participation and effort in recreational fishing. These improvements would also provide identification of individuals that did not hold a RFL at the time of the screening survey, but were new entrants into the fishery during the phone-diary survey. Sampling for calibration surveys could then be confined to these new fishers, resulting in cost savings when compared with the present study, where all licence holders were necessarily included in the calibration survey.

7.3 Planned Outcomes

The primary outcome of this project has been the identification of an angler survey design for obtaining regular harvest estimates for key recreational fisheries in a cost-effective manner. Implementation of this design can provide information for:

1. Assessments that require annual estimates of the recreational fishery as well as the commercial fishery.
   Periodic estimates of recreational catch from this survey and the NRIFS will be used by Fisheries Victoria for: fishery assessment workshops (such as PPB, Western Port and Gippsland Lakes); stock assessment workshops of key species (such as snapper, King George whiting and flathead); and to a lesser extent stock assessment workshops of species with lower total recreational catch (such as Australian salmon, calamary and garfish).

2. Resource allocation decisions.
   Resource allocation issues between the commercial and recreational fishing sectors are of increasing importance for fisheries managers. Victoria is likely to implement a formal resource allocation process that will require estimates of total catch by each fishing sector. The development of a method of providing such data for the recreational sector will allow for more objective resource allocation decisions.

3. Development, implementation and review of fishery management plans.
   Fishery management plans are likely to be more effective and have greater stakeholder acceptance when they are based on current estimates of the relative impact of each sector. Adaptive fishery management plans for Victoria's bay and inlet fisheries are being developed, adding a further important management context to the provision of estimates of total catch by the recreational sector.

Victoria's marine and estuarine recreational fisheries are characterised by the presence of large well-defined and protected waterways in which the majority of fishing activities occur. This makes it feasible and desirable to consider surveys of recreational fishing on this spatial scale. Management decisions are more likely to meet their objectives and more defensible when they are informed by data collected at the spatial scale at which the fishery is administered.

An initial workshop to evaluate alternative survey methods for estimating total recreational catch was held at DPI Queenscliff on 15 February 2005. The workshop provided a forum for presenting preliminary results; discussing assumptions, methods and alternative approaches; inviting feedback on work completed; and determining the future direction of the project. Participants at the workshop were representatives from stakeholder groups, managers and researchers from around Australia with expertise in the design and implementation of angler surveys. Considerations from this workshop were incorporated into the design of the 2006/07 phone-diary survey.

A final project workshop was held at DPI Queenscliff on 26–27 November 2007 to review the phone-diary survey of recreational fishing in coastal Victoria with representatives from stakeholder groups, managers and researchers. Outcomes included recommendations for design features of an off-site survey to estimate total recreational catch using a RFL sampling frame.

Results from this project have been presented to FRDC, Fisheries Victoria, VRFish and at various scientific forums.

7.4 Conclusion

The present survey has demonstrated that accurate estimates of the annual snapper harvest can be cost-effectively obtained for the vast majority of the recreational fishery through an off-site survey of RFL holders. Snapper harvest estimates for smaller spatial scales have also been obtained at acceptable precision levels for fisheries management purposes, principally through over-sampling of avid anglers. Parallel on-site surveys have confirmed that anglers not covered (primarily exempt fishers) accounted for a small minority of the total snapper harvest, where the likely magnitude approximates one standard error of the harvest estimate obtained for the RFL holders concerned.

Subject to further analysis of the database, similar data quality and coverage are likely for other marine species, where RFL holders dominate the total recreational harvest. For species where exempt fishers account for larger harvest proportions (such as black bream), future research might require the use of dual-frame surveys, where White Pages sampling would enable exempt fishers to be quantified and included in the phone-diary phase. Also, although excluded from the present survey, equivalent assessments for freshwater fishing activity could be obtained through similar surveys.

The project has demonstrated the importance of the RFL database as a cost-effective sampling frame and also identified areas for improvement in the database, including: routine collection of contact details for all licence holders (especially telephone numbers); profiling of avidity and target species; and ensuring that the database is as up-to-date as possible. These improvements would further enhance data quality for future surveys and substantially reduce costs, especially through more efficient sampling in the screening and calibration surveys. Extension of the RFL to include exempt fishers has also been identified as a major potential benefit for future research.

The excellent response rates achieved across all components of this survey have been attributed to careful development work, the use of skilled interviewers and high levels of co-operation by anglers, who appreciate the importance of such research to ongoing sustainability of these fisheries. Aside from any contentious fisheries management issues that might arise, similar co-operation levels could be expected from future surveys of this kind.

Development of future surveys using the RFL database should consider coverage and disaggregation requirements for various temporal, spatial and fishery-specific factors. Such surveys range from relatively brief single-contact surveys to assess opinions or awareness of fishers, detailed catch and effort assessments for specific fisheries and state-wide assessments using a dual-frame sample.

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Appendix 1: Intellectual Property

No intellectual property has arisen from the research that is likely to lead to significant commercial benefits, patents or licenses. Intellectual property associated with information produced from the project will be shared equally by the Fisheries Research and Development Corporation and by the Victorian Department of Primary Industries.

This project utilises design-related components, such as specific survey methodologies and interviewing techniques (in particular, the 'memory jogger' diary system) from the National Recreational Fishing Survey. The NRIFS was a joint initiative of Commonwealth and State/Territory Governments with intellectual property attributed in proportion to financial contribution. For the development phase this was: 35.5% to the Natural Heritage Trust, 34.8% to the Fisheries Research and Development Corporation and 30% to the participating States/Territories. The design copyright, certain specific and continuing rights of consultants, Kewagama Research, were recognised prior to the development phase of the NRIFS. This agreement entitles all client bodies to full usage of survey materials in conducting the National Survey (or future repeats), but restricts clients in terms of any "on-selling" or provision of the instrument to a third party, including any "unnecessary" publication of methodological details.

The Victorian data component of the NRIFS was used extensively in this research. The Victorian RFL database was used as a sampling frame for several components of the survey. This survey has produced databases from the screening, phone, wash-up and calibration survey components.

Appendix 2: Staff

Alexander Morison, MAFFRI (Principal Investigator 2003–06)

Karina Ryan, MAFFRI (Principal Investigator (2007–09)

Simon Conron, MAFFRI (Co-investigator 2003–09)

Laurie West, Kewagama Research (Consultant 2006–09)

Natalie Bridge and Pam Oliveiro, MAFFRI (implementation of phone-diary survey)

Robyn Cameron, Pauline Kempton, Eva Kerstens, Robyn McGilvery, Shirley Munro, Robyn Parry, Marie Rampe, Sally West (telephone interviewers 2006–07)

Appendix 3: Publications of original research reviewed

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Appendix 4: Publication from project

Evaluation of precision and cost effectiveness of bus route, creel and phone surveys for estimating recreational catch

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Keywords: recreational fishing, catch rate, Monte Carlo simulation, Port Phillip Bay, Victoria

Abstract

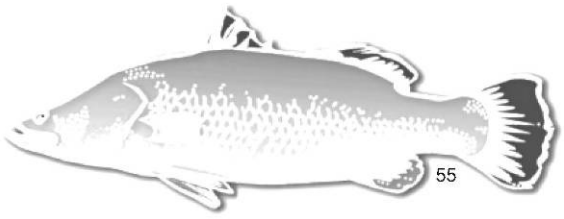
The majority of recreational angling in Victorian bays and inlets occurs in Port Phillip Bay, where 95 % of the harvest is taken by anglers in boats. Three alternative survey methods have been used to estimate the total recreational catch of key species from boat-based angling in Port Phillip Bay: an off-site phone survey and on-site bus route and creel surveys. Ad hoc estimates indicate the total recreational catch of key species in Port Phillip Bay can exceed commercial catches. While logbook monitoring of commercial catches provides a continuous time series of catch data, routine estimates of total catch from the recreational sector have never been obtained. This project aims to evaluate survey methods for monitoring recreational harvest of key species. Monte Carlo simulations were used to estimate catch rates across a range of sample sizes using estimated probabilities and distributions from previous recreational fishing surveys. Estimated catch rates remained constant with increasing sample size for all survey methods; however, the precision increased with more samples. Assessment of the cost effectiveness of each survey method was made using the simulated precision and estimated survey costs. The cost of conducting a phone survey was considerably lower for the number of samples required to achieve reasonable precision, making this a cost effective survey method. The information obtained from the simulations will be used to design a precise and cost effective monitoring program to estimate recreational catch from Port Phillip Bay.

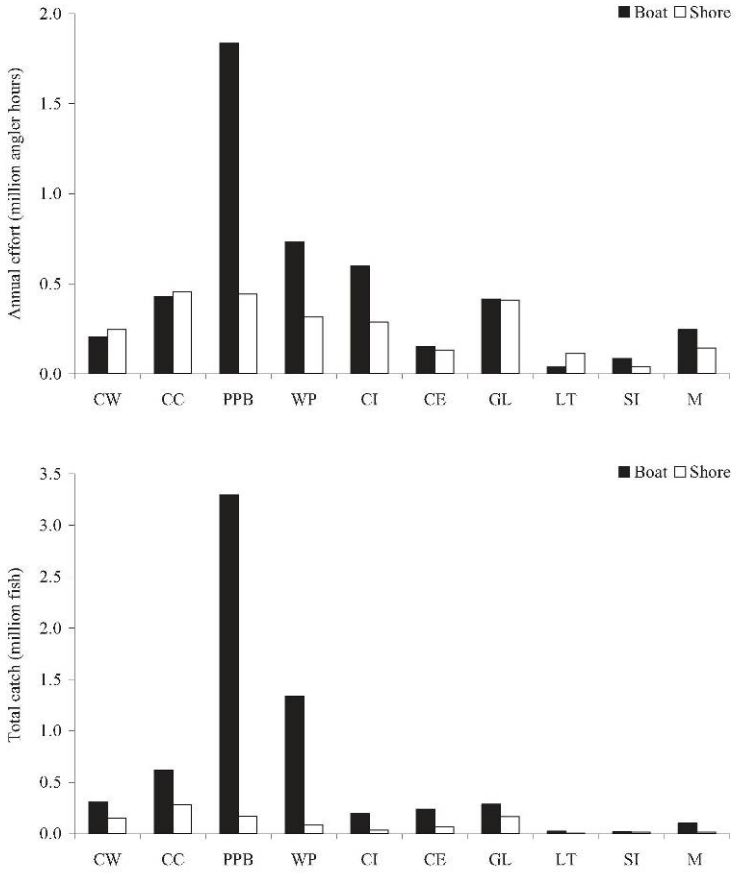
Introduction

Assessment of the impact of commercial and recreational fishing in Victoria's bays and inlets is hindered by the limited catch and effort data and the lack of rigorous stock assessments (Dragun 1991, Li 1999, Kearney 2002). A continuous time series of catch data is generally available for the commercial sector, but routine estimates of total catch from the recreational sector have never been obtained. Ad hoc estimates suggest the total recreational catch can exceed commercial catches for key species, such as snapper (*Pagrus auratus*), King George whiting (KGW) (*Sillaginodes*

punctata) and sand flathead (*Platycephalus bassensis*). For example, the estimated total recreational catch of snapper (211 t), KGW (93 t) and flathead (395 t) in Port Phillip Bay during 2001 (Henry and Lyle 2003) exceeded commercial catches of 53, 85 and 23 t (Anon 2004), respectively. The aim of this project is to find a survey method that could be used every year to estimate the total recreational catch on a small spatial scale. The initial aims of this project were to review previous survey methods used to estimate total annual recreational catches in Victorian bays and inlets and statistically assess the costs and sampling requirements of different survey methods. Comparisons of bus route, creel and phone surveys are made for a range of sample sizes by computer simulations using data from previous surveys, developing a cost model and evaluating the trade-offs between precision and cost.

There have been 25 published recreational fishing surveys for coastal Victoria including studies in Port Phillip Bay, Western Port, Corner Inlet, Gippsland Lakes, Lake Tyers and Mallacoota. These have included off-site surveys, such as door to door, telephone, mail and diary surveys, and on-site surveys, such as bus route, creel and aerial surveys. The majority of fishing effort in Victoria occurs in estuarine habitats (42.8%) compared to offshore (0.8%), coastal (13.5%), rivers (21.7%) and lakes and dams (21.2%) (Henry and Lyle, 2003). Recreational fishing effort is also distributed among water body types according to population distribution and access. Port Phillip Bay and Western Port are within close proximity to Melbourne, the major urban population centre in Victoria (Henry and Lyle, 2003). Recreational fishing in Port Phillip Bay alone accounts for 30% of the state-wide effort and 50% of the state-wide catch (Figure 1). Within Port Phillip Bay, 80% of the effort and 95% of the catch is from boat anglers. Many surveys have been conducted in Port Phillip Bay where the recreational fishery provides an opportunity to compare survey methods using a simulation approach without repeating surveys simultaneously.





Abbreviations: CW – Coastal West, CC- Coastal Central, PPB – Port Phillip Bay, WP - Western Port, CI – Corner inlet, CE – Coastal East, GL – Gippsland Lakes, LT – Lake Tyers, SI – Sydenham Inlet, M – Mallacoota.

Figure 1. Total annual effort and catch for boat and shore anglers in Victorian bay and inlets

Previous estimates of total annual catch in Port Phillip Bay

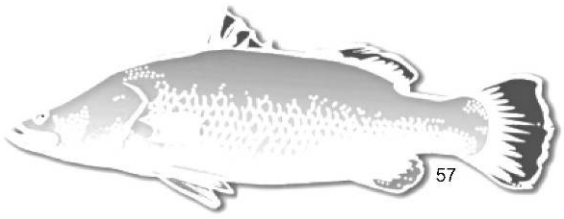
The methods of estimating total catch are different among survey methods (Pollock et al., 1994). For bus route and creel surveys, the total annual catch is estimated by multiplying the daily catch rate with the estimated total annual effort. Effort is determined by the amount of time trailers are observed at each ramp in a bus route survey and the number of boats engaged in fishing and the average number of anglers per boat from an aerial survey. In a phone survey, total annual effort does not need to be calculated. The total catch is estimated by expanding the total catch for each

household with an expansion factor that uses population census data to scale. Catch in numbers is converted to catch in weight with appropriate weight conversion factors.

Three alternative survey methods have been used to estimate the total catch from the boat-based fishery in Port Phillip Bay: creel surveys (supported by aerial surveys) (Beinssen, 1977; MacDonald and Hall, 1987; Coutin et al., 1995), bus route surveys (Conron and Coutin, 1998) and a phone survey (Henry and Lyle, 2003). There was no shore estimate taken in the bus route survey. Effort from boats was extrapolated to an annual estimate and multiplied by the average number of anglers per boat to convert boat hours to angler hours. Data from these five previous surveys (Figure 2) indicates the proportion of effort for boat and shore anglers remained similar. There was a decline in shore effort, which halved from 0.8 million angler hours in 1982 to 0.4 million angler hours in 2000 that has been confirmed by anglers. The estimated boat effort has remained around two million angler hours between 1977 and 2000.

The total catch in Port Phillip Bay is compared from four previous surveys conducted between 1982 and 2000. The proportion of catch from boat and shore anglers remained similar with catches from boat anglers representing about 90% of the total catch (Figure 2). The estimated total annual catch from boat anglers appears to have declined between 1982 and 1995 and increased in 2000, but the larger catch in 2000 might also reflect the complete coverage of the NRIFS or recent recruitment. Total annual catch has averaged 2.5 million fish between 1982 and 2000.

The species catch composition from boat anglers in Port Phillip Bay indicates sand flathead, KGW and snapper have been the three main species from 1982 to 2000 (Figure 2). In the NRIFS, for example, flathead constituted 66% of the catch, KGW 13 % and snapper less than 10%.



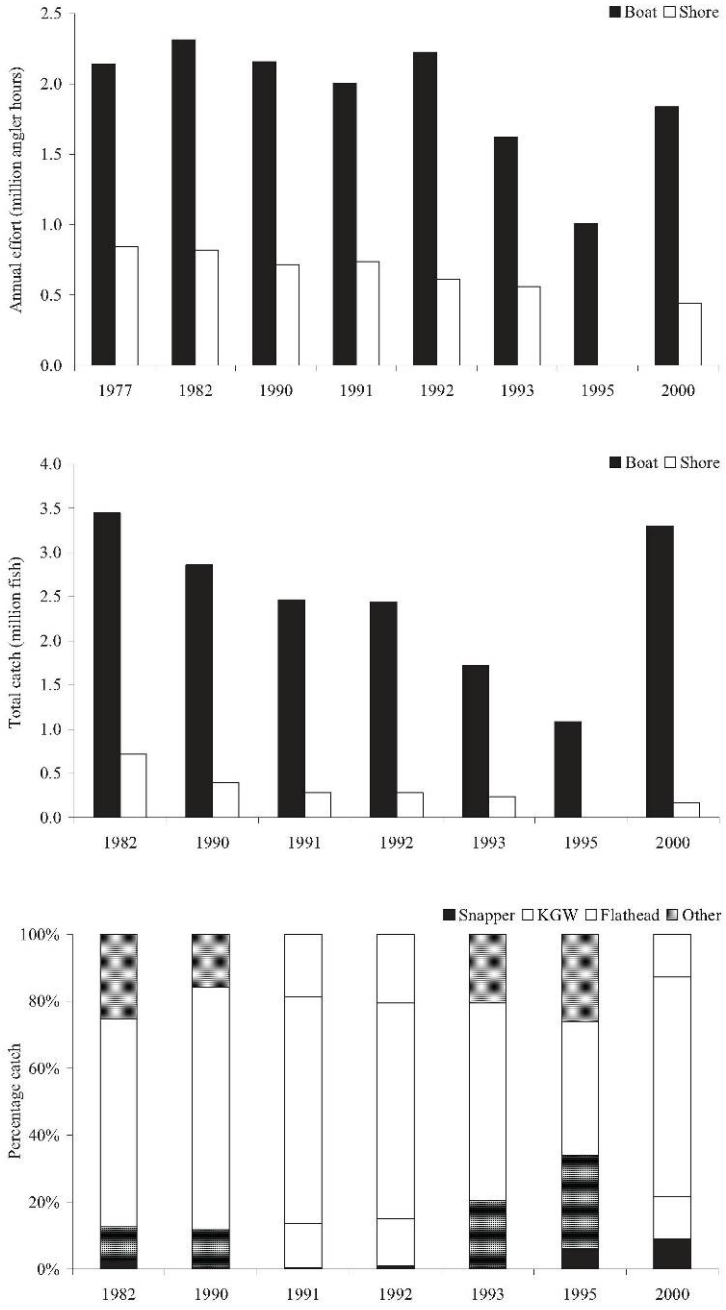


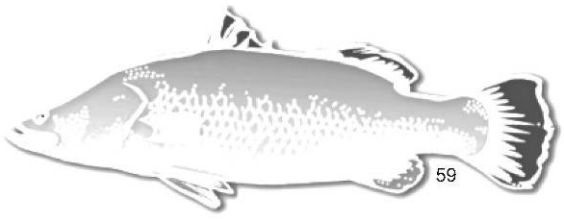
Figure 2. Boat based effort, catch and species composition in Port Phillip Bay

Simulations to compare survey methods

The sample frames and units are different among these three survey methods. The bus route and creel surveys use an area and time sampling frame, while the sampling frame for the NRIFS survey was a list of anglers obtained through a screening survey. The primary sample unit, which can be altered within a sample design, was sample day for the bus route or creel surveys and household for the phone survey. The secondary sample, which is the basis for each angler interview, is the number of fishing parties per sample day in the bus route and creel surveys or the number of recorded events per household in the phone survey.

Monte carol simulations were used to calculate the catch rates from bus route, creel and phone surveys. The simulations used data from three previous recreational fishing surveys of boat angling in Port Phillip Bay. Simulations were repeated for 50 to 650 primary sample units, indicating the number of sample days for bus route and creel surveys or households for a phone survey (with increments of 100). Simulations were repeated for snapper, KGW and flathead, but only the results for snapper are presented here. This approach required an assumption that the sampling frames were the same as the original surveys (ramps and waiting times for the bus route, list of anglers for the NRIFS and ramps for the creel survey). Anglers in the simulations were also assumed to be harvesting the same population, so the probability of a catch and distribution of non-zero catches were considered the same for all survey methods.

The first step in the simulations was to generate a secondary sample for each primary sample. This required allocating the number of fishing parties per sample day in a bus route or creel survey or the number of recorded events per household in the phone survey. The distributions that formed the basis for allocating the secondary samples were established from previous surveys (Figure 3). The number of secondary samples was generally small; 50% of sample days in the bus route and creel surveys had less than eight fishing parties. But 85% of households in the NRIFS had less than eight recorded events per household. In fact, 45% recorded only one fishing trip.



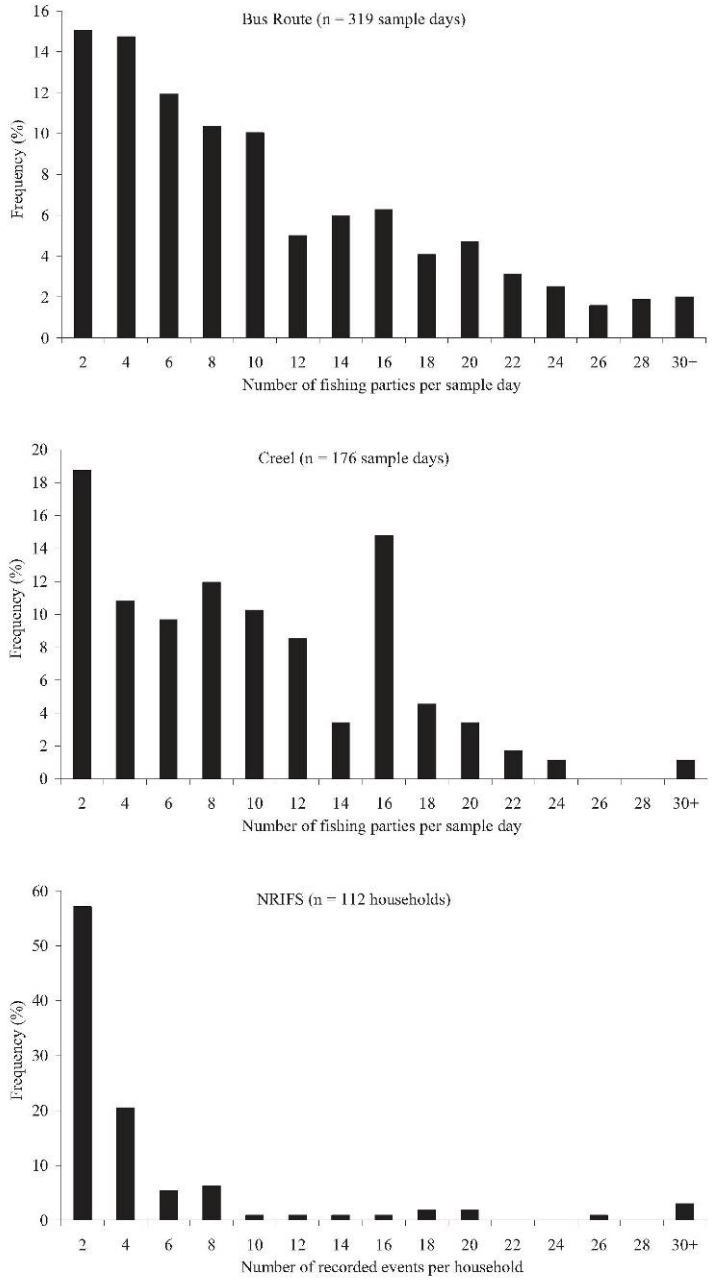


Figure 3. Distribution of secondary sample units for bus route, creel and phone surveys in Port Phillip Bay

The next step was to generate a catch for each interview. This involved firstly determining the likelihood of a catch according to the binary response of zero and non-zero catches (O'Neill and Faddy 2003) for eight species in Port Phillip Bay from the three different survey methods (Figure 4). There were differences between surveys, perhaps due to the survey methods or the different years that they were conducted, but similar trends in catch probability were observed among survey methods. For example, the probability of catching flathead was highest for all surveys, followed by KGW and snapper.

These pooled data from all surveys indicated that anglers in Port Phillip Bay were most likely to catch flathead (with a 51.49% chance). There was 21.69% chance of catching KGW and 13.02% chance of catching snapper. In the simulations, a random number between 0 and 1 was generated and if this was greater than the probability of a non-zero catch then zero catch was recorded, but if the random number was less than the probability of a non-zero catch, then a catch was generated.

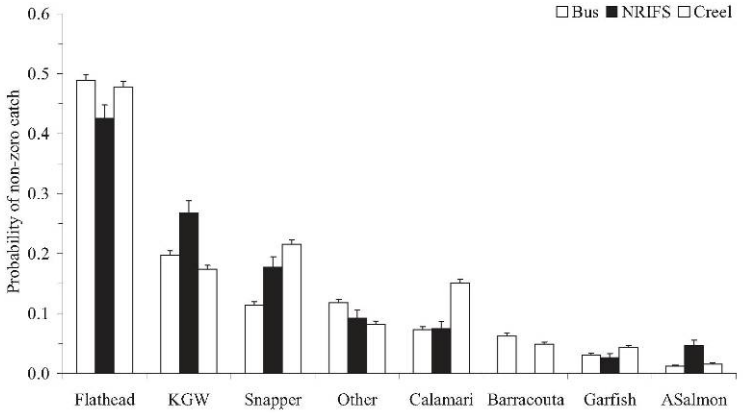
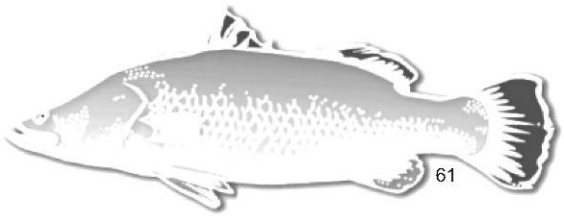


Figure 4. Probability of catching a fish in Port Phillip Bay

The distributions of (non-zero) catches were standardised to catch per angler for each interview; in most cases the average number of anglers was two. The range in catch reflects the maximum bag limit, which was 10 for snapper, 20 for KGW and 30 for flathead. Snapper were mostly caught in small numbers (61% of anglers caught only a single snapper), but 62% of anglers caught up to four KGW and 60% caught up to three flathead (Figure 5).



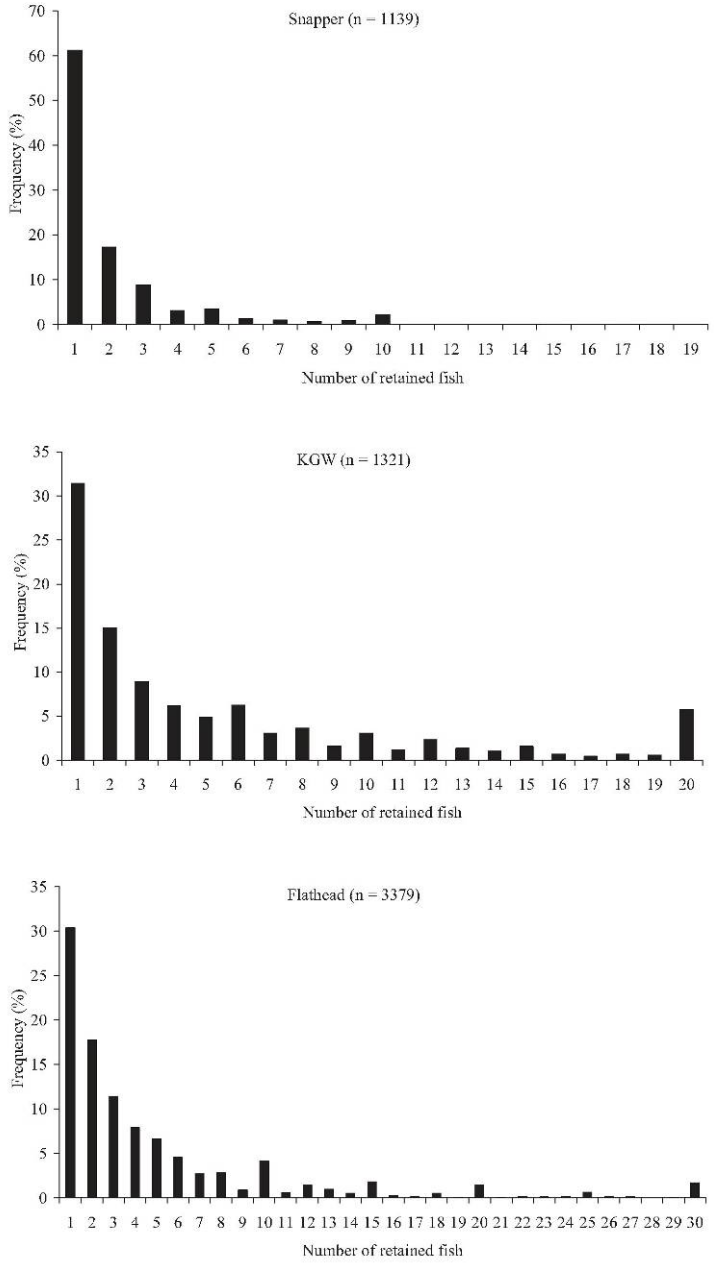


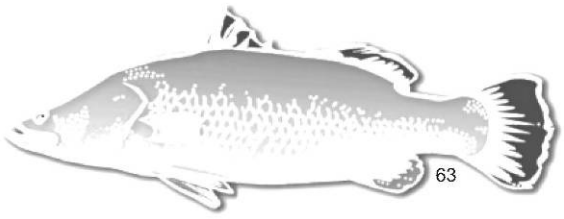
Figure 5. Distribution of non-zero catch of snapper, KGW and flathead in Port Phillip Bay

The simulated catches were repeated for 1000 iterations at each primary sample unit with catch rates estimated for each iteration. The mean catch rates were then estimated for each primary sample unit according to mean of ratios estimator (Jones et al., 1995; Pollock et al., 1997), where the sum of the catch rates for each angler was divided by the total number of anglers. This estimator accounts for the bias associated with roving creel surveys that target anglers whilst fishing where the probability of being sampled is proportional to their trip length (Pollock et al., 1997; Malvesestuto et al., 1978). The mean of ratios estimator can also be appropriate when equal weighting is given to each angler (Malvestuto, 1996) bus route and phone surveys that target anglers after completing their fishing activity with equal probability.

Results

The mean catch rate provides a comparison of the accuracy for a range of primary sample units (Figure 6). The mean catch rates remained constant with increasing sample size indicating the accuracy of the estimated catch rates did not change. But the range in maximum and minimum mean catches is larger for smaller samples indicating lower sample sizes are less likely to accurately estimate catch. These ranges are also different between survey methods, but it should be noted that the primary sample unit is not comparable between survey methods; one sample day is not the same as one household. What this does suggest is that the accuracy of the bus route and creel surveys increases rapidly between 50 and 150 sample days and accuracy of the phone survey improves more gradually between 150 and 250 households.

The standard error of the mean catch provides a comparison of the precision for different primary sample units (Figure 6). The standard error of the mean catch decreased as the number of samples increased. Higher samples had lower standard error and higher precision. The ranges between the lowest and highest standard error of the mean catch also decreased with increasing sample size. This is related to the nature of the survey method where eight or fewer recorded events were observed in 85 % of households in the phone survey, but eight or fewer fishing parties were observed in 50 % of sample days in the bus route and creel surveys.



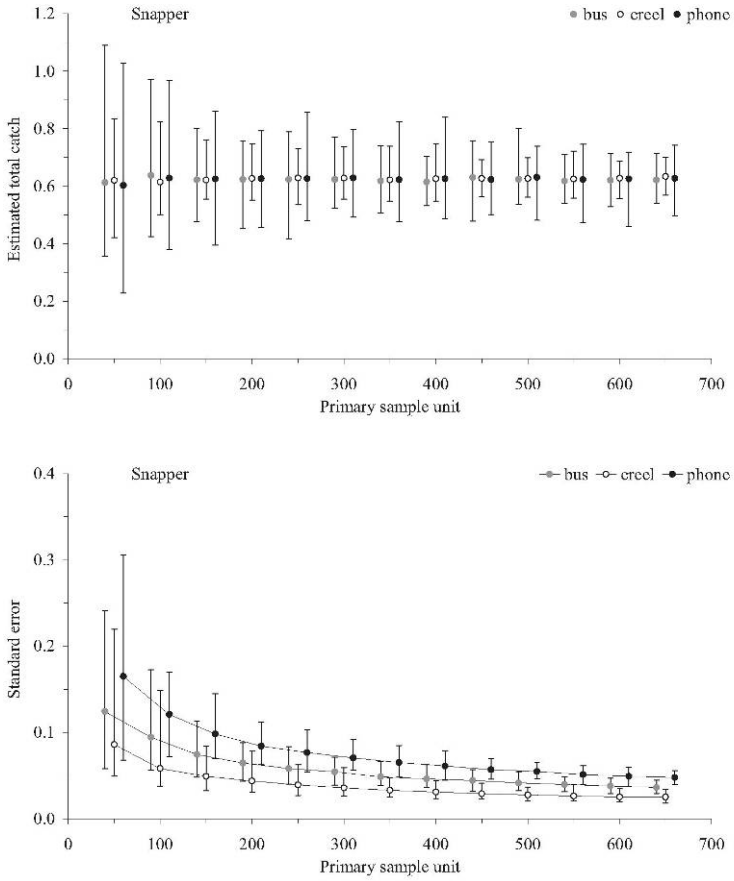


Figure 6. Predicted mean catch rate and standard error of snapper from bus route, creel and phone surveys in Port Phillip Bay

A cost model for the different survey methods, based on expenditure from previous recreational fishing surveys, was developed that was linear (costs increased with sample size), continuous and deterministic (there were no stochastic properties) (Figure 7). Costs were calculated as a combination of fixed and variable costs. The fixed costs for a phone survey ($130 000) were much higher than for bus route and creel surveys (both $50 000), reflecting the work required to establish a good sampling frame for a phone survey; however, the phone survey had much lower variable costs for collecting samples. These were estimated to be about $100 per household, compared to $700 for a sample day in the bus route and $900 for a sample day in the creel survey.

The standard error and cost for the three survey methods were compared to assess the sampling errors relative to the costs of collecting and processing the data (Figure 7). The initial high curve for a phone survey reflects the high fixed costs and low precision of small sample sizes, but the lower variable costs of a phone survey allow the precision and cost to become comparable with bus route and creel surveys. For example, at $190 000, there is a similar precision between 380 households for a phone survey or 190 sample days from a bus route survey. At $240 000, there is a similar precision between 750 households for a phone survey and 190 sample days from a creel survey. The cost effectiveness reaches a point at about $300 000 where the cost of taking additional samples produces minimal further decreases in standard error and has limited potential to increase precision for all survey methods.

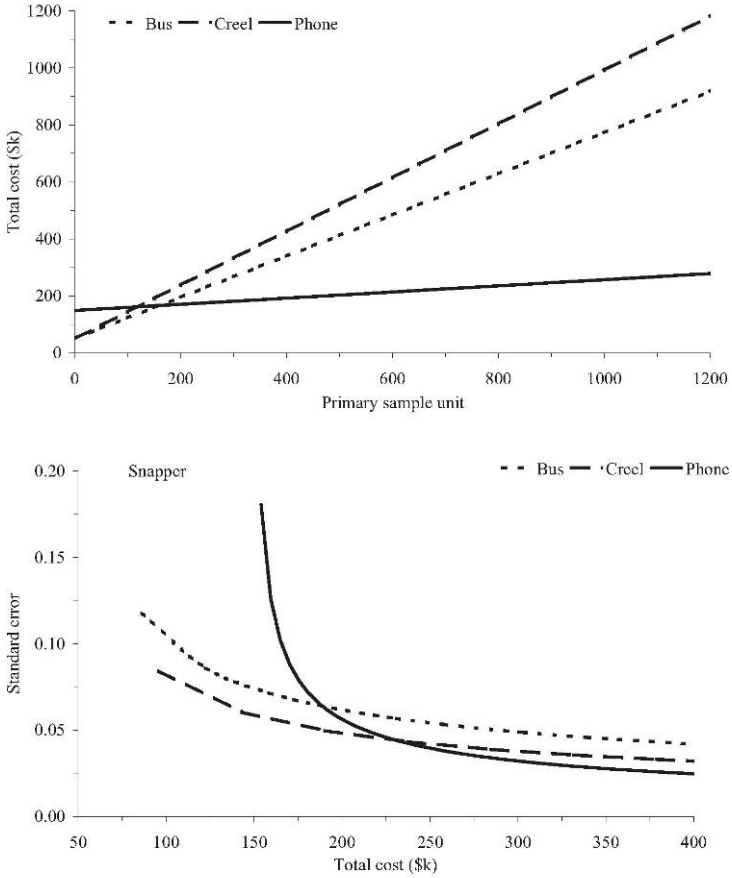
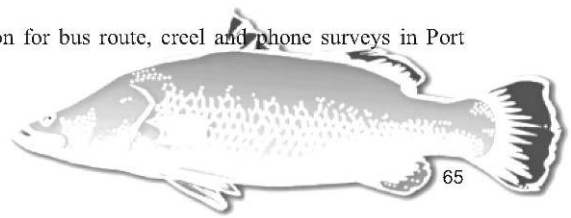


Figure 7. Comparison of total cost and precision for bus route, creel and phone surveys in Port Phillip Bay



Conclusions

The simulations create an estimate of catch rates, but further refinements are required to incorporate sampling errors associated with estimating annual effort. These are possibly higher for an aerial survey compared with the expansion procedure of the phone survey. The creel survey provided lower standard errors for the estimates of catch rate than the Bus Route survey at all levels of expenditure. The phone survey produced the most rapid decreases in standard error with increasing expenditure (but from a higher starting level) and produced the lowest standard errors at higher expenditure levels.

The recreational fishery in Port Phillip Bay is suitable for assessing the use of bus route, creel and phone surveys to estimate recreational catch within a small spatial scale. Ultimately the preferred survey method for estimating the recreational catch may depend on the ability and costs to reduce bias, objectives of the survey and available funds. If the survey objectives are purely to estimate catch by numbers, then a phone survey is most likely to provide this information at the lowest cost, particularly if the costs incurred with establishing a sampling frame can be reduced, for example, by using a database of fishing participants. Survey errors and survey costs are reflections of each other (increasing expenditure reduces uncertainty for all survey methods) and in planning a survey, effort should be directed toward both reducing the errors and producing the greatest usefulness with the funds available.

Acknowledgments

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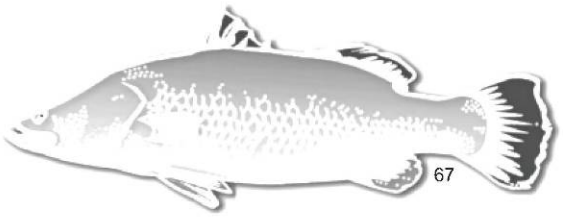

Appendix 5: Survey Instruments

Survey Instrument	Explanation Description & Function
Flow chart (pilot survey)	Sequence of events for pilot survey
Questionnaire (pilot survey)	Questionnaire administered to all selected RFL holders in the sample that asks a range of questions relating to previous and intending fishing activity
Workload Control Sheet (pilot survey)	Used by interviewers to monitor progress and performance during the pilot survey, and is updated by interviewers and returned to the survey office
Interviewer Timesheet (pilot survey)	Used to calculate he 'through-put' rates for the next part of the survey
Interviewer Feedback Sheet (pilot survey)	Used to assist with survey debriefing and evaluating the questionnaire, which will be invaluable for the next part of the survey. To be completed at the end of the survey.
Flow chart (screening survey)	Sequence of events for screening survey
Questionnaire (screening survey)	Questionnaire administered to all selected RFL holders in the sample that asks a range of questions relating to previous and intending fishing activity
Workload Control Sheet (screening survey)	Sample of RFL holders for each interviewer, which forms the basis of contact between interviewer and survey office, to quantify the progress of the interviewer and response rates achieved
Field Query Sheet (screening survey)	Pink sheets for writing notes for the attention of the survey office
Covering Letter (phone-diary survey)	Establishes communication link with respondent, interviewer and survey office, explaining the survey objectives and scientific credentials of the staff; acknowledges appreciation and assures confidentiality
Fishing Diary (phone-diary survey)	Personal diary for respondents to serve as a "memory jogger" during the survey period, to provide an opportunity to record recreational fishing details, thus minimising recall bias by respondents, includes some examples
Species Identification Booklet (phone-diary survey)	Contains images of the most commonly encountered fish in coastal Victoria based on local knowledge and past surveys to minimise errors associated with inaccurate reporting of catch data by respondents and interviewers
Explanation Interview (phone-diary survey)	Details the interview to be conducted before phone-diary period commences, but after respondent receives the survey kit, to discuss survey kit (and examples in diary), provide further information and make arrangements for the first call.
Workload Control Sheet (phone-diary survey)	Used by interviewers to monitor progress and performance during the phone-diary survey, and is updated by interviewers and returned to the survey office each month. May be an electronic or paper sheet.
Cover Sheet (phone-diary survey)	Used by interviewers during the phone-diary survey interviews to record respondent information, contact details and appointments, and to detail the definitions, questions and sequencing for collecting recreational fishing data
Event Sheet (phone-diary survey)	Basis for recording respondents' recreational fishing data for the phone-diary survey on a fishing event basis, including data on fishing effort, catch, catch rate, species composition and other fishing related data.
Regional Maps (phone-diary survey)	Maps identifying regions to locate the exact fishing position of respondents and for interviewers to assign region codes accordingly
Questionnaire (wash-up survey of diarists)	Final interview of the phone-diary survey with additional questions on relevant management issues.
Questionnaire (calibration survey)	Questionnaire administered to all selected RFL holders in the sample
Workload Control Sheet (calibration survey)	Used by interviewers to monitor progress and performance during the calibration survey, and is updated by interviewers and returned to the survey office each week. May be an electronic or paper sheet.
Questionnaire (on-site survey)	On-site representative creel surveys for verifying data collected by the phone-diary survey, including data on license eligibility, home postcode, species identification and size composition of the recreational catch