AQUATIC SCIENCES


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QUANTIFICATION OF RESOURCE ALLOCATION IN THE SOUTH AUSTRALIAN MARINE SCALEFISH FISHERY

## PHASE 1: METHOD EVALUATION

FINAL REPORT

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## EXECUTIVE SUMMARY

"Quantification of resource allocation in the South Australian marine scalefish fishery" is a three year study aimed at providing quantitative data for the resolution of resource conflicts within this fishery.

The study aims to provide this information by 1 ) evaluating the bus-route survey method as a cost-effective means of obtaining recreational fishing data over large-scale coastal areas, 2) implementing the method throughout South Australian inshore waters and 3) using the information obtained to make comparisons with commercial fishery statistics to establish current resource allocation.

The first year of the project (to which this report is addressed) dealt with item 1) above, and was comprised of three phases -

1) Baseline data collection

Census data on fishing effort were collected at 4 metropolitan and 4 country boat ramps in two seasons, providing actual fishing effort over 24 hour periods for 40 days. This information was used as a benchmark for the accuracy of estimates subsequently generated by computer

The results of the computer simulations and pilot surveys have confirmed that the bus-route method is a cost-effective means of obtaining fishing catch and effort estimates for marine recreational fisheries over large geographical areas. This has two important implications for Australian fisheries management. Firstly, it will allow resource allocation issues to be resolved over the entire distribution of many inshore species. Secondly, it will facilitate the design of cost-effective, ongoing monitoring programmes.

These factors will alleviate the major deficiency of current recreational fisheries data - the lack of temporally repeated, large-scale studies.

## INTRODUCTION

"Quantification of resource allocation in the South Australian marine scalefish fishery" is a three year study aimed at providing quantitative data for the resolution of resource conflicts within this fishery. Phase 1 of the study has been partly funded by a Fisheries Research and Development Corporation (FRDC) grant in 1992/93, with further funding being provided by the South Australian Research and Development Institute (Aquatic Sciences).

This document represents the final report for Phase 1 of the study, as requested by $F R D C$ and the $S A$ Fisheries Research and Development Board. It provides an overview of the work completed between July 1992 and October 1993, and a discussion of the results in relation to further studies in this field.

## Project background and justification

The project was conceived as a means to address two interlinked issues of marine scalefish research. Firstly, there has been no cost-effective method for conducting recreational fishing research on fisheries which cover large geographical areas. Secondly, inadequate data are available for resolving conflicts between the commercial and recreational sectors of the $S A$ marine scalefish fishery.

To a large degree, the second situation has arisen as a result of the first. Without cost-effective methods of gathering recreational fishing data, few agencies have the resources to undertake regular, large scale surveys. This fact is confirmed by a current literature review of Australian marine recreational fishing studies (McGlennon, in prep) which shows that most studies have been conducted in relatively small, sheltered areas. Most of these have been undertaken only once, meaning that no trends in effort and catches are available.

Traditional survey methods present difficulties when used over large waterbodies. Access site surveys, where interviewers attend access sites on survey days, necessarily require more personnel as the area (and therefore number of sites) increases. Roving creel surveys, where interviews are conducted from a vessel, face difficulties when the waterbody is large, is exposed to regular adverse weather conditions or when fishing activity is widely dispersed, as is the case in many Australian marine coastal areas. The South Australian gulfs often exhibit all three conditions.

A pressing need existed, therefore, to develop a cost-effective method for undertaking large-scale surveys. Phase 1 of this project has been devoted to evaluating and trialing a method deemed appropriate for meeting this objective.

A secondary objective of the project was to evaluate the effectiveness of surveys to validate commercial catch and
effort statistics. While commercial catch and effort data have been collected for many years, its accuracy has been disputed by the commercial industry during recent negotiations on proposed quota allocations. Information gathered via interviews undertaken during field surveys, provides potential for validation of these statistics.

## Overview of the method

The survey method to be evaluated in this project has been described as a "bus-route" survey, and will be referred to as such in this report. The theoretical basis of the method was developed by Robson and Jones (1989), and was claimed to be suitable for any large fishery. It combines elements of both an access site survey and a roving survey, in that survey agents travel through the survey area, stopping along the route to conduct interviews with returning anglers at access sites. The method is designed to provide an unbiased estimate of fishing effort, in addition to the information obtained from the interviews.

A brief description of the method follows.

The person conducting the survey (referred to as the survey agent) travels along a pre-defined route around the fishery, arrives at each access site on precise schedule, waits at the site for a pre-determined period and then departs to the next site along the route (see Figure 1 for an example in the current

Fig 1: Bus-route and schedule for survey Block 1

study). While at the boat ramp, the agent records the amount of time that each boat trailer is at the ramp, including those that launch or retrieve during the waiting period, and interviews returning anglers to determine catch and other variables of interest.

The travel route is designed to be circular. In the case of a fishery spread along a single shore, the route can be made circular by alternating sites (Fig 1). This reduces the potential that a long travel time from one end of the circuit to the other will occur during a peak retrieval time.

Daily fishing effort is then calculated from a simple equation involving the duration of encounters between agent and trailers $(X)$, waiting time at the ramp (w) and circuit travel time (T). The equation varies with the sampling regime employed, and is given in the sections referring to the pilot surveys.

From each daily effort estimate, a mean daily estimate can be calculated, and extrapolated to calculate total fishing effort for the survey period.

This report sets out the methods used to evaluate the bus-route survey method, the results obtained and the conclusions drawn from our investigation.

## METHODS

## Introduction

The objective of this evaluation was to rigorously test the method within the environment of an Australian marine recreational fishery. The theoretical development has previously been evaluated on the fishing activity of selected North American river tributaries (Jones et al. 1990). However, the angling population was itself simulated (albeit based on real data), and it was considered appropriate to further test the method for the conditions inherent in many Australian marine fisheries.

The performance of the bus-route method for estimating fishing effort was evaluated for the statistical properties of accuracy, precision and bias, as well as for its logistics. All statistical properties were tested under a variety of sampling regimes.

In order to test statistical validity, a set of census data of actual fishing effort was collected and subjected to repeated computer simulations of bus-route sampling. By this means, the value of the sampling estimate was directly compared with the true, known value of fishing effort under a variety of sampling regimes. Additionally, the influence of a number of factors (such as number of days sampled, length of the sampling period
and the waiting times at ramps) on the accuracy of the estimate was determined.

The results of these simulations were then used to design and undertake two pilot surveys in the field. These surveys evaluated the logistics of bus-route sampling, and allowed assessment of the influence of factors such as daytype and time of day on effort.

Phase one of the project was therefore undertaken in three stages; 1) census data collection, 2) computer simulations and 3) pilot surveys. The methods and results of each stage will be discussed separately, with final conclusions being drawn at the end of the report.

## 1. CENSUS DATA COLLECTION

## a. Methods

To obtain actual fishing effort, census data were collected from two different regions during two different seasons, to cover a range of weather conditions and levels of fishing activity. Four boat ramps were selected in the Adelaide metropolitan area and four in a regional country area at the top of Gulf st Vincent. Staff were stationed at boat ramps in shifts for 24 hours a day for 5 days at a time. This was done twice for each region in November and twice for each region in January giving a 20-day data set per area. Whilst at ramps, staff recorded

Fig. 2: Distribution of fishing effort over 24 hours


## b. Results

Although the census data were to be used primarily for subsequent computer simulations, they also provided information on such factors as the distribution of fishing effort during the day and the proportion of effort at individual ramps. This allowed decisions to be made on factors such as fishing day length, shift times and waiting times, which are important input parameters to the computer simulation trials.

An examination of hourly distribution of fishing effort revealed that for both regions, in both seasons, less than $5 \%$ of fishing effort occurs between midnight and 4 am (Fig 2). Thus it was deemed that 20 hours per day was the maximum amount of time that needed to be spent in the field. In fact $80-90 \%$ of effort is concentrated between the hours of 0600 to 1800 (Fig 2). It was therefore decided to experiment with fishing day lengths of between 12 and 20 hours.

## 2. COMPUTER SIMULATIONS

The simulations were run by the Australian Bureau of Statistics on their mainframe computer using the SAS software system.

Preliminary analyses were undertaken treating each season separately for each area, and further stratifying according to day type (e.g holiday and non-holiday periods, weekend and week days). However, it became apparent that insufficient data were
available for this degree of stratification. To increase the amount of information available for simulations, the seasonal data were pooled for each region, providing a 20-day data set for each region. Pooling the data was justified by statistical tests (Student's "t") performed on the census data, which showed little or no significant difference in daily effort between these strata (e.g. weekend $v$ weekday; holiday $v$ non-holiday).

Pooling had the additional advantage of providing data which covered the full range of variability in effort, from days of no effort at all to extremely high fishing effort during the Australia day long weekend. Thus, simulations would be dealing with a "worst case scenario" (ie. highest data variability likely), and subsequent stratification in field surveys would lead to an improvement in the estimates.

A total of 12,000 simulations were run to examine the effects of varying the following parameters:

1) fishing day length (between 12 and 20 hours),
2) the number of shifts per day ( 2 v 3 )

- given the range of daylengths above, two options become available: either two long shifts divided at the mid-point of the day, or three shorter shifts. For example, a fishing day length of 18 hours can be divided into 2 shifts of 9 hours or three shifts of 6 hours.

3) the length of the survey agent's shift (which is a function of 1) \& 2)),

The range of options 1), 2) and 3) tested is shown in Table la.

Table la. Sampling regimes used in computer simulations; fishing daylength $=$ the number of hours per day that are available for sampling, shift length $=$ number of hours worked each sampling day.
i) Two shifts per day

| Fishing daylength | 13 | 16 | 19 |
| :--- | :---: | :---: | :---: |
| Shift length | 6.5 | 8 | 9.5 |
| Shift times | $0530-1200$ | $0400-1200$ | $0230-1200$ |
|  | $1200-1800$ | $1200-2000$ | $1200-2130$ |

ii) Three shifts per day

| Fishing daylength | 16.5 | 18 | 19.5 |
| :--- | :---: | :---: | :---: |
| Shift length | 5.5 | 6 | 6.5 |
| Shift times | $0400-0930$ | $0400-1000$ | $0400-1030$ |
|  | $0930-1500$ | $1000-1600$ | $1030-1700$ |
|  | $1500-2030$ | $1600-2200$ | $1700-2330$ |

- as the length of a shift and the amount of time taken to travel between ramps is fixed, the remaining time can be allocated to waiting times at ramps. This can be done in two ways, either by assigning an equal amount of the remaining time to each ramp (FIXED $W$ ) or by apportioning waiting times differentially according to the amount of activity (effort) at each ramp (DIFFERENTIAL W). Differential waiting times were calculated from the census data, proportional to the mean fishing effort per ramp with the proviso of setting a minimum waiting time of 15 minutes at any ramp (Table 1b).

Table 1b. Ramp waiting times under different sampling regimes.

| $2-\operatorname{SHIFT}$ |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| FD = 13h | ARDROSSAN | WAKEFIELD | PRICE | ROGUES PT |  |  |  |
| FIXED | 55 min | 55 min | 55 min | 55 min |  |  |  |
| DIFFERENTL | 80 min | 35 min | 90 min | 20 min |  |  |  |
| FD $=16 \mathrm{~h}$ |  |  |  |  |  |  |  |
| FIXED | 80 min | 80 min | 80 min | 80 min |  |  |  |
| DIFFERENTL | 110 min | 45 min | 125 min | 30 min |  |  |  |
| FD $=19 \mathrm{~h}$ |  |  |  |  |  |  |  |
| FIXED | 100 min | 100 min | 100 min | 100 min |  |  |  |
| DIFFERENTL | 140 min | 60 min | 160 min | 40 min |  |  |  |

Table 1b. (cont.)

| $3-$ SHIFT |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| FD $=16.5 \mathrm{~h}$ | ARDROSSAN | WAKEFIELD | PRICE | ROGUES PT |
| FIXED | 40 min | 40 min | 40 min | 40 min |
| DIFFERENTL | 60 min | 25 min | 65 min | 15 min |
| FD $=18 \mathrm{~h}$ |  |  |  |  |
| FIXED | 50 min | 50 min | 50 min | 50 min |
| DIFFERENTL | 70 min | 30 min | 80 min | 20 min |
| FD $=19.5 \mathrm{~h}$ |  |  |  |  |
| FIXED | 55 min | 55 min | 55 min | 55 min |
| DIFFERENTL | 80 min | 35 min | 90 min | 20 min |

## 5) the number of sampling days (sampling frequency)

- when the seasonal data were pooled (giving a 20-day set for each region), the selections of number of days sampled were $5,7,10,15$ and 20 .

The following steps were followed for each series of iterations. The number of days to be sampled was chosen and the dates randomly selected from the 20 days available. 20 iterations were then run for each day, varying the shift selection 4 times and the random start location 5 times.

For each day selected, estimated daily fishing effort from the first iteration was averaged over the number of days sampled to
give a mean daily estimate. This was repeated for each of the 20 iterations. These 20 mean daily estimates were compared to the actual mean daily effort (as calculated from the census data) using mean absolute percentage error (MAPE) i.e. the percentage difference between the estimate and the actual.


Thus, the lower the MAPE, the more accurate the estimate \& vice versa. It should be noted that the actual value used in these MAPEs is that for the 24 hour period, not for the sampling period covered by each individual sampling design. The real MAPE (for that sampling period) will therefore be lower.

## Results

## a. Accuracy

The results of the computer simulations (i.e. the MAPEs under the various combinations of parameters (sampling regimes)) are shown in Figures 3-5.

Fig. 3: Effect of fishing day length on MAPEs
(a) COUNTRY

> 2-shifts; fixed W



Number of sampling days

Fig. 3: (contd)
(b) METROPOLITAN

2-shifts; fixed W


3-shifts; differential W


Number of sampling days

From these Figures, various trends become apparent:
a) In all instances, MAPEs decreased with increasing number of sampling days (Figs. 3-5). This trend was to be expected from general sampling theory, but quantification allows determination of a sampling frequency which yields a known level of error.
b) In the majority of scenarios, lower MAPEs were achieved with shorter fishing day lengths (13h for 2 -shifts and 16.5 h for 3 shifts) (Fig. 3). This reflects a sampling period which better matches the distribution of fishing effort during the day. The poorer estimates for longer daylengths no doubt result from oversampling the low effort extremities of the day (the tails of the distribution in Fig. 2), which are not representative of the bulk of the fishing day. Therefore it is better to confine sampling to the hours between 0600 and 1800.
c) In most cases, there was little difference between a 2 -shift or 3 -shift scenario for fishing days of equal length (Fig. 4). However, where there was a difference, MAPEs were consistently lower under a 2 -shift regime. As this results in shifts of longer duration, which in turn leads to longer waiting times at ramps and therefore an increased probability of interviews, as well as making better use of an agent's working day, 2 shifts per day was the preferred option.

Fig 4: Comparison of MAPEs for 2 vs 3 shifts per day for a fishing day length of $\mathbf{1 6 / 1 6 . 5}$ hours


Fig 5: Comparison of fixed vs differential waiting times for two fishing day lengths

d) There was also no consistent or marked difference between fixed and differential waiting times overall (Fig. 5). However under a 2 -shift, 13 h fishing day regime, fixed waiting times were better in both the country and metropolitan areas (Fig. 5).

Thus, following on from points b) and c), a regime consisting of a 13 hour fishing day split into two shifts of 6.5 h each was trialed. Further, given d) above, waiting times were apportioned equally between ramps (FIXED W). The MAPEs for this regime (FD $=13 \mathrm{~h}, 2$-shifts, FIXED $W$ ) for the two areas are shown in Figs 3a, b. From this it can be seen that a level of error in the region of $10-15 \%$ is achieved for both regions at a sampling frequency of 7 days or greater. This level of error was considered acceptable, particularly as it was calculated against effort for the 24 hour fishing period, rather than the effort for the shorter sampling period.

## b. Precision

The precision of an estimate, as measured by its standard error (SE), is used to determine its reliability, and is a component of the calculations undertaken to determine the confidence intervals of the estimate. The range of these confidence limits can be narrowed by reducing the standard error of the estimate, which can be achieved by increasing sampling frequency and/or stratification of the survey period.

A measure of the effect of increased sampling frequency was undertaken by calculating the coefficient of variation (CV) for a series of iterations. The CV was calculated by

$$
\mathrm{CV}=(\mathrm{SE} / \text { mean }) * 100 \% .
$$

For example, where 7 sampling days were chosen for simulations, a single estimate from each day was randomly chosen and the daily mean (ie mean of the 7 estimates), SEM and CV calculated. This was repeated 5 times and the mean CV calculated for each sampling frequency (Table 2).

It can be seen that increasing the sampling frequency from 7 to 15 days in the metropolitan area halves the mean $C V$, but a further increase to 20 days yields no further improvement. The country data were considerably less variable and the same number of sampling days yielded a smaller mean $C V$ than the comparable metropolitan figure. Again, an improved value was obtained by increasing sampling frequency.

The combined data (November and January) were highly variable, and would be expected to produce high CV values. Stratification of the data into more homogeneous seasons would improve these values. This can be seen by comparing the values in Table 2 for metropolitan combined seasons and January only. For the same number of sampling days, the mean $C V$ was approximately half for January data only.

This analysis allows assessment of the effect of both sampling frequency and stratification, and will greatly enhance the full survey design.

Table 2. The effect of increased sampling frequency on the reliability of mean daily effort estimates. Values are mean coefficient of variations of 5 estimates produced from each sampling frequency.

| Sampling <br> frequency | Metropolitan <br> (combined) | Metropolitan <br> (Jan. only) | Country <br> (combined) |
| :---: | :---: | :---: | :---: |
| 7 | 48.4 | 22.0 | 24.2 |
| 10 | 33.7 | 18.0 | 24.3 |
| 15 | 24.9 | - | 17.8 |
| 20 | 24.8 | - | 16.2 |

The estimates were tested for bias by plotting the frequency distribution of their residuals, which were calculated as the difference between the individual estimates and the actual effort value for the sampling period (ie. effort for the 24 hour period was reduced by the amount that was attributed to boats fishing entirely outside of the sampling period). The distribution for an unbiased estimator is evenly divided around zero difference ie. equal numbers above and below the actual value (= 0 difference).

One hundred estimates were used in the calculations. As an example, the results for November 24 th in the metropolitan region are shown in Fig. 6. The residuals are normally distributed around 0 , with approximately $50 \%$ above and $50 \%$ below.

## 3. PILOT SURVEYS

## a. Introduction

Following the conclusions drawn from the computer simulations, the bus route survey method was evaluated in the field by conducting two pilot surveys. The first was conducted in JuneJuly, 1993 and, after assessment of the results, was followed by a second in September-October, 1993.

Fig 6: Frequency distribution of residuals for 24/11/92, metropolitan region


The pilot surveys were designed to
a. field test the method for i) logistical difficulties (e.g. travel and interview times) and ii) questionnaire design and interviewee response.
b. elicit information which would facilitate optimal sampling design in the full survey. This information consisted of several factors.
i. difference in fishing effort estimates from morning and afternoon surveys
ii. difference in fishing effort between weekday and weekend days
iii. difference in fishing effort between different regions of Gulf St. Vincent
c. evaluate the sampling design in terms of the number of interviews gained and, therefore, the amount of catch information that would be collected.

## b. Methods

Collection of the census data, and other preliminary work in the rest of Gulf St Vincent, had identified 22 boat ramps which were of significant importance to recreational boat anglers. The
relative importance of these ramps varied considerably but, collectively, they were considered to represent all access sites other than those used only occasionally. Methods to evaluate the contribution of these minor ramps will be discussed later in the report.

The access sites were grouped into travel routes containing 5-6 ramps, thereby dividing the gulf into 4 blocks (Fig. 7). In making the initial groupings, efforts were made to provide blocks that minimised travel times, thereby maximising waiting and interviewing times at ramps. Efforts were also made to match the blocks with established Marine Scalefish Fishery commercial catch and effort blocks (Nos. 34-45), to readily enable resource allocation comparisons to be made.

Prior to the start of the survey a publicity and promotional campaign was embarked upon. Press releases were sent out to newspapers and angling magazines and to local and regional radio. The media generally showed great interest in the survey and several groups sought interviews at various stages. A poster was designed and displayed at tackle and bait shops and various other appropriate outlets. As well as providing information about the survey, the poster also advertised the lottery which was being run as an incentive to facilitate cooperation from the angling community. This was sponsored by the Mobil Oil Company which had agreed to donate a $\$ 200$ fuel voucher as a prize.

Fig 7: Pilot survey sampling blocks


## Pilot survey 1

The first survey was established with 6.5 hour working shifts, comprised of total travel time plus waiting times at each ramp. The fishing day covered by these shifts was 0530-1830 hours. Waiting time was divided evenly between ramps, following the results of the computer simulations. Because of the different travel times involved in each block, waiting times at ramps varied between blocks. These ranged from 30 minutes in Block 4, to 40 minutes in Block 1 and 45 minutes in Blocks $2 \& 3$.

To properly evaluate the factors noted above, the sampling designs of the pilot surveys were constructed orthogonally for each factor. This design allows a powerful analysis of the effect of these factors, enabling a more quantitative approach to be made in decisions relating to future survey design. Consequently, each block was sampled 8 times in the 6 week period of the pilot survey, $(2$ mornings and 2 afternoons on 4 weekdays and 4 weekend days), making a total of 32 survey days. Blocks $1 \& 3$ were sampled on the same days, as were Blocks 2 \& 4. This allows direct comparisons to be made of fishing effort in different parts of Gulf St Vincent.

## Results

## a) i. Logistics

Preliminary trials of travelling the four routes meant that no difficulties were encountered in adhering to the prescribed schedules. It was found, however, that conducting interviews (including fish measuring) sometimes extended the prescribed ramp waiting times. To allow for this, and any other unforeseen delays, travel times have been deliberately made slightly longer than necessary. Trailer counts are based on the actual time spent at the ramp, and the database allows for variations from the pre-determined times.

## ii. Questionnaire design

Analysis of results from the original questionnaire and interview form (Appendix 1) revealed some deficiencies that required improvement. The areas where greater detail was needed were:
a) the breakdown of fishing effort in relation to target species
b) the use of fishing gear and methods, and their relationship to target species

During and after the first survey, substantial effort was undertaken in establishing the computer database to receive the survey data. Response variables were coded to facilitate easy data entry and validation controls were added to the programme to eliminate keying errors.

## iii. Interviewee response

Publicity for the pilot surveys assisted in the positive response received from recreational anglers. No angler refused the interview and most were happy for catches to be counted and measured. No adverse comments were received on the time taken for the interview, or of the information asked.
b) Differences in fishing effort

The orthogonal design of the pilot surveys allowed direct evaluation of factors affecting fishing effort by multifactorial analysis of variance (ANOVA). As no interaction effects between factors were significant (Table 3), results for individual factors can be analysed.

## i. Morning $v$ afternoon surveys

The bus-route method estimates fishing effort by counting trailers. It compensates for sampling only half the day by multiplying the observed effort by two (in this sampling design). No difference was recorded between estimates obtained
from morning and afternoon surveys (Table 3; time factor), indicating that fishing effort is similar in mornings and afternoons. This is supported by the results of the census data (Fig. 2).

Table 3. Analysis of variance results from the first pilot survey. Data transformed by $\ln (\mathrm{X}+1)$ to achieve homogeneity of variance.

| Source | Mean square | F-ratio | P |
| :--- | :--- | :--- | :--- |
| Block | 1.391 | 2.693 | 0.081 |
| Daytype | 0.004 | 0.008 | 0.932 |
| Time | 0.420 | 0.813 | 0.380 |
| Block* <br> daytype | 0.148 | 0.287 | 0.834 |
| Block* <br> time | 0.490 | 0.948 | 0.441 |
| Block* | 0.212 | 0.411 | 0.748 |
| daytype* | 0.517 |  |  |

Similarly, no difference was recorded for estimates from weekend and weekday surveys (Table 3; daytype factor). Although mean effort was higher for weekend days (118 v 81 hours), the variability associated with the estimates means that no significant difference can be concluded.

Because mean daily estimates are not significantly different, the contribution of each daytype to total effort in the Gulf is approximately proportional to their occurrence ie. weekdays account for approximately $5 / 7$ of total effort.

## iii. Regional differences

Surprisingly, mean daily fishing effort was also not significantly different between the four regions of Gulf st. Vincent (Table 3; block factor). Although statistically insignificant, the mean effort for Block 3 (Adelaide metropolitan) was approximately 5 times the effort for each of the other three Blocks. The high variability associated with these estimates, and particularly the effect of one outlier in Block 3, appears to have masked an apparent difference.
c) Number of recreational angler interviews

As a means of assessing the method's utility in obtaining interviews, an index was calculated by dividing the number of
interviews obtained by the total number of trailers observed, expressed as a percentage.

The number of interviews was also calculated as a percentage of total boats fishing on that day (Table 4). The total number of boats was calculated by dividing the fishing effort estimate by the average fishing trip duration (5 hours).

In the first pilot, a substantially higher percentage of interviews was obtained from afternoon surveys than from mornings (Table 4; $10.6 \%$ v. $0.7 \%$ ). This result was expected given the characteristics of the fishery (ie. a daytime fishery, with most boats launching in the morning and retrieving in the afternoon).

Table 4. The number and percentage of interviews obtained during the first pilot surveys.

No. interviews $\%$ trailers $\%$ boats

Time of day

| Morning | 5 | 2.0 | 0.7 |
| ---: | :---: | :---: | :---: |
| Afternoon | 58 | 20.2 | 10.6 |

Daytype

| Weekday | 28 | 11.8 | 5.4 |
| :--- | :---: | :---: | :---: |
| Weekend | 35 | 11.9 | 4.7 |

There was little difference in interview percentages between daytypes.
d) Commercial interviews

Seven interviews were conducted with commercial fishermen. The utility of these will be discussed later in the report.

## Calculation of fishing effort

It was not an objective of the pilot survey to estimate fishing effort for the survey period. However, an example of these calculations is demonstrated below, using the data from this survey. Calculation of estimates and their standard errors follows that of Malvestuto et al. (1978).

The estimate of an individual boat's fishing time is made by calculating

```
                        T
                        E = 2 X * -
            w
where
```

```
E = fishing effort (boat-hours)
```

E = fishing effort (boat-hours)
X = time an individual trailer is observed at a ramp
X = time an individual trailer is observed at a ramp
T = travel time for the route (including waiting
T = travel time for the route (including waiting
times)
times)
w = waiting time at that ramp

```
        w = waiting time at that ramp
```

Fishing effort (E) is then summed for all the trailers observed during that day's survey. In this pilot survey, waiting time (w) is the same for all ramps, but it can be varied if necessary.

From the calculations for each survey day, a mean daily fishing effort (MDE) can be calculated for each stratum.
a) mean daily fishing effort (each stratum)

|  | Weekdays |  | Weekends |  |
| :---: | :---: | :---: | :---: | :---: |
|  | mean | mean | SD |  |
| Block 1 | 32.0 | 31.3 | 38.1 | 42.1 |
| 2 | 39.9 | 34.3 | 76.7 | 59.1 |
| 3 | 215.4 | 109.1 | 291.2 | 404.5 |
| 4 | 39.3 | 22.1 | 68.1 | 75.2 |

The mean daily fishing effort for each block for the entire survey period is then calculated by multiplying the mean of each stratum by the proportional weighting of that stratum, and then summing across strata.
b) weighted mean daily fishing effort (all survey period)

|  |  | mean |
| ---: | :--- | :--- | SE $\quad 11.51$

Mean daily fishing effort for the entire Gulf can then be determined by summing the daily means of each block.

Mean $368.77 \quad 22.3$ (SE)

Finally, the total fishing effort for the Gulf is calculated by multiplying the daily mean by the number of days in the survey period.
c) total fishing effort (SE)
15.488 (936.6) boathours

Similar calculations can be made from interview data to estimate CPUE and total harvest.

## Comparison with previous results

A previous survey was conducted in the Adelaide metropolitan region in 1990/91 (McGlennon 1992). Fishing effort in that
survey was obtained from boom gate records at the major ramps, therefore providing an accurate record of total boat launches in the region. The proportion of boat launches relating to recreational fishing was calculated from observations on survey days. Similarly, launches from two ramps not surveyed were calculated from proportional data collected during the survey period.

Fishing effort for June and July, 1991, for the same ramps as those covered in Block 3 of the first pilot survey, is estimated at 2,928 boatfishing trips.

By using the daily mean effort estimates from Block 3 from the first pilot survey, and extrapolating them for 61 days (ie. all June and July), a comparison can be made. Estimated fishing effort for the two month period becomes $14,460(3,630)$ boathours. The average fishing trip length is 4.8 boathours (in 1990/91 and 1993), yielding an estimate of 3,012 recreational boatfishing trips for June - July 1993.

The two surveys therefore provide very close agreement (1991: 2,928; 1993: 3,012). As the 1991 figures were obtained from direct records (ie not requiring any sampling or estimation), the similarity with the 1993 figure strongly supports the busroute method as being appropriate for this fishery, and being able to accurately reflect the real fishing patterns.

## Pilot survey 2

Following the findings of the first survey, some modifications were made to the second. In particular, efforts were made to increase the number of interviews obtained by lengthening the shifts. The working day was increased from 6.5 to 8.0 hours, while retaining the overall fishing day of 0600 - 1800. This was done by overlapping the morning and afternoon shifts between 1000 and 1400 hours (ie. morning shift $=0600$ - 1400; afternoon shift $=1000-1800$. This resulted in waiting times at the ramps increasing to 45 minutes for Block 4,55 minutes for Block 1 and 60 minutes for Blocks $2 \& 3$, an increase of 15 minutes at each ramp.

The questionnaire and interview forms were re-designed (Appendix 2), to incorporate the changes discussed in questionnaire design earlier, add questions relating to fishing experience and local knowledge and to facilitate data entry. Further, the collection of environmental data was added, to be used in the future for correlating fishing effort with weather conditions.

The survey routes and ramps were left unchanged to enable ready comparison of this sampling design with the first survey.

## Results

a) i. Logistics

The travel logistics were unchanged from the first survey.

The increased waiting time at ramps allowed greater flexibility with interviews, and resulted in less interference to the travel schedule

## ii. Questionnaire

Although there were additional and more detailed questions in this survey, interviews were not noticeably lengthened. Rationalisation of the interview form allowed easier and quicker reporting of interviewee response, as well as reducing the quantity of paperwork associated with the survey.

## iii. Interviewee response

No change was detected in co-operation levels or to the generally positive attitude observed in the first survey.
b) Differences in fishing effort

A multi-factorial analysis of variance was used to analyse the second pilot survey (Table 5). Interactions between the factors
were not significant, allowing direct comment on the factor effects.

Table 5. Analysis of variance results for the second pilot survey. Original data were transformed to $\ln (X+1)$ to achieve homogeneity of variance.

| Source | Mean square | F-ratio | P |
| :---: | :---: | :---: | :---: |
| Block | 4.127 | 4.531 | 0.018 |
| Daytype | 0.131 | 0.144 | 0.710 |
| Time | 0.837 | 0.919 | 0.352 |
| Block* |  |  |  |
| daytype | 0.971 | 1.065 | 0.391 |
| Block* |  |  |  |
| time | 0.369 | 0.405 | 0.752 |
| Daytype* |  |  |  |
| time | 3.305 | 3.628 | 0.075 |
| Block* |  |  |  |
| daytype* |  |  |  |
| time | 1.013 | 1.112 | 0.373 |
| Error | 0.911 |  |  |

## i. Morning v afternoon surveys

As in the first pilot survey, no significant difference was observed in effort estimates between morning and afternoon surveys (Table 5; time factor).

## ii. Weekend v weekday surveys

Similarly, no significant difference was observed between mean weekend and weekday estimates (Table 5; daytype factor).

## iii. Regional differences

In contrast to pilot survey 1, a significant difference was observed between Blocks (Table 5; block factor). Post hoc tests revealed that mean daily fishing effort in Block 3 (metropolitan Adelaide) was $2-6$ times higher than other Blocks. This result was expected, as Block 3 contains 3 of the 4 major metropolitan Adelaide boat ramps. As each Block is to be surveyed separately, this result does not present any difficulties and will be dealt with by non-uniform probability sampling.
c) Number of recreational angler interviews

Afternoon surveys again produced a greater number of interviews per boats fishing (Table $6 ; 6.4 \% \mathrm{v} 3.5 \%$ ). However, while this sampling design increased morning interviews from $0.7 \%$ to $3.5 \%$ of boats fishing, afternoon interviews decreased from $10.6 \%$ to
6.4\%. Although more interviews were conducted during the afternoon surveys of the second pilot ( 89 v 58 ), the number of boats fishing rose more dramatically (1,383 v 549), resulting in a lower percentage.

Table 6. The number and percentage of interviews obtained during the second pilot surveys.
No. interviews \% trailers \% boats

| Time of day |  |  |  |
| ---: | :---: | :---: | :---: |
| Morning | 60 | 7.0 | 3.5 |
| Afternoon | 89 | 12.6 | 6.4 |

Daytype

| Weekday | 81 | 11.8 | 6.1 |
| :--- | :---: | :---: | :---: |
| Weekend | 68 | 7.7 | 3.8 |

## d) Commercial interviews

Nine interviews were conducted with commercial fishermen, with one refusal. It became apparent during the second pilot survey that the quantity and quality of information from commercial interviews were inadequate for validation of catch and effort returns. In essence, too few interviews were conducted to provide meaningful information. Further, time spent on
interviews with commercial fishermen limited the time available for interviews with recreational anglers.

Ongoing discussions with the commercial industry are leading towards the introduction of catch and effort records which will be self-validating against processor's records, thus removing the need for other validation techniques.

## DISCUSSION AND CONCLUSIONS

After consideration of the results of the computer simulations and pilot surveys, several conclusions can be drawn.

The computer simulations utilised a highly variable data set to fully test the limits of the bus-route method. Despite this, fishing effort estimates have been shown to be accurate at the relatively low sampling frequencies of 7 days per stratum. Similarly, precision levels of $20-25 \%$ are achieved for combined data at sampling frequencies of 10-15 days per stratum.
Improvements to these results can be expected from
stratification of the survey period into more homogeneous time
units. For example, separate analysis of the January
metropolitan data immediately doubled the precision of the
estimate compared with the same sampling frequency for the
combined season data. Results for combined data sets can
therefore be viewed as a 'worst-case scenario'.

The results of the method evaluation, and experience gained while undertaking it, suggest some further improvements that may be made.

1) As no differences in estimates were found between morning and afternoon surveys, and as more interviews were obtained from afternoon surveys, the final sampling design will incorporate proportionally more afternoon surveys. A ratio of 1:3-5 will substantially increase the number of interviews, but still allow some morning sampling for those anglers who regularly return early (e.g. snapper anglers).
2) As no differences in estimates were found between weekend and weekday surveys, sampling can be randomly spread throughout the days of the week, rather than requiring stratification between the daytypes. Efforts will be made to ensure that all daytypes are represented.
3) By combining the census data and the results of the two pilot surveys, extensive information is now available on proportional fishing effort in different regions of Gulf St. Vincent. This will allow sampling to be directed to regions of the Gulf proportionally to fishing effort, thereby maximising its effectiveness.
4) The information above will also be used to slightly modify existing travel routes. These will be made more
flexible by visiting low use ramps alternately, and increasing time spent at high use ramps.
5) As it is not possible to incorporate every access site into the survey, those not included will be separately but concurrently surveyed to determine the percentage fishing effort not included.

The bus-route survey has proven to be an appropriate method to effectively sample a large-scale marine fishery. The length of coastline surveyed in this study amounts to approximately 500 kilometres.

The full survey, of Spencer Gulf, Gulf St Vincent and parts of the west coast of Eyre Peninsula (1500-1800 kms), will utilise 4 persons full-time over two years. This relatively low personnel requirement makes large-scale surveys feasible for all Australian States. As examples, an equivalent distance covers the entire coast of Victoria ( 1200 km ), New South Wales (1200 km ) or Tasmania ( 1200 km ), the Queensland coast from Cairns to the NSW border ( 1800 km ) and from Albany to Carnarvon in Western Australia (1500 km).

While these calculations do not allow for different levels of fishing activity or number of access sites, they strongly suggest that the bus-route method could be utilised in all States.

Further, although this project has concentrated on boat fishing, the method is applicable to any fishing platform. Fo example, shore and jetty fishing could be surveyed where the jetties or shorelines can be monitored from a vantage point during the waiting time at that site. The bus-route survey method, therefore, has widespread applicability.

In conclusion, the bus-route survey method represents an important tool for the collection of accurate recreational fishing data. It provides information that will allow resolution of resource allocation conflicts at both localised and regional spatial scales. Because the method is costeffective, regular surveys can be undertaken, therefore allowing detection of trends or changes in fishing effort and catch over time.

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The pilot surveys were conducted jointly by SARDI staff and volunteer recreational anglers, in conjunction with project staff. Les Brown (Australian National Sportfishing Association) and Maureen Moritz (Australian Amateur Anglers) co-ordinated the volunteer recreational anglers, while Gavin Wright rostered SARDI staff. Mobil Oil Australia donated a fuel voucher of $\$ 200$ for a lottery of participating anglers.

Andrew Maiese and Keith Evans constructed the databases and programmes necessary to store and analyse the pilot survey information. Gavin Wright and Michael Luscombe produced the Figures contained in this report, while Dr Keith Jones provided comments on an earlier draft.

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## RECREATIONAL BOAT FISHING SURVEY QUESTIONNAIRE

Introduction: My name is and I represent SARDI. We are interviewing recreational fishers in this area as part of a research survey designed to provide valuable information on fishing activities in Gulf St. Vincent. Could you assist us by answering some questions about your fishing trip?

1) At what time did you depart from the ramp to go fishing? (to nearest half hour)
2) Where were you fishing? (show map) For how long?
3) Were you fishing on an artificial reef?
4) What species were you hoping to catch before you started fishing?
5) What species were you targeting on whilst fishing?
6) How many people were fishing?
7) What gear did you use?
8) What did you catch?
9) Has anyone on board fished previously at this location?
10) Do you have an echosounder?
11) Do you have a GPS?
12) We would like to examine and measure your catch now for identification purposes and to record length composition, which we will be comparing with commercial catches. (On a separate sheet record size composition for each species.)
13) Were any fish returned alive to the water?
14) What is postcode of owner/skipper? If not local, is a local on board?

## RECREATIONAL BOAT FISHING SURVEY QUESTIONNAIRE


6) Include fractions for people fishing only part of the time and/or children. $\square$
7)

| Method | Tick | No. Used |
| :--- | :--- | :--- |
| Rod |  |  |
| Handline |  |  |
| Net |  |  |
| Crabnet |  |  |
| Dabnet |  |  |
| Squid jig |  |  |
| Diving |  |  |
| Other |  |  |
|  |  |  |



## RAMP SURVEY QUESTIONNAIRE CODING SHEET

| Column Title | Entry Code Description |
| :---: | :---: |
| Form No | Day No Ramp No |
| Day Type | WE - Week End <br> WD - Week Day <br> PH - Public Holiday <br> SH - School Holiday |
| ID No | Consecutive interview number for that ramp on that day |
| LTime | Launch time ( to nearest half-hour) |
| RTime | Retrieve time ( to nearest half-hour) |
| ANo | Number of anglers (0.5 for "children") |
| Experience |  |
| Tot | Number of years of fishing experience (to nearest 0.5 year) |
| Loc | Number of fishing trips to today's location |
| R'dent | ```Y - most experienced person is a local resident N - most experienced person is not a local resident``` |
| ES | Echosounder: $\mathbf{N}$ - No <br>  $\mathbf{C}$ - Colour <br>  L Liquid Crystal Display <br>  P - Paper |
| GPS | $\begin{aligned} & \mathrm{y} \text { - yes } \\ & \mathrm{N} \text { - no } \end{aligned}$ |
| PL | Plotter: $\begin{array}{ll} & \mathbf{y} \text { - yes } \\ & \mathbf{N} \text { - no }\end{array}$ |
| Location | Use a separate line for each block (BkNo) |
| BkNo | Block in which party was fishing |
| BTime | Hours (to nearest 0.5 h ) spent fishing in a block |


| Column Title | Entry Code Description |
| :---: | :---: |
| Gear \& Catch | Use a separate line for each gear type (GType) |
| GType | Rod \& Reel: RB (bottom fishing) <br> (R) RS (surface fishing) <br>  RL (lure) <br>  RJ (jig) <br>  RF (fly) |
|  | Handline: HB (bottom fishing) <br> (H) HS (surface fishing) <br>  HL (lure) <br>  HJ (jig) <br>  HF (fly) |
|  | Other: <br> CN - crab net <br> DN - dab net <br> CR - crab rake <br> HS - hand spear <br> SG - spear gun <br> MN - mesh net |
| Sp | Coded abbreviation for each species caught |
| Tgt | Y - yes, this was the target species ( Sp ) <br> N - no, this was not the target species (Sp) |
| FTime | Time spent fishing for this specie in this location |
| NKept | Number of fish of this species kept |
| NRet | Number of fish of this species returned to the water |
| Why | US - undersize <br> BL - legal bag limit reached <br> EN - caught enough <br> NW - not wanted |



