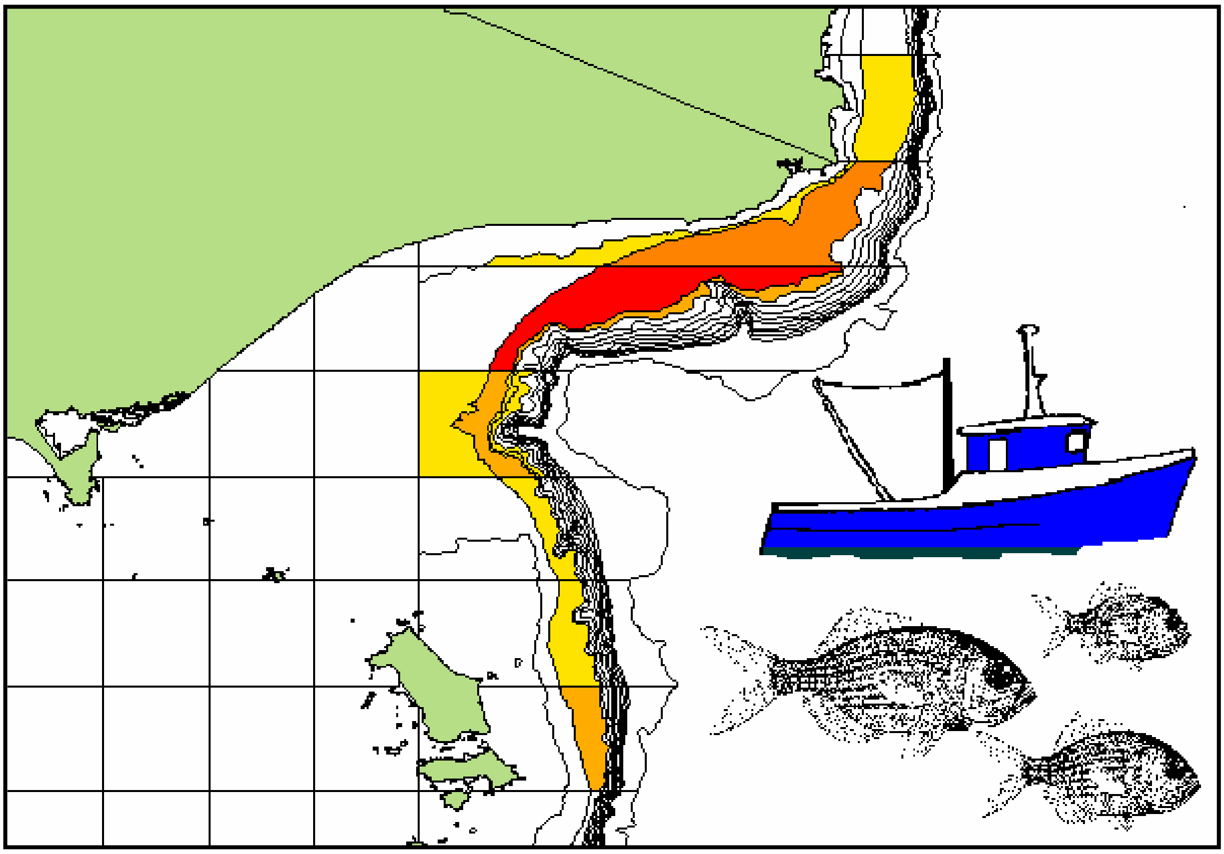
# Assessing the Feasibility of an Industry-based Fishery-independent Survey of the South East Fishery



*Ian A. Knuckey and Anne S. H. Gason*

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**OBJECTIVES:**

1. Conduct a power analysis of the shot-by-shot data from commercial logbooks and the ISMP so that an initial assessment can be made of the sampling intensity that will be required to develop robust indices of relative abundance on the basis of trawl surveys.
2. Design and hold a workshop involving industry, scientists, managers and invited experts with experience with industry-based surveys in multi-species, shelf edge and slope fisheries like the South East Fishery.
3. Develop industry support for implementing industry-based surveys.

**NON TECHNICAL SUMMARY**

OUTCOMES ACHIEVED TO DATE:

All three objectives of the project were achieved and resulted in several important outcomes.

Power analyses were conducted for species in both the South East Trawl Fishery (SETF) and the Great Australian Bight Trawl Fishery (GABTF). In the SETF, depending on which and how many quota species acceptable coefficients of variation (CVs) were required, there was a wide range in the number of survey shots needed. Of the 11 species analysed, 5 would require a large number (200–2000) of survey shots to achieve a CV ≤ 20%. In contrast, 76 shots were required in the GABTF to achieve the same CVs for the main target species of Bight redfish and deepwater flathead.

Successful workshops and industry meetings were held with representatives from both fisheries. As a result, industry understood the benefits of fishery-independent surveys as a better means of providing relative indices of abundance than commercial Catch per Unit Effort (CPUE) data. Whilst both fisheries accepted the importance of implementing such surveys, the level of uptake was quite different, largely driven by the different costs of the surveys and the industry's economic situations.

In the planned outcomes of the project it was stated that a positive outcome would be agreement to implement a long-term industry-based fishery-independent survey. As a direct result of this project, the GABTF has already initiated such surveys and is committed to their continued application. Whilst the initial commitment from the SETF industry was not strong due to their poor economic situation, subsequent to the structural adjustment it is recognised that fishery-independent surveys will be an integral part of the fishery's future.

The successful outcomes of the project are probably best reflected in Section 3.7 of AFMA's response to the Ministerial Direction for the SESSF which states "A fishery-independent survey will be implemented in the SESSF. This will be based on the model developed in the GABT Sector, which was developed in 2005. The FIS will provide independent estimates of abundance for the main SESSF quota species". The current project formed the foundation of this commitment. The subsequent project FRDC 2006/028 "Implementation of fishery-independent surveys for the Southern and Eastern Scalefish and Shark Fishery" will ensure this commitment is achieved.

Commercial CPUE data is often used in fisheries stock assessment as an index of fish abundance. While it has long been recognised that there are numerous problems with this approach, the lack of any "fishery-independent" index of abundance often leaves no alternative. Such has been the case for many years in the SETF and GABTF. The need to investigate and develop fishery-independent methods for surveying the relative abundance of SETF and GABTF fish stocks was a high priority and prompted the initiation of the current project. Could an industry-based fishery-independent survey provide cost-effective and statistically robust indices of abundance in a multi-species trawl fishery?

Based on overseas experience, a stratified random sampling design was suggested as the most appropriate for the surveys. The first stage of the study was to determine suitable stratifications for each fishery on which to base the sampling. Commercial logbook data was analysed for this, providing spatial and temporal information on catches, catch rates and associated variation for the main species. Power analyses were then conducted to determine the expected number of survey shots that would be required in each stratum to achieve a certain coefficient of variation (CV – a measure of precision) for the indices of abundance of the different species. Based on international experience, a CV $\leq$20% was agreed as an acceptable target. With this information available, approximate costs for the surveys could be established and a series of workshops and meetings were held with the key industry, research and management stakeholders to determine the survey designs and their feasibility in each of the two fisheries.

At these workshops, scientists gave a number of presentations on similar surveys conducted overseas and in Australia. This allowed participants to understand the pros and cons of different fishery-independent survey design options and the potential level of industry involvement in such surveys. Ultimately, it was agreed to use a survey model in which industry worked closely with scientists and managers to develop survey objectives and designs that were scientifically robust, aligned with current management requirements and were cost-effective to achieve. It was agreed that the use of industry vessels with independent scientific observers was a critical aspect of this approach.

A very contentious issue amongst industry was the concept of fixed-station shots for a trawl survey. To overcome this, yet retain scientific rigour, it was agreed that random positions would be chosen in each stratum and a survey shot would be considered valid if it passed within a 500m radius of this position at some point in the trawl. In this manner a fixed random position could be legitimately fished by the skipper using his best knowledge of the grounds, tides, currents etc yet still meet the scientific requirements of the survey design.

Given the multi-species nature of both fisheries, it was agreed that a standard "generalist" net would need to be constructed solely for use on the survey. Because this net would have ongoing use for all future surveys, the plans for the net design needed to be clearly detailed, well distributed and have broad agreement from industry prior to its use in the first survey. The need for a backup duplicate survey net was also highlighted in case of any damage during the survey.

With respect to survey quota, industry was adamant that additional quota should not simply be "made available" for a survey above the allocated Total Allowable Catches (TACs) as this could undermine the quota system and influence the value of commercial quota packages. This view was supported by both scientists and managers. All stakeholders realised, however, that there were many options for the ownership and sale of the survey catch and also how the proceeds could be distributed to the vessel, the survey or the quota holders. Given the variety of permutations, it was agreed that the most appropriate model would need to be selected with input from all stakeholders once the specifics of the survey design had been finalised.

With this general information at hand, the project then focused on determining the feasibility of implementing industry-based fishery-independent surveys in the SETF and GABTF through project workshops and industry meetings.

SETF

The preliminary stratification used for the SETF survey design was a modified version of that used for the Integrated Scientific Monitoring Program (ISMP). Initial simulations were run assuming separate summer and winter surveys either using only daylight shots or shots over a 24 hour period. Allocation of the shots to the strata was made in a number of different ways including: evenly across the strata, in proportion to the planar area of the strata, or in proportion to the CPUE variation of the strata. The preliminary power analysis for the SETF was conducted on 11 of the major quota species: blue eye trevalla; blue warehou; gemfish; jackass morwong; ling; mirror dory; ocean perch; redfish; silver trevally; silver warehou; and tiger flathead. Acceptable CVs (≤20%) could be achieved for a number of species (eg. ling, flathead, morwong, mirror dory, ocean perch and silver warehou) with less than 200 survey shots, but a far greater number of shots was required for others (eg. silver trevally and blue eye trevalla). This trend was apparent for a variety of model simulations using different data sampling and shot allocation scenarios. These analyses showed that at least 500 shots would be required to provide CVs of ≤ 20% for nine quota species. Based on rough estimates of charter costs, salaries and operational expenses, this suggested that conducting an annual SETF survey would cost over $500,000 plus the initial cost of purchasing the nets.

Despite a number of meetings held with SETF industry members to discuss the feasibility and the short- and long-term cost/benefits of conducting a fishery-independent survey, there were a few that supported proceeding with the implementation of the surveys. The majority considered it was too expensive given the current economic situation of the fishery. As a result, no further design or planning of a fishery-independent survey for the SET was undertaken as part of this project.

GABTF

The main objectives of the proposed GABTF survey were to determine a relative abundance index for Bight redfish and deepwater flathead in the current region of the main GABTF shelf fishery and collect biological and population data on these and other main species. Potential stratification, survey design and sampling procedures to achieve these goals were decided over a period of one year. Ultimately, four longitudinal strata were chosen across the main area of the fishery in depths between 100 and 200m with night and day shots included. Power analyses revealed that the optimal survey period was February to April, largely determined by the catch and catch rate variability of redfish. If the survey was conducted in these months, the number of tows required to achieve a CV of ≤20% for Bight redfish was estimated at ~80 whereas at other times of the year it was >200. In contrast, for deepwater flathead it was estimated that only <50 tows were needed to achieve a CV ≤20%. Based on a 14-day survey in both February and March, costs to conduct an annual survey of the GABTF were estimated at about $250,000.

With the impending introduction of quota management for the main species in the GABTF (Bight redfish and deepwater flathead) in 2006, industry was keen to obtain as much information as possible from a fishery-independent survey to help reduce the current high uncertainties in model estimates of stock abundance and set appropriate initial TACs. Moreover, with the introduction of quotas there was concern that the use of commercial CPUE data as the main index of abundance in the models would be compromised. This provided significant incentive for industry to adopt a fishery-independent survey to begin a time-series of relative abundance indices for deepwater flathead and Bight redfish that could be used to improve the stock assessment models. As a consequence, industry agreed to conduct their first fishery-independent survey of the shelf resources of the GABTF beginning in 2005.

In conclusion, this project demonstrated that industry-based fishery-independent surveys are a feasible means of collecting independent indices of fish abundance. Subsequent surveys carried out in the GABTF as a result of this project have proven that industry vessels can be a very cost-effective and suitable platform from which to undertake scientifically robust fishery-independent surveys of species abundance.

**KEYWORDS:** South East Trawl Fishery, Great Australian Bight Trawl Fishery, Fishery-independent survey.

# TABLE OF CONTENTS

**LIST OF FIGURES**

## LIST OF TABLES

## ACKNOWLEDGEMENTS

The authors wish to thank Mike Bergh (OLRAC) and Paul Starr for their valuable input into the workshop and advice on statistics and survey design. The close cooperation of the South East Trawl Fishing Industry Association (SETFIA) and the Great Australian Bight Industry Association (GABIA) were critical to the success of the project. We are indebted to Gail Richey, the Executive Officer of these two associations at the time, for coordinating their input. Also thanks to industry members Fritz Drenkhahn, Michael Thomas, Anthony Jubb, Joe Lavalle, Joe Puglisi and Semi Skoljarev, for their comments on the practicalities of the design and Crispian Ashby (FRDC), Ken Graham (NSW FRI), Sonia Talman and Matt Koopman (PIRVic), Trent Timmiss and Ian Towers (AFMA), Richard Tilzey, Brent Wise and James Larcombe (BRS) and Alan Williams and Neal Klaer (CSIRO) for their contributions. Thanks to Russell Hudson for assistance with the Final Report.

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## BACKGROUND

The central assumption underlying the use of Catch per Unit Effort (CPUE) as an index of abundance is that commercial catch rates change in a linear fashion with abundance. This assumption, however, has little independent support for many species in either the South East Trawl Fishery (SETF) or Great Australian Bight Trawl Fishery (GABTF) and is frequently criticised by industry and scientists alike. To help address this, CPUE time series are often "standardised" to incorporate factors such as position, season, time, vessel size, depth, target species etc. thereby reducing the uncertainty about catch rates as an index of abundance. The variables mentioned above are readily available from the logbook data and are easily incorporated into stock assessments. One of the most significant problems with commercial CPUE data as an index of abundance in a multispecies quota fishery such as the SETF, is that fishers often modify their fishing practices to target or avoid particular species, to suit quota availability or meet market demands (Liggins and Knuckey 1999). These factors are much harder to take into account because they are not well recorded and they relate to human behaviour and economic influences that are difficult to interpret and can operate on very fine spatial and temporal scales. The influence of environmental conditions on fish availability also reduces the effectiveness of CPUE as an index of abundance. Despite the above difficulties, the lack of an alternative index of abundance for the SEF leaves most stock assessments relying on reported commercial CPUE data as their main index of abundance (Smith and Wayte 2005).

To redress this situation, South East Fishery Assessment Group (SEFAG) identified the need to investigate and develop fishery-independent methods for surveying the relative abundance of SEF fish stocks. An AFMA Research funded scoping study highlighted the potential for using a long-term program of surveys to simultaneously gather data on the relative abundance and availability of many species. In some specific cases other survey techniques such as egg surveys or acoustic surveys may provide more precise indices of relative abundance for targeted single species. These single species surveys are relatively expensive and are only really cost-effective for the high yield, highly aggregating fish species in the SETF such as orange roughy and blue grenadier. Given the large number of dissimilar SETF species and the relatively low yield and value of most market species, the current single species approach appears unable to meet the fishery's long term need for relative abundance data for most species in a cost effective manner.

A more cost-effective means of conducting fishery-independent surveys for multiple species must be developed if assessments based on fishery-independent data are to be feasible for more of the quota species, let alone the numerous other non-quota and non-commercial species. Theoretically at least, a single program of fishery-independent surveys could simultaneously provide relative indices for many species using the same basic survey infrastructure. This approach has been successfully used in the similar multi-species, fisheries of New Zealand, Spain, North America and Canada; often using government research vessel. The current project was also designed to explore the feasibility of using an industry vessel to conduct the surveys.

## NEED

This proposal is part of a strategy co-ordinated by SEFAG and SEF Research Committee aimed at addressing the need for fishery-independent survey data. In order to address this broader need, SEFAG and the SEF Research Committee have identified two immediate needs.

1. The need to build industry support for this initiative is paramount. As identified by SEF Research Committee, SEF industry members have little faith in the use of commercial catch rates as an index of abundance because they are substantially influenced by quota availability, market demands and environmental conditions. The concern that they express is that short-term variability due to the above factors will be interpreted as a change in actual abundance and acted upon by managers in a knee-jerk manner. In other countries where long-term fishery-independent surveys have been conducted, however, the indices of abundance have been supported by industry and have made it possible to remove the influences of quota and market demand and quantify the impact of environmental variability on catch rates. This has made it possible, over time, to standardise survey catch rates for the impact of environmental effects. Exposing members of the SEF community to this international experience should go some way to addressing these concerns and building support.

2. If it is to succeed, there is a need to develop a cost-effective and statistically robust design for a long-term program of industry-based surveys. To build support and move towards implementation it is necessary to develop a survey design. Obviously any survey design needs to be cost-effective and capable of providing statistically robust indices of abundance. With an agreed survey design, members of the SEF community can start considering a concrete proposal for implementation and assessing the costs and benefits of proceeding with implementation.

## OBJECTIVES

1. Conduct a power analysis of the shot-by-shot data from commercial logbooks and the ISMP so that an initial assessment can be made of the sampling intensity that will be required to develop robust indices of relative abundance on the basis of trawl surveys.
2. Design and hold a workshop involving industry, scientists, managers and invited experts with experience with industry-based surveys in multi-species, shelf edge and slope fisheries like the South East Fishery.
3. Develop industry support for implementing industry-based surveys.

## METHODS

For a fishery-independent survey to be relevant and informative it must adequately sample the spatial and temporal dynamics of the fishery and have sufficient statistical power to provide an annual estimate of the relative abundance of key species within a certain precision level. The first stage of the study was to determine suitable stratification on which to base the survey design. Then, it was necessary to conduct a power analysis of existing commercial catch and effort data to determine the expected number of shots that would be required to achieve a certain coefficient of variation (CV) for the catch per unit effort as an index of abundance.

### Data inputs

The primary data used in the analyses were the commercial catch and effort logbook information from the trawl sectors of the South East Trawl Fishery (SETF) and Great Australian Bight Trawl Fishery. Independent on-board monitoring Information was also derived from the Integrated Scientific Monitoring Program (ISMP) during the period 1993-2003 (SETF) and 2001-2003 (GABTF) and through a number of short term trawl surveys conducted by NSW Fisheries Research Institute, PIRVic, Tasmanian Department of Primary Industry and Energy and CSIRO.

### Stratification

A number of options for stratification of the survey were explored. Initially, an innovative approach to a multi-species stratification was undertaken. In this method the fishery was subdivided into cells based on 0.5 degree lines of latitude and/or longitude together with 100m depth intervals and one month time intervals. For each species these cells were grouped into strata based on their similarity of mean annual catch and CPUE from the commercial logbook data. Through an iterative process, grid cells could be grouped into a number of strata for each species until the strata consisted of 90% of the average annual catch. Random allocation of shots was then applied to each stratum to determine the total number of shots needed to estimate annual catch rates for each species within a specified coefficient of variation. This allocation was then optimised by overlaying the individual species stratification to determine the fishery-wide survey design.

Concerns about this approach were raised at the workshop, especially the initial consideration of separate strata for each species and also that this process may result in too many strata requiring more shots than if a more conventional approach was adopted. Most importantly, it was pointed out that the design may be considered to be too complex for people to understand, and this may have ramifications in the long-term acceptance of the results of the survey by stakeholders. It was agreed that this situation should be avoided given the significant expense and long-term commitment that is required to return value from such a survey. Another concern was that calculation of the number of samples required from the commercial logbook data would be biased because they are not random samples. This was acknowledged, but with no alternative data sets, the logbook data provided the best basis on which to consider initial stratification. It was recognised that this situation would exist regardless of the method of stratification and similar approaches (based initially on commercial catch and effort data) had been adopted successfully in many other international fisheries.

Ultimately, it was agreed that a more conventional means of stratification should be adopted. The justification for the stratification adopted in both the SETF and the GABTF is provided in the Results and Discussion section.

**Power Analysis and Simulation Modelling**

Based on an agreed stratification for each case study, these analyses were conducted to provide estimates of the location and number of survey shots that would be required in a fishery-independent survey to deliver a relative index of abundance for the main species within an agreed precision level. The results of these analyses provided the basis for ongoing development of the initial survey design.

It was generally agreed at the Project Workshop that the method outlined by Schnute and Haigh (2003), should be used to test and compare the different survey stratification and shot allocation to determine the optimal survey design for the fishery.

The expected CVs of the abundance estimates for each species were calculated using the binomial-gamma method (Schnute and Haigh, 2003), where:

The mean density of non-zero measurements in each stratum is

$$\mu_h = \frac{1}{n_h}\sum_{i=1}^{n_h}\mu_{hi}$$

The squared inverse of CV of non-zero measurements is

$$v_h = \mu_h^2 / s_h^2$$

The mean density of measurements each stratum is

$$\delta_h = (1 - p_h)\mu_h$$

The variance of density of measurements each stratum is

$$\sigma_h = \sqrt{\left((1 - p_h)(1 + p_h v_h)\left(\mu_h^{\ 2} / v_h\right)\right)}$$

The estimated biomass of each stratum is

$$b_h = A_h \delta_h$$

The CV of biomass estimate of each stratum is

$$cv_h = \sqrt{\sigma_h} / b_h\, n_h$$

Where $p_h$ is the proportion of hauls with zero catch for the species in stratum h, $\mu_h$ is the mean kgs per area swept ($m^2$) of species where catch >zero, $s_h$ is the std kgs per area swept ($m^2$) of species where catch >zero, $A_h$ is the total area of stratum , $n_h$ is the number of tows and $b_h$ is the estimated biomass.

Total biomass and CV for each species were calculated as follows:

$$B = \sum_h b_h$$

$$cv = \sum_h cv_h$$

The number of shots, $n_h$, in each stratum that produced the desired coefficient of variation, $cv_h$, were randomly allocated within each stratum, along with four alternative shots in case the location of the first shot was untrawlable. Different approaches to the allocation of these shots amongst strata were examined.

**Survey Design Workshop**

A SEFAG-coordinated workshop was held at the Brassey Hotel, Canberra, on October 7–9th 2003. The first day was held to discuss what survey design best suited the fisheries and how stratification could be best approached. Summaries of commercial catch and effort data were presented to provide participants with an understanding of spatial and temporal aspects of the fishery and to help elucidate potential stratification and inform the survey design. Project funding was available to enable a number of Australian and international experts to be invited. The invited experts were selected on the basis of their experience with the design and implementation of fishery-independent surveys.

The aim of the workshop was to:

- Present preliminary results of the power analysis and simulation modelling;
- Provide participants with international experience on the design, implementation, and results of the fishery-independent surveys being used in the similar shelf edge and slope fisheries;
- Develop an agreed design for surveys in the SEF and an agreed plan for implementation.
- Discuss the potential use of maps of the SEF trawl grounds developed through an FRDC project entitled "Integrating fishing industry knowledge of fishing grounds with scientific data on seabed habitats for informed spatial management and ESD evaluation in the SEF".

The workshop involved a mix of structured presentations, free-ranging discussions of industry concerns and then structured discussions to develop an agreed survey design and plan of implementation.

**Feasibility**

Following the workshop and based on its discussions and outcomes, the project worked with industry and scientists to determine the feasibility of industry-based fishery-independent surveys. Two Case Studies were used: the South East Trawl Fishery and the Great Australian Bight Trawl Fishery. The same approach was adopted for both fisheries. Information about the value of conducting fishery-independent surveys was presented at a number of industry meetings for both the South East Trawl Fishermen's Association (SETFIA) and the Great Australian Bight Industry Association (GABIA). This involved discussion on potential survey design and how the results of the survey could be used to address various issues facing industry. It also included discussion about practical issues of costs, vessel selection, quota availability, sales of fish etc. Information on the potential of fishery-independent surveys was also presented at the relevant Resource Assessment Group (RAG) and Management Advisory Committee (MAC) meetings. The outcomes of the feasibility studies for the two Case Studies are presented.

## RESULTS/DISCUSSION

### Case Study 1 – SETF

*Workshop*

The first day of the workshop focused on the design and preliminary analysis of a fishery-independent survey. Participants on this day were mainly from a scientific background and included: Mike Bergh (OLRAC), Anne Gason (MAFRI), James Larcombe (BRS) Neal Klaer (CSIRO), Ian Knuckey (Chair – Fishwell Consulting), Matt Koopman (MAFRI), Paul Starr (Fisheries consultant), Richard Tilzey (BRS), Trent Timmiss (AFMA), Ian Towers (AFMA) and Brent Wise (BRS).

A summary of the South East Fishery was provided as a background for those participants not familiar with the SEF and to facilitate discussion on potential stratification of the fishery. The summary included information on the spatial and temporal dynamics of species composition, and factors that influence catch rates and catch compositions in the fishery. The background and need for a fishery-independent survey were outlined prior to examination of the more detailed aspects of survey design.

Underpinning the design of the survey, all participants agreed that it was necessary to have the primary goals of a fishery-independent survey well defined. This was discussed at length and workshop participants agreed that the primary goals of the survey were to:

1) Provide annual estimates of the relative abundance of the commercially recruited biomass for the major species in the SEF at an acceptable level of precision.

2) Provide population biology characteristics (e.g. age, sex and length frequency) for the major species.

Based on international experience, workshop participants agreed that an acceptable level of a coefficient of variation (CV) for the relative index of abundance should be ≤20%.

Following this, Dr Mike Bergh and Dr Paul Starr, two research scientists with expertise in designing fishing surveys, provided valuable insight into fishery-independent surveys that had proven successful overseas. The results of industry-based surveys being used in the similar shelf edge and slope fisheries of New Zealand, North America and Canada were presented. The method developed by Schnute and Haigh (2003), in which simulation modelling is used to design demersal trawl surveys, was also presented to workshop participants. The method was considered appropriate for the SETF because it can use commercial fishery data to provide input parameters for each stratum and thereby investigate variances and test different tow allocations to determine optimal sampling design. An example of where this technique had been applied to a survey design in Canada was presented. Preliminary application of this method to the SETF data was undertaken.

The other item discussed on the first day of the workshop was the methods used to determine potential stratification for a fishery-independent survey of the SEF. The results of these discussions are presented separately below.

The second day of the workshop was attended by a broader range of stakeholders including: Crispian Ashby (FRDC), Mike Bergh (OLRAC), Fritz Drenkhahn (Industry), Anne Gason (MAFRI), Ken Graham (NSW FRI), Anthony Jubb (Industry), Neal Klaer (CSIRO), Ian Knuckey (Chair – Fishwell Consulting), Matt Koopman (MAFRI), James Larcome (BRS), Joe Lavalle (Industry), Paul Starr (Fisheries Consultant), Sonia Talman (MAFRI), Richard Tilzey (BRS), Trent Timmiss (AFMA), Ian Towers (AFMA), Joe Puglisi (Industry), Alan Williams (CSIRO), Brent Wise (BRS).

A number of presentations were given to provide further information to assist in the development of fishery-independent surveys. These included a presentation on the previous Kapala surveys, the ISMP and an industry mapping project.

Mr Ken Graham gave a presentation on the fishery-independent Kapala surveys undertaken off the coast of New South Wales during the 1976-77 and the repeat surveys conducted 20 years later in 1997 (Graham *et. al.* 1997, Andrew *et. al.* 1997). Information on the survey design (fixed sites) and the sampling protocol used in these surveys was provided. Participants discussed the pros and cons of these surveys and whether this type of survey could be expanded to sample the entire SEF.

Dr Sonia Talman summarised the design of the ISMP, highlighting that the objectives of this program was to estimate discard rates, and provide information on the age and size composition of all quota and some non-quota species with specified CVs (10%) by sampling both onboard commercial vessels and port based landings.

Mr Alan Williams outlined the methods and results of a survey conducted by CSIRO to map the structure of the sea bed off south-east Australia using acoustic backscattering, sediment samples, photographic and video samples alongside information from fishers' plotters. This provided a simple seabed classification scheme and spatial reference that was considered useful in determining suitable sampling sites throughout the survey area by identifying established fishing grounds and untrawlable areas.

The more practical aspects of survey design were discussed in the afternoon, including the potential to have an "industry-based" fishery-independent survey. A few options for the implementation of a survey were considered:

A) <u>Industry designs & implements survey independently of government</u>
   This was considered a high risk option, where industry basically "goes it alone" from the government-run research and management bureaucracy. This option was considered to require significant industry resources and they must be able to tap into high quality independent scientific advice, but this could be offset by industry providing vessels and other infrastructure at reasonably rates. The high risk related to the potential for the results of such survey to be ignored or disputed by researchers and managers to a point where it does not influence management decisions. It was also thought that this option may be more difficult if industry was not united in its support for the survey or if there was no well-functioning industry association.
B) <u>Industry designs & implements survey with government input and co-operation</u>
   Workshop participants considered this a lower risk than Option A, because it is far more likely that, with government and research involvement, the results of the survey would be accepted and influence management decisions. Issues against this approach were that it may be much more time consuming and therefore frustrating and expensive to work with the government bureaucracy.

C) Industry contracts government to design & implement survey

This option was considered to have a low risk of lack of adoption but could be very expensive due to the total dependence on government agency resources and infrastructure. The risk associated with this option was that the project's priority may not be recognised by government or that it may not meet industry requirements. It was felt that these risks could be minimised if a good process was put in place to gain ongoing industry input into decisions regarding the survey.

Consistent with the goal of determining the feasibility of an industry-based fishery-independent survey, workshop participants considered that some variant of Option B was the most appropriate.

Workshop participants discussed the need to develop standardised requirements for the vessels that may undertake the survey. It was agreed that there were three main options for a survey vessel:

- A government-owned research vessel;
- A single industry-owned vessel dedicated to the survey;
- Multiple industry-owned vessels to undertake the fishery at specified times.

The first option was not considered feasible for a number of reasons. Importantly, there are very few government-owned research vessels in Australia that are suitable for this type of work. Most agencies can not afford to maintain these large vessels unless they are deployed constantly throughout the year and there simply is not enough work in Australia. For the few agencies that own suitable vessels, the commitment to an extensive ongoing survey program may be prohibitive and the high costs of chartering such vessels ($7,000 - $15,000/day) would probably be prohibitive. The second option was considered, but was thought to be too difficult for the SEF as the vessel would be required to work over a very large area and practical aspects of operation and funding would be problematic. The third option was considered the most feasible for the SEF, but would require strict parameters governing vessel selection and operation to ensure the number of variables that may influence catch rates were minimised.

*Stratification*

The large spatial extent of the SETF over a range of regions and depths was considered a critical factor in the potential survey stratification. Previous analysis of catch compositions (Klaer and Tilzey 1994) and the design of the ISMP fishery monitoring surveys (Smith *et.*

*al.* 1997; Knuckey and Gason 2001) have highlighted natural spatial divisions in the fishery based on catch composition and fishing activity. The initial stratification of the SETF used for the analyses was therefore generally based on that used for the ISMP design model (Knuckey and Gason 2001, Table 1, Figure 1) which had been modified from Smith *et al.* (1997) using information contained in the annual ISMP reports presented to SEFAG (Knuckey and Sporcic 1999; Knuckey 2000; Knuckey *et al.* 2001). The primary factors that define these strata are region, main species caught, depth (inshore / offshore), season and gear type. The regions used to summarise the spatial distribution of the fishery are very similar to those first described by Klaer and Tilzey (1994) based on species composition. Overall, the stratification adopted by the ISMP has stood the test of time and is widely accepted as a sound stratification of the SETF. Its consistency over many years leant weight to the use of a modified ISMP stratification for the initial survey design.

A number of variations to the above stratification were considered necessary if it was to be used for the preliminary survey analyses; these are explained. The Bass Strait region was not included due to the relatively low otter-board trawl catches taken there. Other strata dropped from the IMSP design included the targeted blue grenadier and orange roughy strata on the understanding that more specific fishery-independent acoustic surveys were being undertaken for these species. We also considered omitting the Danish seine and royal red prawn strata because these fisheries used significantly different fishing gear. The decision to omit the Danish seine fishery from the survey design effectively prevented the survey from providing abundance estimates for school whiting.

The depth structuring used in the ISMP design is simply inshore (<200m) and offshore (>=200m). The need for finer scale structuring of the depth strata for the fishery-independent survey was discussed. Depth strata of 0-80fm, 80-150fm, 150-220fm and >220fm were initially suggested. The need for the deepest stratum was questioned because deepwater species (blue grenadier and orange roughy) were already sampled by single species surveys. It was also suggested that shallow (<180m) strata be left out in West Victoria as it is untrawlable. Countering the above, it was thought that to limit the preliminary analyses was not necessary at this early stage and participants agreed that three depth strata (0-100 fathom, 100-340 fm and >340 fm) would be appropriate for the preliminary analyses.

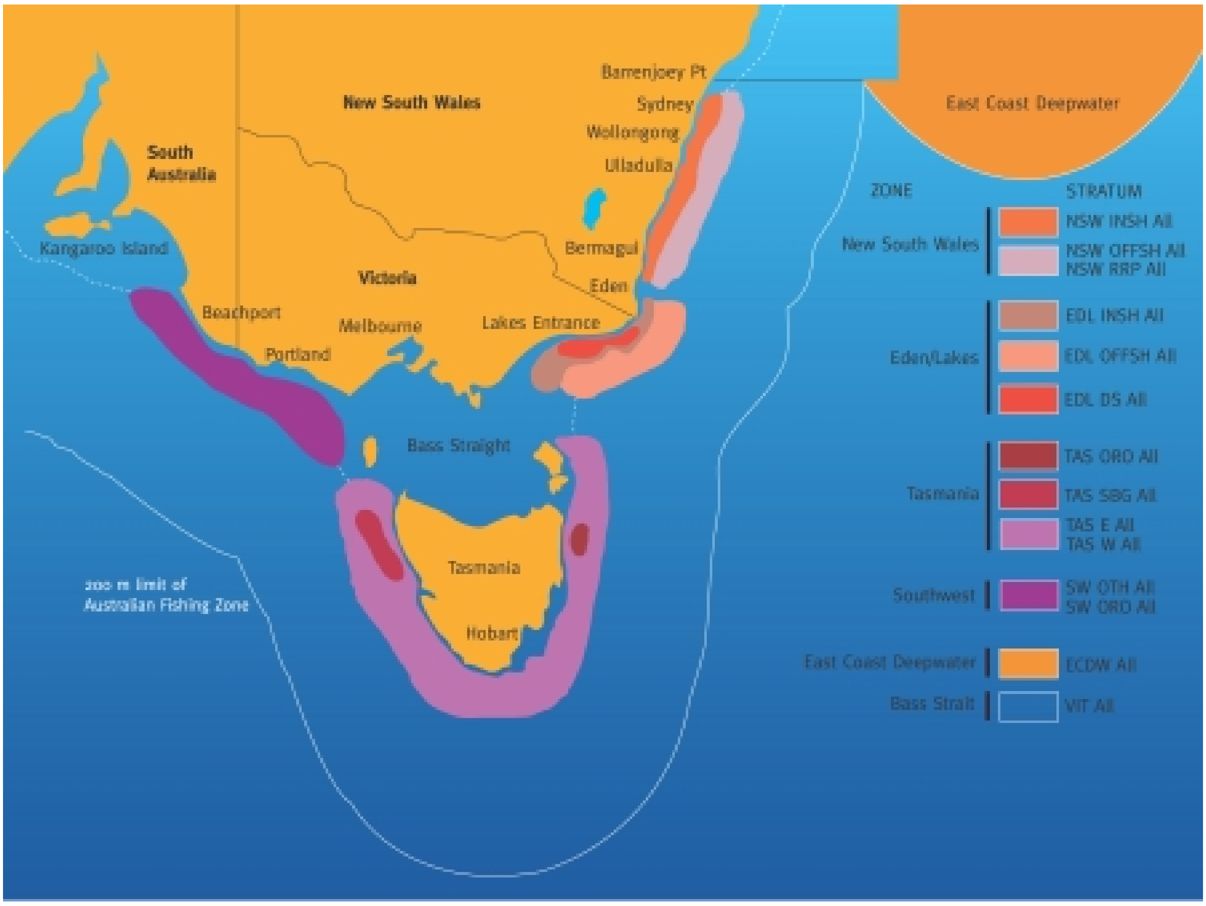



Figure 1. Geographical extent of Australia's South East Trawl Fishery, showing the major fishing ports and the strata used in the design of the ISMP (from Koopman *et. al.* 2005).

Table 1. Proposed definition of SEF strata used in the ISMP trawl sectors (modified from Knuckey and Gason 2001).

| **Stratum code** | **Defining Species** | **Gear** | **depth** | **month** | **Region** | **Catch** |
|---|---|---|---|---|---|---|
| SW_ORO_TR | Orange roughy | trawl | | 6<=m<=9 | South West | ORO >.5* total catch |
| TAS_ORO_TR | Orange roughy | trawl | | 6<=m<=9 | West Tas, East Tas | ORO >.5* total catch |
| SW_BGS_TR | Blue grenadier | trawl | | 6<=m<=9 | South West | |
| TAS_BGS_TR | Blue grenadier | trawl | | 6<=m<=8 | West Tas, East Tas | |
| NSW_RRP_TR | Royal red prawn | trawl | >200m | | NSW East Vic | RRP >50 kg |
| NSW_TR_IN | Silver warehou, blue warehou, morwong, silver trevally, John dory, redfish, school whiting, flathead, reef perch | trawl | <200m | | NSW East Vic | |
| NSW_TR_OFF | gemfish, ling, ocean perch, mirror dory, blue grenadier | trawl | >=200m | | NSW East Vic | |
| ECDW_TR | Blue eye trevalla, alfonsino | trawl | | | ECDW | |
| EDL_TR_IN | Silver warehou, blue warehou, morwong, silver trevally, John dory, redfish, school whiting, flathead, reef perch | trawl | <200m | | East Vic | |
| EDL_TR_OFF | gemfish, ling, ocean perch, mirror dory, blue grenadier | trawl | >=200m | | East Vic | |
| EDL_DS | School whiting, Flathead | seine | | | East Vic | |
| VIC_TR_IN | School whiting, Flathead | trawl | | | Bass Strait | |
| ETAS_TR | | trawl | | | East Tas | |
| WTAS_TR | | trawl | | | West Tas | |
| SW_TR | | trawl | | | West Vic | |

The seasons during which the survey should be undertaken was also discussed as it was considered an important factor in the dynamics of the fishery. At a minimum, separate surveys should be undertaken during the summer and winter fishing seasons. It was considered that a survey during spring and autumn would be problematic because it is during these times that most of the environmental change occurs on the trawl grounds which might confound annual abundance estimates. As a simple initial approach, it was agreed that initial simulations would be run with half the shots in summer (January – February) and half in winter (July - August). This would be reviewed later and the exact timing of the sampling periods was to be determined from further analysis and discussion with fishers.

Participants also discussed the time of day to conduct survey shots. If there was to be diurnal stratification, it was agreed that it should be between 1 hour before sunrise to 1 hour after sunset, and the time of day must be recorded. For simplicity, the initial model simulations were run with either daylight (0600 – 1800 hrs) shots only or all shots combined.

Finally, it was agreed that only commercial data from trawl gear after 1995 would be used in the initial analyses. Shot allocation to the strata in the simulation would be evenly across the strata, based on the planar area of each stratum, or in proportion to the CPUE variation of the strata.

*Power Analysis*

The preliminary power analysis for the SETF was conducted on 11 of the major quota species: blue eye trevalla (*Hyperoglyphe antarctica*); blue warehou (*Seriolella brama*); gemfish (*Rexea solandri*); jackass morwong (*Nemadactylus macropterus*); ling (*Genypterus blacodes*); mirror dory (*Zenopsis nebulosus*); ocean perch (inshore) (*Helicolenus percoides*); redfish (*Centroberyx affinis*); silver trevally (*Pseudocaranx dentex*); silver warehou (*Seriolella punctata*); and, tiger flathead (*Neoplatycephalus richardsoni*).

Results of some example runs of the power analyses are presented (Figure 2) and a summary of the number of shots required to meet a CV of 20% is provided in Table 2. It was apparent that acceptable CVs (<20%) could be achieved for a number of species (eg. ling, flathead, morwong, mirror dory, ocean perch and silver warehou) with less than 200 survey shots, but a far greater number of shots was required for others (eg. silver trevally and blue eye trevalla). This trend was apparent for a variety of model simulations using different data sampling and shot allocation scenarios. Interestingly, the species that continually required higher sampling levels are known by industry to be species with particularly patchy spatial or temporal distributions. It indicates that further analysis would be required to determine what factor/s were influencing the high CPUE variability of some species and whether this could be overcome by alternate stratification tailored to these species. It also suggests that a very extensive fishery-independent survey would be needed if the same CV requirement is expected for every major quota species. If alternatively, the survey was designed to achieve good CVs for the majority of the species and there was some level of flexibility about the CV level expected for other species, there is potential for a reasonably cost effective and statistically robust fishery-independent survey to be designed.

Table 2. Range of number of shots required in a fishery-independent survey of the SETF to achieve a CV <20%. Note: the exact number of survey shots would depend on what stratification was ultimately chosen.

| **Species** | **Number of shots** |
|---|---|
| Jackass morwong | <200 |
| Ling | <200 |
| Mirror dory | <200 |
| Ocean perch (inshore) | <200 |
| Silver warehou | <200 |
| Tiger flathead | <200 |
| Blue warehou | 200–1000 |
| Gemfish | 500–1000 |
| Redfish | 500–1000 |
| Silver trevally | 1000–1500 |
| Blue eye trevalla | 1500–2000 |

Figure 2. Simulation modelling of the CVs achieved for different SETF species for a range of survey sampling shots. Achievement of a CV <20% was the objective. Note: the exact number of survey shots would depend on what stratification was ultimately chosen.

**a)**

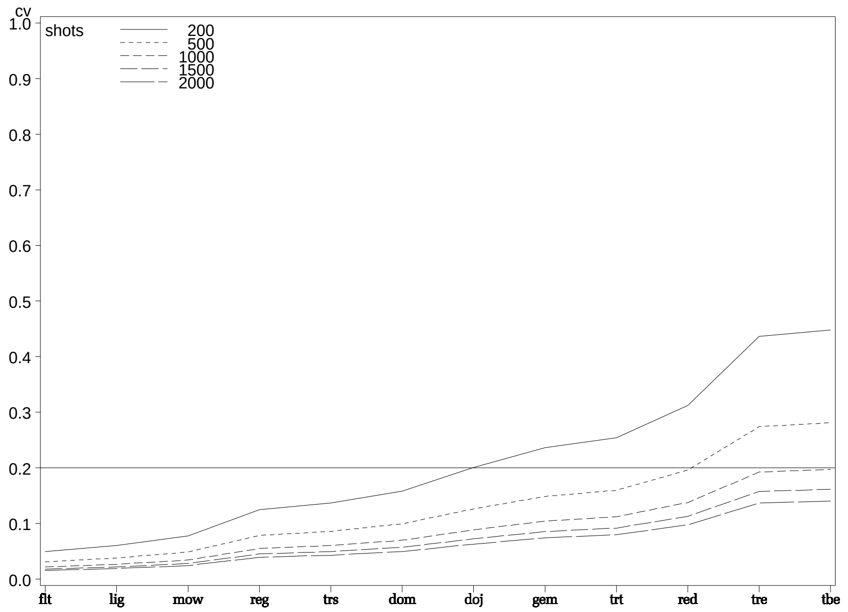
**Sampling:**

All months

Day and night

**Allocation:**

Evenly across strata




**b)**

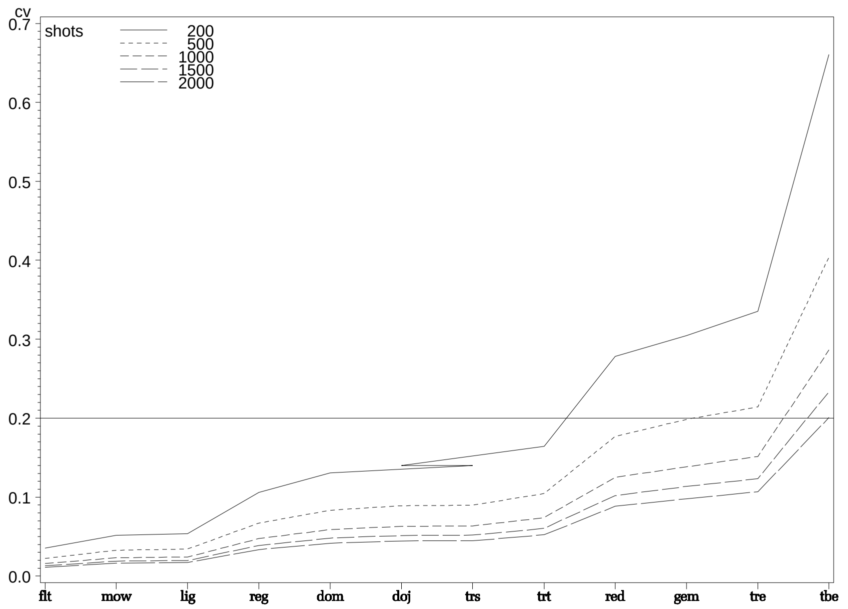
**Sampling:**

All months

Day and night

**Allocation:**

Proportion of strata area




mow – morwong, lig – pink ling, flt – flathead, reg – ocean perch, trs – silver warehou, dom – mirror dory, doj – John dory, gem – gemfish, trt – blue warehou, tbe – blue eye trevalla, tre – silver trevally

Figure 2 contd... Simulation modelling of the CVs achieved for different SETF species for a range of survey sampling shots. Achievement of a CV <20% was the objective. Note: the exact number of survey shots would depend on what stratification was ultimately chosen.

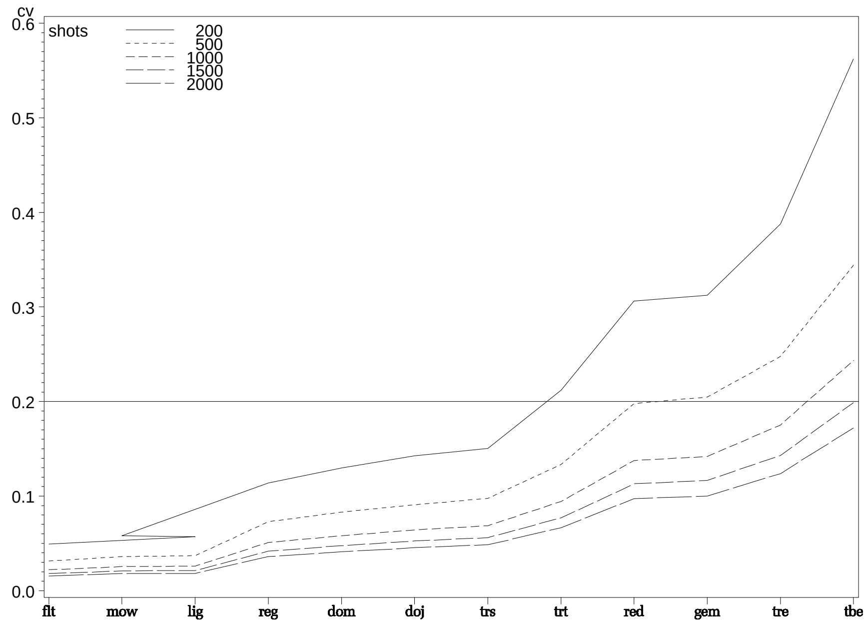
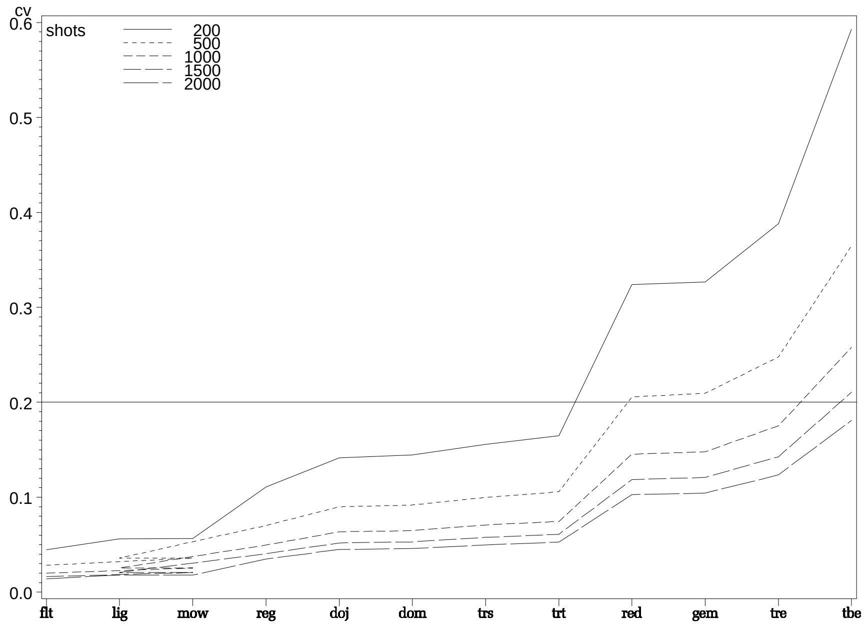
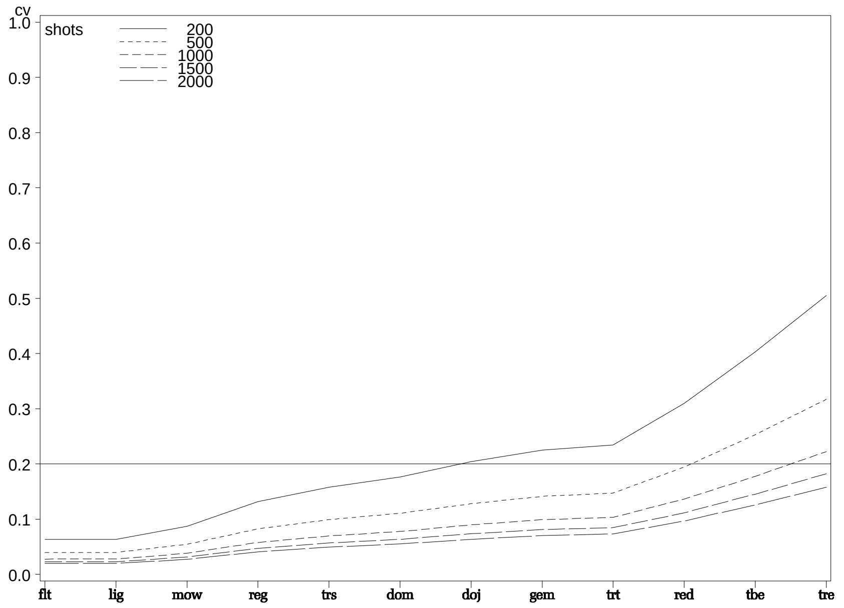
| | |
|---|---|
| **c)**<br><br>**Sampling:**<br>Jan-Feb, Jul-Aug<br>Daylight shots<br><br>**Allocation:**<br>Proportion of CPUE variation of strata |  |
| **d)**<br><br>**Sampling:**<br>Jan-Feb, Jul-Aug<br>Daylight shots<br><br>**Allocation:**<br>Proportion of strata area |  |
| | mow – morwong, lig – pink ling, flt – flathead, reg – ocean perch, trs – silver warehou, dom – mirror dory, doj – John dory, gem – gemfish, trt – blue warehou, tbe – blue eye trevalla, tre – silver trevally |

Figure 2 contd... Simulation modelling of the CVs achieved for different SETF species for a range of survey sampling shots. Achievement of a CV <20% was the objective. Note: the exact number of survey shots would depend on what stratification was ultimately chosen.

<table>
<tr><td>e)<br><br>Sampling:<br>Jan-Feb, Jul-Aug<br>Day and night<br><br>Allocation:<br>Proportion of strata area</td><td>
</td></tr>
<tr><td>f)<br><br>Sampling:<br>Jan-Feb, Jul-Aug<br>Day and night<br><br>Allocation:<br>Evenly across strata</td><td>
</td></tr>
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### *Survey Feasibility*

Fixed stations

One of the issues that raised considerable concern among industry was the concept of fixed-station survey shots. It was unclear exactly why this was, but it was probably partially influenced by the use of a fixed site survey design in the Kapala surveys. Generally, east coast NSW fishers did not agree with the results of the 1997 Kapala surveys that showed a marked decline in the catch rates and size distributions of a number of commercial and bycatch species and they attributed this to the design of the survey. While there is little doubt the survey did provide evidence of some level of decline, unfortunately, because it was a "once-off" repeat survey, other factors which may have effected the results such as small-scale environmental or oceanographic perturbations could not be considered. Fishermen also had difficultly relating to the concept of going back to exactly the same place to repeat a shot because they felt that dynamics of the fish stocks are such that they may simply not be there. Another issue was that they felt it was impractical to carry out exactly the same shot in different years. For example, if in one survey a north-south shot was running with the tide, it might yield a very different result to if the shot was running against the tide in another year. Rightly or wrongly, this issue greatly influenced how fishers perceived fishery-independent surveys, particularly the fixed station design. This perception had to be overcome before there would be general acceptance of a fishery-independent survey for the SETF.

To tackle the issue of "fixed stations", Paul Starr outlined a method that had been used successfully overseas to specify sampling points (Starr *et. al.* 2002). In the example, the survey area was divided up into 500m x 500m grids which were then randomly selected and allocated as survey stations. Once the required number of sampling grids was allocated, a number of random backup grids were chosen in case the original grid was deemed unfishable by the skipper. Instructions were given that it did not matter where the sample shot was started or finished, as long as the shot went through the grid. They conducted the survey over a short time period so the skippers did not have time to optimise their catch according to moon phase or look for marks etc. and used bottom contact sensors to help measure effort. Industry felt much more comfortable with this type of approach as it gave the skippers some flexibility in how a "fixed-station" site could be approached and fished. Industry suggested that when the shots are initially allocated, the local fishers would be able to tell right away whether or not they will be able to sample that area. Industry members commented that to make the survey reasonably efficient, subsequent shots in a survey should be no more than 20 nm apart. The scientists considered that this level of flexibility did not compromise the statistical requirements of the survey design. As agreed at the workshop, a method very similar to this was adopted for the GATF survey as shown in Appendix 3.

Vessels and gear

Industry raised concerns that it might be hard to keep the skippers and boats consistent in the longer term because crews and boats change over time. This was acknowledged as a significant issue for fishery-independent surveys regardless of whether industry or research vessels were used. Ways of addressing this were discussed and included tight specifications of shot parameters, including position, tow speed, tow duration etc. If vessels were to change, it was recommended that some attempt at standardisation of vessels be made through parallel tows or duplicate surveys.

With respect to gear, it was agreed that a standard "generalist" net be constructed solely for use on the survey. Such a net would not be designed to specifically target any one species, but would have characteristics that would enable it to capture a broad range of species. The plans for the net design needed to be clearly detailed, well distributed and have broad agreement from industry prior to its construction. This same net plan would be used for the construction of any future survey nets to ensure a standard gear was used over time. The need for a backup duplicate survey net was also highlighted in case of any damage during the survey. It was also agreed that any new survey net should be used for a couple of weeks prior to the commencement of a survey to "stretch" the meshes so that it was fishing consistently by the time it was used in the survey.

It was suggested that using 15 minute shots would reduce the cost of the survey by enabling more tows to be conducted in a day but it was pointed out that if the shots were less than 1 hour duration the catchability of some species of fish would be lowered. One hour shot duration was considered a minimum but two hours was suggested as more appropriate.

Workshop recommendations about vessel and gear specifications specific to the SETF are presented in table 1. In order to monitor net dynamics during any survey, it was suggested that a survey requirement be that the vessel has electronic net monitoring devices installed.

Quota and Markets

Industry was adamant from the outset that, in principle, additional quota should not simply be "made available" for a survey above the allocated Total Allowable Catches (TACs) as this could undermine the quota system and influence the value of commercial quota packages. As such, it was agreed that catch of quota species during the survey should be covered within the ITQ system. Methods of obtaining the quota needed to be further refined, but one suggested option was that it could be leased at market price from quota holders with first option given to the charter vessels. An advantage of this system was that quota holdings of the charter vessels, tailored to suit their annual fishing operations, would suffer minimal disruption during the charter. Proceeds from the sale of the fish caught during the survey may have to cover costs of quota lease and expenses associated with icing, freighting and selling the fish.

There were some concerns by Industry that if survey-caught fish were sold on the market, they could affect market prices. Some considered that this would not be a problem because after handling by scientists (eg measuring, otolith extraction) the fish may not in a marketable condition. The issue of sale of survey fish needed to be further examined.

Industry support

As highlighted in the introduction, industry initially gave their support for this project because of the problems associated with the use of commercial CPUE data in current assessments. They also saw the increasing involvement of industry in data collection and R&D as important. There was also good support at the workshop to scope and design the survey and obtain a rough estimate of the cost of undertaking such a survey.

Preliminary estimates of survey costs for the SETF were based on the initial power analyses which showed at least 500 shots would be required to provide CVs of < 20% for nine quota species. Based on conducting 4-5 two hour shots/day, at least 100 sea days would be required. Industry members suggested a suitable vessel with crew could be chartered to undertake the surveys for about $5,000 a day without retaining the proceeds from the sale of fish. A further $1000/day would be required for a scientific observer and data collection and analysis, but this might be paid for by the sale of the fish. Thus for the sake of preliminary discussions with industry, a rough figure for the total cost of the survey was put at $500,000 plus the cost of purchasing the nets.

During the year following the workshop, a number of meetings were held with SETF industry to discuss the feasibility of conducting a fishery-independent survey in line with the above. Although there were a few people that supported the need for the survey, the majority considered it was too expensive given the current economic situation of the fishery. Despite many hours explaining the long-term benefits of the survey, there was no agreement to proceed with the implementation of the surveys as part of this project.

Table 3. Gear and vessel specifications agreed at the workshop.

| Characteristic | Needed | Value | Comments |
|---|---|---|---|
| **Vessel characteristics** | | | |
| Length (m) | Yes | 20-25 | |
| Accommodation | Yes | 5-6 | |
| Deck space | Yes | | Enough |
| Insurance | Yes | | Public Indemnity |
| Vessel survey | Yes | | With extra people |
| Engine power | No | 350 | Not if suitable for net |
| Tow speed (kts) | Yes | 3 | +/- 10% |
| Winch HP | Yes | | 15 min/600 fm |
| Drum capacity | Yes | | 800 fm |
| No. net drums | Yes | 1-2 | Spare net |
| Net sound | Yes | | Measure gear |
| **Skipper characteristics** | | | |
| Experience | Yes | 5 years | Crew/skipper |
| Local | Yes | | Shots/region |
| Scientist friendly | Yes | | |
| **Net characteristics - type** | | | |
| Wing trawl | Yes | | Generalist net |
| Opening | Yes | 2000-2500 | Inch round |
| Bottom gear | Yes | 5-8 | Inch rubber discs |
| **Net characteristics - opening** | | | |
| Door spread | Yes | 50fm | |
| Wing spread | no | | ? |
| Headline height | Yes | 2.5fm | |
| Footrope length | | | |
| Headline length | | | |
| Sweep length | | 100fm | 28mm (soft/steel) |
| Bridle length | | 18fm | 16 up/28 low |
| **Net characteristics - doors** | | | |
| Door type | Yes | 7 foot | V-door |
| Door area ($m^2$) | No | | |
| Door weight | Yes | 600kg | |
| Warp wire | Yes | 16mm | Soft core |
| Sweep wire | Yes | 14mm | Steel core |
| **Net characteristics – wings** | | | |
| Length | | | |
| Material | Yes | | Braided poly |
| Diameter | Yes | 3mm | |
| Mesh size top | Yes | 9 | |
| Mesh size bot. | Yes | 6 | |
| verandah | Yes | 9-6 | 50 meshes |
| **Net characteristics – belly** | | | |
| Length | | | |
| Material | | single | Braided poly |
| Ply | | | |
| Diameter | | 5mm | |
| Mesh size | | 6-45 | inch |
| other | | | |
| **Net characteristics – extension** | | | |
| Length | | 50 | mesh |
| Material | | single | Braided poly |
| Ply | | | |
| Diameter | | 5mm | |
| Mesh size | | 3.5 | |
| other | | | |
| **Net characteristics – cod end** | | | |
| Length | | 20-25 | |
| Material | | single | Braided poly |
| Ply | | | |
| Diameter | | 6mm | |
| Mesh size | | 90 | |

## Case Study 2 – GABTF

### *Workshop*

On the 9th October 2003 a similar workshop to that conducted for the SETF was held on the Great Australian Bight Trawl Fishery to discuss the design and implementation of an industry-based fishery-independent survey. GABIA members hoped the workshop would provide advice on options for the design of a survey for the GABTF and potential costs to industry of undertaking such a survey. Participants of the workshop included: Mike Bergh (OLRAC), Gerry Geen (Ocean Fresh); Ian Knuckey (Chair – Fishwell Consulting), Jeff Moore (Ocean Fresh), Christian Pyke (Raptis), Richard Stephens (AFE), Paul Starr (Fisheries consultant), Richard Tilzey (BRS), Ian Towers (AFMA), Marcia Valente (Valente Fishing), Brent Wise (BRS).

It was highlighted that this workshop was specifically requested by GABIA to investigate the potential to design and implement an industry-based resource survey of the GABTF. A brief background to the workshop was provided noting that this day was to provide information on fisheries surveys to GABIA members including the types of surveys that were available and experiences in their design and implementation in other fisheries. The goals specific to the GABTF survey workshop were to:

- Specify the objectives of a GABTF survey;
- Develop a preliminary design of a survey;
- Develop a process to implement a survey.

To assist in this, a summary of the Great Australian Bight Trawl Fishery (Figure 3) was provided that included information on the value, species caught, and factors that influence catch rates and catch compositions in the fishery. Meeting participants discussed the current stock assessments in the fishery, and the need for an independent survey to add information for inclusion in both the existing stock assessment models and on resources within the GABTF in general. Although the current model structure was considered sound, the main problem was that there was no contrast in the commercial CPUE data. Some considered that the model's use of commercial catch and effort data from the developing stages of the fishery (as in the GABTF) was invalid, but all agreed there were few alternative options at this stage.

With the impending introduction of quota management for the main species in the fishery, industry was concerned that current model estimates of stock abundance would be inappropriately used to set initial TACs. It was considered that current increases in fishing effort would be useful to obtain contrast in the CPUE data which would better define the impact of the fishery on stock abundance. It was believed that this potential would be lost once quotas were introduced. Modellers emphasised that at the current time (with current data inputs and lack of contrast in biological and CPUE data) the models were not appropriate to be used to estimate actual biomass and it would be inappropriate if the model outputs were used in this manner to aid setting TACs for Bight redfish and deepwater flathead. The need for independent indices of abundance that could help tune the models and provide a better understanding of the extent of the shelf resources was supported by all participants.

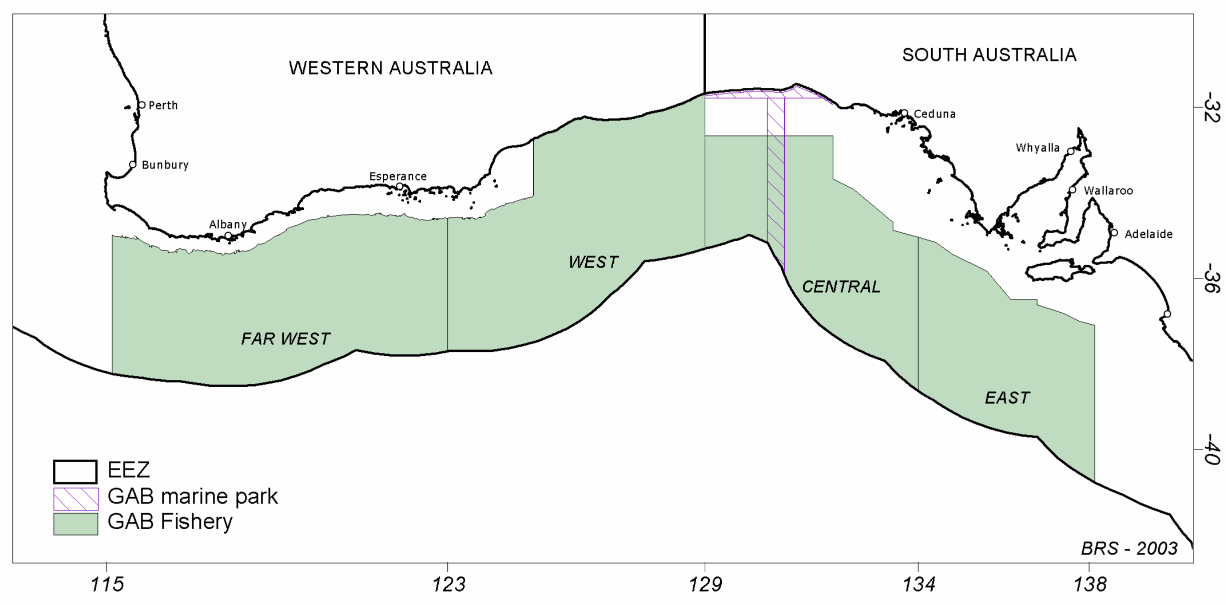



Figure 3. Area of the GABTF showing the four fishery management zones.

Although GABIA members had agreed to the principal of an industry-based resource survey of the GABTF, it was considered that an important part of the workshop was to carefully define the objectives of such a survey. To help elucidate this, all industry members and the GABTF research and management members were invited to outline their expectations of such a survey.

The various expectations of industry and other participants can be summarised as follows:

Shelf

- Determine actual recruited abundance of redfish and flathead – current fishery
- Determine actual recruited abundance of redfish and flathead - entire shelf
- Search for pre-recruits of redfish and flathead

- Time series of relative abundance indices for redfish and flathead - current fishery
- Exploratory search for Bight redfish and deepwater flathead resources across the fishery.

Slope

- Exploratory search for other midwater fish resources
- An improved attempt at BRS survey

Deepwater

- Exploratory search for additional deepwater resources (eg. roughies, oreos)

Pelagic

- Exploratory search for pelagic resources (eg. squid, mackerel)

There was considerable discussion by all participants about the merits of the different expectations and the likelihood of a survey being able to achieve such goals. The ability and timeliness of the survey results for input into impending management decisions about the GABTF was a major part of the discussions. It was emphasised that the value of the survey results increases with time and an individual annual survey point (the first of which would only be available in December 2004 at best) had only limited scientific value. Thus, with regard to the implementation of quotas in the fishery, survey results available prior to January 2005 would probably only influence the perception of resource extent.

Following these discussions, it was agreed that the objectives of the proposed GABTF survey would be as follows.

- Primary Goals:
  - Determine a relative abundance index for Bight redfish and deepwater flathead in the current region of the main GABTF shelf fishery;
  - Collect biological and population data on these species.
- Secondary Goals:
  - Determine a relative abundance index of other main species in the current shelf fishery;
  - Provide a density estimate of Bight redfish and deepwater flathead in areas inshore to the current fishery.

To develop a survey that would meet these goals, workshop participants discussed potential stratification, survey design and sampling procedures.

Visual interpretation of catch rate data for the two species indicated that the main survey would operate along the shelf break between 126° – 132° 30’ longitude. There were obvious variations in the catch rates of the two species which suggested there would need to be 4-6 longitudinal strata within this region. Catches of both species occurred within a small depth range, so it was agreed that only one depth strata would be used in the main survey area. It was agreed that there would only be one annual sampling period for the survey which would be determined by the month with the most seasonal stability of catch rates and reduced CPUE variability for the two species combined. The upper and lower depth boundaries would be determined by the catch rate distribution of the two species across the shelf break. Using the method of Schnute *et. al.* (2003), the effectiveness of the different stratifications and method of allocation of shots to these strata would be modeled to determine the optimal survey design to achieve <20% coefficient of variation for estimates of the relative abundance of the two species.

In addition to the main survey described above, GABIA members agreed to run a parallel secondary survey of Bight redfish and deepwater flathead resources on the inner-shelf region. It was agreed that this survey would operate between 125° – 129° longitude from the upper depth boundary of the main survey inshore to the 50 m depth contour. With little previous catch data available from this stratum, it was agreed that between 10-20% of the shot allocation required for the main survey would be allocated to this inshore stratum. Over the coming year, it was agreed that GABIA skippers should undertake ad-hoc soundings of the area to determine potential trawl areas and possibly undertake a number of trial shots (at their expense) within this region to ground truth this information and provide an indication of catch rates.

If GABIA agreed to go ahead with the survey, it was suggested that a trial survey could be undertaken during 2004. The results and practicalities of this trial survey would then be reviewed. Pending the results of this review, any amendments to the survey design would be incorporated and a further two years of the survey would be undertaken. A major review of the survey would then be held following the results of the third year of the survey.

Regarding the practical issues of conducting a survey, it was made clear that it would be most likely that industry would bear most of the survey costs and it would need to be undertaken on industry vessels to be cost-effective.

The method by which the survey could be funded was discussed. It was suggested that FRDC funding may be obtained for the first year trial survey, but this was considered unlikely given the nature of the survey. One of the options was that all SFR holders would contribute equally into a pool to cover the costs of the survey and a tender process would be used to decide the vessel which would undertake the survey. Any returns in the way of fish catches would be returned to the pool to offset the costs. It was agreed that further discussion on the funding and practical implementation of the survey would be discussed at the next GABIA meeting, once a better understanding of the survey requirements was understood.

At the close of the workshop, the next steps required to progress implementation of the survey were agreed as follows:

- A summary of the workshop results would be written up and distributed to meeting participants;
- Undertake analysis of stratification and shot allocation for the survey design with the results sent to GABIA members by the end of October 2004; and
- Results of the survey design and potential cost implications for the first year of the survey would be presented at the GABIA meeting for discussion and then taken to GABMAC.

*Stratification*

The final design and stratification of the survey was developed over a one-year period subsequent to the workshop, with extensive liaison between scientists and GABIA operators. There were many iterations of the survey design over this time as the scientific robustness and practical requirements were considered, but eventually an agreed survey design was reached. A summary of the underlying reasons for the final stratification that was adopted for the GABTF is provided below with the final agreed recommendations highlighted. More details on the survey design can be found in Knuckey *et. al.* (2005).

<u>Month</u>

- Catch rates for Bight redfish are far more variable than those for deepwater flathead.
- The limiting factor in the survey design is obtaining precise estimates of catch rates for Bight redfish.
- Catches and catch rates of Bight redfish are highest during the early months of the year (February to April, Figure 4).

- Bight redfish catch rate variation is also highest during these months but is less in March and April than in February.
- Although catches of Bight redfish during February are greater, there is higher variation in redfish CPUE during this month.
- Catches and catch rates of deepwater flathead are reasonably consistent throughout the year. Highest catch rates are near the end of the year.
- It was initially recommended that the survey be undertaken during the month of March alone, but industry was concerned that this may not allow for the between-year variability in the onset of the main redfish fishing season. Subsequently it was agreed to run the survey over the two months of February and March. Further meetings conducted later in the year decided an additional survey should be conducted during December for deepwater flathead.
- Within February and March it was agreed that the best time for targeting redfish was in the week leading up to the full moon.

The primary survey is to be carried out over two separate trips on the week leading up to the full moon during both February and March for Bight redfish and an additional survey during December for deepwater flathead.

Depth

- Virtually all of the Bight redfish and deepwater flathead catches in the GABTF are taken between 120 – 200m (Figure 5).
- There are only minor catches of both species outside this depth range (Graphs do not start at zero due to non-reporting of depth on some catch and effort logbooks).
- There is very low trawling effort in inshore waters (50 < 120m) but incidental catches of Bight redfish are taken.
- There are some high catch rates at depth >200m but these are derived from a very low percentage of the total catch (Figure 6).

Primary survey strata restricted to a depth range of 120 – 200 m. Option of a secondary inshore stratum from 120 m to 50m.

Longitude

- The majority of the Bight redfish and deepwater flathead catch is taken between longitude 126°00’ and 132°30’ (Figure 7).
- Catch rates are not uniform across longitude for either species.

- Inconsistencies in catch, CPUE and CPUE variation suggest some stratification by longitude is required.

Four longitudinal primary strata for the February and March survey design are: 126°00' - 127°45'(West2), 127°45' - 129°00' (West1), 129°00' - 130°15' (Central1), 130°45' - 132°30' (Central2)

One additional strata 125°00' – 126°00' (West3) and one depth strata (inshore, 100–120m) were proposed for the Flathead survey in December, but not the Feb-Mar survey.

Day / night

- Diurnal differences in the catch rate, CPUE and variation in CPUE are shown for deepwater flathead (Figure 8) and Bight redfish (Figure 9).
- During February–April, catch rates of deepwater flathead are significantly higher during the day than during the night (Figure 10).
- There were no significant differences of catch rates of Bight redfish during the day and night (Figure 11).
- Inclusion of day and night shots in the survey will considerably reduce the amount of sea days required for the survey.

Recommend data from day and night shots be pooled in the survey design.

Trawl duration

- Most shots for either deepwater flathead or Bight redfish have a trawl duration of > four hours (Figure 12).
- Based on logbook data, the variation of catch rates for Bight redfish is much higher for shots <2.5 hours than for shots of longer duration (Figure 13).
- This trend is similar for deepwater flathead, but to a far lesser extent (Figure 12).
- Logbook data records shot time from net away to net retrieved (not bottom time) and half an hour was allowed for setting and retrieving.

Recommend minimum trawl duration of 2.5 hours bottom time for each shot undertaken for the survey.

# Month

Deepwater flathead                                        Bight redfish

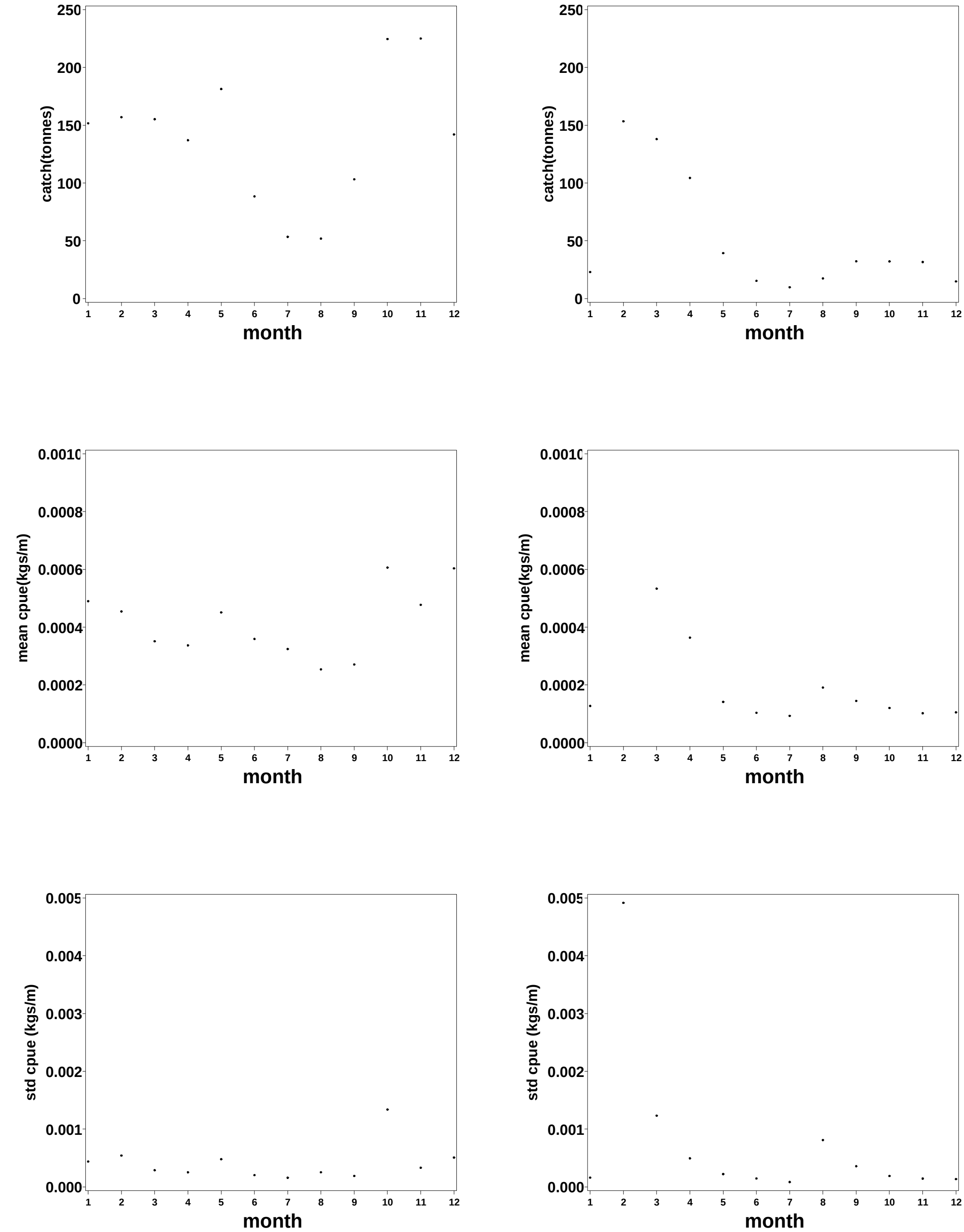
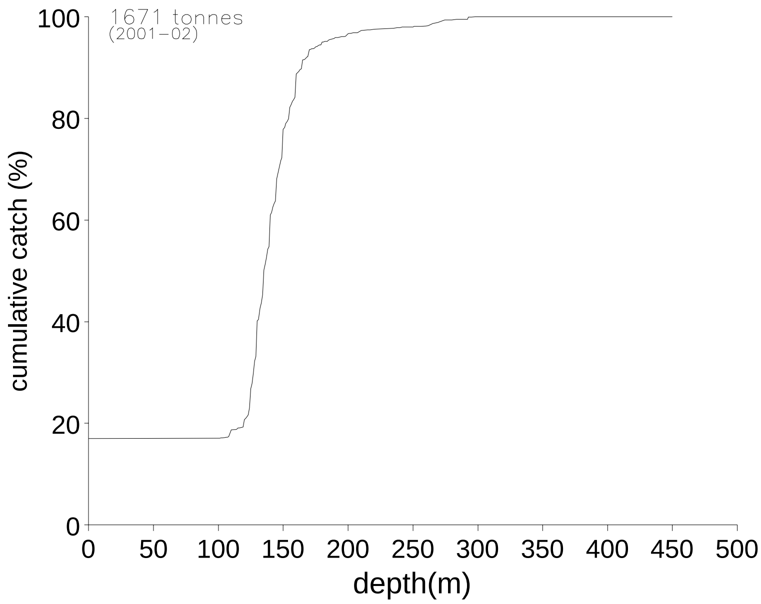



Figure 4. Distribution of catches (t), mean catch rates (kg/m$^2$) and variation of catch rates with month. Note the high variation in redfish catch rates for February.

# Cumulative catch by depth (m)

## Deepwater flathead




## Bight redfish

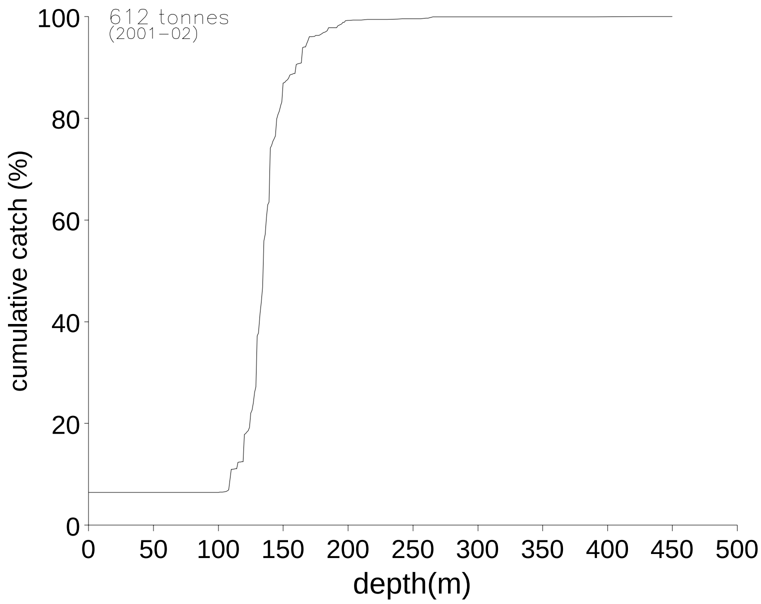



Figure 5. Percentage cumulative catch of deepwater flathead and Bight redfish with depth.

# Depth category

Deepwater flathead Bight redfish

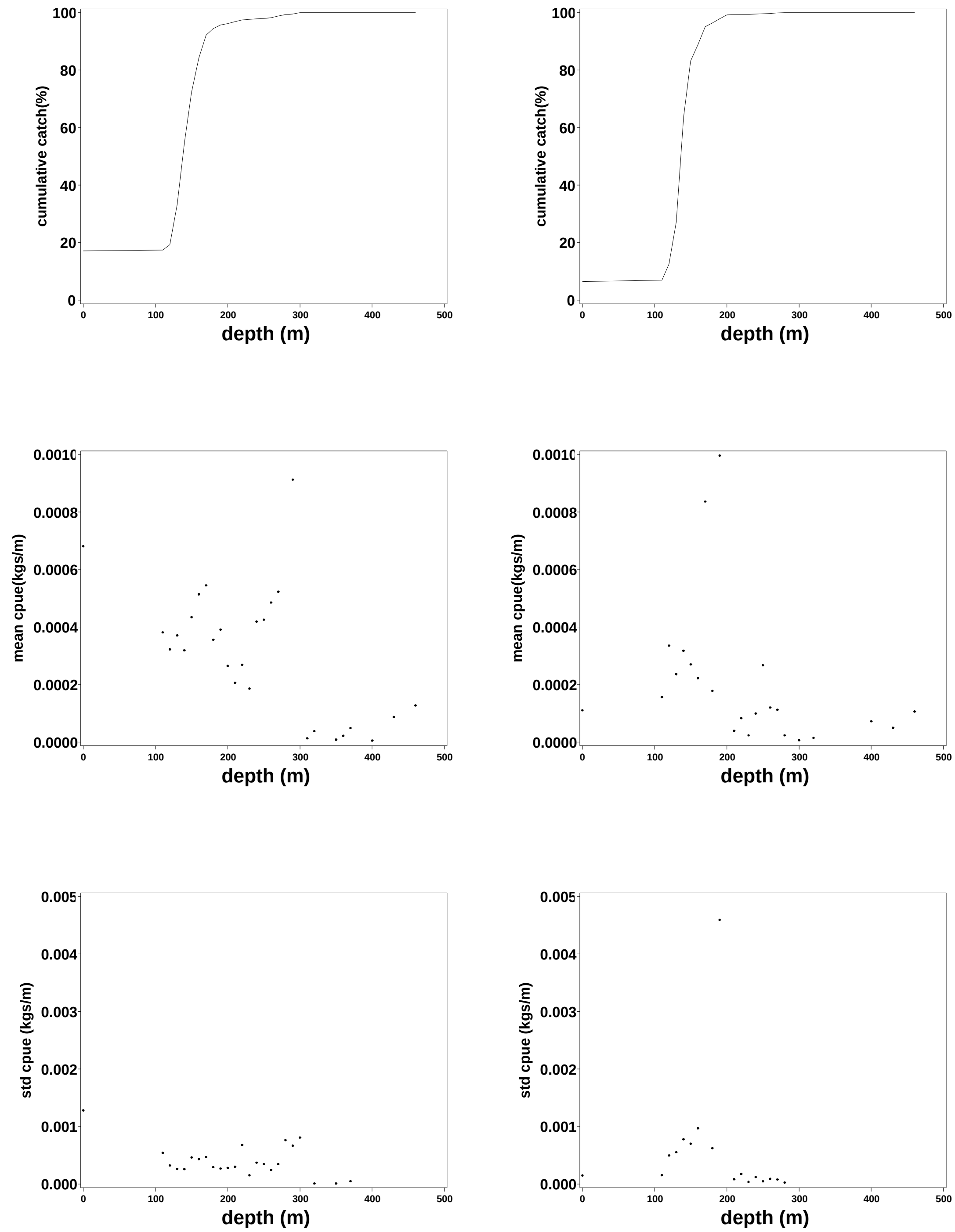



Figure 6. Graphs showing the catch (t), mean CPUE (kg/m2), and CPUE variation of Bight redfish and deepwater flathead with depth.

## Longitude

### Deepwater flathead

### Bight redfish

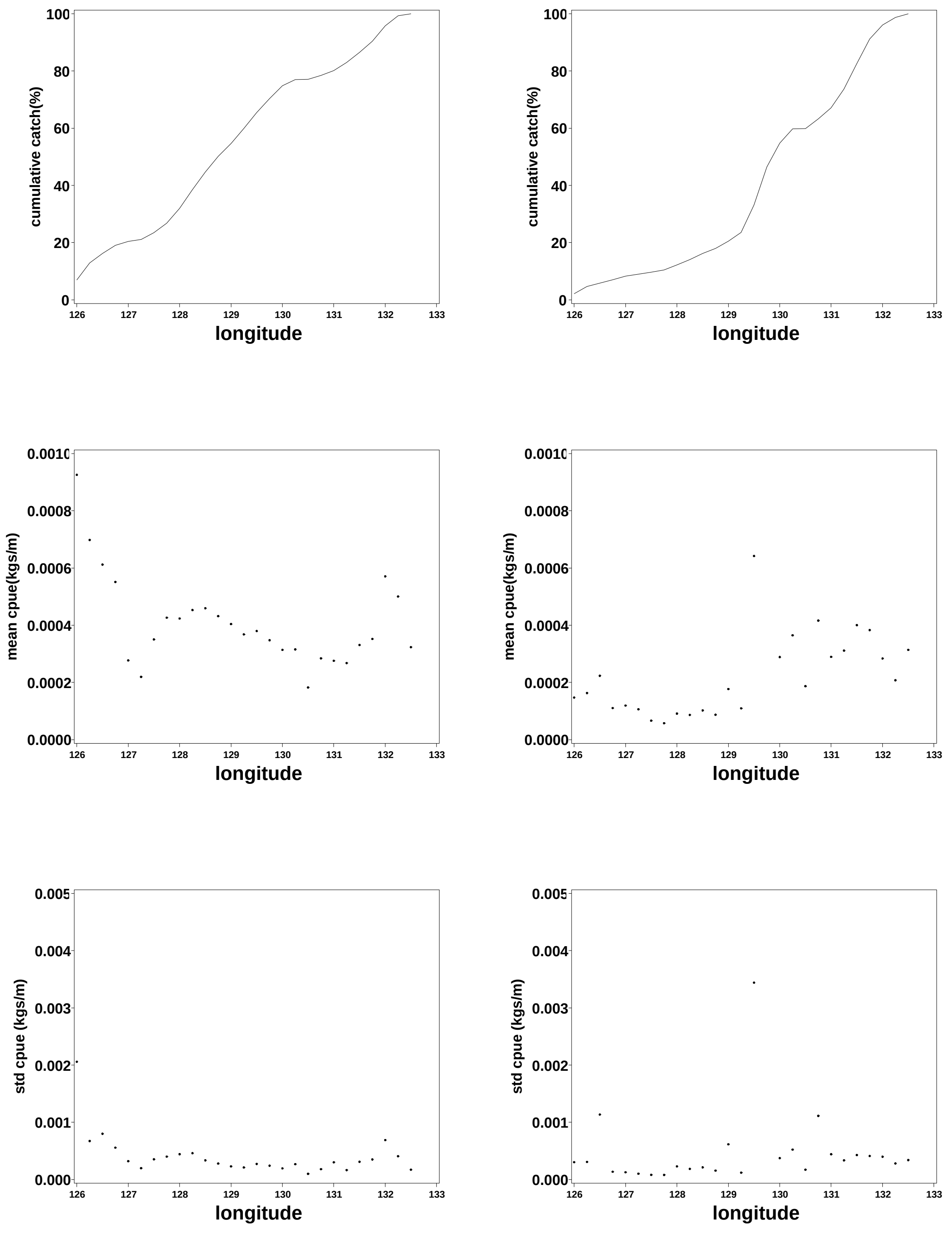



Figure 7. Distribution of catches (t), mean catch rates (kg/m$^2$) and variation of catch rates with longitude.

Deepwater flathead day  Deepwater flathead night

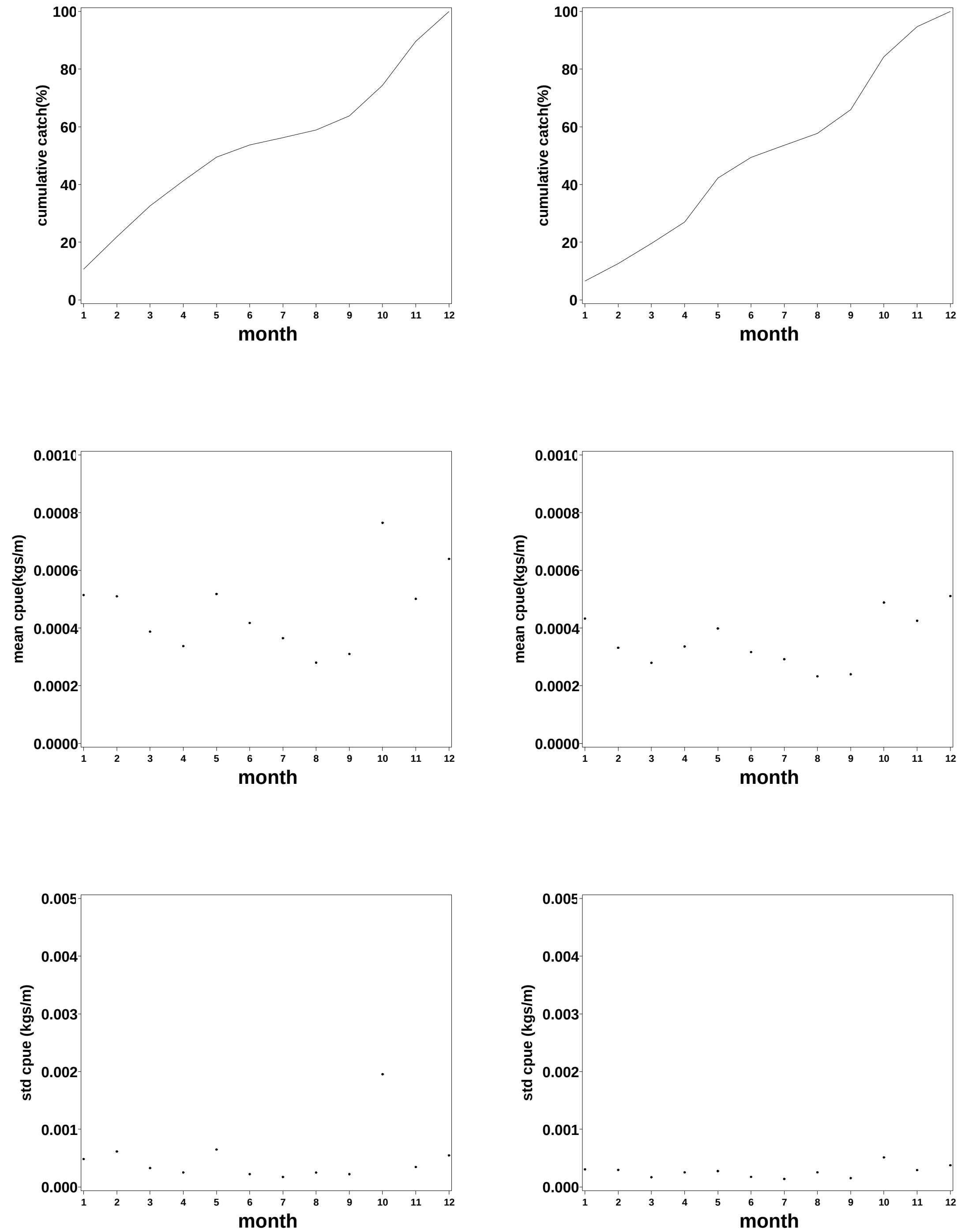



Figure 8. Distribution of deepwater flathead catches (t), mean catch rates (kg/m$^2$) and variation of catch rates with diurnal period.

## Bight redfish day

## Bight redfish night

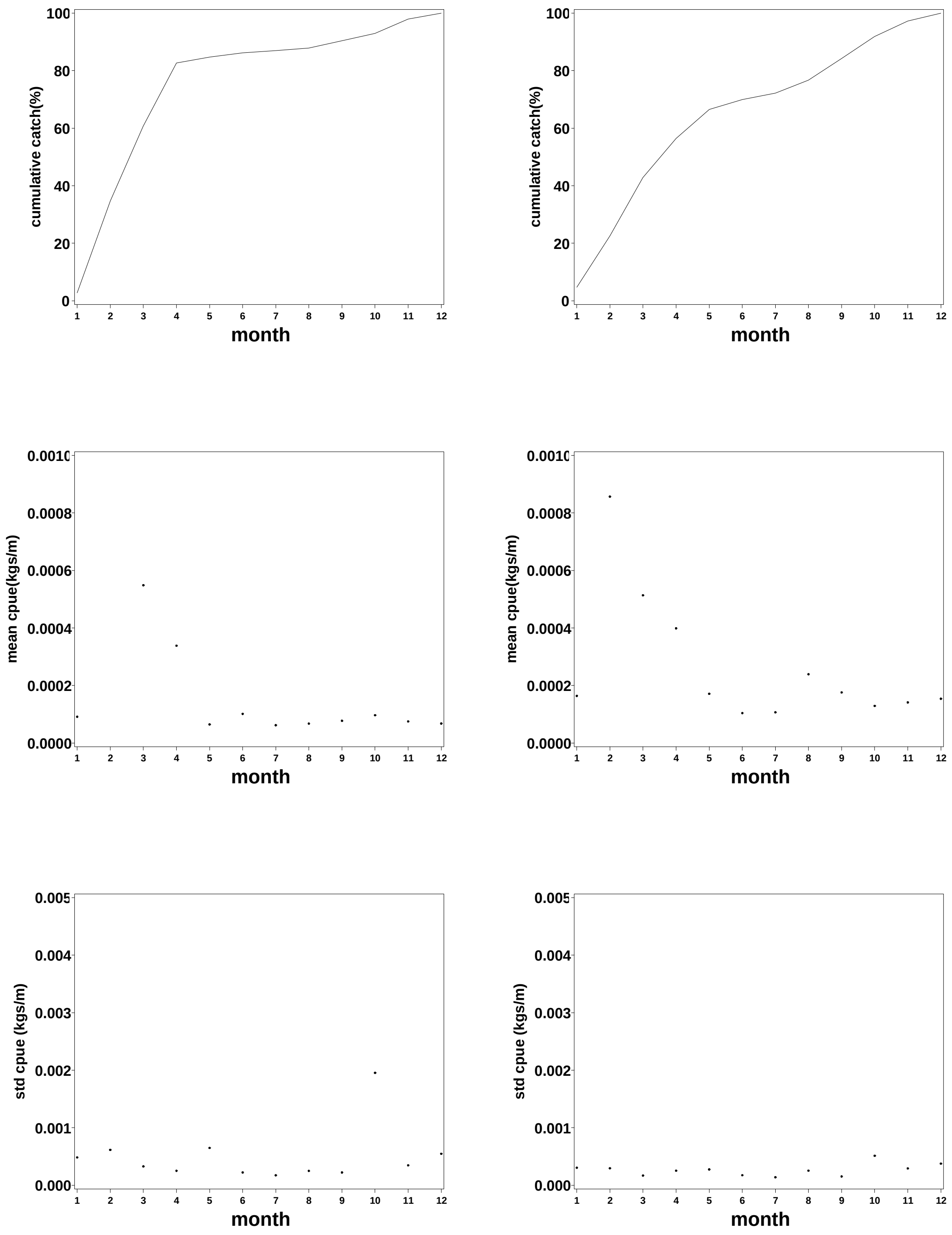



Figure 9. Distribution of Bight redfish catches (t), mean catch rates ($kg/m^2$) and variation of catch rates with diurnal period.

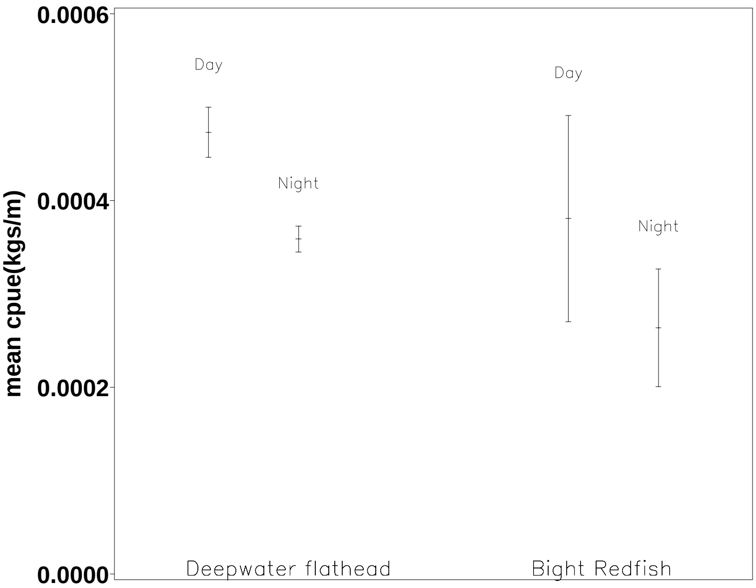



Figure 10. Mean CPUE (kg/m$^2$ +/- 2 std) of catches of Bight redfish and deepwater flathead caught during the day (0401 – 2000hrs) and night (2001 - 0400 hrs).

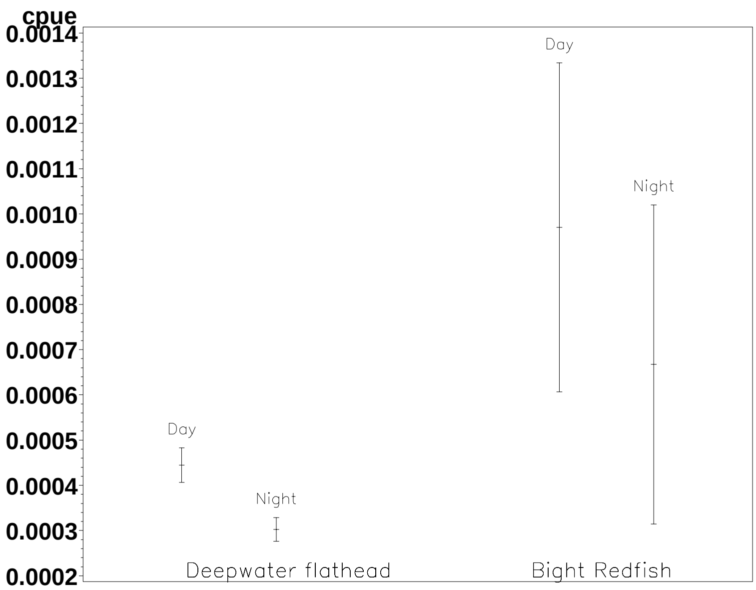
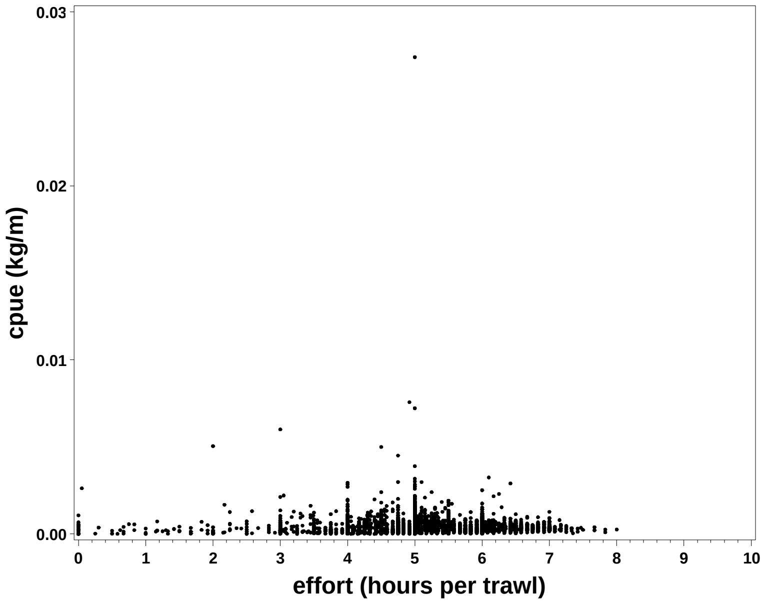



Figure 11. Mean CPUE (kg/m$^2$ +/- 2 std) of catches of Bight redfish and deepwater flathead caught during the day (0401 – 2000hrs) and night (2001 – 0400 hrs) for the months of February and March only.

## Deepwater flathead




## Bight redfish

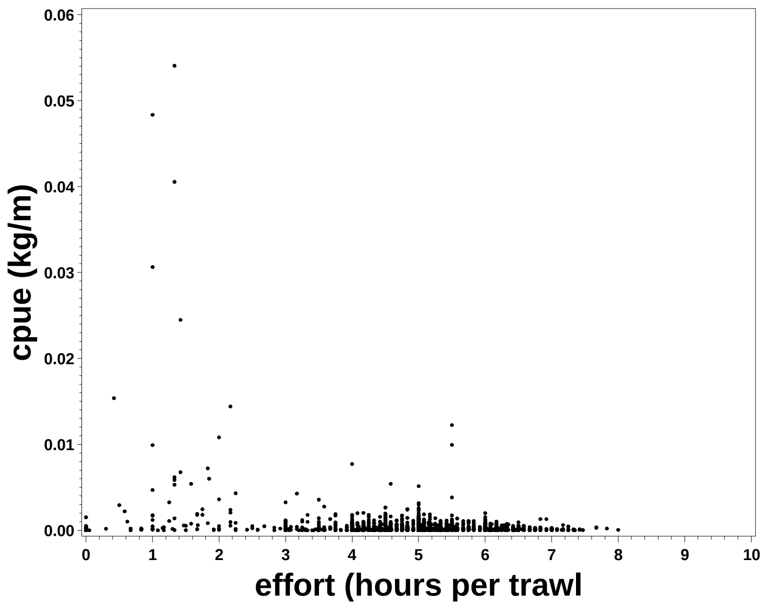
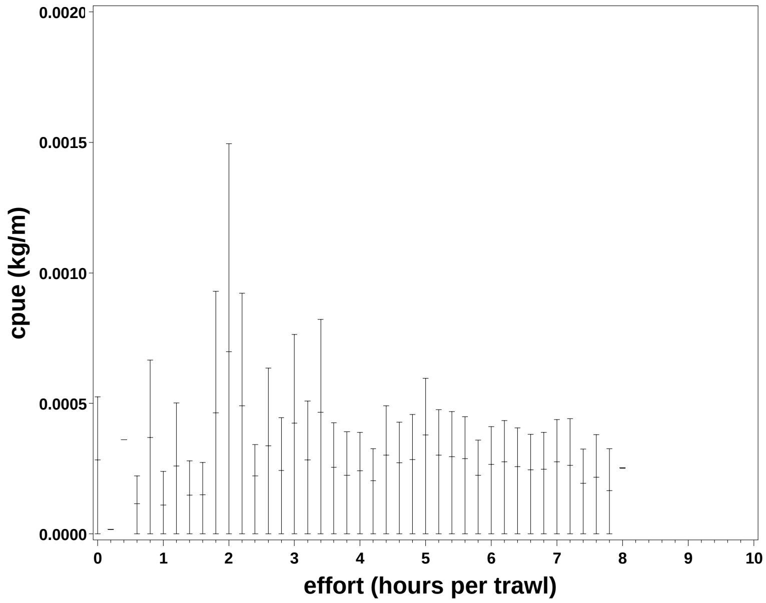



Figure 12. CPUE (kg/m$^2$) of catches of Bight redfish and deepwater flathead plotted against trawl duration.

## Deepwater flathead




## Bight redfish

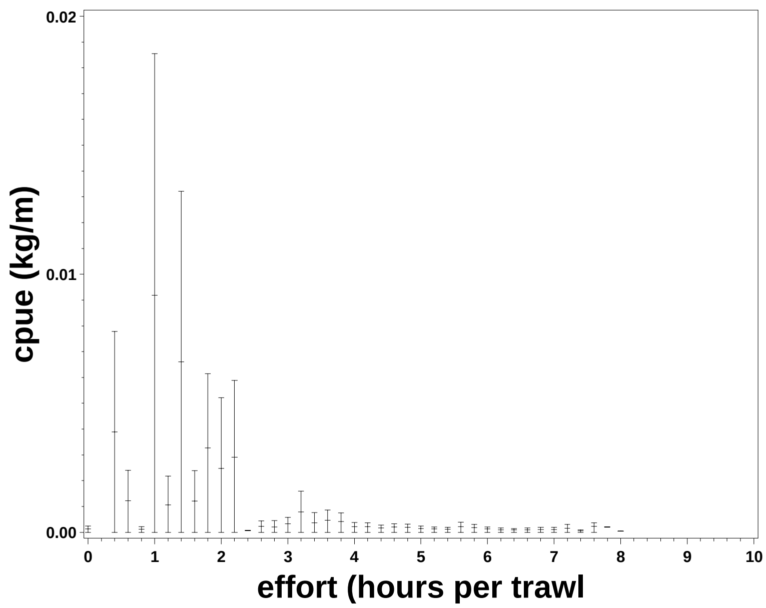



Figure 13. Mean CPUE (kg/m$^2$ +/- 2 std) of catches of Bight redfish and deepwater flathead plotted against trawl duration.

*Power analyses*

A power analysis similar to that conducted for the SEF species was undertaken for the GABTF to determine the number of tows required for a survey of the shelf resources. In this case the survey only focused on 2 species with most catches occurring in a smaller depth range (120–200m), and only 4 strata were used. As well as analysing for day/night shots, seasons were also tested and a coefficient of variation <20% was estimated to be achievable in <100 tows for both species, though there was higher variability in catches of Bight redfish. Catches, catch rates and catch rate variation were higher during February to April (Figure 4). For Bight redfish, if the survey was conducted in these months, the number of tows required to achieve a CV of 20% would be <100; at other times of the year >200. For deepwater flathead the estimates were more optimistic with <50 tows needed to achieve a CV <20%.

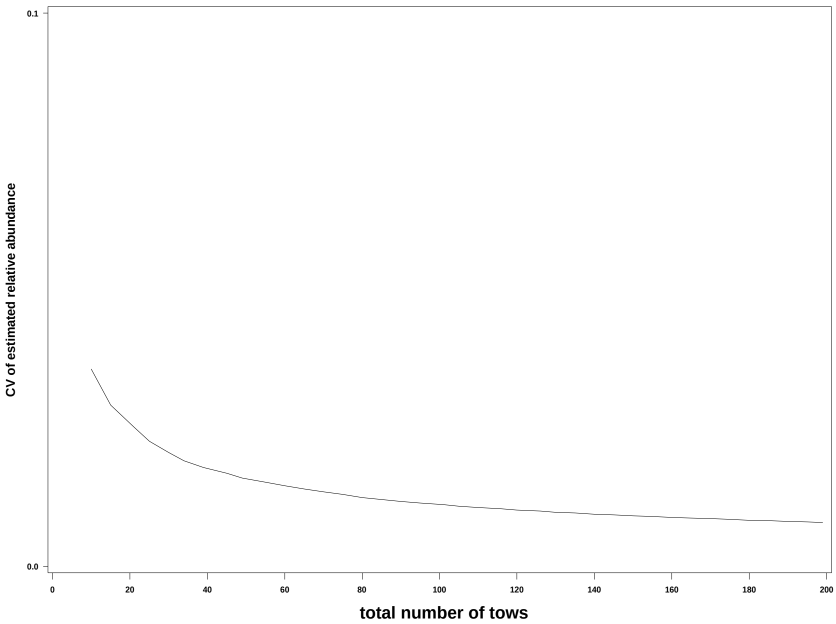
<u>Number of shots</u>

- To determine the number of hauls required in each stratum to achieve a target coefficient of variation (CV) of 20% for Bight redfish and 10% of deepwater flathead, the mean and standard deviation of catch rates (per area swept) for each haul were calculated from logbook data for each species.
- For a given number of shots, the coefficients of variation (CVs) for Bight redfish are much higher than those for deepwater flathead (Figure 14).
- Estimates of a relative abundance index (with a given precision level of 20% CV) for Bight redfish is therefore the critical factor in the survey design.
- March was the optimal month for the survey because it combined high redfish catches and low variations in catch rates, thereby producing the lowest CVs (Figure 15). To allow for potential yearly variations in the onset of good redfish catches the months of February to April also provide relatively low CVs for a low number of shots (Figure 16).
- Abundance indices based on commercial catch rate data (as used in these analyses) may underestimate the variation that will occur in a random survey because fishers are endeavouring to maximise their catch rates.

Endeavour to achieve a target CV of 20% for Bight redfish from the random survey.

A target CV of 10% should easily be achieved for deepwater flathead. 76 shots was recommended as the minimum number of shots required for the survey of the primary strata during February and March; and 35 shots for a December flathead survey.

## Deepwater flathead March




## Bight redfish March

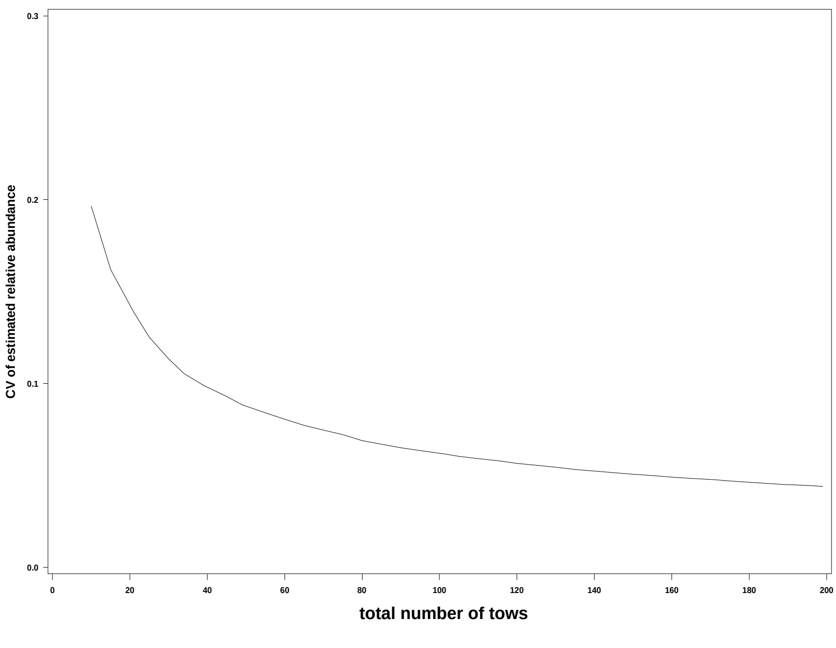
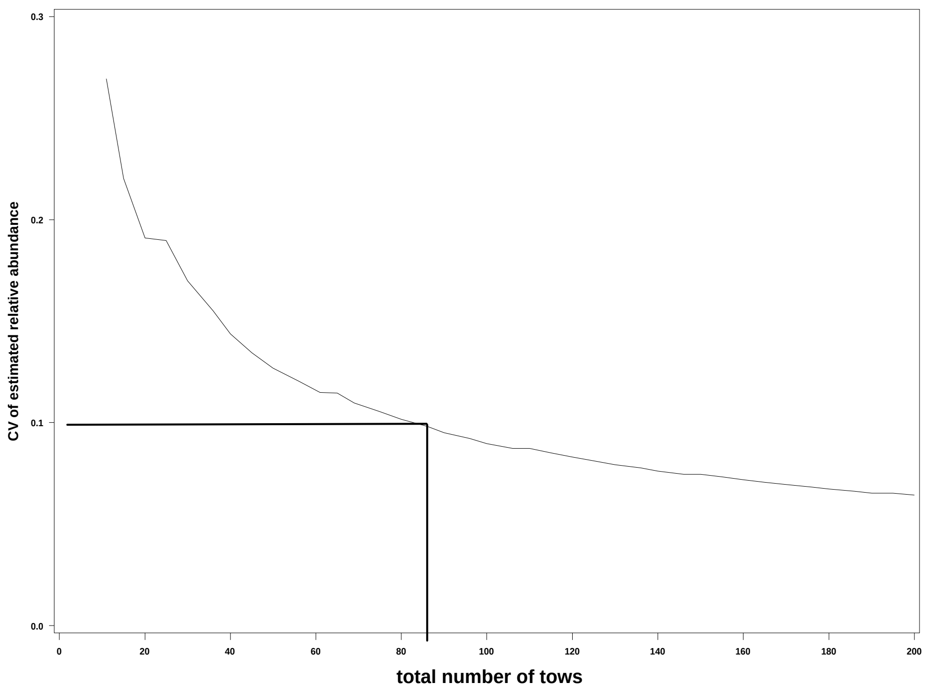



Figure 14. CV of estimated relative abundance index for Bight redfish and deepwater flathead plotted against number of shots (March only).

Bight redfish February




Bight redfish March

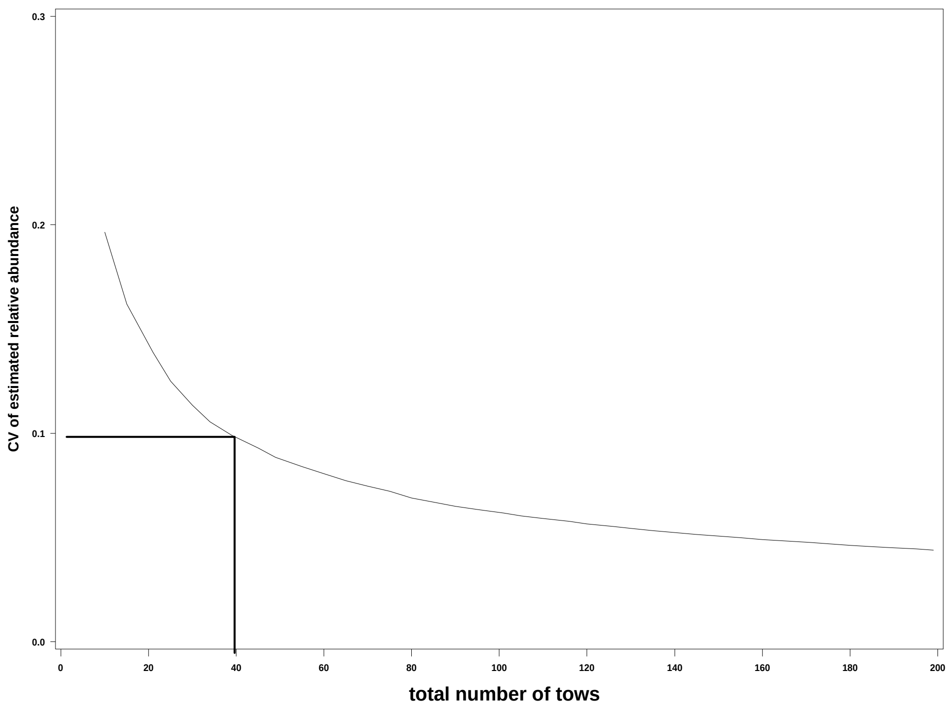
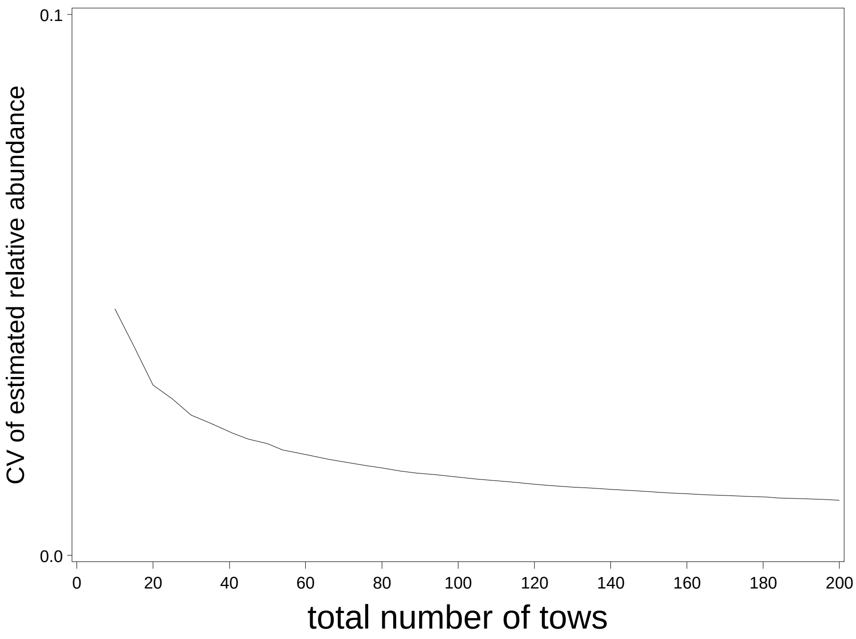



Figure 15. CV of estimated relative abundance index for Bight redfish plotted against number of shots for February and March separately. Note the larger number of shots required to achieve a CV of 0.1 in February (~80 shots) compared to March (~40 shots).

**Deepwater flathead – February to April**




**Bight redfish – February to April**

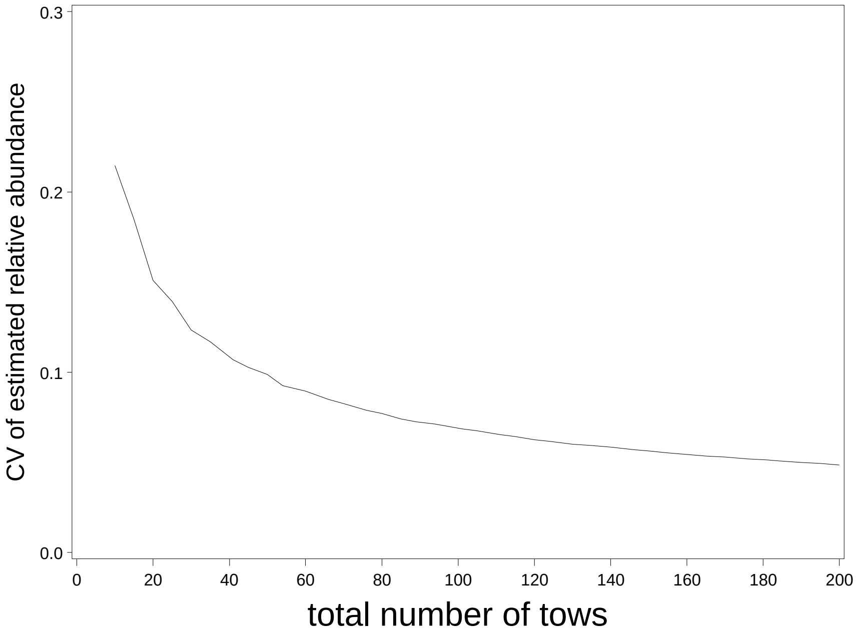



Figure 16. CV of estimated relative abundance index for Bight redfish and deepwater flathead plotted against number of shots (February – April combined).

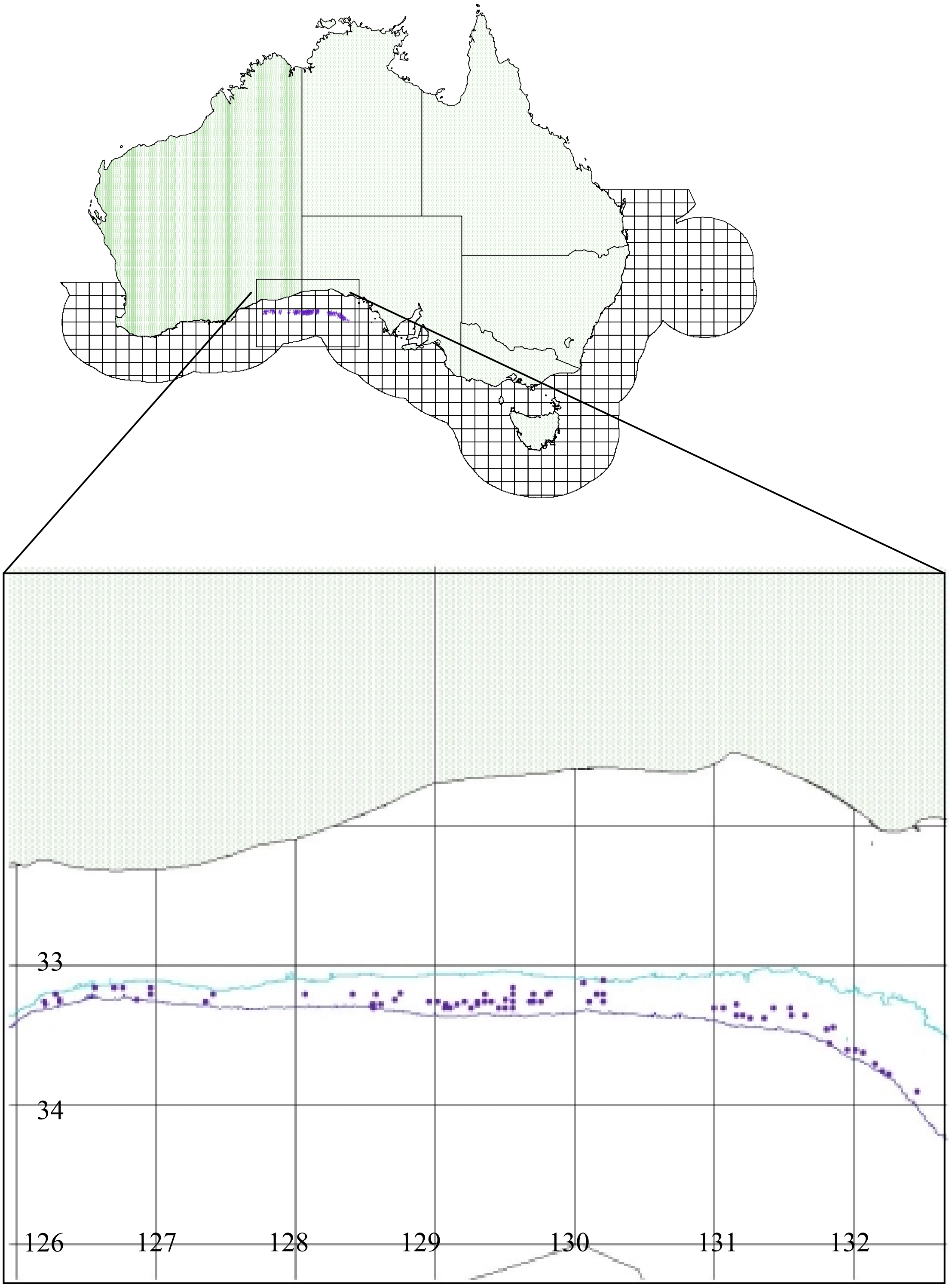



Figure 17. Shot locations for trawl survey during February/March (From Knuckey *et. al.* 2005).

*Survey Feasibility*

Fixed stations

Similar to the SETF industry members, GABIA was also concerned about the concept of "fixed-station" survey shots. Based on discussions at the initial workshop, a modified approach to conducting a survey shot at a given "fixed" random position was developed.

Shot allocation to each of the primary strata was proportional to the catch-weighted standard deviation of CPUE. Descriptions of the different strata and the number of shots allocated to each stratum are shown in Table 4. Randomly chosen positions within each stratum are provided in Table 5 and displayed in Figure 17. The recommended position for the random shot is provided in column 1, but four alternate positions are provided for each shot to allow for replacement of a position that may not be able to be fished or that might fall outside the recommended depth range. A valid shot was considered to be one in which the trawl passed within 500m of the survey shot position. This was explained diagrammatically to the survey skipper (See Appendix 3).

It was agreed that the survey would be carried out over two separate trips during February and March. During each trip, the vessel was to depart from Port Lincoln and half of the tows were conducted while travelling west from Port Lincoln, the other half completed on the return journey. The tows were to be completed in a specified order to reduce temporal biases in the data collection Figure 18. During each tow, fish were to be identified to species where possible, and total catch composition determined. Length frequency measurements were to be taken for important commercial species. Otolith samples were to be collected from flathead and redfish along with length and sex.

Vessels and gear

GABIA members agreed on the vessel that would undertake the survey based on the vessel characteristics, availability of an experienced skipper and an agreed charter price. After considering their options, the fishing vessel Explorer S was agreed to be the most suitable for the survey. It had the following specifications: length overall 30 m; beam 9 m; gross tonnage 430 t; power 1140 hp.

Because the survey was designed to get relative abundance indices for both Bight redfish and deepwater flathead, a good general net design was used but it was one that would not optimise catches of either flathead or redfish. The design of the net made for the survey is shown in Figure 19. Dimensions of the net are as follows.

Headline: Length = 32.6 m, V = 3.45, Middle to last flymesh = 3.05, Centre = 2.24.
Footline: Length = 38.5 m, V = 3.95 m Centre = 2.24.
Codend mesh = 90 mm.
Bridles = 37 m.
Sweeps = 160 m.

It was agreed that a duplicate net should be constructed for the survey in case of damage to the main net.

Quota and Markets

GABIA operators were not particularly concerned about the impact of survey-caught fish in their commercial markets. They agreed to pay the survey vessel a fixed daily charter fee to conduct the survey. It was also agreed that fish from the survey would be retained by the vessel to help offset the cost and risk of lost fishing opportunity of being involved in the survey.

Industry support

Following the initial workshop, GABIA was very supportive of the concept of a fishery-independent survey for the shelf resources of the GABTF. This was largely driven by industry's desire for a better understanding on the extent of the shelf resources of their main target species, deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*) and the level of impact that fishing might be having on these resources. As explained below, however, there were also a number of other issues in the fishery that gave incentive for industry to support a fishery-independent survey.

At the time of this project, the GABTF was managed primarily by input controls limiting the number of operators in the fishery to ten. Only a small number of the ten SFR holders had been active in the fishery during any one year over the decade to 2002. Catch and effort data from these vessel's logbooks showed no overall trend in catch rates for either deepwater flathead or Bight redfish and there was little contrast in these data. Time series data on length- and age- frequency also did not indicate any significant impact on the resources from this level of fishing. The stock assessment models for Bight redfish and deepwater flathead were advanced, but suffered from this lack of contrast in any of the main fishery indicators. As a result, there was considerable uncertainty surrounding model outputs and estimates of stock biomass obtained from these models.

There was increased participation in the fishery and significant increases in fishing effort and fishing efficiency of active vessels during 2003 and 2004. Given the uncertain status of the stocks, this raised concerns about future sustainability of the shelf resources. Under this scenario, industry has agreed that quota management of the main target species should be introduced. They also agreed on equal allocation of quota between the ten SFR holders.

With the impending introduction of quotas, there was concern that low TACs would be introduced based on the uncertainty of biomass estimates resulting from the stock assessment models and this might have inhibited the sustainable development of the fishery. Moreover, once quotas were introduced it was believed that the use of commercial CPUE data as the main index of abundance in these models would be compromised and would be unlikely to provide the contrast that is needed to improve model outputs. This provided significant incentive for industry to adopt a fishery-independent survey to begin a time-series of relative abundance indices for deepwater flathead and Bight redfish that could be used as an input to the stock assessment models.

Finally, despite scientific advice that the survey was designed to provide a relative index of abundance rather than an absolute measure, industry realised that ball-park estimates of absolute abundance of Bight redfish and deepwater flathead could be estimated from the survey (despite scientific warnings of high uncertainty and potentially invalid assumptions) and that these could be used as additional information to help support the setting of appropriate TACs for 2006.

It was under the above conditions that Industry supported this project and the concept of conducting a fishery-independent survey of the shelf resources of the GABTF. Initial estimates of the cost of the survey were $250,000. The largest component of the budget was the $160,000 charter fees required for nearly 30 days of survey. Other main budget components were $45,000 for operational costs and $45,000 for observer and scientific salaries. GABIA agreed that the survey costs would be shared equally between all 10 SFR holders. Ultimately, GABIA agreed to conduct the first year of the survey in 2005.

Table 4. Distribution of survey shots required in each primary longitudinal stratum. Allocation of shots to the strata was proportional to the catch-weighted standard deviation of CPUE. Power analysis indicated that the total number of required shots was 76.

| Stratum | Longitude W | Longitude E | Depth Max. (m) | Depth Min. (m) | % of shots in stratum | No. of shots |
|---|---|---|---|---|---|---|
| WEST 1 | *126° 00′* | *127° 45′* | 200 | 120 | 17% | 14 |
| WEST 2 | *127° 45′* | *129° 00′* | 200 | 120 | 11% | 8 |
| CENTRAL 1 | *129° 00′* | *130° 15′* | 200 | 120 | 42% | 32 |
| CENTRAL 2 | *131° 00′* | *132° 30′* | 200 | 120 | 28% | 22 |
| | | | | | | |
| INSHORE | *125° 00′* | *129° 00′* | 120 | 50 | | 10 |
| | | | | | | |

Table 5. Random positions for survey shots required in each primary longitudinal stratum.

| Survey Stratum | Shot | Trip | Order | Recommended random position | | Alternate random position 1 | | Alternate random position 2 | | Alternate random position 3 | | Alternate random position 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Lat | Long | Lat | Long | Lat | Long | Lat | Long | Lat | Long |
| CENTRAL 2 | 1 | 1 | 1 | 33 55 | 132 28 | 33 17 | 130 49 | 33 22 | 131 54 | 33 21 | 131 28 | 33 23 | 131 40 |
| CENTRAL 2 | 10 | 1 | 2 | 33 43 | 132 10 | 33 58 | 132 24 | 33 46 | 131 28 | 33 17 | 131 25 | 33 22 | 131 49 |
| CENTRAL 2 | 5 | 1 | 3 | 33 27 | 131 52 | 34 2. | 132 30 | 33 37 | 132 04 | 33 19 | 130 58 | 33 17 | 131 10 |
| CENTRAL 2 | 19 | 1 | 4 | 33 37 | 131 46 | 33 22 | 131 07 | 33 19 | 131 04 | 33 28 | 131 48 | 33 31 | 131 58 |
| CENTRAL 2 | 18 | 1 | 5 | 33 23 | 131 22 | 33 23 | 131 26 | 33 23 | 131 19 | 33 32 | 131 58 | 33 19 | 130 55 |
| CENTRAL 1 | 12 | 1 | 6 | 33 16 | 130 13 | 33 13 | 130 05 | 33 19 | 129 1. | 33 16 | 129 58 | 33 10 | 129 50 |
| CENTRAL 1 | 25 | 1 | 7 | 33 07 | 130 13 | 33 19 | 129 10 | 33 12 | 130 5. | 33 13 | 130 1. | 33 17 | 129 25 |
| CENTRAL 1 | 32 | 1 | 8 | 33 16 | 130 07 | 33 19 | 129 07 | 33 15 | 129 41 | 33 19 | 129 7. | 33 16 | 129 31 |
| CENTRAL 1 | 17 | 1 | 9 | 33 13 | 129 49 | 33 13 | 129 28 | 33 19 | 129 16 | 33 15 | 130 1. | 33 16 | 130 7. |
| CENTRAL 1 | 20 | 1 | 10 | 33 16 | 129 41 | 33 15 | 130 00 | 33 08 | 129 56 | 33 8. | 129 46 | 33 13 | 129 7. |
| CENTRAL 1 | 4 | 1 | 11 | 33 13 | 129 34 | 33 19 | 129 16 | 33 17 | 129 16 | 33 19 | 129 19 | 33 17 | 129 28 |
| CENTRAL 1 | 5 | 1 | 12 | 33 16 | 129 25 | 33 15 | 129 22 | 33 10 | 129 43 | 33 7. | 130 13 | 33 10 | 130 4. |
| CENTRAL 1 | 7 | 1 | 13 | 33 16 | 129 19 | 33 15 | 129 22 | 33 10 | 129 40 | 33 15 | 129 55 | 33 17 | 129 4. |
| CENTRAL 1 | 1 | 1 | 14 | 33 17 | 129 10 | 33 13 | 129 37 | 33 10 | 129 39 | 33 16 | 129 31 | 33 16 | 129 4. |
| CENTRAL 1 | 28 | 1 | 15 | 33 19 | 129 04 | 33 16 | 130 15 | 33 13 | 130 8 | 33 19 | 130 0 | 33 16 | 130 7. |
| WEST 2 | 9 | 1 | 16 | 33 17 | 128 33 | 33 15 | 128 13 | 33 16 | 127 49 | 33 16 | 128 5. | 33 16 | 128 31 |
| WEST 2 | 5 | 1 | 17 | 33 13 | 128 04 | 33 13 | 128 33 | 33 15 | 127 46 | 33 16 | 128 37 | 33 19 | 128 58 |
| WEST 1 | 12 | 1 | 18 | 33 10 | 126 58 | 33 17 | 126 17 | 33 13 | 126 49 | 33 16 | 126 13 | 33 17 | 126 17 |
| WEST 1 | 9 | 1 | 19 | 33 16 | 126 19 | 33 16 | 127 22 | 33 19 | 126 7. | 33 13 | 126 55 | 33 16 | 126 16 |
| WEST 1 | 6 | 1 | 20 | 33 17 | 126 13 | 33 13 | 126 10 | 33 13 | 126 25 | 33 12 | 126 25 | 33 13 | 126 28 |
| WEST 1 | 2 | 1 | 21 | 33 13 | 126 17 | 33 17 | 126 13 | 33 13 | 126 17 | 33 13 | 127 1. | 33 16 | 126 7. |
| WEST 1 | 7 | 1 | 22 | 33 10 | 126 42 | 33 13 | 126 43 | 33 16 | 126 13 | 33 15 | 127 16 | 33 15 | 126 0 |
| WEST 1 | 13 | 1 | 23 | 33 13 | 126 58 | 33 17 | 126 01 | 33 12 | 126 49 | 33 19 | 126 2. | 33 10 | 126 55 |
| WEST 2 | 2 | 1 | 24 | 33 13 | 128 25 | 33 17 | 128 43 | 33 16 | 128 45 | 33 16 | 128 18 | 33 16 | 128 28 |
| WEST 2 | 6 | 1 | 25 | 33 17 | 128 37 | 33 15 | 128 25 | 33 19 | 128 46 | 33 16 | 127 58 | 33 15 | 128 46 |
| CENTRAL 1 | 18 | 1 | 26 | 33 19 | 129 07 | 33 19 | 129 54 | 33 19 | 129 34 | 33 12 | 130 15 | 33 15 | 130 13 |
| CENTRAL 1 | 30 | 1 | 27 | 33 16 | 129 13 | 33 16 | 129 52 | 33 12 | 129 28 | 33 12 | 129 49 | 33 10 | 129 52 |
| CENTRAL 1 | 8 | 1 | 28 | 33 16 | 129 22 | 33 19 | 129 03 | 33 16 | 129 49 | 33 12 | 129 31 | 33 12 | 129 55 |
| CENTRAL 1 | 2 | 1 | 29 | 33 19 | 129 31 | 33 19 | 129 43 | 33 12 | 129 37 | 33 16 | 129 18 | 33 13 | 129 22 |
| CENTRAL 1 | 24 | 1 | 30 | 33 19 | 129 34 | 33 19 | 129 16 | 33 17 | 129 16 | 33 15 | 130 1. | 33 16 | 129 9. |
| CENTRAL 1 | 15 | 1 | 31 | 33 13 | 129 43 | 33 13 | 129 52 | 33 10 | 129 50 | 33 17 | 129 58 | 33 17 | 129 33 |
| CENTRAL 1 | 3 | 1 | 32 | 33 08 | 130 04 | 33 13 | 129 25 | 33 13 | 130 10 | 33 10 | 129 46 | 33 16 | 129 48 |
| CENTRAL 1 | 14 | 1 | 33 | 33 13 | 130 10 | 33 13 | 129 50 | 33 10 | 129 34 | 33 19 | 129 4. | 33 10 | 129 52 |
| CENTRAL 1 | 11 | 1 | 34 | 33 13 | 130 13 | 33 10 | 129 52 | 33 13 | 129 50 | 33 19 | 129 5. | 33 16 | 129 7. |
| CENTRAL 2 | 17 | 1 | 35 | 33 22 | 131 13 | 33 58 | 132 28 | 33 45 | 132 16 | 33 40 | 132 7. | 33 22 | 131 54 |
| CENTRAL 2 | 6 | 1 | 36 | 33 22 | 131 34 | 33 58 | 132 28 | 33 27 | 131 43 | 34 1. | 132 38 | 33 31 | 131 49 |
| CENTRAL 2 | 4 | 1 | 37 | 33 25 | 131 46 | 33 19 | 131 25 | 33 57 | 132 25 | 33 17 | 130 48 | 33 19 | 131 33 |
| CENTRAL 2 | 13 | 1 | 38 | 33 38 | 132 04 | 33 17 | 130 45 | 33 19 | 130 46 | 33 17 | 130 46 | 33 22 | 131 9. |
| CENTRAL 2 | 11 | 1 | 39 | 33 46 | 132 13 | 33 42 | 132 03 | 33 22 | 131 26 | 33 25 | 131 43 | 33 25 | 131 46 |
| | | | | | | | | | | | | | |
| CENTRAL 2 | 9 | 2 | 1 | 33 47 | 132 16 | 33 28 | 131 48 | 33 22 | 131 16 | 33 17 | 130 49 | 33 37 | 131 46 |
| CENTRAL 2 | 21 | 2 | 2 | 33 37 | 131 58 | 33 21 | 131 19 | 33 19 | 131 26 | 33 25 | 131 31 | 33 17 | 131 0 |
| CENTRAL 2 | 8 | 2 | 3 | 33 28 | 131 49 | 33 36 | 131 52 | 33 19 | 131 13 | 33 19 | 130 46 | 33 55 | 132 24 |
| CENTRAL 2 | 14 | 2 | 4 | 33 19 | 131 26 | 33 36 | 131 58 | 33 23 | 131 31 | 33 17 | 130 56 | 33 22 | 131 25 |
| CENTRAL 2 | 20 | 2 | 5 | 33 22 | 131 10 | 33 34 | 131 55 | 33 25 | 131 31 | 33 22 | 131 3. | 33 40 | 132 10 |
| CENTRAL 2 | 15 | 2 | 6 | 33 28 | 130 58 | 33 19 | 131 00 | 33 46 | 132 15 | 33 22 | 131 7. | 33 17 | 130 45 |
| CENTRAL 1 | 23 | 2 | 7 | 33 16 | 129 46 | 33 13 | 129 37 | 33 19 | 129 34 | 33 18 | 129 37 | 33 19 | 129 13 |
| CENTRAL 1 | 13 | 2 | 8 | 33 16 | 129 34 | 33 19 | 129 25 | 33 12 | 129 40 | 33 16 | 129 0 | 33 15 | 129 28 |
| CENTRAL 1 | 9 | 2 | 9 | 33 15 | 129 31 | 33 19 | 129 09 | 33 13 | 129 34 | 33 13 | 129 56 | 33 13 | 129 46 |
| CENTRAL 1 | 31 | 2 | 10 | 33 13 | 129 22 | 33 19 | 129 11 | 33 13 | 129 49 | 33 17 | 130 7. | 33 10 | 129 37 |
| CENTRAL 1 | 27 | 2 | 11 | 33 19 | 129 16 | 33 16 | 129 33 | 33 13 | 129 43 | 33 12 | 129 43 | 33 10 | 129 52 |
| CENTRAL 1 | 22 | 2 | 12 | 33 17 | 129 05 | 33 19 | 129 28 | 33 10 | 129 52 | 33 13 | 129 49 | 33 16 | 129 39 |
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| WEST 2 | 10 | 2 | 14 | 33 15 | 128 43 | 33 15 | 128 48 | 33 13 | 128 22 | 33 16 | 128 4. | 33 16 | 128 1. |
| WEST 2 | 4 | 2 | 15 | 33 19 | 128 34 | 33 16 | 128 34 | 33 16 | 127 45 | 33 15 | 127 47 | 33 16 | 128 31 |
| WEST 1 | 4 | 2 | 16 | 33 13 | 127 25 | 33 13 | 126 31 | 33 17 | 126 15 | 33 10 | 126 38 | 33 12 | 126 54 |
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| WEST 1 | 5 | 2 | 18 | 33 16 | 126 22 | 33 16 | 127 43 | 33 10 | 126 34 | 33 16 | 127 43 | 33 13 | 126 19 |
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| WEST 1 | 11 | 2 | 20 | 33 15 | 126 19 | 33 16 | 126 19 | 33 13 | 127 10 | 33 15 | 126 25 | 33 13 | 126 25 |
| WEST 1 | 3 | 2 | 21 | 33 10 | 126 46 | 33 16 | 126 16 | 33 19 | 126 1. | 33 19 | 126 4. | 33 13 | 126 42 |
| WEST 1 | 1 | 2 | 22 | 33 16 | 127 22 | 33 12 | 126 17 | 33 12 | 126 35 | 33 16 | 126 25 | 33 16 | 127 12 |
| WEST 2 | 3 | 2 | 23 | 33 17 | 128 34 | 33 16 | 128 25 | 33 19 | 128 40 | 33 15 | 128 11 | 33 16 | 127 49 |
| WEST 2 | 8 | 2 | 24 | 33 13 | 128 35 | 33 13 | 128 16 | 33 12 | 128 34 | 33 19 | 128 34 | 33 16 | 128 35 |
| WEST 2 | 7 | 2 | 25 | 33 12 | 128 45 | 33 13 | 128 43 | 33 10 | 128 19 | 33 12 | 128 45 | 33 15 | 127 57 |
| CENTRAL 1 | 26 | 2 | 26 | 33 16 | 129 01 | 33 16 | 129 45 | 33 13 | 129 49 | 33 10 | 129 38 | 33 16 | 129 18 |
| CENTRAL 1 | 16 | 2 | 27 | 33 16 | 129 13 | 33 17 | 129 11 | 33 13 | 129 28 | 33 16 | 130 15 | 33 16 | 129 43 |
| CENTRAL 1 | 21 | 2 | 28 | 33 17 | 129 19 | 33 15 | 129 46 | 33 17 | 129 5. | 33 19 | 129 0 | 33 19 | 129 15 |
| CENTRAL 1 | 6 | 2 | 29 | 33 19 | 129 28 | 33 17 | 129 04 | 33 13 | 129 7. | 33 10 | 129 58 | 33 16 | 129 1. |
| CENTRAL 1 | 29 | 2 | 30 | 33 10 | 129 34 | 33 07 | 130 11 | 33 19 | 129 24 | 33 17 | 130 4. | 33 16 | 130 1. |
| CENTRAL 1 | 19 | 2 | 31 | 33 16 | 129 43 | 33 10 | 129 50 | 33 16 | 129 34 | 33 13 | 129 55 | 33 16 | 129 43 |
| CENTRAL 1 | 10 | 2 | 32 | 33 12 | 129 50 | 33 16 | 129 37 | 33 7. | 130 13 | 33 13 | 130 7. | 33 12 | 129 34 |
| CENTRAL 2 | 2 | 2 | 33 | 33 17 | 131 10 | 33 22 | 131 20 | 33 27 | 131 16 | 33 17 | 131 4. | 33 22 | 131 43 |
| CENTRAL 2 | 16 | 2 | 34 | 33 23 | 131 16 | 33 16 | 130 58 | 33 17 | 130 50 | 33 52 | 131 52 | 33 22 | 131 40 |
| CENTRAL 2 | 12 | 2 | 35 | 33 22 | 131 40 | 33 25 | 131 19 | 33 19 | 131 7. | 33 52 | 132 22 | 33 21 | 131 37 |
| CENTRAL 2 | 3 | 2 | 36 | 33 34 | 131 50 | 33 21 | 131 37 | 33 31 | 131 54 | 33 25 | 131 28 | 33 28 | 131 43 |
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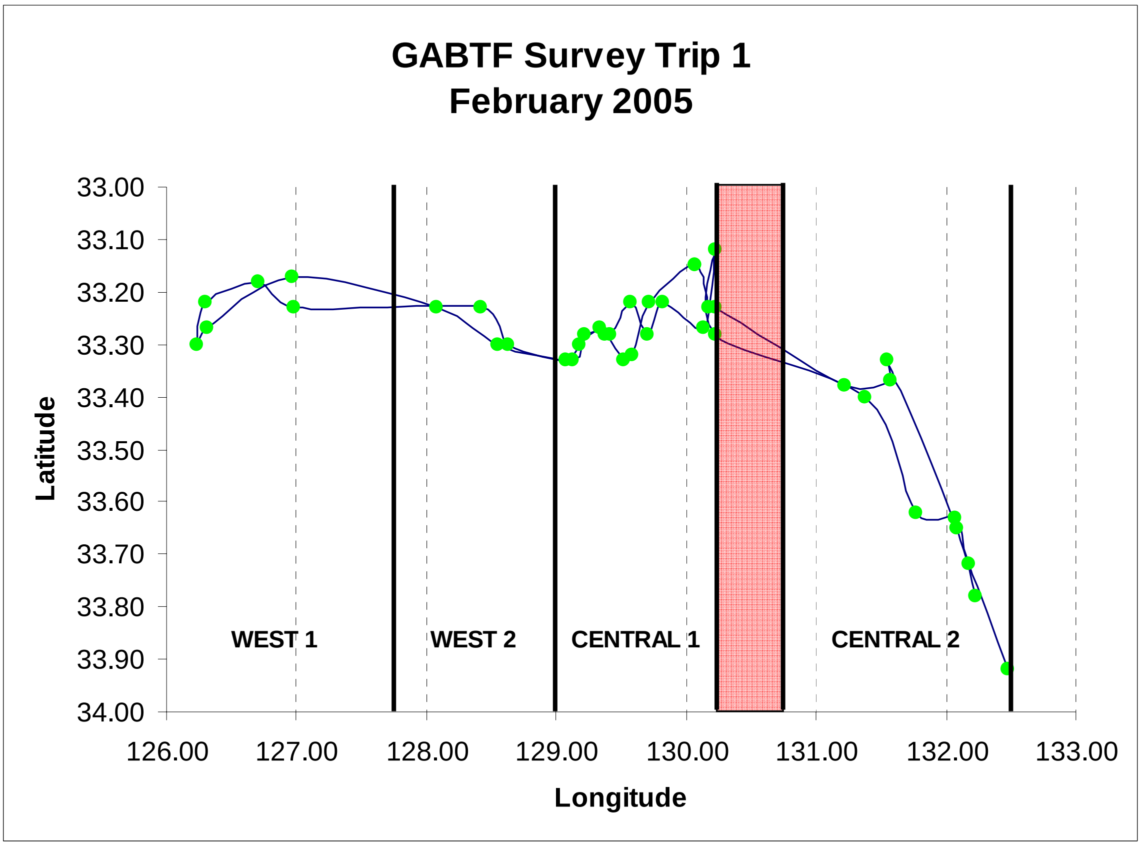


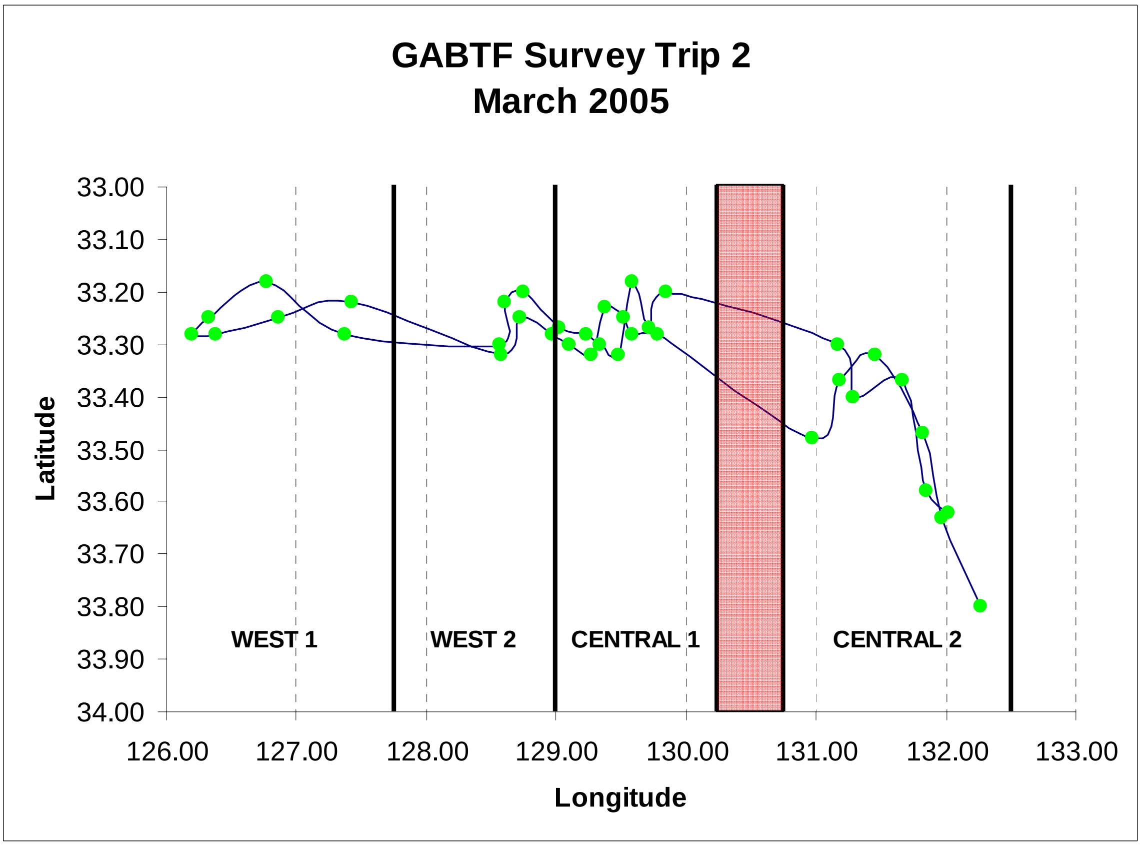


Figure 18. Schematic representation of the position and order of survey shots to be undertaken during the two survey trips. The shaded area represents the Marine Protected Area in which no survey shots could be taken.

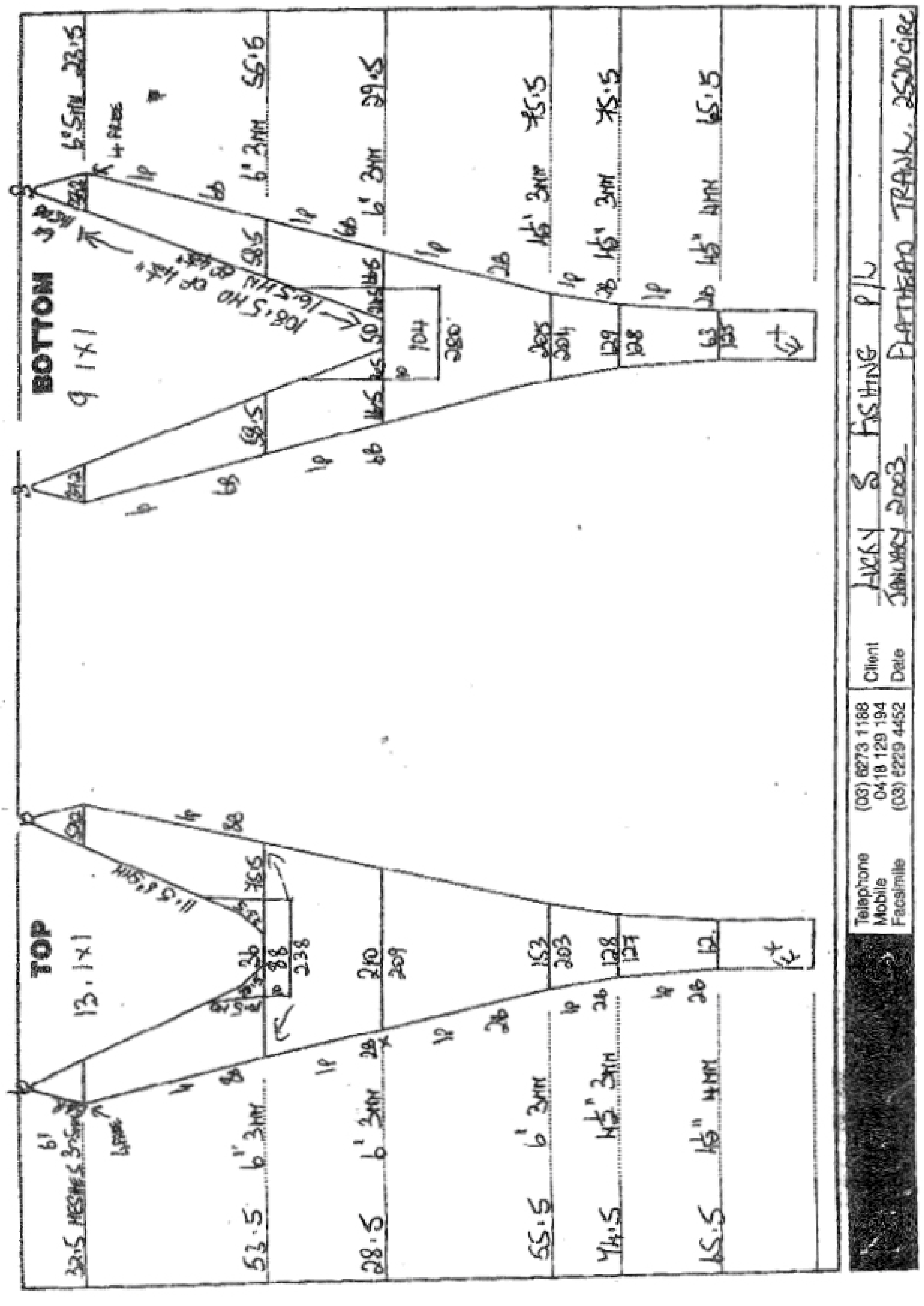


Figure 19. Schematic diagram of the agreed net design to be used for the survey.

## BENEFITS AND ADOPTION

During this project two case-studies were investigated as potentials for the implementation of an industry-based fishery-independent survey: the SETF and the GABTF. The potential benefits and adoption of the project results were quite different for the two fisheries. The industry members of the SETF, while supportive of this project, decided it was not feasible to conduct a fishery-independent survey in the current financial climate of the fishery. Whilst recognising that it was technically feasible, the costs were considered prohibitive. The industry members of the GABTF, on the other hand, could clearly see the potential benefits of the project despite the potential costs and continued with the full development and implementation of a fishery-independent survey. The full benefits of this project were realised with GABIA operators agreeing to adopt the survey design developed in the project and establish an ongoing fishery-independent survey to begin in 2005. Subsequently, successful surveys were conducted during February, April and December 2005 and again in 2006, providing relative abundance estimates for Bight redfish and deepwater flathead (Knuckey *et al*. 2005) that were incorporated into the stock assessments. While this has been a big step forward, the full benefits of this project will be realised with the development of a long time-series of robust fishery-independent indices of abundance for the key species on the GABTF shelf.

## FURTHER DEVELOPMENT

The potential for further work is dependent on the different fisheries. In the GABTF, as a direct result of this project, successful industry-based fishery-independent surveys have been conducted in 2005 and 2006 and funding has been provided to continue the surveys in 2007 and 2008. This shows a level of commitment by industry to the value of such surveys for the long-term management of the fishery. Further work will involve ensuring the commitment to conduct the survey remains ongoing and that any refinements that might be made to the survey design in the future do not compromise its value as a long term index of abundance. In the SETF, there is a need to keep working with industry to convey the potential value of such a survey. This was not able to be achieved in the term of the project, but may be more likely to occur of the economic situation in the fishery improves as a result the restructure of the fishery that occurred during 2006.

## PLANNED OUTCOMES

In the planned outcomes of the project proposal it was stated that a positive outcome would be "an agreement by industry and SEFAG to implement a long-term industry-based survey to monitor the SEF". The two workshops highlighted the shortcomings of using CPUE data as an index of abundance and raised the profile and value of fishery-independent surveys amongst industry. This project has established the foundations for undertaking independent surveys in trawl fisheries in Commonwealth waters. The subsequent success of the GABTF survey has given the survey method strong credibility, and may encourage participants in the SETF to adopt an industry-based fishery-independent survey for their fishery.

That the project outcomes were achieved successfully is probably best reflected in ongoing support by GABIA to fund and conduct the GABTF survey. In the SETF, initial industry support was not as strong, but subsequent to the structural adjustment it is recognised that fishery-independent surveys will be an integral part of the fishery. This is reflected in Section 3.7 of AFMA's response to the Ministerial Direction for the SESSF which states "A fishery-independent survey will be implemented in the SESSF. This will be based on the model developed in the GABT Sector, which was developed in 2005. The FIS will provide independent estimates of abundance for the main SESSF quota species". The current project formed the foundation of this commitment. The subsequent project FRDC 2006/028 "Implementation of fishery-independent surveys for the Southern and Eastern Scalefish and Shark Fishery" will ensure this commitment is achieved.

## CONCLUSION

This project demonstrated that industry-based fishery-independent surveys are a feasible means of collecting independent indices of fish abundance. Subsequent surveys carried out in the GABTF as a result of this project have demonstrated that industry vessels can be a very cost-effective and suitable platform from which to undertake fishery-independent surveys and achieve scientifically robust results. This can only work, however, if there is strong support from the majority of industry and strict scientific guidelines are in place to underpin the survey. The importance of spending the time to discuss and agree on the survey design is absolutely critical to gain the support of all stakeholders, including industry, scientists and managers. This is more difficult, but all the more important, in multi-species, spatially diverse fisheries in which there are a lot of operators. It should also be recognised that in multi-species fisheries, the target precision for abundance indices may not be achieved in a cost effective manner for every key species. Due to aspects of their life histories or spatial / temporal distributions, target CVs may not be achieved for certain fish species (eg. blue eye trevalla, blue warehou, gemfish, redfish, and silver trevally in the SETF). In these cases, stakeholders may need to accept less precision in abundance estimates. Alternatively, more intense surveys (more shot samples) or separate surveys focused specifically on these species could be implemented, but this would come at a significantly greater cost. Regardless of the options taken, there is no doubt that the implementation of fishery-independent surveys will be a tremendous step forward for both the GABTF and SETF over the current use of commercial CPUE data for providing indices of abundance.

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## APPENDIX 1 INTELLECTUAL PROPERTY

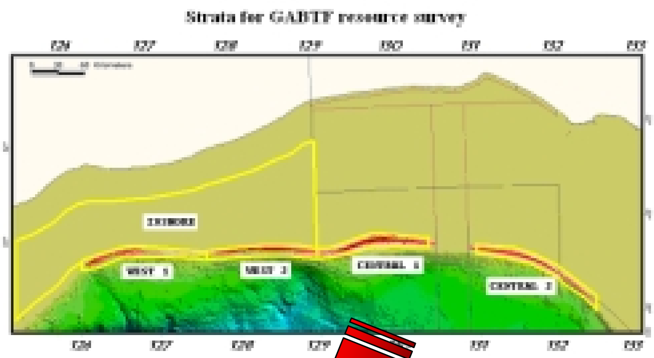
No intellectual propery was developed as part of this project. The knowledge gained through this project is shared between the Fisheries Research Development and Fishwell Consulting and is available to the broader Australian fishing industry.

## APPENDIX 2 PROJECT STAFF

Dr Ian Knuckey was the Principal Investigator and fisheries scientist involved in the project. Anne Gason was the biometrician with assistance from Dr Mike Bergh and Dr Paul Starr. Mrs Gail Richey was the Executive Officer for SETFIA and GABIA and coordinated the input of industry members from both associations.

# APPENDIX 3 A VALID SURVEY SHOT

1

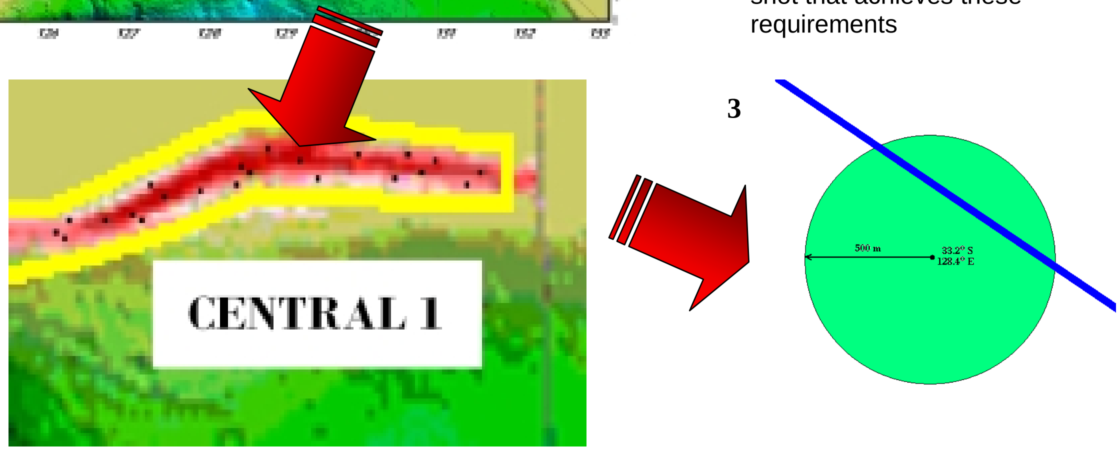



Conducting a valid survey shot

1. Four primary strata in the survey
2. A number of randomly chosen Lat/Long locations have been allocated within each stratum
3. A valid survey shot must pass within 500m of the specific Lat/Long location
4. The skipper chooses a 2.5 hour shot that achieves these requirements

2

3




**Invalid shots**

**Valid shots**

**Valid shots**