ISSN 0817 - 3680

Technical Report 23

An Analysis of Catch Statistics from the South-Western Sector of the Australian South-East Demersal Trawl Fishery

Ian Woodward

1987

DEPARTMENT OF SEA FISHERIES, TASMANIA
MARINE LABORATORIES

Technical Report 23

An Analysis of Catch Statistics from the South-Western Sector of the Australian South-East Demersal Trawl Fishery

Ian Woodward

1987

DEPARTMENT OF SEA FISHERIES, TASMANIA.
MARINE LABORATORIES
CRAYFISH POINT, TAROONA
AUSTRALIA 7006

CONTENTS

An Analysis of Catch Statistics from the South-Western Sector of the Australian South-East Demersal Trawl Fishery

Ian Woodward

ABSTRACT

Catch statistics for 13 species from commercial and research trawls conducted between 1979 and 1984 in the southern areas of the South-East Trawl fishery are examined. Catch and catch per swept area from demersal trawls were stratified by position, depth and month and shots were subsequently amalgamated into statistically different groupings. It is suggested that these groups be targetted by fisheries managers for particular attention when conducting biological studies of the fish stocks. A novel management regime based on deliberate over exploitation of selected discrete stocks is proposed and it is argued that only a combination of biological studies and experimental manipulation can lead to a reliable management strategy. It is suggested that catch per unit effort of trawl could never be refined to the extent required by any reasonable population model and that CPUE is valid only for models of that part of the fishery that exists above sea level, such as the economic component. This report was prepared for the Tasmanian Department of Sea Fisheries FIRTA Grant 86/45.

1 INTRODUCTION

1.1 Rationale

The history of the South-East Australian trawl fishery, and a review of research into the fishery, has been described by McKoy (1986). Allen (1985) has summarised the most recent assessments of catch per unit effort studies. Wilson (1982, 1984) estimated standing stocks of a number of species in the south-western sector using swept area as a measure of fishing effort. Standing stocks for some species have also been estimated by Wankowski and Moulton (1986), using a similar technique.

The estimates of standing stock from these studies are highly variable for a given species and these workers suggest that improvements to the parameters making up the measure of effort are needed to improve the reliability of the stock estimates. Obviously, a population model is only as good as its data inputs and, if fishing effort is to be regarded as a satisfactory statistical sampling procedure, its sampling efficiency and consistency would need to be quantified.

In anticipation of the arguments that will be presented in this report, it is suggested that trawl effort cannot be quantified and standardised to the degree required of any robust sampling procedure or, if it can, the amount of work required to do so is not justifiable when there are better means to achieve the same ends. It will be argued that stock assessment based on catch per unit effort is not an effective basis on which to manage this (if any) fishery. While this flies in the face of traditional practice, there is a growing realisation among fisheries scientists that such stock assessments have not been successful in the past and are not likely to be so in the future. With a young fishery like the South-East Trawl, we have the opportunity of establishing better assessment procedures quite early in its history. This objective is addressed by the present report.

1.2 Firta Grant 86/45

The Tasmanian Department of Sea Fisheries (D.S.F.) was granted FIRTA (Fishing Industry Research Trust Account) funding for 1986/87 to assess the resource sizes and potential yields of the principal commercial shelf and slope demersal trawl fish species in the south western sector of the South East Trawl fishery. The proposal included the investigation and development of assessment and analytical models suitable for application to the catch and biological data bases maintained by the D.S.F.. This report presents the results of that study.

The following species have been considered in this anaylsis:

Pink ling (*Genypterus blacodes*)
Blue grenadier (*Macruronus novaezelandiae*)
King dory (*Cyttus traversi*)
Red gurnard perch (*Helicolenus percoides*)
Latchet (*Pterygotrigla polyommata*)
Tiger flathead (*Platycephalus richardsoni*)
Morwong (*Nemadactylus macropterus*)
Gemfish (*Rexea solandri*)
Spotted trevalla (Silver warehou) (*Seriolella punctata*)
Warehou (Blue warehou) (*Seriolella brama*)
Orange roughy (*Hoplostethus atlanticus*)
Warty dory (*Allocyttus verrucosus*)
Spiky dory (*Neocyttus rhomboidalis*).

Figure 1.1 shows the area considered in this study. The area is effectively an amalgamation of the Southwestern Sector and the Eastern Sector Region B, which were established in early 1985 (Anonomous 1984). All data in this report were obtained prior to that date. The D.S.F. database and the principal data selector program - 'CrassCollector'- that are used to manage those data are described in the Section 2 of this report.

The D.S.F. also has a considerable biological database from research cruises over this period. These data are not examined in the present work but their examination represents a logical next step and subsequent studies could use the findings presented here as a framework for the biological analysis.

1.3 Problems in using catch per effort to measure fish abundance

Of all areas of population ecology, it is perhaps fisheries population biology that demands the most information from the least amount of data. While fisheries catch and effort data are undoubtedly comprehensive and often extend over a considerable time period, in terms of population modelling fisheries biologists face an acute shortage of the type of information routinely expected by population biologists in other fields.

An ideal study of a natural population would be conducted in three distinct stages:

1) a chance observation would establish the existence of the population
2) a pilot study would be used to establish the geographical boundaries of the population and,
3) a detailed sampling program would be conducted.

This sampling could be designed *a priori* around a random or stratified random sampling strategy. The sampling procedure would be designed explicitly to be <u>independent</u> of the structure and distribution of the population itself.

In contrast, studies of natural fish populations that are based on commercial catch statistics usually have to cope with:

1) as before, a chance observation establishing the existence of the population

2) no pilot study; instead the pilot sampling occurs during the sampling process itself as fishermen move out from established fields to seek new fields

and 3) a sampling program that has no design, is not random and in fact is not even known until <u>after</u> the sampling is complete. The sampling is also <u>inextricably</u> tied up with the structure and distribution of the fish population. Instead of a random *a priori* sampling strategy, we must face a non-random *a posteriori* sampling strategy if, in fact, we see fit to desrcibe it as a 'sampling strategy' at all.

Appropriately designed research surveys, such as stratified random trawl sampling, can be used to overcome these deficiencies but the data being considered in this report are not derived from such a sampling scheme.

These problems are further compounded by the problems caused by heterogeneity among the sampling units. It is useful to highlight the properties that an ideal sampling unit should have. Morris (1955) has laid down six criteria for the sample unit in population studies. These are listed below, with comments on their validity when using catch and effort data from a commercial fishery:

1. It must be such that all units of the habitat universe have an equal chance of selection. This will rarely be the case in a commercial fishing operation in which fishermen tend to concentrate on areas which are known to produce economic catches. As Wilson (1984) notes, this criterion will only hold during the initial exploratory phase of a fishery.
2. It must have stability, or if not its changes should be easily and continuously measured. Fishing effort is certainly not stable; change could be measured for a given net, boat skipper etc. but cannot be measured retrospectively for historical effort data without invoking untestable assumptions.
3. The proportion of the population using the sample unit as a habitat must remain constant. Since fishing effort, by its very nature, samples the population rather than the habitat, this criterium demands that the population adjusts to changes in numbers by coalescing or dispersing within the (unmeasured) habitat, so that the proportion of fish available to be caught by a fishing device located in space will remain constant. This is discussed in more detail in section 1.3.1.
4. The sampling unit must lend itself to conversion to unit areas or volumes. Again, his cannot be achieved easily with commercial catch data because those fishing operations sample the population and not the habitat. The sampling is therefore locatable with respect to the population but not necessarily with respect to physical space.
5. The sampling unit must be easily delineated in the field. In some fisheries this is possible but in many, particularly trawl fishing, it is very difficult to accurately measure the efficiency of the gear as it fishes.
6. The sampling unit should be of such a size as to provide a reasonable balance between the sampling variance and the sampling cost. Commercial catch and effort data is unbalanced in that while sampling cost is low, sampling variance is high (and possibly unmeasurable).

Clearly, few of these criteria can be met by a commercial catch and effort sampling program.

1.31 Trawl sampling as a particular example

Even if all factors leading up to the actual deployment of the physical sampling device (trawl net) were homogeneous throughout the fishery, there is still the problem of how the trawl works as it samples the fish population. Target trawling works by sampling the population itself, not the physical region in which the population resides. The effectiveness of the trawl as a sampling device is dependent on the physical relationship between the trawl and the positioning of the population in space.

Consider the following example. This is simply one of a number of criticisms that could be raised about the use of a trawl as a statistical sampling device, even if the trawl behaved perfectly every time.

Suppose we accept that fish aggregate for a combination of two reasons: firstly, they may aggregate purely according to the physical characteristics of the region where they happen to be found; secondly, they may aggregate purely for reasons of social behaviour. In reality, of course, natural fish aggregations will be dependent on varying degrees of combination of the two principles.

The use of trawling as a sampling measure implicitly assumes that fish aggregate (however loose that aggregation may be) according to the first principle only. This assumption is not often recognised. If catch per unit effort is to be regarded as a genuine measure of relative abundance, it must be a genuine measure of the relative density of the fish in three dimensional space. Only by measuring relative changes in fish density can it measure relative changes in fish abundance.

If fish are removed from a population, either through natural or fishing mortality or through emigration, trawl sampling must detect the change through a change in fish density. This implies that the fish population must adjust to the decrease in density by dispersing through space, to take up the 'slack' left by the departing fish. Similarly, if fish are added to the population, either through reproductive recruitment or immigration, trawl sampling must detect the increase in fish density. This implies that the fish population must adjust to the increase in density by coalescing within the constraints imposed by the available space.

If the population does not adjust in the above manner, then trawl sampling cannot measure the changes in relative abundance by measuring changes in relative density.

If a population of fish aggregates for social reasons only, there will be some fixed range of distances between individual fish which will be found regardless of the population size; individual fish will always seek to maintain those distances. In this case, the removal of fish from the population will change the population density only briefly while the remaining fish adjust to the decrease by coming together. The population as a whole will shrink in space but the density will be unaffected apart from the initial perturbation. Similarly, the addition of fish will cause the population to expand in space as the individual fish adjust by moving apart to reestablish their set inter-individual distances. The net result of any changes in abundance will not be reflected by changes in fish density and trawl sampling cannot measure the changes in relative abundance by measuring changes in relative density.

For any natural population, it will be impossible to determine *a priori* the actual mix of physical-only and social-only factors that contribute to the changes in population density. There is therefore no way in which catch per effort through trawl sampling can be regarded as an adequate measure of anything other than the catchability of those fish in the region of space through which the that trawl passed when towed by that boat (nb. 'catchability' used in this sense should not be confused with the catchability coefficient). Any inferences about the abundance of the whole population will be not simply inaccurate, they will be pure guesswork.

Of what use are catch and effort data then? It is suggested that they are of little use in assessing changes in size of the fish stock but rather that they can prove invaluable in economic models of a fishery. As indicated above, catch per effort is really a measure of the catchability of the stock with regard to a given species, area, net, boat and skipper etc. It gives a direct measure of the effort expended by a fishing enterprise for a measurable financial return. If catch and effort data are used in this manner, they have a reasonable statistical sampling basis and can confidently be used in economic models.

There is definitely a case for improving our quantification of commercial catch and effort data but the goal should be to apply those data to <u>economic</u> and not <u>biological</u> models.

A useful rule that we could work by is to recognise that catch per effort data form a quite suitable basis for models that examine that part of a fishery that exists above sea level but they are quite unsuitable for any models concerned with the part of the fishery below the sea surface.

1.4 Problems in using traditional population models to assess fish stock size and yield

The above difficulties associated with using fishing effort as a sampling unit are further compounded by the assumptions used in most of the commonly used fish population models.

The classical models of fisheries population science (eg. those described by Gulland 1969, and derivatives) are fundamentally based on the logistic model of population growth: $N_t = N_0e^{rt}$, where N_t is the number in the population at time t, e is the base of natural logarithms and r is the intrinsic rate of natural increase.

This model is central to the majority of population models in all areas of population ecology, whether it be aquatic, terrestrial, invertebrate or vertebrate populations that are being studied. It has also been the basis for most of the studies of population theory. In fact, it has been so widely used that it is now often accepted without question and has come to be regarded almost as a truism.

The model is a long way from the truth, however. Very few populations have ever been shown to behave according to the logistic model and those that have have typically been contrived laboratory populations raised in monospecific, stable, homogeneous environments.

In terrestrial population ecology, where population sampling is considerably easier than it is in fisheries ecology, modellers have tended to reject the logistic model as being unworkable and have adopted stochastic statistical models instead of such simple analytical models. It is recognised that the classic models are not tenable even with the luxury of easy sampling.

One of the most serious criticisms of the logistic model (and therefore all derivitive models) is that it assumes the population to have a stable age structure throughout the modelling period. That is, it assumes that the relative proportions of the various age classes do not change with time. Lotka (1925) showed that a population with fixed survivorship and fecundity schedules (fixed with respect to age) will, in an unlimited environment, eventually assume a stable age distribution. The parameter r is defined only for a population with a stable age distribution (Birch, 1948). Such an assumption is patently untrue for virtually all fish populations. In fact, another assumption classical stock assessments often make when using these models is that recruitment is density independent. Density independent recruitment and a stable age distribution are a contradiction in terms. If the later assumption is to hold, individuals must be recruited to the population in numbers proportional to the numbers (density) of all other age classes, meaning that recruitment is implicitly density dependent.

The majority of fish stock analyses have used dubious catch per effort sampling statistics as inputs to simplistic analytical models that have been shown to be invalid in all but synthetic environments. It is not surprising that many fisheries management regimes have run into difficulty.

1.5 Consequences for the present study

In short, the use of commercial fishing effort as a sampling unit in fish population studies is a highly dubious practice. In the past, these problems have been noted and the studies have 'proceeded with caution, recognising the underlying problems' but nevertheless they have proceeded. In many cases, population modelling exercises are little more than a charade, used unwittingly to give credence to an otherwise arbitrary figure. The intense pressure that fisheries managers face due to the highly valuable nature of the populations they study, coupled with importance of ensuring a stable economic platform for investors, has meant that questionable assumptions have had to be accepted. They are not accepted in the present study. Instead, a framework will be described that has been developed to ensure that more suitable stock assessment procedures can be followed in the future.

Of course, it could be argued that any stock assessment, albeit an inaccurate one, is better than no stock assessment at all. This is a moot point. But is a relatively arbitrary yield estimate, based on untenable assumptions, really any better than, for example, using last year's catches as this year's quota with an upward increment if the quota is fullfilled, say, L years running, where L is the lag to recruitment for that species? Such a practice would minimise the chances of over exploitation and over capitalisation, while allowing for an increase in yield should the population be able to stand it. These are precisely the objectives of sustained yield models. This is not to say that this type of simplistic management plan is the best. It merely highlights the difficulty in justifying the use of elaborate models when a simple one is probably no worse, and may even be safer.

With a relatively young fishery like the South East Trawl, we have the opportunity to circumvent the diffuculties of relying on catch per effort data and collect the appropriate data in the appropriate manner from the outset. Early work, such as that of Wilson (1984) has proved useful in providing an order of magnitude estimate of the available biomass but catch per effort data is not appropriate for building resilient models of the fish populations. This report suggests the type of data that should be collected for future management of the fishery. Only by following long term (a decade or more) of changes in the biological structure of the populations, in conjunction with innovative experimental approaches, can we hope to establish genuine management plans for the fishery.

2 CRASS - the database maintained by the Tasmanian Department of Sea Fisheries

2.1 Introduction

The Tasmanian Department of Sea Fisheries has maintained comprehensive catch records for all commercial trawl and Danish seine vessels operating in Tasmanian waters since 1979. The log books and data collection methods have been described by Williams (1986).

The data obtained through this monitoring program were initially housed on CSIRONET's CYBER 76 mainframe computer and were managed by a suite of custom written FORTRAN IV programs developed by the D.S.F. In 1984 the system was transferred to the CYBER 205 and upgraded. The mainframe database is known by the acronym CRASS (Catch Return Analysis and Storage System).

While CRASS is a powerful system of programs, and the data set that it addresses is particularly comprehensive, CRASS could not be adequately utilised by the D.S.F.. CSIRONET costs are now too prohibitive for CRASS to be used in a general enquiry ('browsing') manner and the nature of CSIRONET also means that it cannot be used without a great deal of training. This has meant that a considerable amount of valuable data has effectively been locked up due to computing overheads of one form or another.

The FIRTA Grant that funded the current project was directed towards formulating a stock assessment regime that could be used to ensure the efficient management of the fishery in future years. It was therefore considered imperative that the CRASS database be made more accessible to casual users, without the need for comprehensive training, and not just to the few that are well versed in the vagracies of CSIRONET, NOS and FORTRAN.

As a matter of principle, it was decided that the CRASS database system should be so simple to use that anyone, whether it be Research Officer, Technical Officer or fisherman, should be able to cope with it with only a few minutes training.

Since 1985, the computing policy of the D.S.F. has been committed primarily to Apple Macintosh microcomputers. These computers are simple to use, have an intuitive interface and are ideally suited to the above objectives. Of course, being microcomputers, they somewhat restrict the size of the database that can be practically handled. Nevertheless, the reduction in the size and scope of the dataset is more than compensated for by the increase in accessibility.

2.2 Structure of the Macintosh Crass database

Williams (1986) has described the structure of the CSIRONET CRASS data files. Essentially, the system has a three level hierarchcy of files and this is depicted pictorially in Fig. 2.1.

For each trawl shot, information about the shot itself (eg. position, depth) is recorded on the 'station' file. For each species caught in a given shot, information (eg. weight, number) is recorded on a separate 'species' file. Finally, any information about individual animals (eg. length, weight, sex) collected from each species is recorded on a distinct 'biological' file. Thus, for each station record there may be several species records and for each species record there may be several biological records.

Before any analysis of the catch data can be conducted, the must be a means of extracting the required data from the database according to chosen parameters. The Macintosh Crass sytem (denoted by lower case Crass cf. upper case CRASS for the mainframe) revolves around a central data selection program named CrassCollector. CrassCollector forms the heart of the entire Crass system, and a great deal of effort has gone into making it as simple to use as possible.

Once data has been selected from the master files, there are a number of analytical programs that have been developed to examine those data. Each program is an independent entity but all work with Crass station, species and biology files. Examples of these programs that will be described in subsequent sections include CrassShotview, CrassWhatSpecies, CrassCE, and CrassCEStratify.

2.21 Format of Crass files and user's guide to CrassCollector

Crass data are held in three separate files, each of which has a corresponding file on CSIRONET CRASS:

Crass	CRASS
Crass.Station.Master	AMDPSTX
Crass.Species.Master	AMDPSPX
Crass.Biology.Master	ABDTNWD

Raw log book data passes through several laundering stages before becoming a Crass.x.Master file. The data not found in the above Crass files can still be found elsewhere (on CRASS) , but CrassCollector is not the means to find it.

Crass.x.Master files are flat ASCII text files that can be viewed with a suitable text editor, such as Apple's Edit. Do not attempt to edit these files unless you know exactly what you are doing. Due to their large size (>1Mb) you will find that most editors, including Edit, will have problems handling changes. Since they are Master files for the whole Crass system, you should have no need to edit them anyway.

Files created by CrassCollector are subsets of the Master files and have an identical format to the latter, apart from the number of records they contain. Master files and all new files created by CrassCollector are sorted by vessel code by cruise number by station number. These three fields form a unique index to each shot.

For historical reasons, the field structures of Crass files have remained the same as those of CSIRONET CRASS, as shown below:

Crass.Station.x file format:

Column	Format	Description
1-2	A2	Vessel code
3-5	I3	Cruise number (for commercial data, last 2 digits of the year)
6-9	I4	Station number (for commercial data, 310 * (month-1) + 10 * (day-1) + shot number)
10-11	I2	Year
12-13	I2	Month
14-15	I2	Day
16-20	F5.2	Latitude at start of shot (degrees.minutes, not minutes as a fraction as in CRASS)
21-26	F6.2	Longitude at start of shot (degrees.minutes)
27-30	I4	Time at start of shot (24 hour clock)
31-33	I3	Duration of shot in minutes
34-37	F4.1	Surface temperature in ^{o}C
38-41	F4.1	Net sonde temperature in ^{o}C

42-45	F4.1	Bottom temperature in ^{o}C
46-48	I3	Gear code
49-52	I4	Bottom depth at start of shot in metres
53-56	I4	Minimum depth of shot in metres
57-61	F5.2	Latitude at end of shot
62-67	F6.2	Longitude at end of shot

Crass.Species.x file format

1-2	A2	Vessel code
3-5	I3	Cruise number
6-9	I4	Station number
10-15	I6	Species code (CSIRO code)
16-21	I6	Weight of that species caught in kilograms
22-25	I4	Number of that species caught
26	I1	Length frequency data flag (present/absent)

Crass.Biology.x file format

1-2	A2	Vessel code
3-5	I3	Cruise number
6-9	I4	Station number
10-15	I6	Species code
16-18	I3	Individual's index number
19-23	F5.2	Individual's length (cm)
24-29	I6	Individual's weight (g)
30	I1	Sex (0=unsexed, 1=male, 2=female, 3=unsexable/juvenile)
31	I1	Macroscopic gonad index (range 1-5)
32-37	F6.1	Gonad weight (g)
38	I1	Gonad kept (0=no, 1=yes)
39-42	F4.2	Ova diameter (mm)
43	I1	Otoliths kept (0=no, 1=yes)
44-48	I5	Otolith number
49	I1	Scales kept (0=no, 1=yes)
50-54	F5.2	Age in years
55	I1	Stomach kept (0=no, 1=yes)
56	I1	Stomach fullness (range 1-5)
57-60	I4	Displaced volume of stomach (ml)
61	I1	Stomach analysis done (0=no, 1=yes)
62-67	I6	Weight of fish gutted (g)
68-73	I6	Weight gutted minus head (g)
74-79	I6	Weight of whole fillet (g)
80-85	I6	Weight of fillet minus skin (g)
86-91	I6	Weight of fillet minus skin and bones (g).

CrassCollector can be used to extract data from master files according to any combination/permutation of the following categories:

1. Vessel codes
2. Cruise numbers
3. Station numbers
4. Regions (eg. West Bass)
5. Areas (rectangles specified by latlong boundaries)
6. Depths (bottom and/or shot depth)
7. Dates

8. Times
9. Durations
10. Nets (gear code and/or net length)
11. Temperatures (surface, net and/or bottom)
12. Trawl distances (calculated)
13. Trawl speeds (calculated)
14. Trawl bearings (calculated)
15. Species codes
16. Species weight caught
17. Species number caught
18. Length frequency flag (presence/absence of data)
19. Individual fish id (unique number given to individual fish)
20. Fish lengths (for individual fish)
21. Fish weights (for individual fish)
22. Sex
23. Gonads
24. Otoliths
25. Scales
26. Ages
27. Stomachs (presence/absence of data)
28. Dressed weights (presence/absence of data)

For each category, up to 20 different values, or value ranges, can be selected. The selected values for each category can be included or excluded from the new data. This will be useful if, for example, you want to extract data for all vessels except vessel XY. Instead of having to specifically include every vessel but XY in your selection process, you can simply specifically exclude XY and hence implicitly include all others.

Categories 1-14 relate to Crass.Stations.x type files, categories 15-18 relate to Crass.Species.x files and categories 19-28 relate to Crass.Biology.x files. Each category relates directly to data held in the respective files. Categories 12, 13 and 14 are special in that those data are calculated by CrassCollector during the selection process.

CrassCollector can read data from station files, species files and biology files and can write new files of the same types.

Any file created by CrassCollector can in turn be used as a master file. In practice, this procedure is strongly recommended. If, for example, you wanted to make a number of different selection combinations (requiring a number of separate CrassCollector runs) but were only interested in, say, orange roughy, you would:

1) run CrassCollector selecting for orange roughy from the Master files
2) use the resultant subfiles as master files for subsequent runs.

This will avoid having to search through the entire master file(s) each time. You will need to keep a careful record of from where each successive subfile came and of what selection criteria were used for each run.

As an example, suppose you wanted to create the files:

a) orange roughy in West Bass region, January, February & March
b) orange roughy in West Bass region, April, May & June
c) orange roughy in South East region, less than 800m depth
d) orange roughy in South East region, greater than 800m depth.

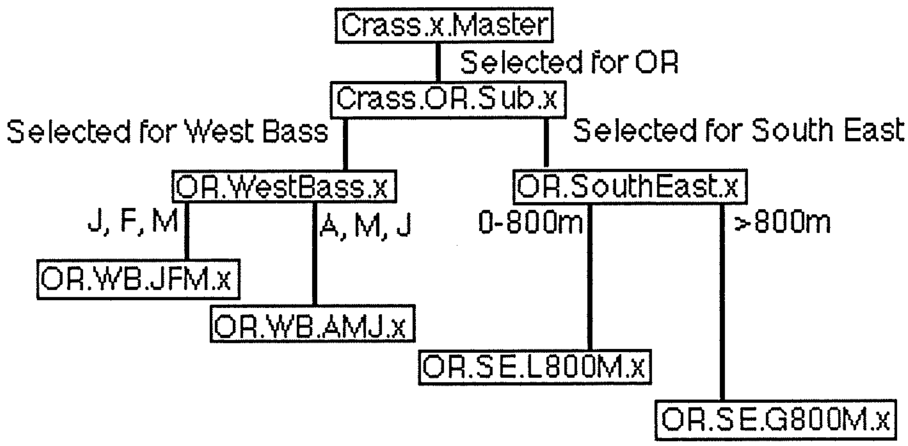
Rather than selecting from the master files each time, you should:

1) run CrassCollector selecting from Crass.x.Master file(s) to make a file(s) called, say, Crass.OR.Sub(s)
2) run CrassCollector selecting from Crass.OR.Sub(s) to make a file(s) called, say, OR.WestBass.x (x being station, species and/or biology)
3) run CrassCollector selecting from Crass.OR.Sub(s) to make a file(s) called, say, OR.SouthEast.x
4) run CrassCollector selecting from OR.WestBass to make a file(s) called, say, OR.WB.JFM.x
5) run CrassCollector selecting from OR.WestBass to make a file(s) called, say, OR.WB.AMJ.x
6) run CrassCollector selecting from OR.SouthEast to make a file(s) called, say, OR.SE.L800M.x
7) run CrassCollector selecting from OR.SouthEast to make a file(s) called, say, OR.SE.G800M.x.

(Here 'file(s)' means you can make station, species and/or biology files as you wish.)

While it may appear that running CrassCollector 7 times instead of 4 is more 'work', each successive selection becomes faster - each time the new 'master' file is smaller and contains proportionally less unwanted data.

For this example, you should make a record of the selections along the following lines:



The above selection process could be speeded up by combining the initial species and region selections into a single CrassCollector run. Instead of selecting for orange roughy and then for the regions, the Master files could be searched for orange roughy in West Bass and South East in the first run. This would remove unwanted data earlier in the selection process. As a general rule, the actual combination of selections you make in any series of CrassCollector runs should be aimed at removing unwanted data as early as possible.

The categories you choose to make selections from will determine which master files CrassCollector will need to read from. If you select from categories 1-14, it will need a station master file; selection from 15-18 requires a species master file; selection from 19-28 requires a biology master file. Also, if you choose to make a new station, species or biology file, you will need to have the respective master files. CrassCollector will ask for the names of these files as required.

The actual file requirements will therefore depend on both your selection categories and the type of files you want to create. If you go through successive runs of CrassCollector (as in the above example) to breakdown the master files, it is good practice to make station, species and biology files each time, even if you don't want all three types of data. This will avoid problems that could arise after several selections when you might otherwise find that you are missing the appropriate file(s).

The golden rule is: always use station, species and biology master files that have come down through the selection process together.

Once you have reached the bottom of the selection process, you can throw the unwanted data files away, if you are running short of disk space or it is becoming hard to keep track of all the files.

Obviously, it is important to use a good naming system that will allow you to keep track of any files that you create. The master files, Crass.Station.Master, Crass.Species.Master and Crass.Biology.Master should not be renamed and <u>must not</u> be thrown away. CrassCollector will give your subfiles the default names Sub.Station.*date*, Sub.Species.*date* and Sub.Biology.*date* unless you specify otherwise. You should give them more appropriate names as you go.

CrassCollector will write a summary of your selections to disk as Info.*date*; you should give this a name to match. The Info.*date* files will allow you to trace the selections and master files used in each run. They will, however, only tell you about the selections made for any given run. To trace through a series of selections, you will need to have the Info.*date* files from each stage. With a large number of selections, this could become unwieldy. It is <u>strongly advised</u> that you keep a written record of your selections, as in the previous example.

The station, species and biology files have a hierarchical relationship. Each station record can have any number (usually <50) of species records associated with it. In turn, each species record can have any number (usually <75) biology records associated with it. A given shot (ie. station record) will have a separate species record for each species caught in that shot. If biological data has been recorded for any species within that shot, each individual fish will have its own biological data record.

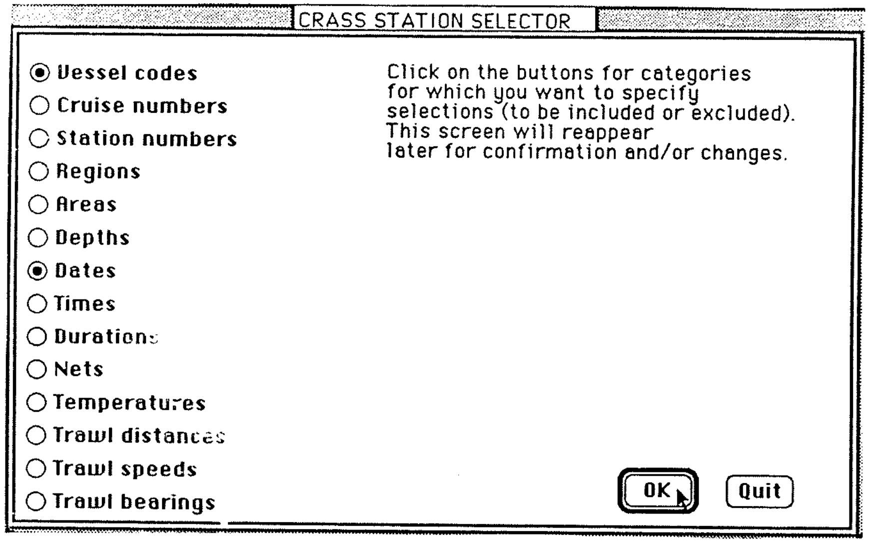
A station record need not have any species records associated with it. Similarly, a species record need not have any biological records associated with it. However, a biological record must have its source species record and a species record must have its source station record. If these records are not found by CrassCollector, it is because they are missing from the master data files, ie. they have not been punched onto the system. A good check for missing data is to run CrassCollector selecting for a given category, species, for example. If the resultant station and species data files have unequal numbers of records, station data is missing for that species. Unfortunately, this sort of check only works backwards (eg. from species to station). When working the other way (eg. from station to species) it is not possible to say whether the data is missing because it was not collected or because it was not punched.

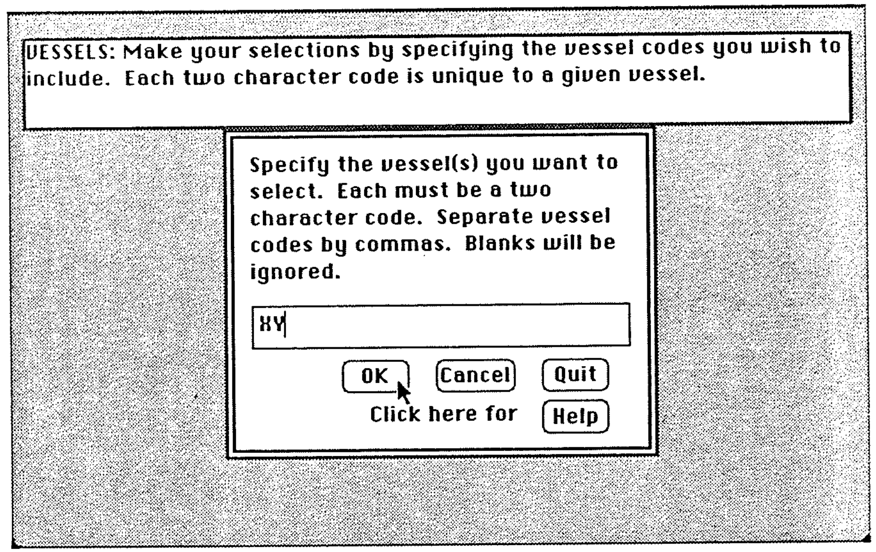
2.22 Example run of CrassCollector

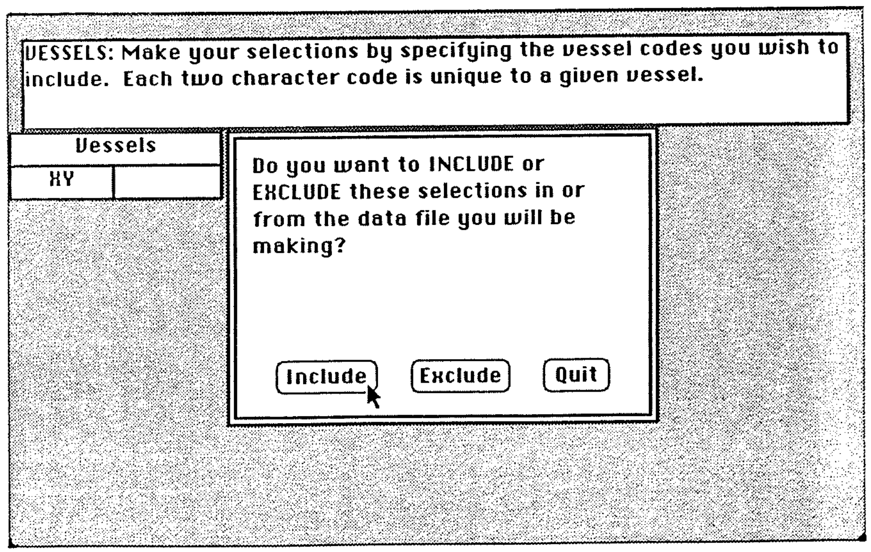
An example run of CrassCollector follows.

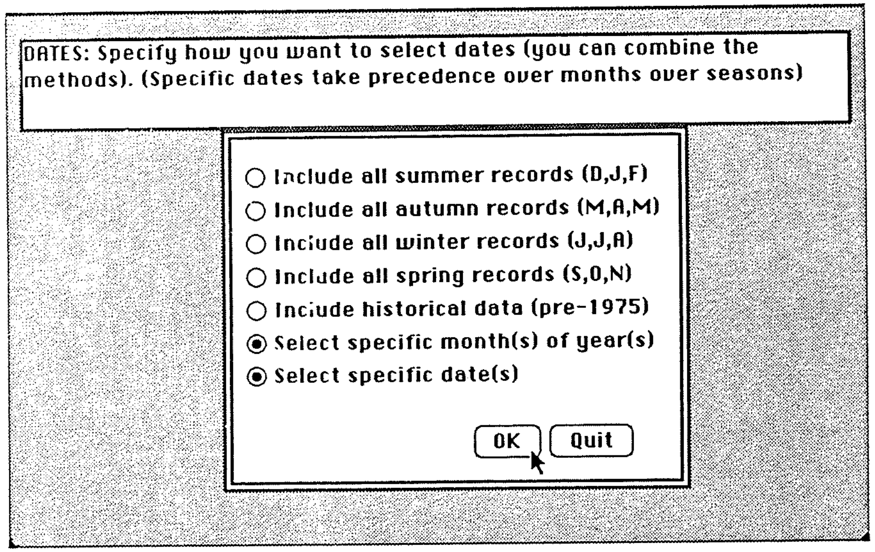
CrassCollector works with 3 files, of type Station, Species and Biology. These are kept separately on disk and can be selected from independently; the records of each are sorted on a unique index made from a concatenation of vessel code, cruise number and shot number. When running, CrassCollector maintains pointers in each file that 'bubble up' through the files as records are tested against user-defined criteria. To be successful, a record must pass all tests in all 3 files. Selections can be made from any combination of the 3 files and new station, species and biology files can be created in any combination if requested.

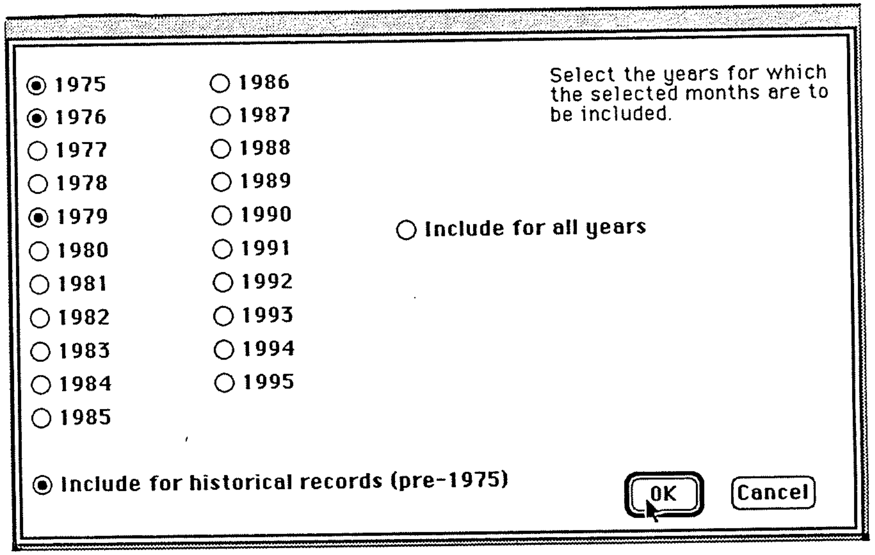
The following sequence of computer monitor screens shows the procedure that a user would follow to select all records relevant to fishing from the vessel code XY, in the months January, February, March and December of years previous to 1975 (ie. early 1900's records), 1975, 1976 and 1979, excluding the dates between the 23rd and 27th of December in 1975, 1976 and 1979. Also selected for were female orange roughy (species code 255009) and blue grenadier (code 232006). These selections can be specified very quickly and quite painlessly after perhaps 30 seconds of training. This contrasts strongly with the complex procedure that another user would need to follow to make the same selections from the CSIRONET CRASS system.

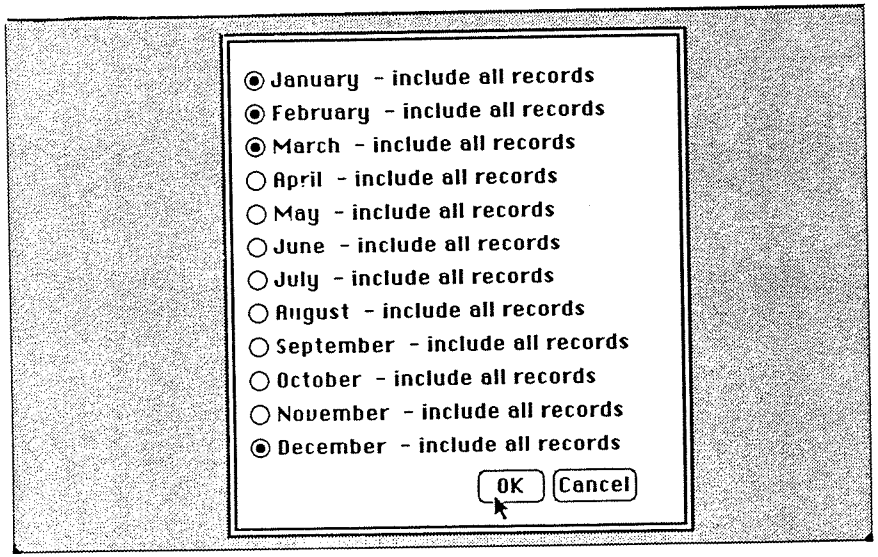

CRASS STATION SELECTOR
Vessel codes
Cruise numbers
Station numbers
Regions
Areas
Depths
Dates
Times
Durations
Nets
Temperatures
Trawl distances
Trawl speeds
Trawl bearings
Click on the buttons for categories for which you want to specify selections (to be included or excluded). This screen will reappear later for confirmation and/or changes.
OK
Quit

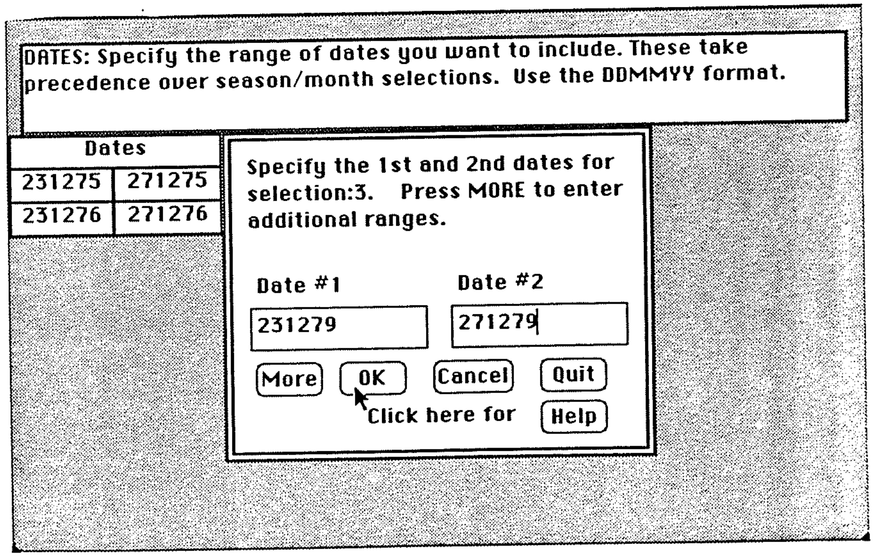

VESSELS: Make your selections by specifying the vessel codes you wish to include. Each two character code is unique to a given vessel.
Specify the vessel(s) you want to select. Each must be a two character code. Separate vessel codes by commas. Blanks will be ignored.
XY
OK
Cancel
Quit
Click here for
Help

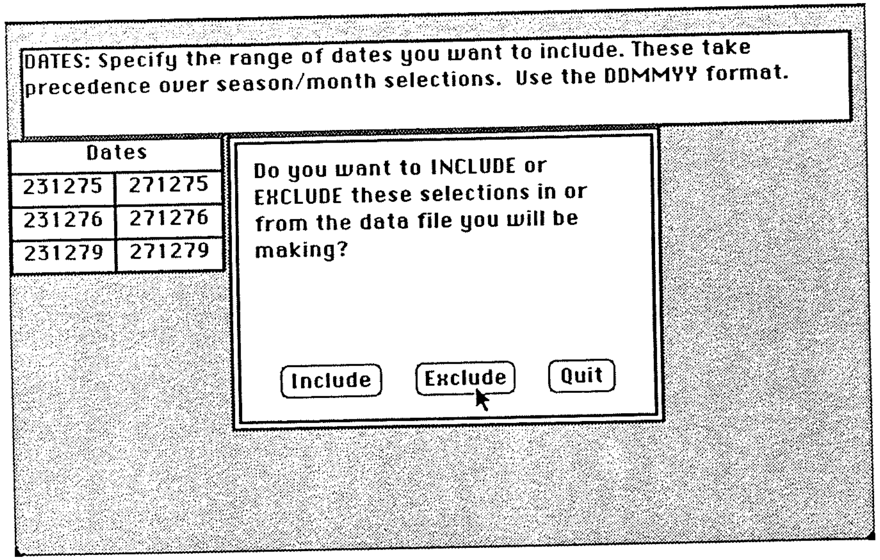

VESSELS: Make your selections by specifying the vessel codes you wish to include. Each two character code is unique to a given vessel.
Vessels
XY
Do you want to INCLUDE or EXCLUDE these selections in or from the data file you will be making?
Include
Exclude
Quit

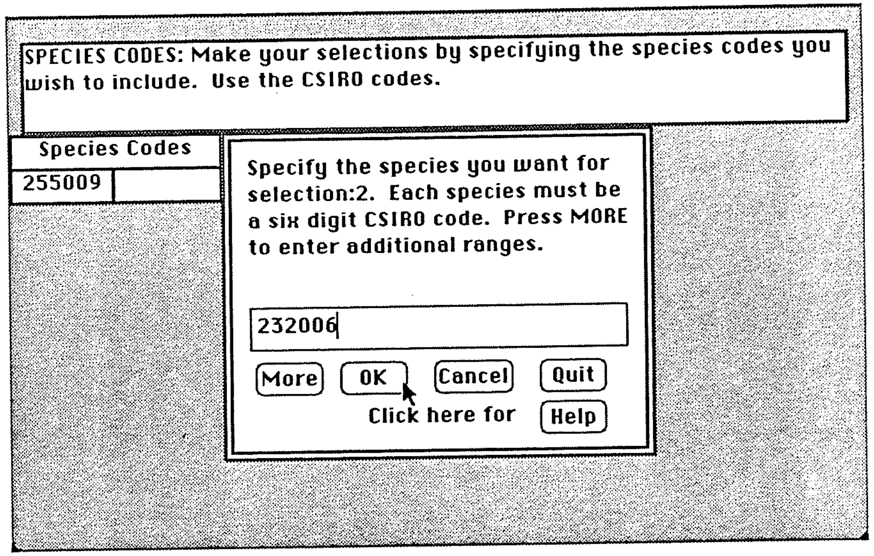

DATES: Specify how you want to select dates (you can combine the methods). (Specific dates take precedence over months over seasons)
Include all summer records (D,J,F)
Include all autumn records (M,A,M)
Include all winter records (J,J,A)
Include all spring records (S,O,N)
Include historical data (pre-1975)
Select specific month(s) of year(s)
Select specific date(s)
OK
Quit

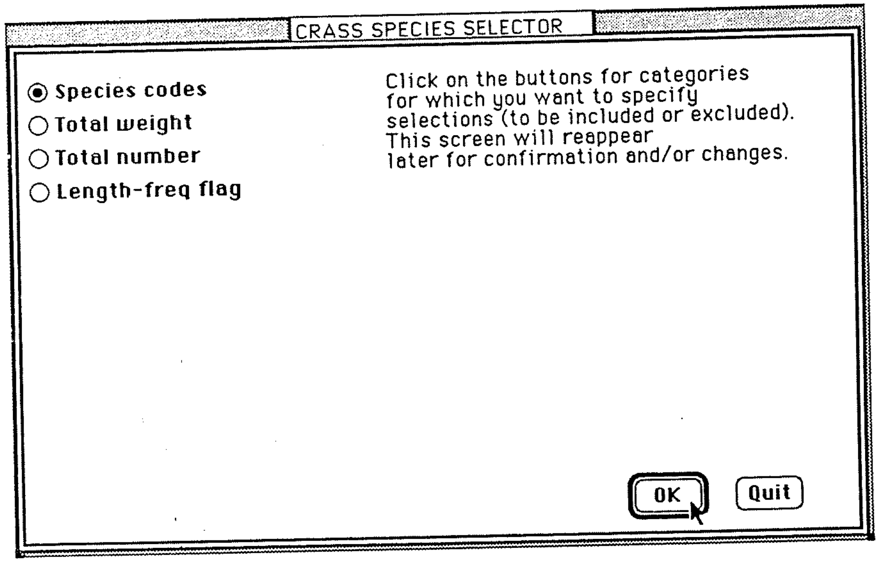

1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Select the years for which the selected months are to be included.
Include for all years
Include for historical records (pre-1975)
OK
Cancel

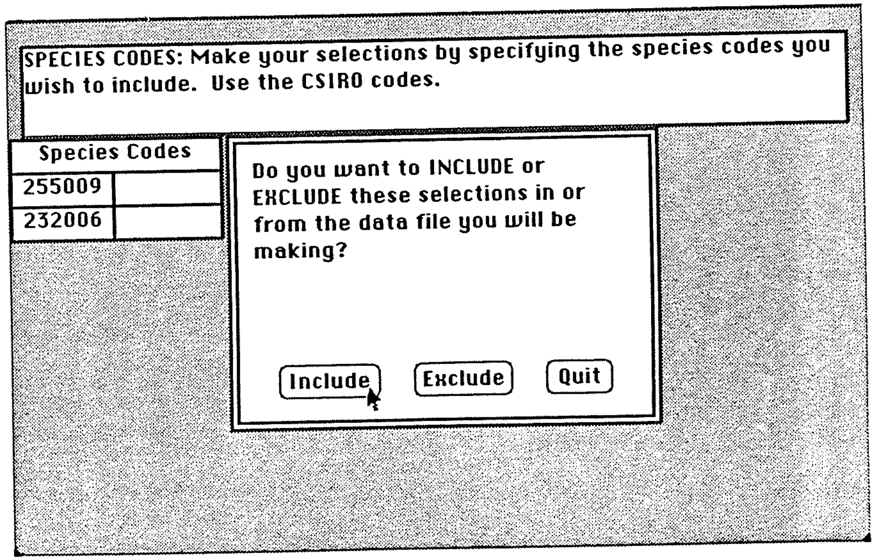

January - include all records
February - include all records
March - include all records
April - include all records
May - include all records
June - include all records
July - include all records
August - include all records
September - include all records
October - include all records
November - include all records
December - include all records
OK
Cancel

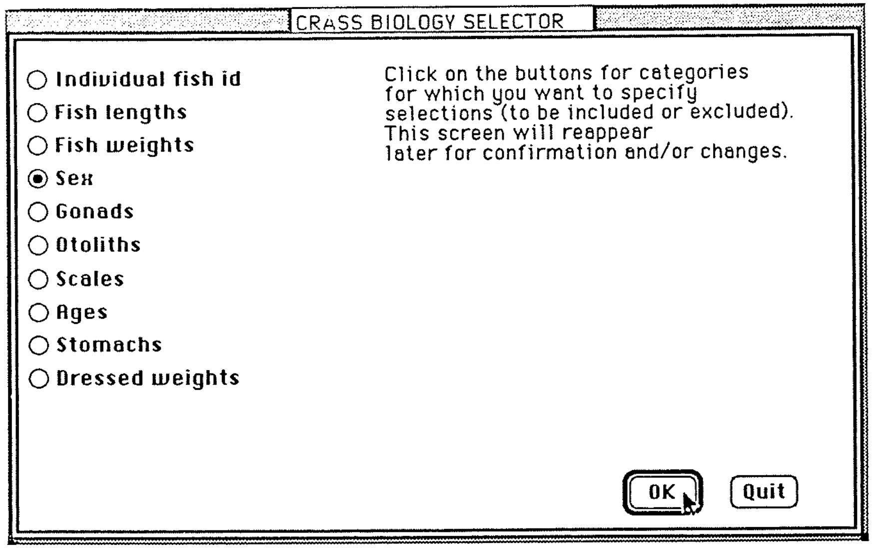

DATES: Specify the range of dates you want to include. These take precedence over season/month selections. Use the DDMMYY format.
Dates
231275 271275
231276 271276
Specify the 1st and 2nd dates for selection:3. Press MORE to enter additional ranges.
Date #1
Date #2
231279
271279
More
OK
Cancel
Quit
Click here for
Help

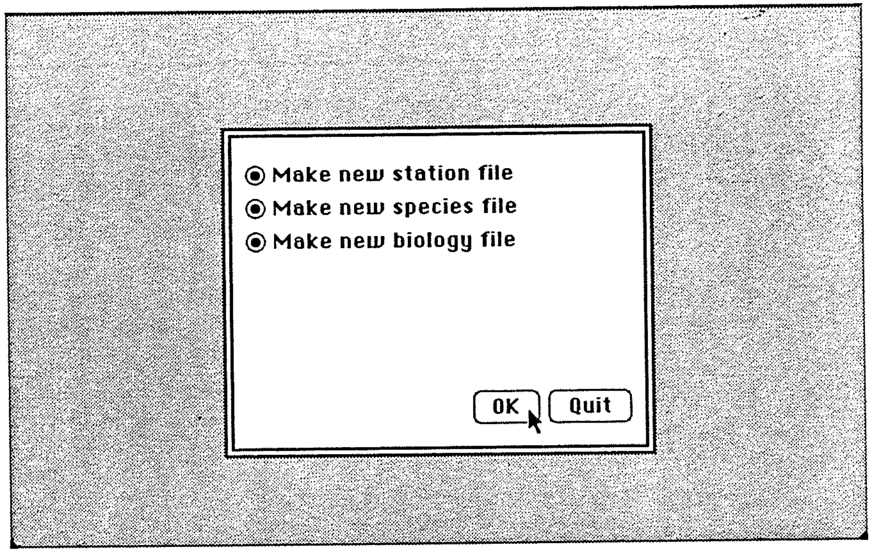

DATES: Specify the range of dates you want to include. These take precedence over season/month selections. Use the DDMMYY format.
Dates
231275 271275
231276 271276
231279 271279
Do you want to INCLUDE or EXCLUDE these selections in or from the data file you will be making?
Include
Exclude
Quit

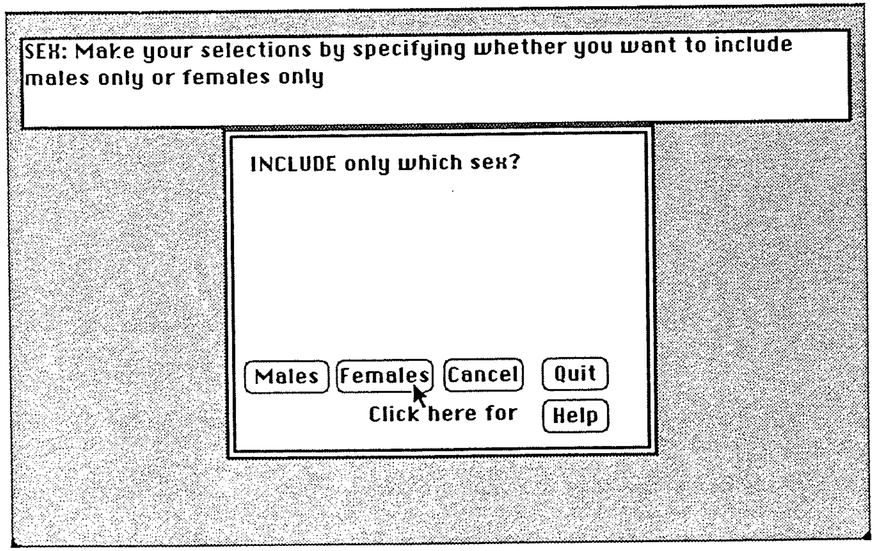

SPECIES CODES: Make your selections by specifying the species codes you wish to include. Use the CSIRO codes.
Species Codes
255009
Specify the species you want for selection:2. Each species must be a six digit CSIRO code. Press MORE to enter additional ranges.
232006
More
OK
Cancel
Quit
Click here for
Help

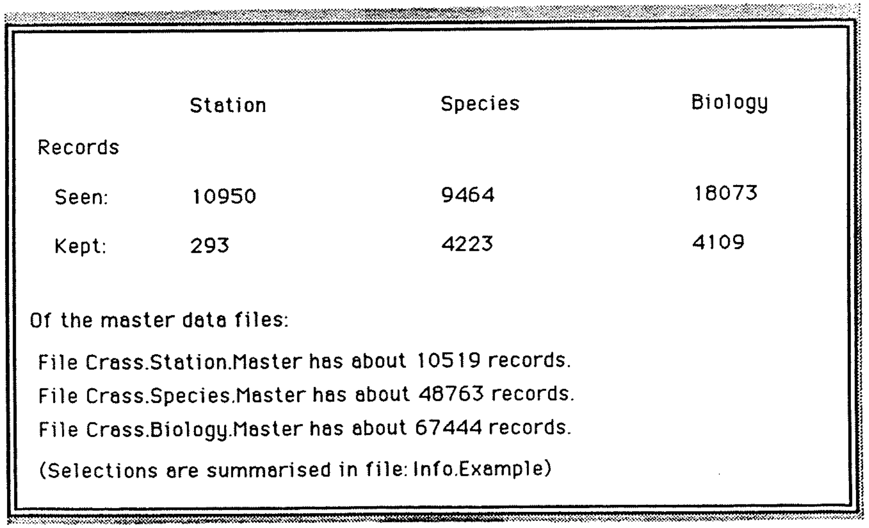

CRASS SPECIES SELECTOR
Species codes
Total weight
Total number
Length-freq flag
Click on the buttons for categories for which you want to specify selections (to be included or excluded). This screen will reappear later for confirmation and/or changes.
OK
Quit


SPECIES CODES: Make your selections by specifying the species codes you wish to include. Use the CSIRO codes.
Species Codes
255009
232006
Do you want to INCLUDE or EXCLUDE these selections in or from the data file you will be making?
Include
Exclude
Quit


CRASS BIOLOGY SELECTOR
Individual fish id
Fish lengths
Fish weights
Sex
Gonads
Otoliths
Scales
Ages
Stomachs
Dressed weights
Click on the buttons for categories for which you want to specify selections (to be included or excluded). This screen will reappear later for confirmation and/or changes.
OK
Quit


Make new station file
Make new species file
Make new biology file
OK
Quit


SEX: Make your selections by specifying whether you want to include males only or females only
INCLUDE only which sex?
Males
Females
Cancel
Quit
Click here for
Help


Station
Species
Biology
Records
Seen:
10950
9464
18073
Kept:
293
4223
4109
Of the master data files:
File Crass.Station.Master has about 10519 records.
File Crass.Species.Master has about 48763 records.
File Crass.Biology.Master has about 67444 records.
(Selections are summarised in file: Info.Example)

3 DESCRIPTION OF THE FISHERY BY INDIVIDUAL SHOTS

3.1 Crass data

Resource surveys conducted by the Department of Primary Industry and the Tasmanian Department of Sea Fisheries (then the Tasmanian Fisheries Development Authority) in the 1970's established the existence of deep water trawl stocks (DPI 1977, 1978, 1980; Webb and Wolfe 1977). In 1979, the D.S.F. initiated a logbook program through which daily fishing logs were introduced to commercial trawl and Danish seine vessels operating in Tasmanian waters. In addition, the D.S.F. conducted numerous research cruises.

The log book design and data collected through the program have been detailed by Williams (1986).

With the advent of the Commonwealth South East Trawl management regime in early 1985, responsibility for the collection of these data passed to the D.P.I. As yet, no mechanisms have been developed to facilitate easy transfer of data between the D.P.I. and the D.S.F. The Crass database is therefore restricted to shots prior to 1985. There are also a considerable number of log sheets that remain to be punched, mainly from late 1984 shots.

The analysis in this study is thus confined to pre-1985 data (1979 to mid 1984). As mentioned, a great deal of effort has gone into developing the CrassCollector suite of programs. It would be particularly prudent for this to be supported by the development of a facility for data transfer between the D.P.I. and the D.S.F., in order that the Crass system can continue to be used for extracting and analysing present and future catch data.

Both research and commercial data have been pooled for analysis. Since unsuccessful shots are not included, the catch and effort data are used to describe the catchability (in a general sense) of fish, <u>given that they are present in the water column</u>. Little credence is given to catch per swept area being a reliable population statistic and there is therefore little value in considering unsuccessful attempts. It must be stressed that unsuccesful shots <u>are</u> relevant to economic models (ie. above sea level models *sensu* Section 1.3) but those are beyond the scope of the present study.

The data analysis that follows in sections 3, 4 and 5 has a threefold aim:

1. To provide an overview of catch data on a shot by shot basis (Section 3).
2. To reduce that data by stratifying with respect to position, depth and time of year (Section 4).
3. To deduce from the stratified data set representative areas, depths and times which can be targetted in subsequent biological and experimental studies (Section 5).

3.2 CrassShotView and CrassWhatSpecies

Files created by CrassCollector can be analysed by a number of purpose written programs. Of these, CrassShotView gives the most immediate expression of catch and effort patterns on a shot by shot basis. CrassShotView creates maps of the southern areas of the South East Trawl and plots shot position, shot depth, shot catch, shot effort (swept area) and shot catch per effort, locating the shots on the map according to the available lat-longs.

These maps quickly give an overview of the fishery, according to the selections made in CrassCollector while the station, species and biology files were being created.

Figs. 3.1 to 3.70 depict ShotView information for the species of interest in this study.

A utility program that often proves useful is CrassWhatSpecies. This simply reads through a Crass Species file and records all species that occur in that file.

4 STRATIFICATION OF CATCH DATA BY POSITION, DEPTH AND MONTH

4.1 Introduction

As discussed earlier (Section 1.3) catch per unit effort in the trawl fishery should not be considered as anything more than a measure of the catchibility of the fish, given that they can be caught at all. Catch per unit efffort can give only a very crude measure of the relative abundance of fish. In the following analysis, unsuccessful shots are not included. No attempt is made to quantify the relative success rate of trawling exercises in terms of presence and absence of fish. This is the province of economic studies and not the province of studies of the fish populations.

4.2 Stratification mechanisms

4.21 Area

Examination of Fig. 3.14 clearly illustrates a number of disparate fishing areas, based on the actual positions of individual shots. These areas form natural divisions within the fishery and have therefore been used as the basis of the stratification by area. A reproduction of Fig. 3.14 is shown in Fig. 4.0, with 11 stratification areas marked. A twelfth area was also used and includes all shots outside areas 1 to 11.

4.22 Depth

Stratification by depth followed Last and Harris (1981) and defined 7 depth strata: 0-27 m, 27-91 m, 91-275 m, 275-457 m, 457-640 m, 640-900 m, 900-1200 m. This division is based on changes in the overall structure of the fish communities with increasing depth. As will be seen in the following sections, the division is reasonably successful in that the majority of species considered show a clear preference for one zone. Of course, a finer division would produce a greater resolution of depth preferences but a compromise must be made between resolution and the need for data reduction.

4.23 Time

The basic unit for time stratification was one month. Many studies have used seasons for time stratification but, as will be seen, the definition of seasons simply by an arbitrary grouping of calendar months is quite unreasonable. An additional problem that arises when using seasons is that the actual biological seasons will vary from one species to another. The month is the minimum resolution that should be used to describe temporal changes in catch patterns.

Stratification with respect to time poses particular problems due to the probable existence of trends in catch and catch per effort for a given month from year to year. Obviously, if long term trends did exist, it would not be legitimate to pool data from different years. Unfortunately, the 5 years of data that are being considered here are insufficient to adequately identify or test for trends. Trends could be tested for by fitting regression lines and testing for non-zero slope but with only 5 points (4 for later months), statistical tests would not be reliable. A less demanding (in a statistical sense) test for trend is to conduct a runs test (Zar 1974). A runs test was used to examine the length of sequences of values that lay above or below the mean catch and catch per effort values for each species in a given month. Again, the scarcity of points means that these test should be interpreted with caution but it appears that no species showed significant trend in either statistic. It was considered reasonable to pool the data for the 5 years.

As data from years subsequent to 1985 are added to the data base, it may be found that significant trends do exist. However, for the present purposes there is no reason to suggest that pooling of yearly data cannot be conducted.

4.3 CrassCE and CrassCEStratify

The structure of the Crass database means that 2 files - the Station file and the Species file - are required to produce catch and effort data for a given species. CrassCE does this by working with the approriate files that have been created using CrassCollector. Crass files are stored in a format that is sorted by vessel code by cruise number by shot number (Section 2.2.1). CrassCE therefore resorts the catch and effort data into a more useable format that is sorted chronologically. In doing so it retains the essential shot information and calculates catch and effort statistics for each shot.

The CE files are stored as ASCII files with the following vaiables included:

1. Date
2. Vessel code
3. Cruise number
4. Shot number
5. Start lat-longs
6. End lat-longs
7. Shot duration (min)
8. Shot depth (m)
9. Shot catch (kg)
10. Shot swept area effort (km^2)
11. Shot catch per swept area effort (kg/km^2).

Swept area is calculated from variables 5, 6 and 7, together with existing information about the average trawl speed of the vessel and net length which is defined by the gear code (Section 2.2.1). If the gear code is not that of a trawl net and/or no finish latlong or duration data are available variables 10 and 11 are flagged as being in error.

Once the CE files have been created, overviews of the data on a shot by shot basis can be produced by CrassCE. Time series of catch, effort and catch per effort can be viewed and printed. Given the short history of the South East Trawl fishery, the production of time series of catch and effort data is only useful on a qualitative basis at present and will not be considered in this report.

CE data can be further reduced by using CrassCEStratify to group the individual shots into the area, depth and time stratifications described above.

The catch and effort data for all the species that this study is concerned with were stratified in this manner and the subsequent analysis is presented in the following tables and figures.

Tables 4.1 to 4.39 list the mean catches and catches per unit efforts for each species under each stratification regime. In each case an ANOVA was conducted to test for variation among means and, if significant variation was exhibited, means were grouped according to a multiple range test of means (Zar 1974).

The relative contribution of each stratification group is given in the tables and is also shown graphically in Figs. 4.1 to 4.42.

Summaries of the multiple range test groupings of means for each stratification regime are given in Figs. 4.43 to 4.45.

5 DISCUSSION

5.1 Introduction

The problems inherent to fish population studies based on catch and effort data have long been recognised (eg. Silliman, 1971; Walter 1978; Roff 1983; Ludwig and Hilborn, 1983; Schnute 1985). Early models such as those of Schaefer (1954), Beverton and Holt (1957), Gulland (1971) and Beddington and Cooke (1983) have been widely accepted by practicing fisheries managers, despite those problems. These models are relatively easy to use, can be applied to commercial catch data and can provide sophisticated outputs that are readily amenable to comparisons within and between fish stocks.

Unfortunately, the high ratio of output quality to input quality is obtained only at the expense of biological credibility. More realistic models have since been developed (Schnute, 1977; Deriso, 1980; Roff, 1983; Schnute, 1985) and these go a long way towards overcoming the criticisms of the simpler models. All, however, require a relatively long time series of data and are not suitable for a developing fishery. For example, the Schnute (1977) and Deriso (1980) models estimate 4 and 7 parameters respectively, and this can be done reliably only if there is sufficient data. Similarly, Roff's (1983) method is based on an autoregressive model and is probably not reliable with less than 15 years of data.

While these later models have a more rigorous fundamental base, they still rely on a series of relative abundance measures. Catch and effort data is subject to error and allowances for this should be made in the population models (Ludwig and Hilborn, 1983). The error is not only in statistical terms, however. Any controlled sampling program is subject to sampling error but catch and effort data is also subject to sampling unit error. Controlled population sampling uses a known sampling unit to sample the habitat that contains the population. Catch and effort 'sampling' uses a variable sampling unit and samples the population, virtually indepently from the habitat. It may be possible to quantify the sampling unit variation, for example by quantifying the efficiency of a trawl net under given conditions for a given species. However, it is not possible to escape from the fact that fishermen tend to fish where they expect to catch fish. They are not likely to fulfill the requirements of random habitat sampling except in the very early, exploratory stages of a fishery or of a season.

Catch and effort data are inadequate as inputs to even the most sophisticated population models because they cannot be relied on to reflect changes in relative abundance in a linear or, for that matter, any analytical manner. Bannerot and Austin (1983) and Richards and Schnute (1986) have shown experimentally that catch per unit effort is proportional to abundance but in both cases the actual relationship was obtained only by direct comparison of visual sampling (eg. manned submersible, scuba diving) with fisheries catch and effort statistics. For deep water trawl fisheries, this would obviously be very difficult and very expensive. An application by the Tasmanian Department of Sea Fisheries to conduct manned submersible surveys of orange roughy concentrations is currently being considered by the NOAA of the United States. This may help to establish a relationship for orange roughy but clearly is a once-off exercise and only considers one species over a short time.

In some instances, stratified random fishing of a region may be able to approximate a legitimate sampling regime (eg. Saville, 1977; Francis, 1981; Robertson *et al*, 1982). In this case, the sampling problems reduce to sampling unit variability but sampling by fishing is inextricably tied up with fish behaviour and thus the fishing sampling unit cannot be fully under the control of the sampler. This problem has already been discussed with respect to trawling (Section 1.3.1) and it is argued that the trawl sampling unit cannot be quantified to the extent required by statistical theory. Some estimates of gross trends in abundance may be gained but such surveying cannot be conducted practically for the 10 or more years required by the appropriate population models, even if the sampling unit variability problems could be overcome.

Three possibilities for the practical management of the South East Trawl fishery can be suggested:

1. Stock assessments based on remote measures of stock abundance. The term 'remote' is used here to denote an independence from the catching sector of the fishery. Saville (1977), Ulltang (1977) and NMFS (1981) have outlined many of the available methods. The models of Deriso (1980) and Schnute (1985), for example, could have great success if applied to abundance data that has been collected in a remote manner. These methods are probably the most useful mechanisms for the management of the fishery but are also likely to be the most expensive.
2. Stock assessments based on a time series of population structure, such as size frequency analysis (Schnute and Fournier, 1980; Jones, 1984; Fournier and Doonan, 1987). The length of the time series of size frequency histograms is a factor of the lag to recuitment to the fishery of a given species. Management regimes based on this information will therefore be retrospective in many ways and will carry considerable momentum meaning that they could not be be responsive to sudden changes in population structure. Nevertheless, this type of stock assessment (as distinct from stock management) is undoubtedly reliable in the long term.
3. Stock assessments by experimental manipulation of the fishery. This is a relatively new concept and would require substantial adjustments to existing management regimes. If these adjustments could be implemented, fishery manipulation could provide measures of the impact of fishing very quickly and relatively cheaply. A more substantial discussion of this approach follows.

5.2 Experimental manipulation as a management strategy

In addition to the basic problems associated with using catch and effort data as a measure of stock abundance that have been discussed previously, three fundamental reasons for the historical failure of traditional fisheries management schemes can be identified:

1. Most stocks do not behave in a simple way when exploited. Caddy and Gulland (1983) describe four possible types of behaviour for fish stocks:

   i. Steady state: the stock can produce a sustainable yield over decades.
   ii. Cyclical: the stock abundance and potential yield cycle in a regular way.

iii. Irregular: the stock quite frequently produces high abundances but it does so in an irregular manner.

iv. Spasmodic: the stock occasionally (perhaps only once) provides a large harvestable stock and at other times is insignificant.

Few stocks have proved to be capable of providing a sustained yield. Instead, cyclic or irregular peaks of abundance appear to be the rule. A key principle in designing a management strategy for a stock is that it should be robust enough to cope with the different types of behaviour that the stock may exhibit. The management regime should be able to distinguish between types of behaviour and respond appropriately.

Consider, for example, the case of a fish stock that behaves in a cyclical fashion. According to the traditional paradigm, we would increase fishing pressure, monitor catch per effort and find it dropping off. As the stocks disappear, we would determine that the stock had been overfished and that the sustainable yield was very low. When the stock eventually returned to high abundaces, we would fish it relatively conservatively and hence forego a considerable potential yield.

2. Even if a stock does behave in the simple way demanded by fisheries models, it is not possible to discover the maximum sustained yield (MSY) without first exceeding it.

3. Usually, the fleet capacity necessary to fish a stock down from its virgin state to the stock size required to detect the MSY far exceeds the fleet capacity that is required to hold the stock at the MSY. Thus, once the stock is reduced to near the optimum, fishing effort per boat and/or total fleet size must be markedly reduced. Since financial forecasts for vessel construction and licence value are normally based on the data obtained during the growth phase of the fishery, fishermen and investors suffer financial downturns when the allowable fishing effort is reduced.

To overcome the unfortunate consequences associated with traditional management methods, a complete reorientation of our approach is required. We are used to regarding fisheries management as something to be imposed once the biological or economic health of the fishery was seen to be in danger; management was reactive rather than preventative. This is no longer true in Australia and limited entry and catch quotas are often introduced into the fisheries quite early, before substantial biological and economic problems have been detected. It is suggested, however, that an additional element should be introduced, namely the deliberate experimentation with fishing mortality rates.

Wherever stocks are thought to be discrete, some stocks should be left relatively unfished to act as controls on environmental and biological change in the fishery while other stocks should deliberately be overexploited to determine how the species respond(s) to over exploitation. If deliberate over exploitation is deemed to be undesirable, an alternative would be to simply close fishing for one stock while continuing to fish another.

The discreteness of stocks is most important in designing such a management strategy. This study has suggested areas, depths and times that appear to produce equal catchability (in terms of catch and effort statistics) for the various species. Two equally catchable stocks are ideally suited to experimental manipulation, provided that they can be shown to be discrete.

5.3 Implications for the assessment of the South-East Trawl fishery

The discreteness of stocks should receive the highest priority in future work in the South-East Trawl fishery. To minimise costs, it is suggested that the results of the present study be used to help identify stocks (by area, depth and time) which appear to be likely candidates for experimental manipulation. Once discrete stocks have been identified, biological studies could also be targetted to those stocks that will be subjected to manipulation.

Since catch per unit effort can be used only as a measure of the catchability (not abundance) of the trawl species, no firm conclusions can be drawn about the status of these stocks from this study. However, these data have been obtained during the early phase of the fishery and provide a baseline study of catchability rates in the various areas, depths and months. Ideally, we would like to find two spatially distinct areas which have equal catchability values. Future biological studies could then be directed towards those areas in the hope of showing that the stocks are effectively discrete. We could then apply different management schemes independently to those stocks and examine the resultant changes in their catchabilities.

Perhaps the most obvious conclusion to be drawn from this study is that the current management divisions of the fishery cannot be the basis for management decisions. While the fishery does need to have simple divisions in political terms, we must be careful not to presume that those divisions represent homogeneous fish stocks. Similarly, while it is convenient to divide a year into seasons, there is no justification in making that division on the grounds of calendar months only. Very few of the species show distinct seasonal changes in catch or catchability, apart from isolated peaks, and the fishing year should not be split into arbitrary divisions.

To highlight the need for flexible time and space divisions, the principal findings of this study for each species will be summarised. Note that the 'all other' area, area 12, contains a significant proportion of the catches meaning that even the division of the fishery into 11 separate areas is insufficient to fully describe spatial patterns.

5.11 Pink ling

Catches are largely restricted to areas 1 and 2 and depth zone 5. Peak November catches are followed by a decline through to July prior to a steady increase. Areas 2+3, 6 and 11 show equally high catches and are spatially distinct and this suggests a strong likelihood of being able to apply independent management schemes.

5.12 Blue grenadier

Area 2, and to a lesser extent area 1, show the greatest proportion of catches, again in depth zone 5. Peak February catches decline through to July before a slight increase to December and a marked increase in January. Areas 3+4 and 6 show high and similar catchability, with low catchability in between, in area 5. This may be evidence of discrete stocks.

5.13 King dory

Most catches are found in areas 1 and 2 in depth zone 5. Catches are highest in April before a rapid decline to a June low. There is then a steady rise to November and a rapid rise in February. There are no spatially distinct, equally catchable stocks and it may be difficult to identify discrete stocks for this species.

5.14 Red gurnard perch

Areas 1 and 2 show the greatest proportion of catches, again in depth zone 5. Peak February catches decline through to July prior to a steady increase. As with king dory, there are no spatially distinct, equally catchable stocks.

5.15 Latchet

While catches are predominantly in area 1, there are also reasonable catches in areas 5, 6, 9, and 10, primarily in depth zone 3. In fact there is no statistically significant difference between these areas and it is likely that spatially discrete stocks could be identified in order to apply independent management regimes.

5.16 Tiger flathead

Area 1 contains the majority of catches with smaller catches in area 6 to 11. Catches are spread across depth zones 3 and 4. Low February catches are followed by a steady increase through to October and there is then a sharp decline. Areas 7 and 11 show equally high catchability and, by being spatially distinct, suggest that independent management could be possible.

5.17 Morwong

Catches are predominantly found in areas 6 and 9, with smaller contributions by areas 1, 5 and 7. Catches are largely restricted to depth zone 3 and are found principally in August to Novemeber, with a peak in October. Areas 6+7+8 and 10+11 show similar catchability while being spatially discrete.

5.18 Gemfish

Areas 1 and 6 and depth zones 3 and 4 represent the principal catching regions. Peak December catches are followed by a steady decline through to July before a steady increase. Areas 5, 7 and 9+10 have similar catchabilities and appear to be good candidates for independent management.

5.19 Spotted trevalla

Catches are mainly found in areas 1 and 2 with smaller proportions in 6, 10 and 11. Catches increase through depth zones 3 and 4 to a peak in zone 5. Temporal patterns are irregular but there are peaks in January/February, May and August. Equal catchability is shown in all areas and separate management should be possible.

5.110 Warehou

Area 6 is the principal region for catches which are spread over depth zones 2 and 3. Catches are virtually confined to December. Areas 5+6 and 9+10 show similar catchabilities while being spatially distinct.

5.111 Orange roughy

The greatest proportion of catches occurs in area 8 while significant proportions also occur in areas 2 and 3 and to a lesser extent in areas 1 and 4. Zone 7 is the principal depth. Catches are mainly found between May and August with peaks in July and October. No spatially distinct areas of equal high catchability are evident although areas 1 and 9 show similar low catchability. Identifying discrete stocks in terms of catch and effort statistics appears to be a problem.

5.112 Warty dory

Most catches occur in area 2 with smaller proportions in areas 1, 3 and 4. Zone 5 is the main catching depth. Most catches occur between October and March with a peak in January. There are no spatially distinct areas of high catchability but areas 7+8+9 and area 11 have equal low catchability. Spatial separation of stocks may prove to be difficult.

5.113 Spiky dory

Catches are mainly restricted to areas 3 and 4 with a smaller contribution from area 8. Depth zone 7 shows the greatest proportion of catches. Catches are restricted to June and July. Areas 2+3+4 and 8 have similar but low catches.

From the above it appears that a number of the trawl species are likely candidates for independent management manipulations. In all cases, similarly catchable stocks, whether they be discrete or not, should be targetted for biological studies. Obviously, it will be most efficient to work in areas of high catchability but in practice it may be more prudent to select low catchability stocks since they could be opened and closed to fishing with less disruptions to the livelihoods of the fishermen.

The Tasmanian Department of Sea Fisheries has a large data base of biological data collected from research cruises. Time constraints prevented those data from being considered in the present study. It would be particularly useful, however, for future studies to examine those data under the same stratification regime used here for the catch and effort data. The effort that has gone into making the Crass database more accessible and flexible means that the mechanisms necessary to facilitate such studies are already in place.

In practice, the manipulative management strategy that has been suggested would need to be interactive and responsive enough for the experimental manipulation to be changed from year to year. Stock opening and closing could possibly be rotated on an annual basis, for example. These management practices could be contained within the broad regime that is currently used but would require close cooperation between all participants because two given experimental candidate stocks may be found in different sectors. With a relatively young fishery like the South-East trawl, we have the opportunity to initiate effective management practices early in its history and so avoid the pitfalls that have characterised fisheries management in the past.

ACKNOWLEDGEMENTS

Howel Williams is thanked for his efforts in sorting out the original CRASS database that ran on CSIRONET and for assisting in the transfer of data to the microcomputer system. Dr Ray Hilborn made substantial contributions to the arguments for the experimental manipulation scheme during a visit to the Tasmanian Department of Sea Fisheries during April-May, 1987 and his advice is gratefully acknowledged. This study was supported by a FIRTA Grant (86/45).

REFERENCES

Allen, K.R. (1985) Report on trawl fish resources of south-east Australia. *DPRFG Report, Sydney, 1985.*

Anonomous (1989) Management plans for the south-eastern trawl fishery. *Australian Fisheries* **43**, 2-6.

Bannerot, S.P. and Austin , C.B. (1983) Using frequency distributions of catch per unit effort to measure fish-stock abundance. *Trans. Am. Fish. Soc.* **112**, 608-617.

Beverton, R.J.H. and Holt, S.J. (1957) On the dynamics of exploited fish populations. *U.K. Minist. Agric. Food Fish. Invest. (Ser 2)* **19**.

Birch, L.C. (1948) The intrinsic rate of natural increase of an insect population. *J. Anim. Ecol.* **17**, 15-26.

Caddy, J.F. and Gulland, J.A. (1983) Historical patterns of fish stocks. *Mar. Biol.* **7**, 267-278.

Deriso, R.B. (1980) Harvesting strategies and parameter estimation for an age structured model. *Can. J.*

Fish. Aquat. Sci. **37**, 268-282.

Fournier, D.A. and Doonan, I.J. (1987) A length-based stock assessment method utilising a generalised delay-difference model. *Can. J. Fish. Aquat. Sci.* **44**, 422-437.

Francis, R.I.C.C. (1981) Stratified random trawl surveys of deep-water demersal fish stocks arounf New Zealand. *N.Z. Fish. Res. Div. Occ. Publ.* **46**.

Gulland, J.A. (1969) Manual of methods for fish stock assessment. Part 1. Fish population analysis. *FAO Manuals in Fisheries Science* **4**.

Gulland, J.A. (1971) *The Fish Resources of the Ocean.* Fishing News Books, Surrey, England.

Jones, R. (1984) Assessing the effects of changes in exploitation pattern using length composition data. *FAO Fish. Tech. Pap.* **256**.

Last, P.R. and Harris, J.G.K. (1981) New locality records and preliminary information on demersal fish fauna assemblages in Tasmanian waters. *Pap. Proc. Roy. Soc. Tas.* **115**, 189-209.

Lotka, A.J. (1925) *Elements of Physical Biology.* Williams and Wilkins, Baltimore. (Reprinted as *Elements of Mathematical Biology* in 1956 by Dover, New York).

Ludwig, D. and Hilborn, R. (1983) Adaptive probing strategies for age-structured stocks. *Can. J. Fish. Aquat. Sci.* **40**, 559-569.

McKoy, J.L. (1986) South-East Australian trawl fishery: A review of research. *AFS Fisheries Pap.* **86-14**.

Morris, R.F. (1955) The development of sampling techniques for forest defoliators, with particular reference to the spruce budworm. *Can. J. Zool.* **33**, 225-294.

NMFS (1981) Stock assessment activities within the National marine Fisheries Service. *N.M.F.S., February 1981* (Final draft seen).

Richards, L.J. and Schnute, J.T. (1986) An experimental and statistical approach to the question: Is CPUE an index of abundance? *Can. J. Fish. Aquat. Sci.* **43**, 1214-1227.

Robertson, D.A., Grimes, P.J. and McMillan, P.J. (1982) Orange roughy on the Chatham Rise; results of a trawl survey, August-September 1982. *N.Z. Fish. Res. Div. Occ. Publ.* **46**.

Roff, D.A. (1983) Analysis of catch/effort data: a comparison of three methods. *Can. J. Fish. Aquat. Sci.* **40**, 1496-1506.

Saville, A. (1977) Survey methods of appraising fishery resources. *FAO Fish. Tech. Pap.* **171**.

Schaefer, M.B. (1954) Some aspects of the dynamics of population important to the management of the commercial marine fisheries. *Bull. Int.-Am. Trop. Tuna Comm.* **1**, 27-56.

Schnute, J. (1977) Improved estimates from the Schaefer production model: theoretical considerations. *J. Fish. Res. Bd. Can.* **34**, 583-603.

Schnute, J. (1985) A general theory for analysis of catch and effort data. *Can. J. Fish. Aquat. Sci.* **42**, 414-429.

Schnute, J. and Fournier, D. (1980) A new approach to length frequency analysis: growth structure. *Can. J. Fish. Aquat. Sci.* **37**, 1337-1351.

Silliman, R.P. (1971) Advantages and limitation of 'simple' fishery models in light of laboratory experiments. *J. Fish. Res. Bd. Can.* **28**, 1211-1214.

Ulltang, Ø. (1977) Methods of measuring stock abundance other than by the use of commercial catch and effort data. *FAO Fish. Tech. Pap.* **176.**

Walter, G.G. (1978) A surplus yield model incorporating recruitment and applied to a stock of Atlantic mackerel (*Scomber scombrus*). *J. Fish. Res. Bd. Can.* **35**, 229-234.

Wankowski, J.W.J. and Moulton, P.L. (1986) Distribution, abundance and biomass estimates of commercially important demersal fish species in eastern Bass Strait, Australia. *MSL Tech. Rep.* **62.**

Williams, H. (1986) Collection and storage of data in the trawl, purse seine and drop-line fisheries. *D.S.F.T. Tech. Rep.* **8.**

Wilson, M.A. (1982) The trawl and Danish seine fishery in Tasmania - its resources. *Rep. Proc. Tas. Scale Fish Seminar. T.F.D.A.*

Wilson, M.A. (1984) An assessment of the lightly exploited trawel fish resources of the developing zone. *DPFRG Paper, Sydney, March, 1984.*

Zar, J.H. (1974) *Biostatistical Analysis.*, Prentice Hall.

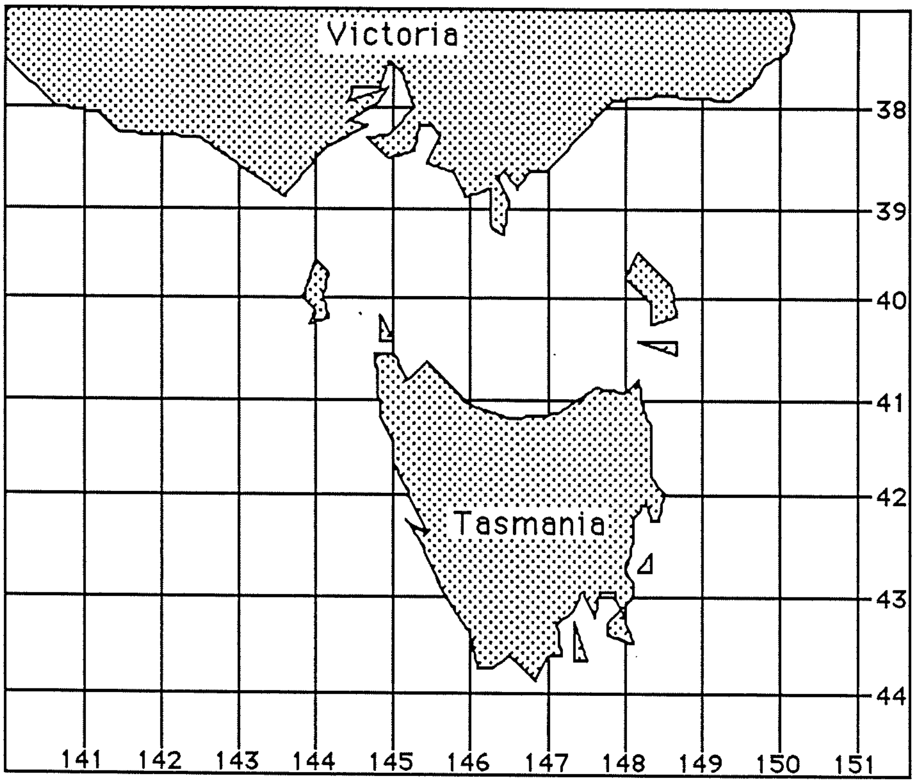


Fig. 1.1: Area considered in this study.

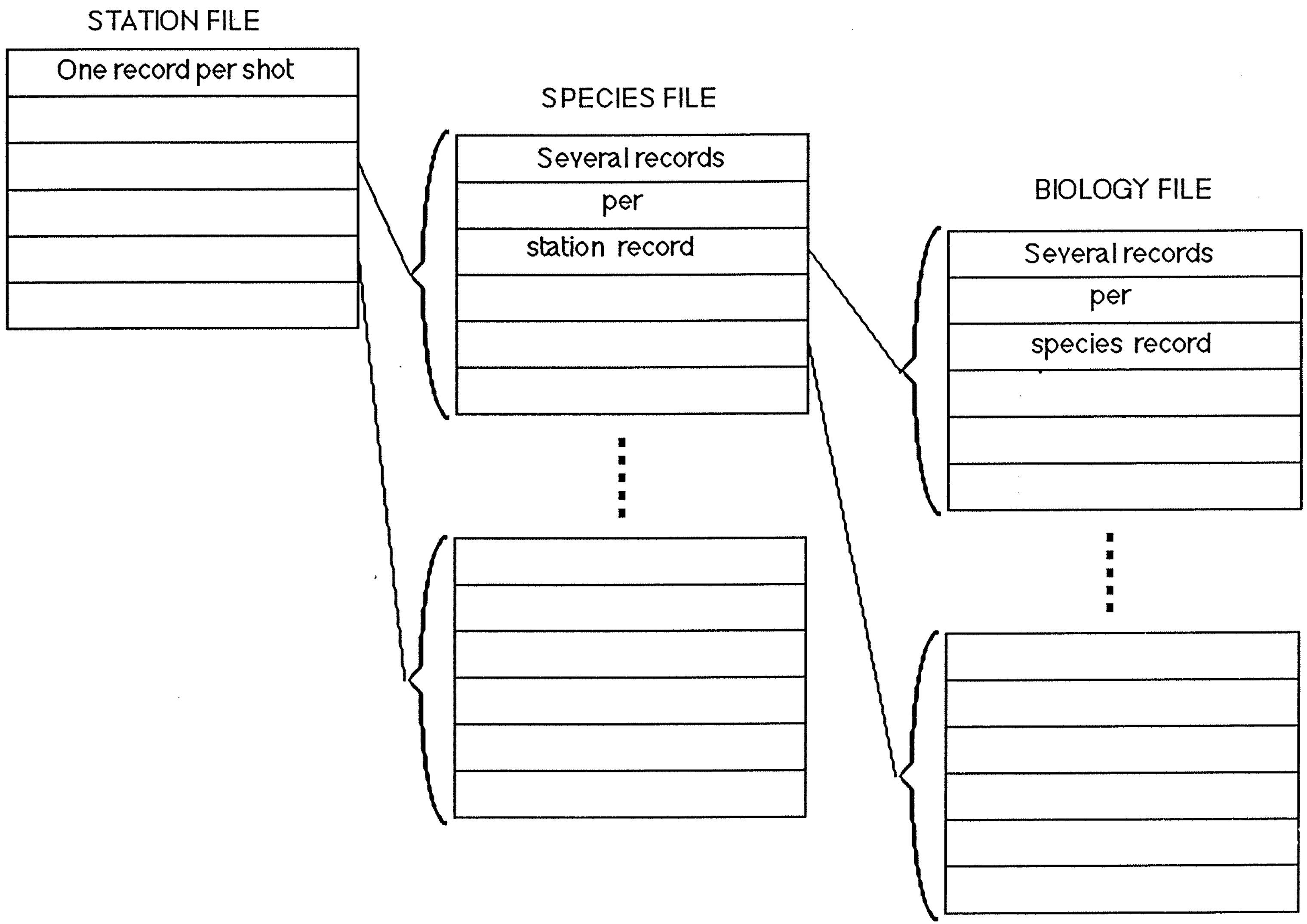


Fig. 2.1: Hierarchical structure of the Crass database.

Notes for Figs. 3.1 to 3.14.

Shot positions (trawls and Danish seines) are shown on the basis of recorded lat-longs. Where start and finish lat-longs are available (eg. demersal trawls), the trawl track is also shown. Single point shots are usually seiners.

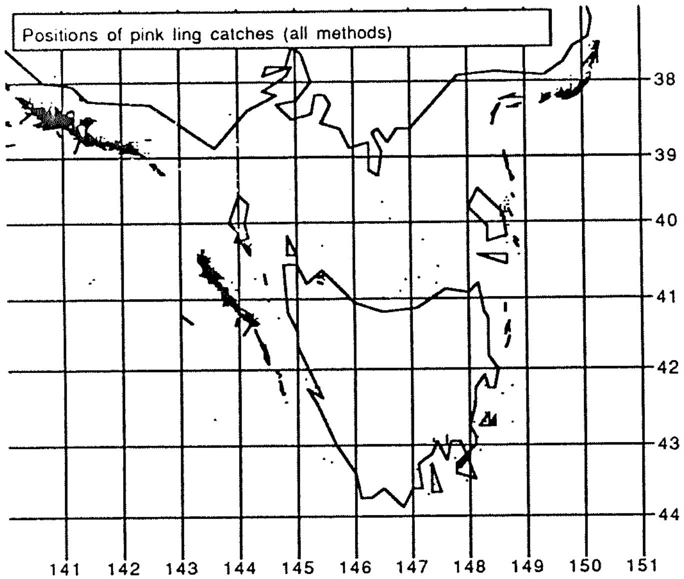


Fig. 3.1: Positions and trawl tracks for shots in which pink ling were caught.

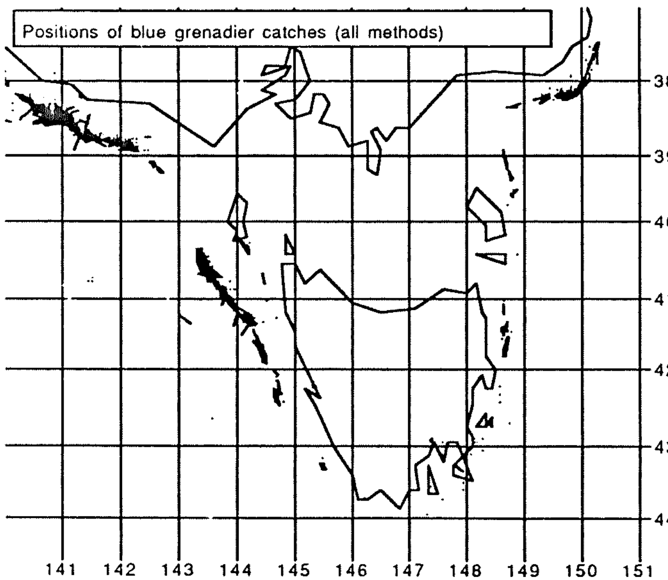


Fig. 3.2: Positions and trawl tracks for shots in which blue grenadier were caught.

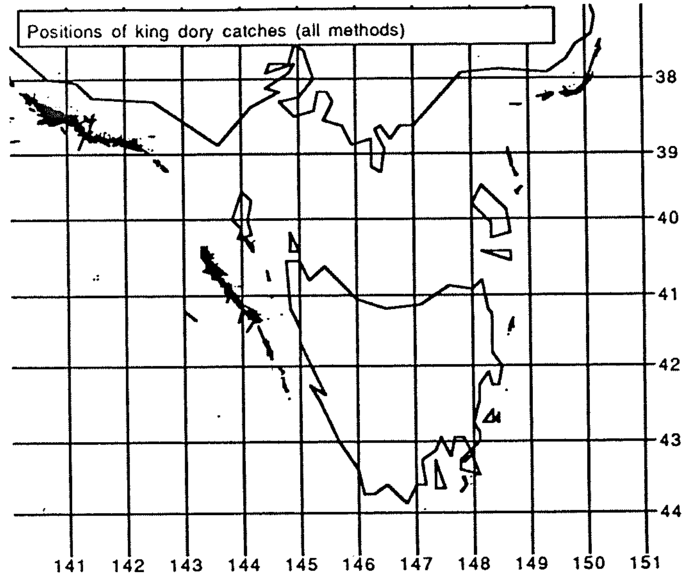


Fig. 3.3: Positions and trawl tracks for shots in which king dory were caught.

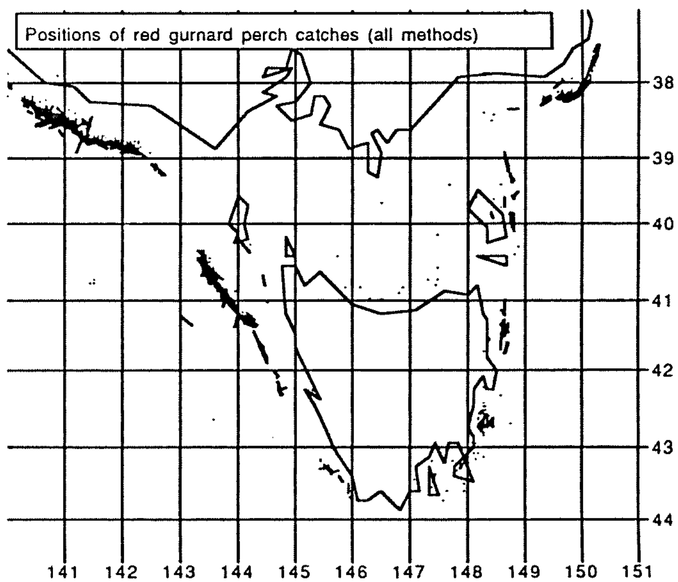


Fig. 3.4: Positions and trawl tracks for shots in which red gurnard were caught.

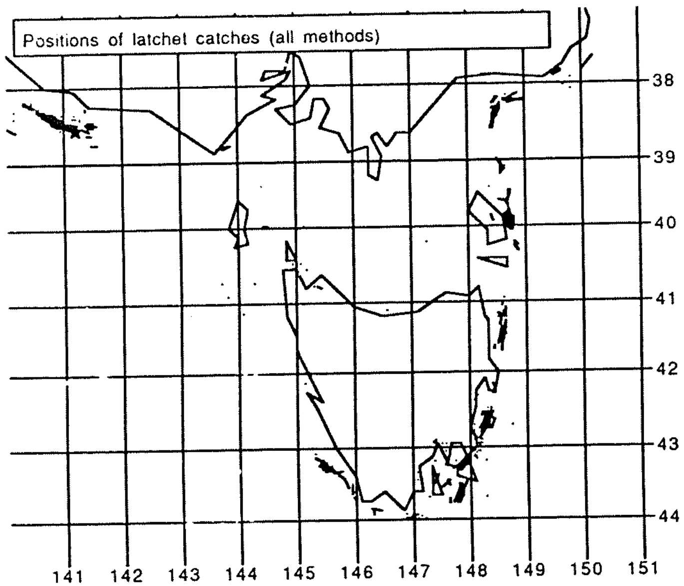


Fig. 3.5: Positions and trawl tracks for shots in which latchet were caught.

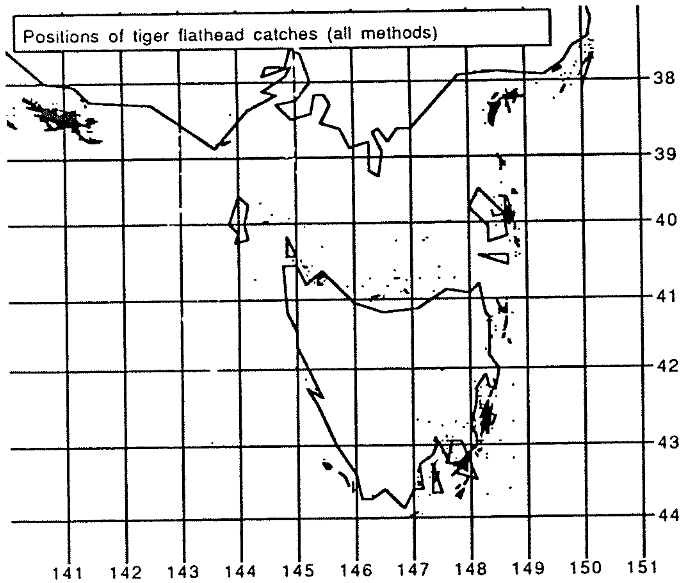


Fig. 3.6: Positions and trawl tracks for shots in which tiger flathead were caught.

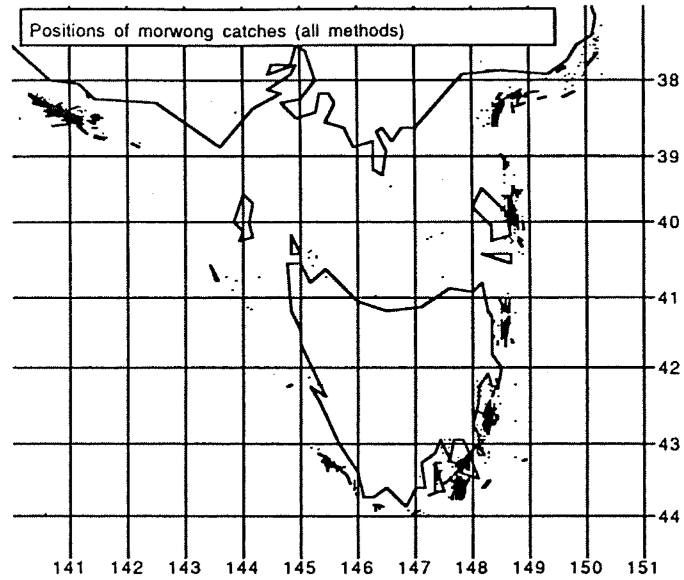


Fig. 3.7: Positions and trawl tracks for shots in which morwong were caught.

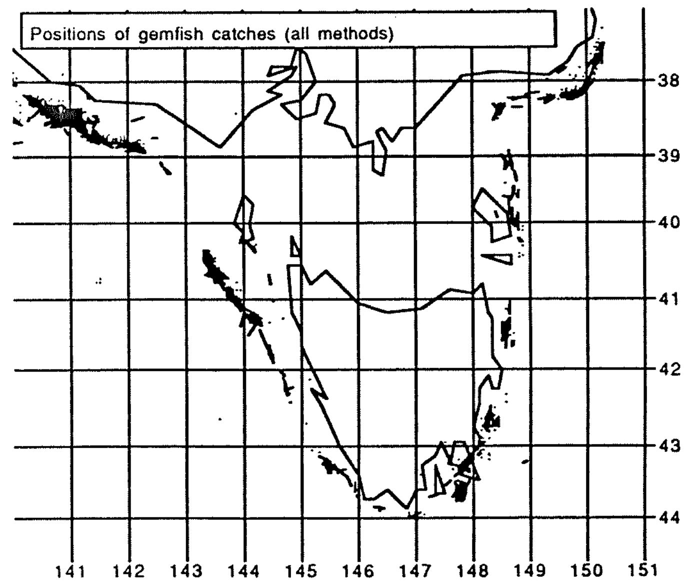


Fig. 3.8: Positions and trawl tracks for shots in which gemfish were caught.

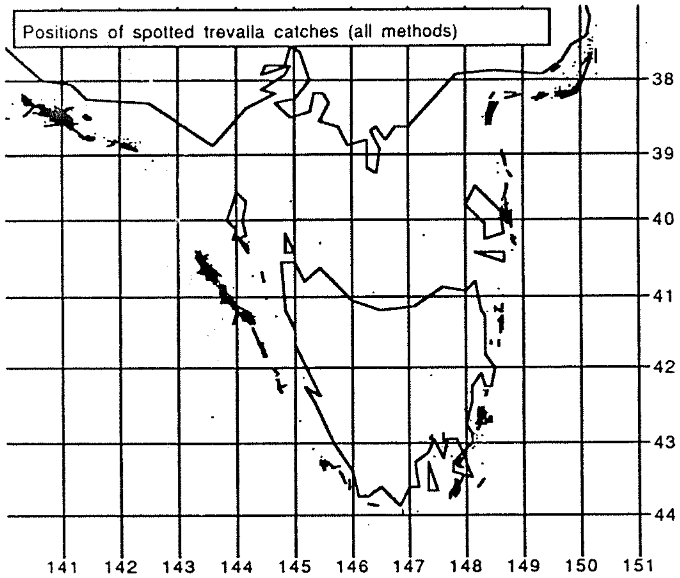


Fig. 3.9: Positions and trawl tracks for shots in which spotted trevalla were caught.

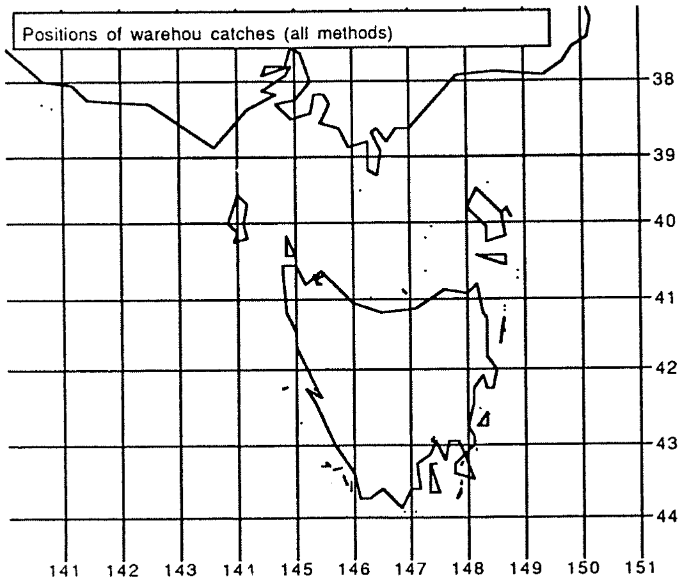


Fig. 3.10: Positions and trawl tracks for shots in which warehou were caught.

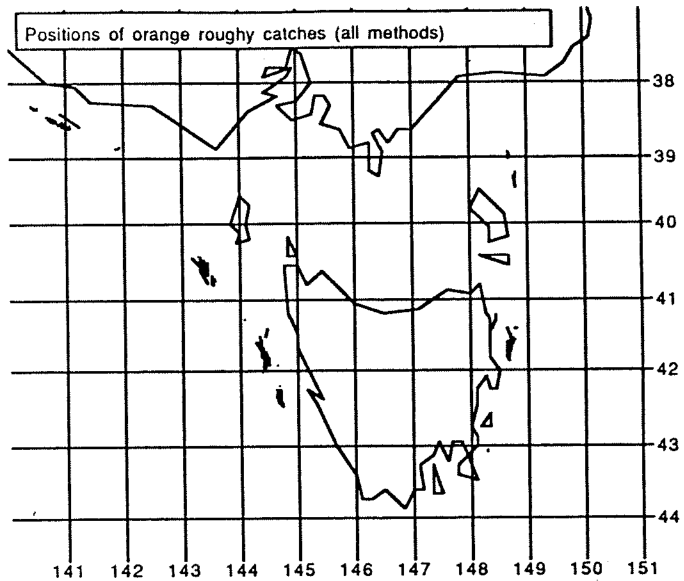


Fig. 3.11: Positions and trawl tracks for shots in which orange roughy were caught.

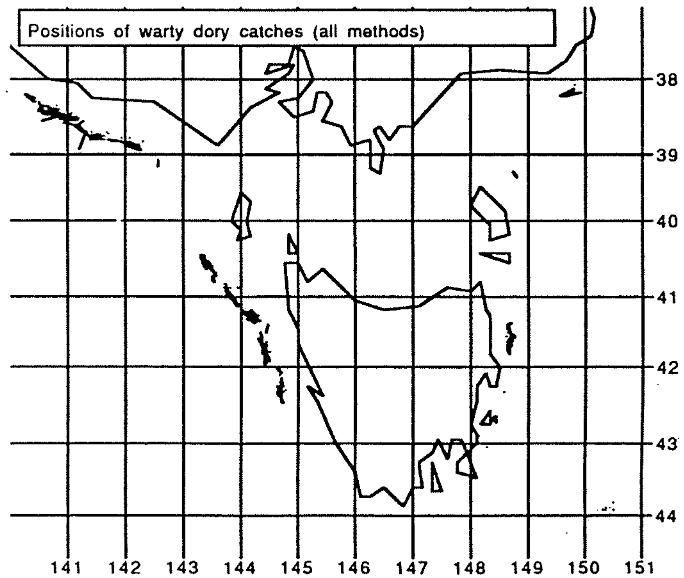


Fig. 3.12: Positions and trawl tracks for shots in which warty dory were caught.

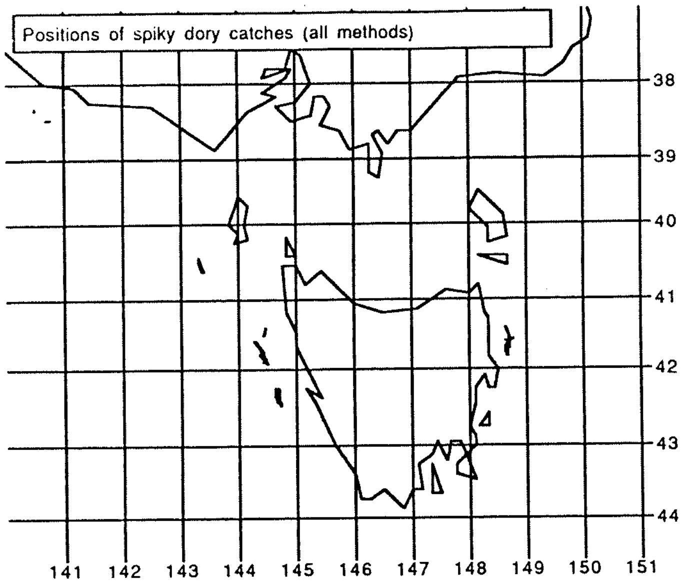


Fig. 3.13: Positions and trawl tracks for shots in which spiky dory were caught.

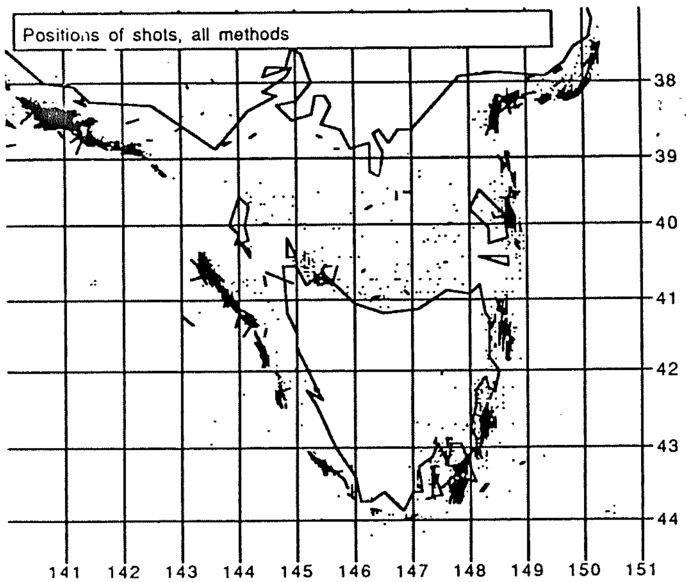


Fig. 3.14: Positions and trawl tracks for all shots.

Notes for Figs. 3.15 to 3.28.

Depths of individual shots (trawls and Danish seines) are shown. Shot positions are located by the top of the bars. The lengths of the bars are proportional to the depth of the shots according to the scale shown in the legends.

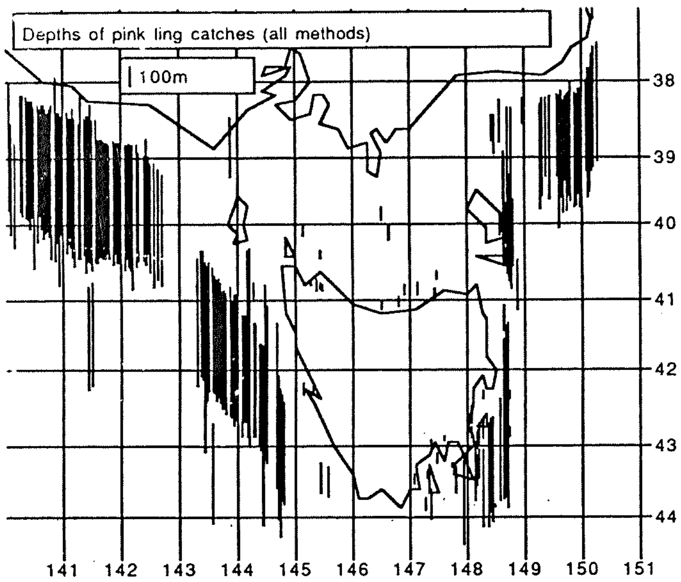


Fig. 3.15: Depths for shots in which pink ling were caught.

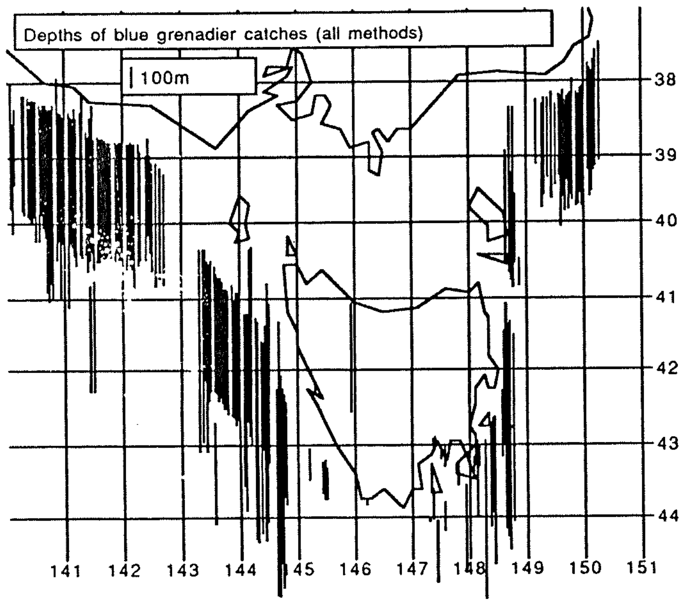


Fig. 3.16: Depths for shots in which blue grenadier were caught.

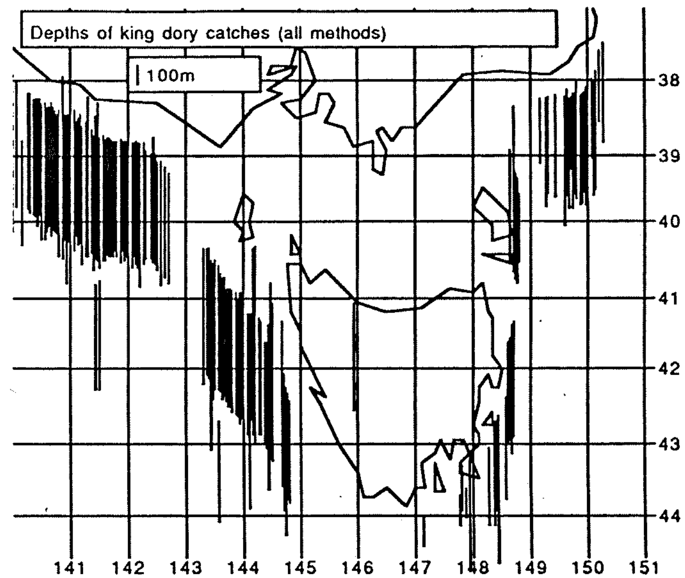


Fig. 3.17: Depths for shots in which king dory were caught.

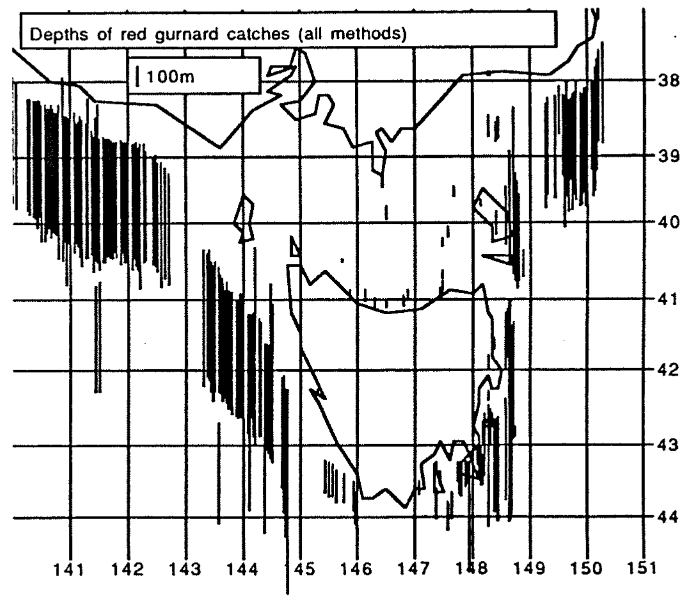


Fig. 3.18: Depths for shots in which red gurnard were caught.

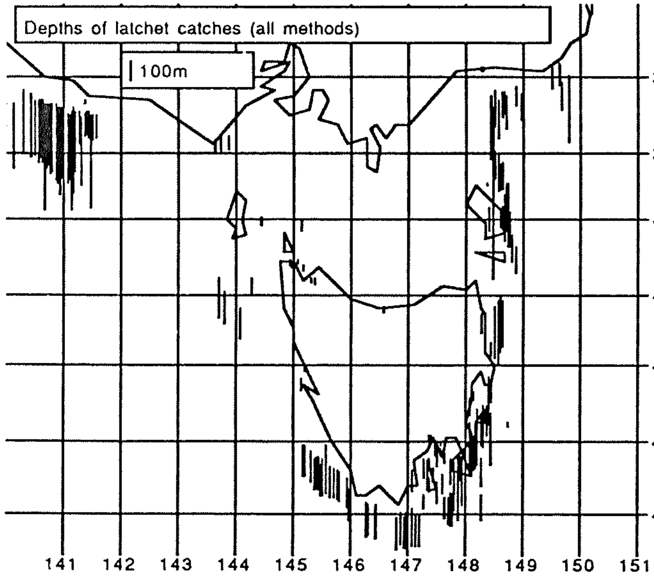


Fig. 3.19: Depths for shots in which latchet were caught.

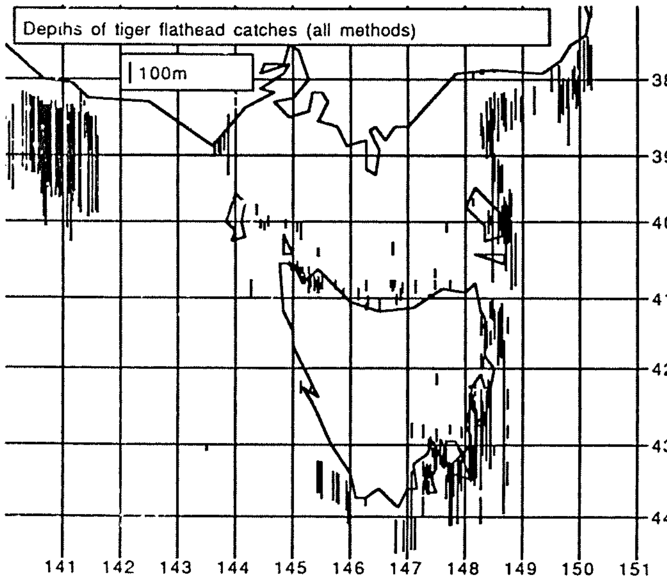


Fig. 3.20: Depths for shots in which tiger flathead were caught.

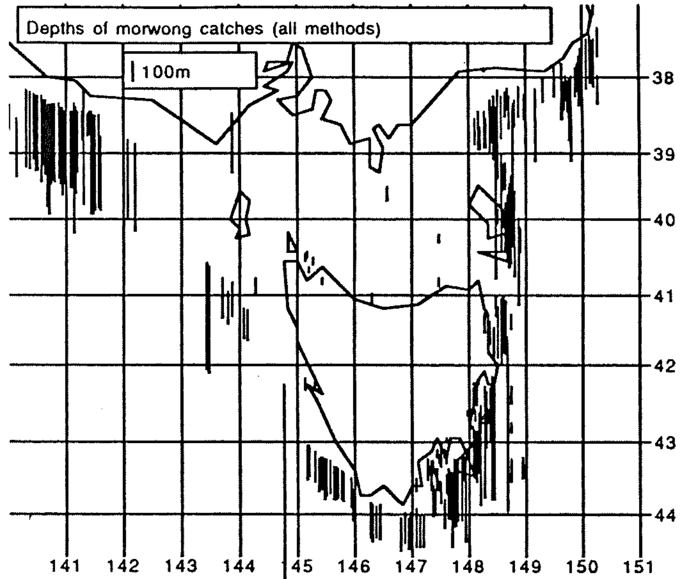


Fig. 3.21: Depths for shots in which morwong were caught.

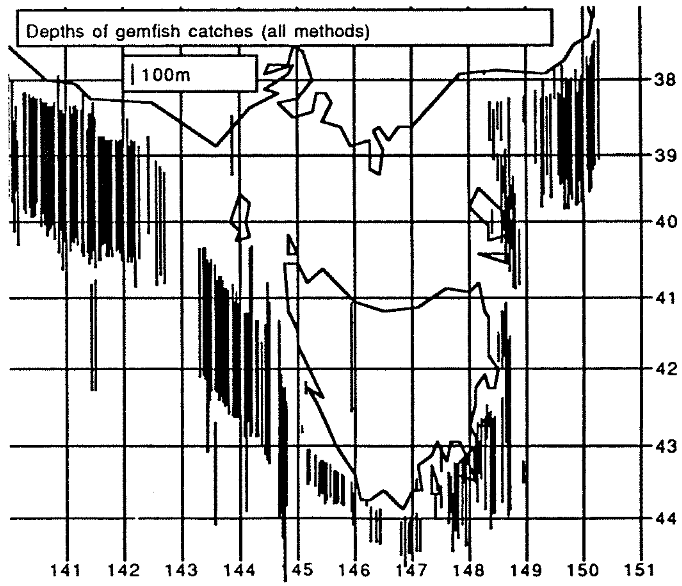


Fig. 3.22: Depths for shots in which gemfish were caught.

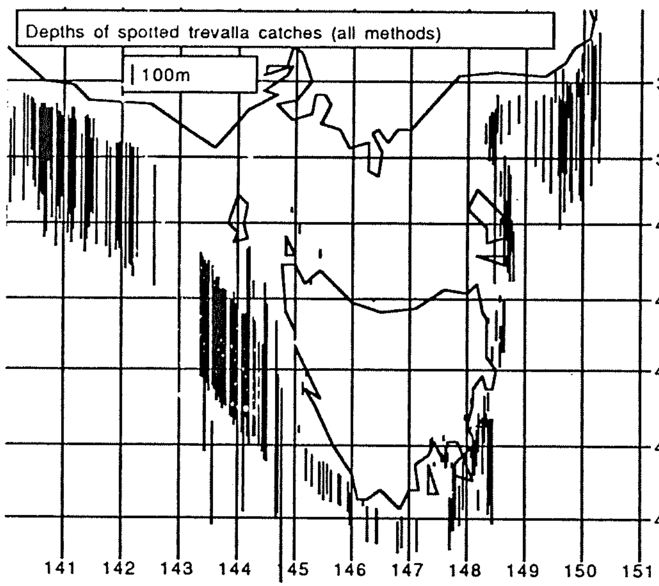


Fig. 3.23: Depths for shots in which spotted trevalla were caught.

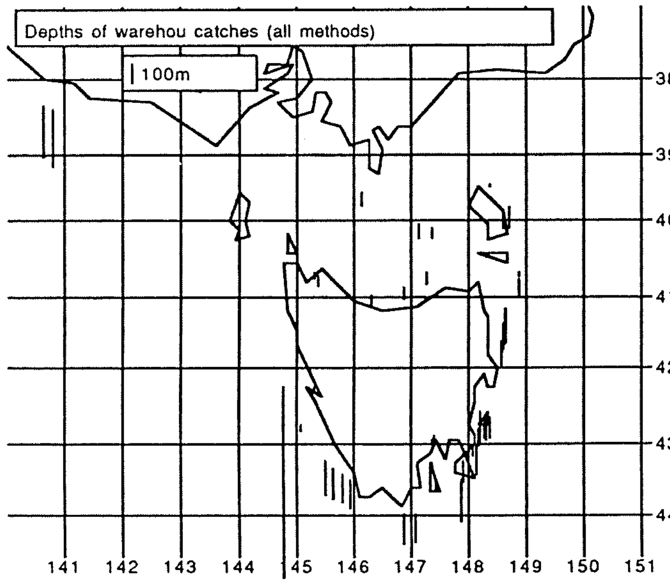


Fig. 3.24: Depths for shots in which warehou were caught.

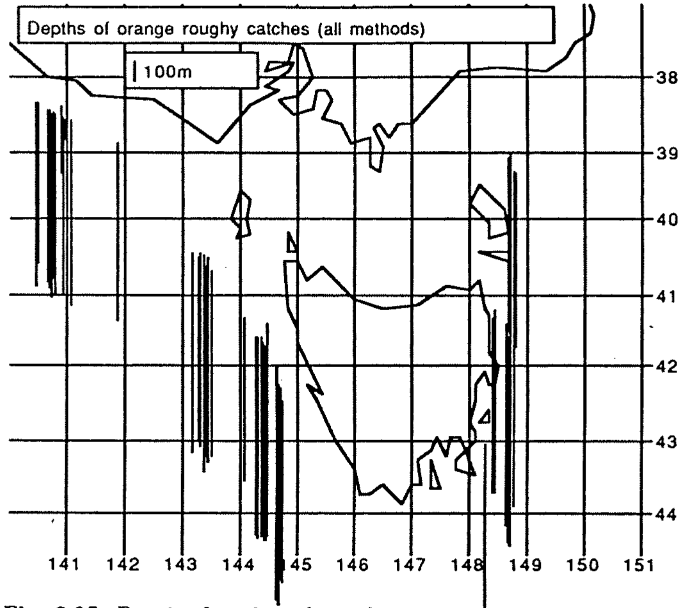


Fig. 3.25: Depths for shots in which orange roughy were caught.

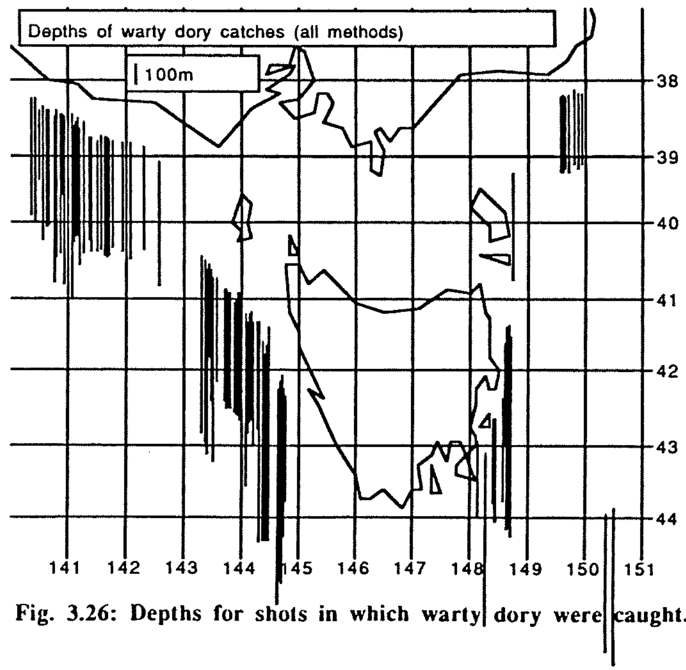


Fig. 3.26: Depths for shots in which warty dory were caught.

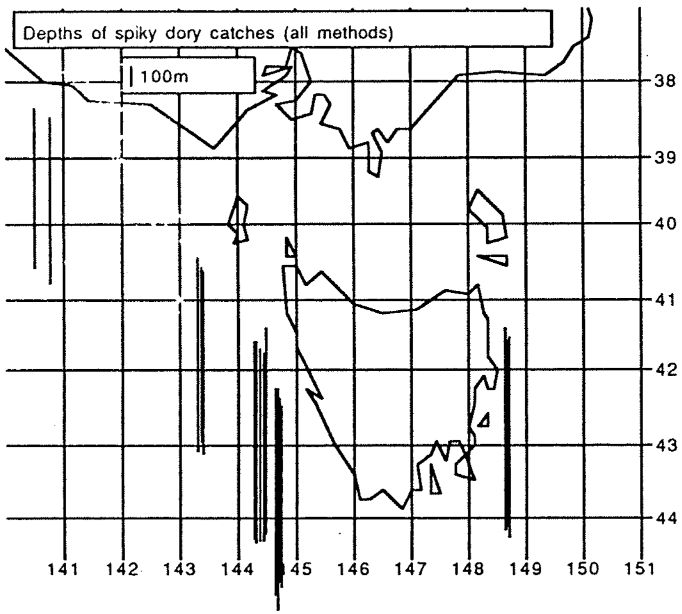


Fig. 3.27: Depths for shots in which spiky dory were caught.

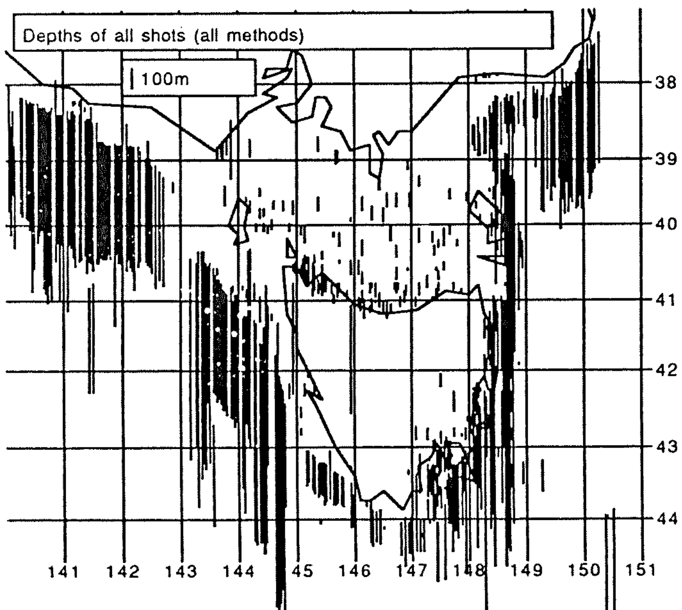


Fig. 3.28: Depths for all shots.

Notes for Figs. 3.29 to 3.42.

Catches of individual shots (trawls and Danish seines) are shown. Shot positions are located by the top of the bars. The lengths of the bars are proportional to the catch of the shots according to the scale shown in the legends.

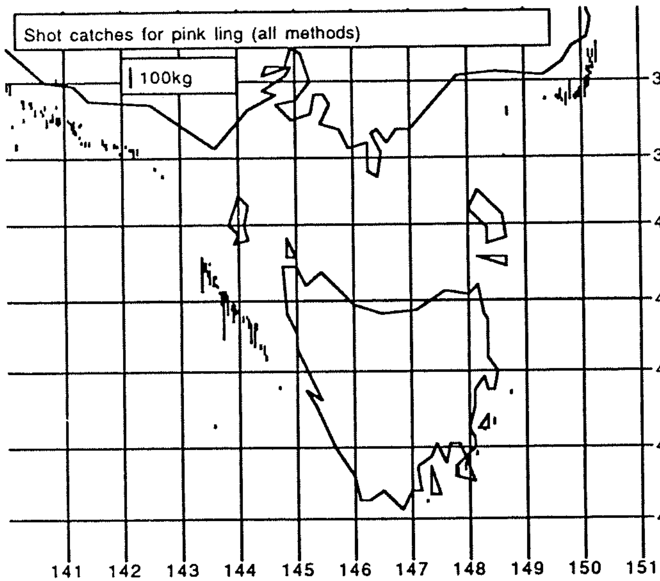


Fig. 3.29: Pink ling shot catch weights.

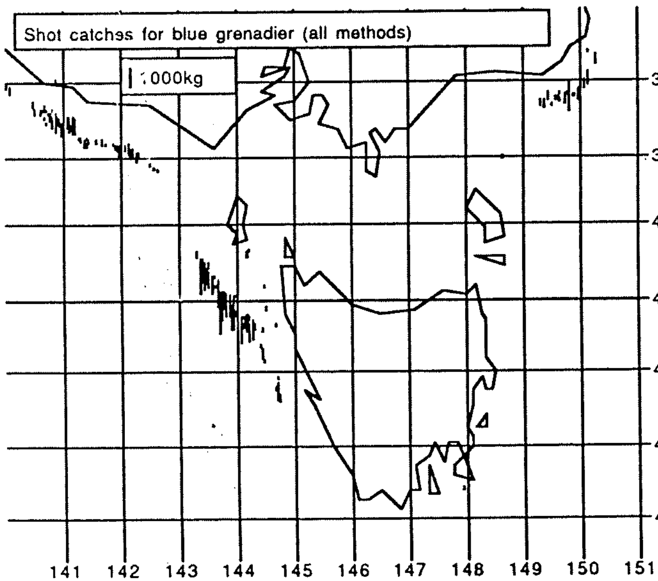


Fig. 3.30: Blue grenadier shot catch weights.

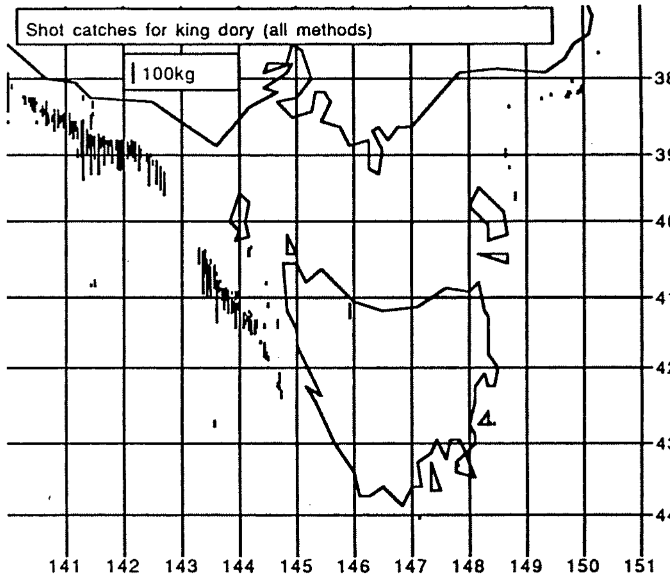


Fig. 3.31: King dory shot catch weights.

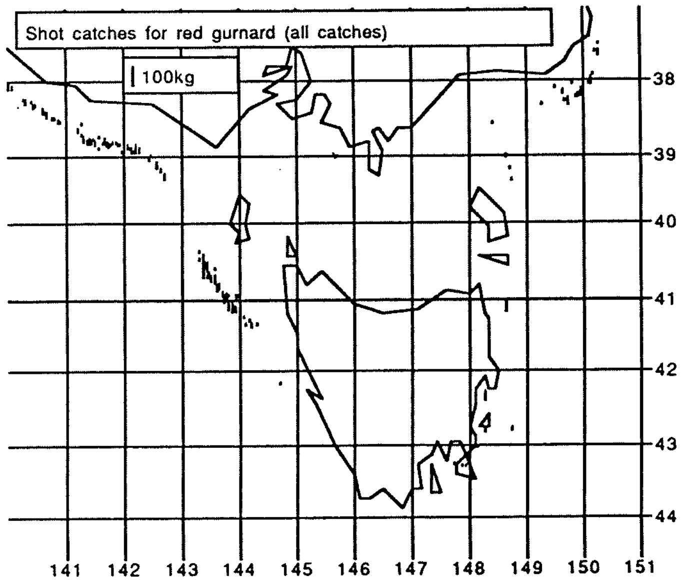


Fig. 3.32: Red gurnard shot catch weights.

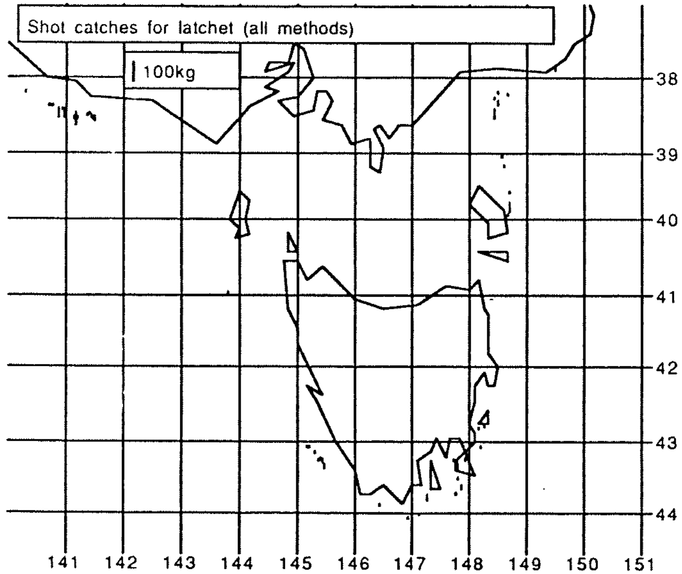


Fig. 3.33: Latchet shot catch weights.

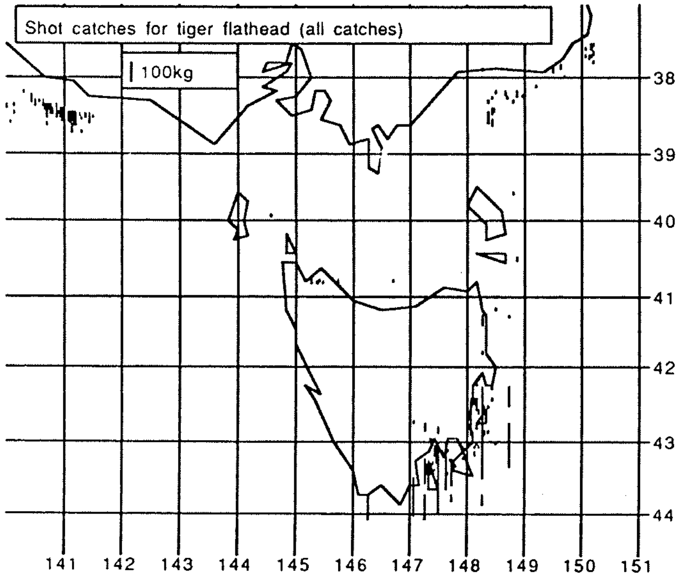


Fig. 3.34: Tiger flathead shot catch weights.

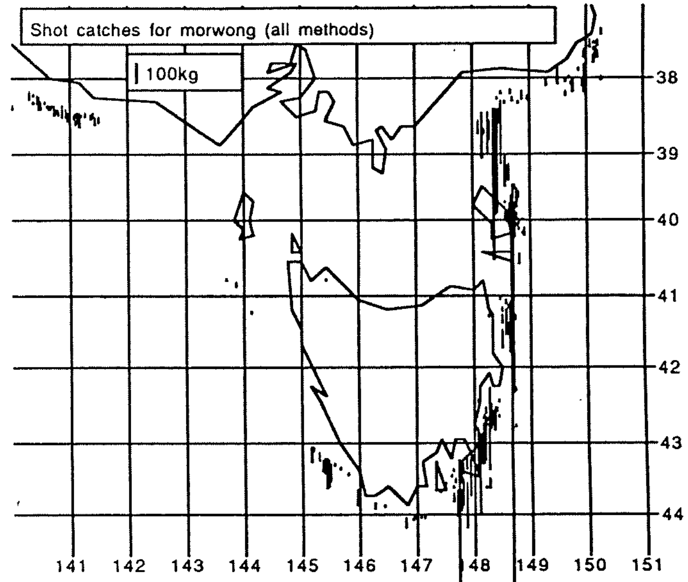


Fig. 3.35: Morwong shot catch weights.

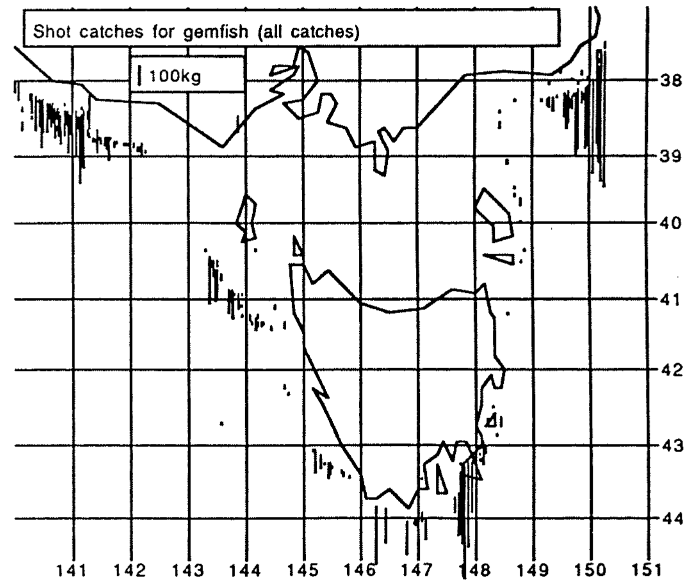


Fig. 3.36: Gemfish shot catch weights.

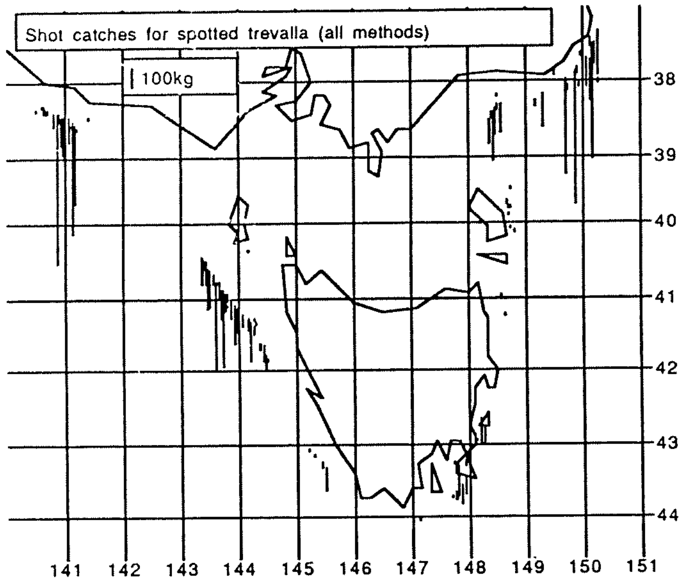


Fig. 3.37: Spotted trevalla shot catch weights.

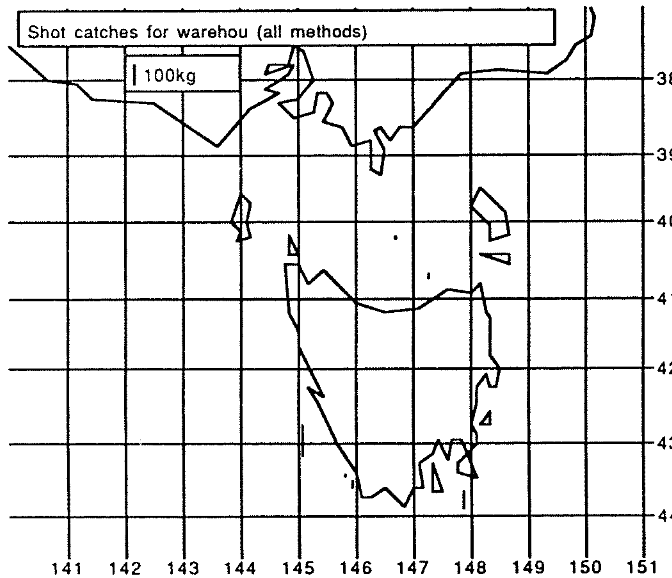


Fig. 3.38: Warehou shot catch weights.

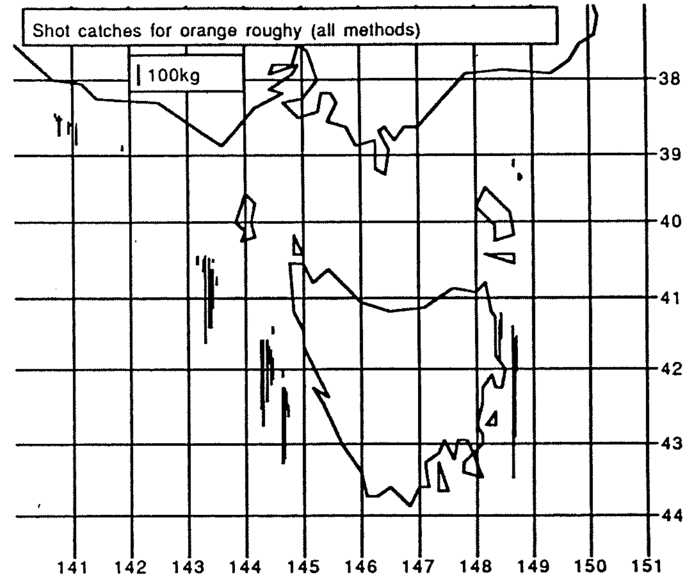


Fig. 3.39: Orange roughy shot catch weights.

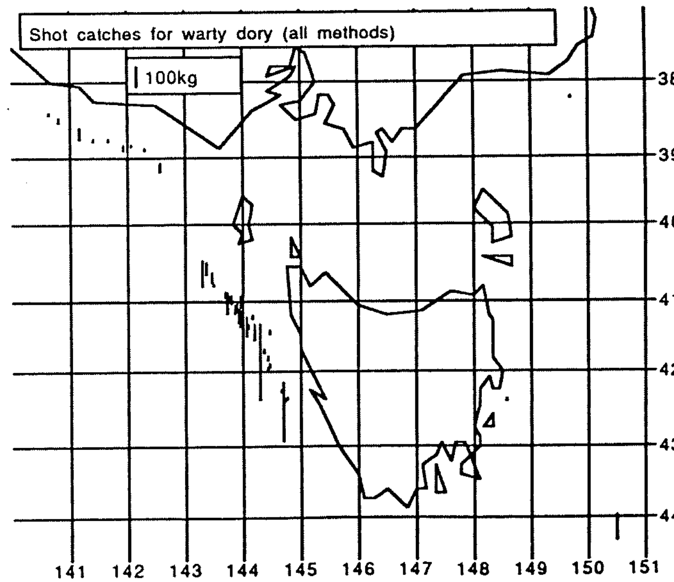


Fig. 3.40: Warty dory shot catch weights.

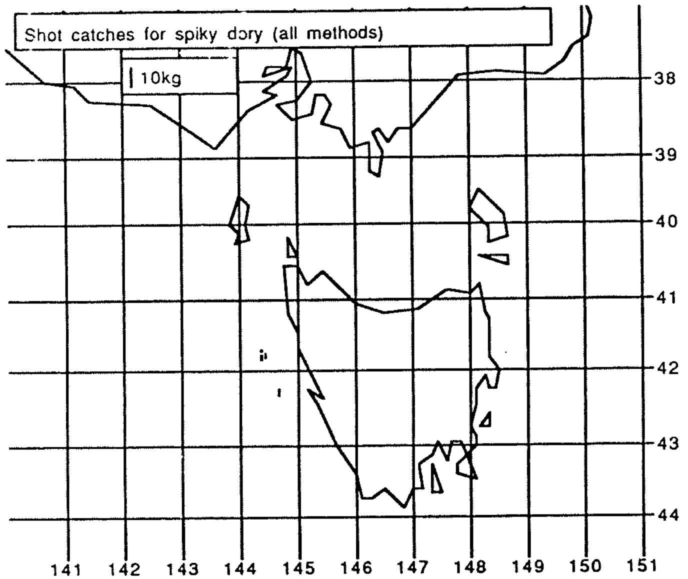


Fig. 3.41: Spiky dory shot catch weights.

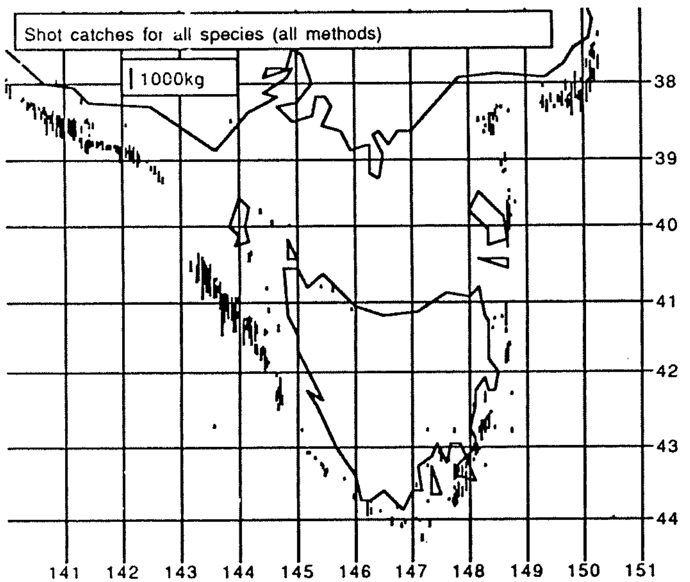


Fig. 3.42: Total shot catch weights.

Notes for Figs. 3.43 to 3.56.

Swept area effort of individual shots (trawls only) are shown. Shot positions are located by the top of the bars. The lengths of the bars are proportional to the swept area effort of the shots according to the scale shown in the legends.

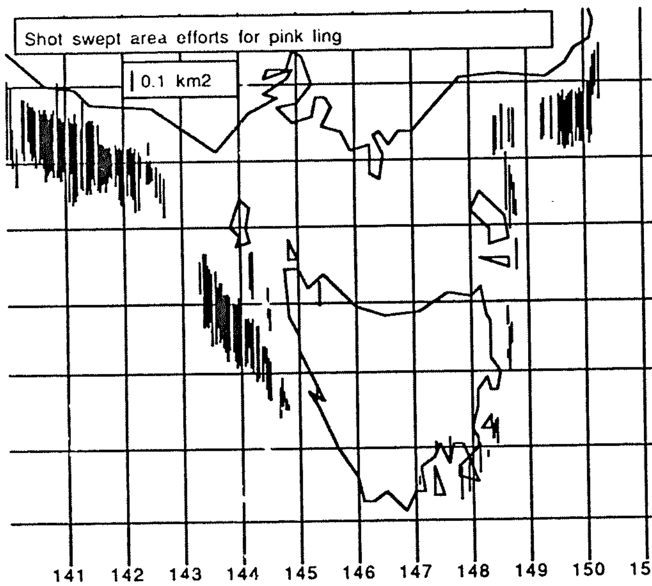


Fig. 3.43: Swept area effort for shots in which pink ling were caught.

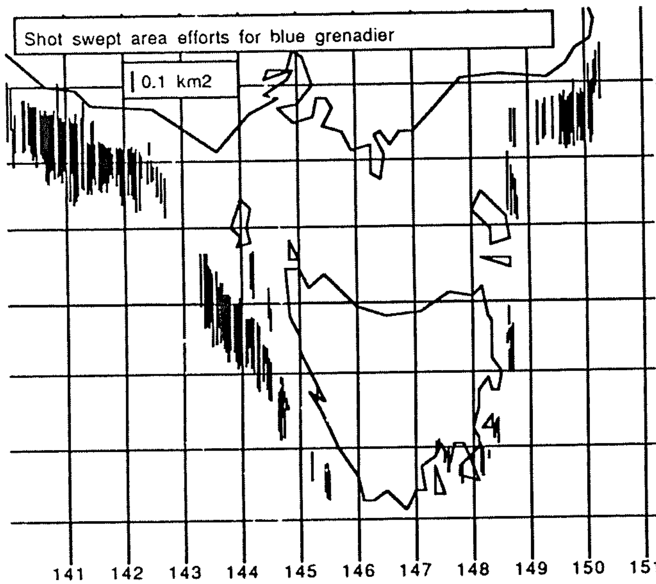


Fig. 3.44: Swept area effort for shots in which blue grenadier were caught.

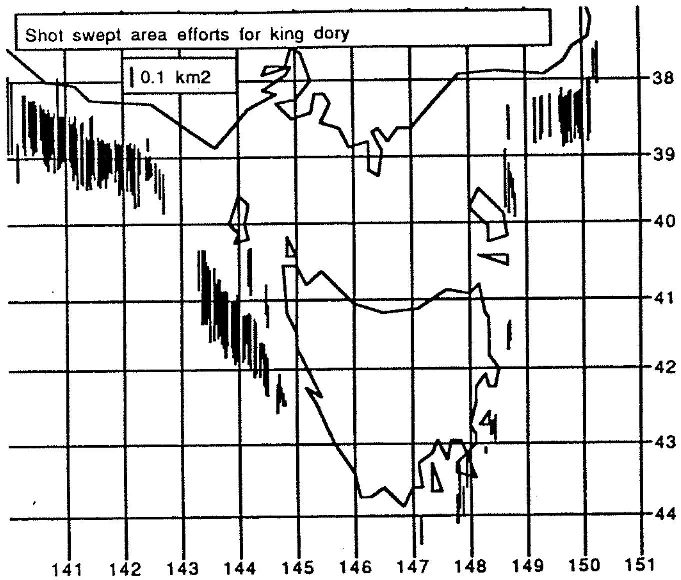


Fig. 3.45: Swept area effort for shots in which king dory were caught.

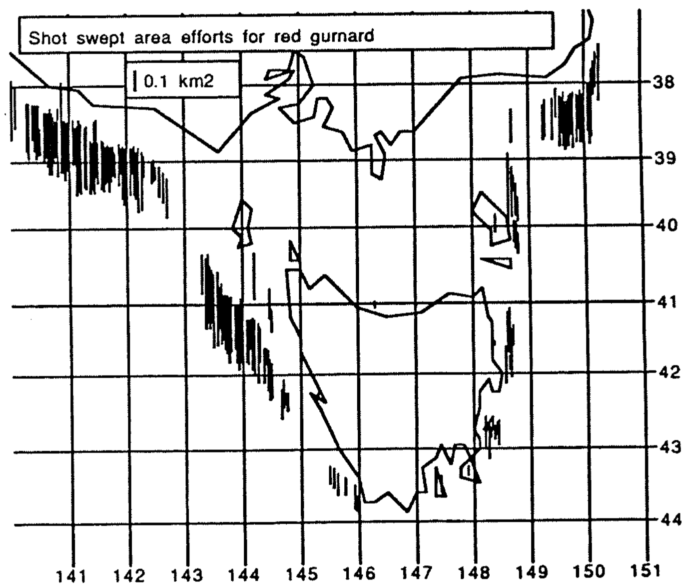


Fig. 3.46: Swept area effort for shots in which red gurnard were caught.

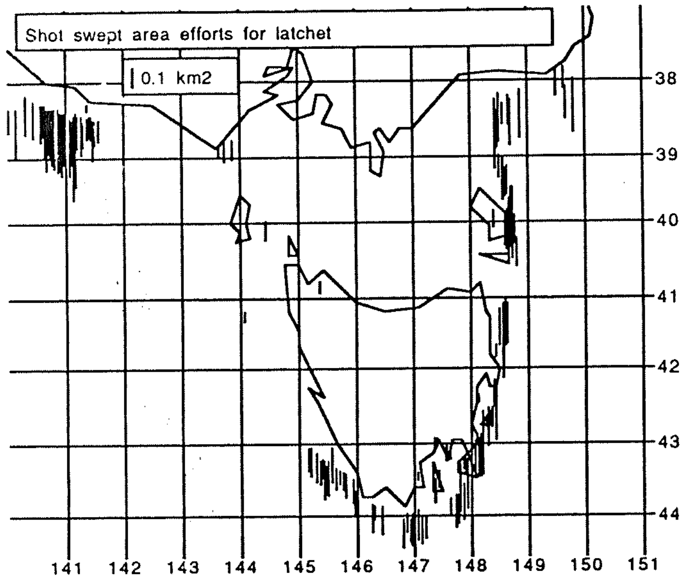


Fig. 3.47: Swept area effort for shots in which latchet were caught.

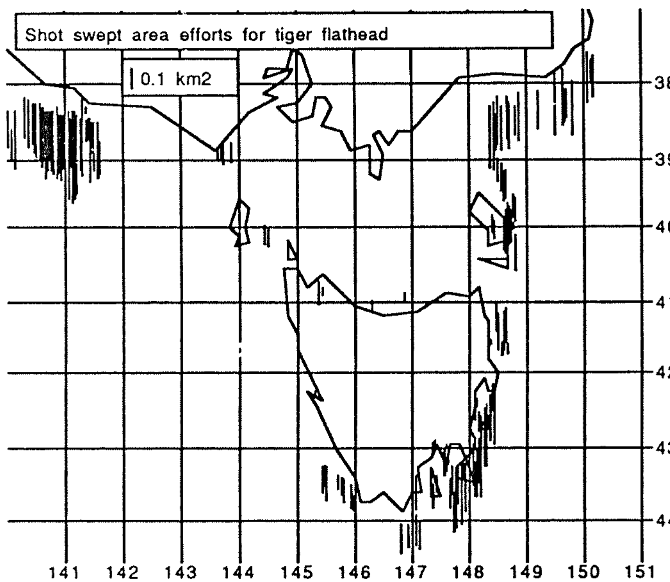


Fig. 3.48: Swept area effort for shots in which tiger flathead were caught.

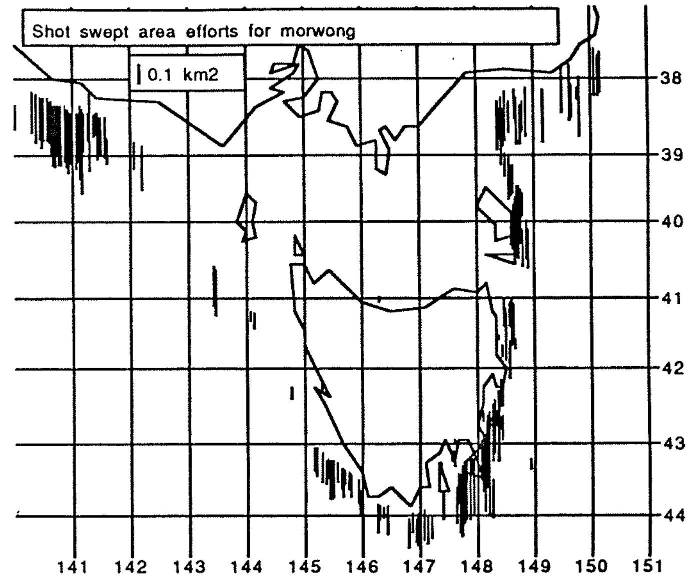


Fig. 3.49: Swept area effort for shots in which morwong were caught.

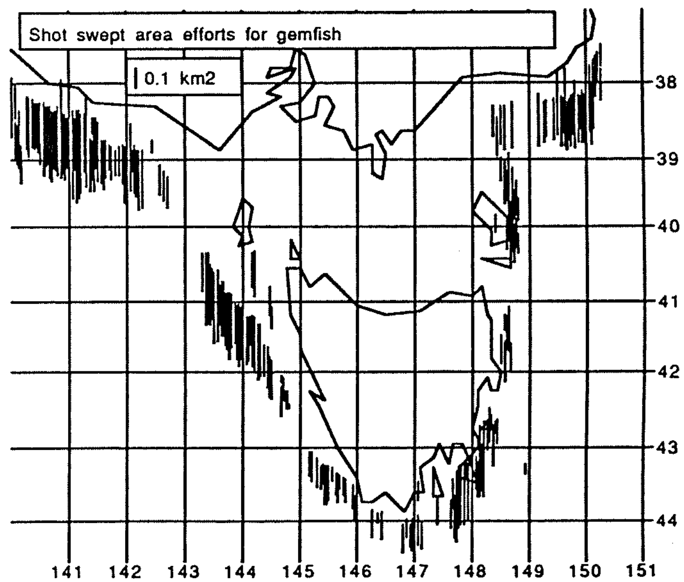


Fig. 3.50: Swept area effort for shots in which gemfish were caught.

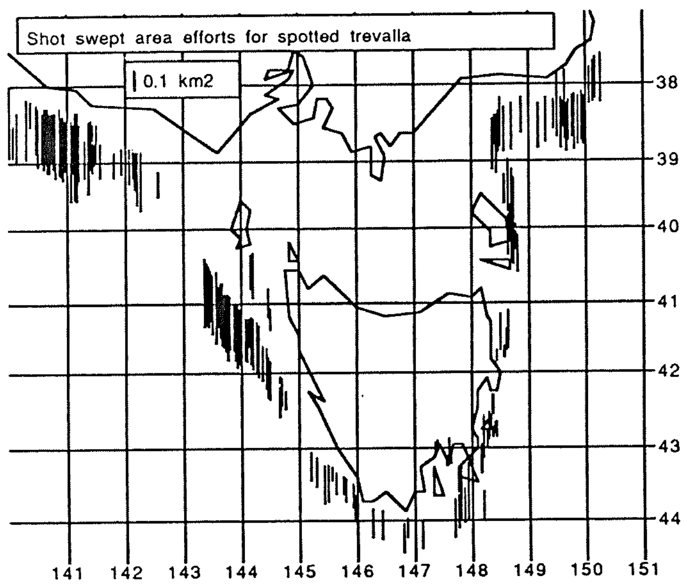


Fig. 3.51: Swept area effort for shots in which spotted trevalla were caught.

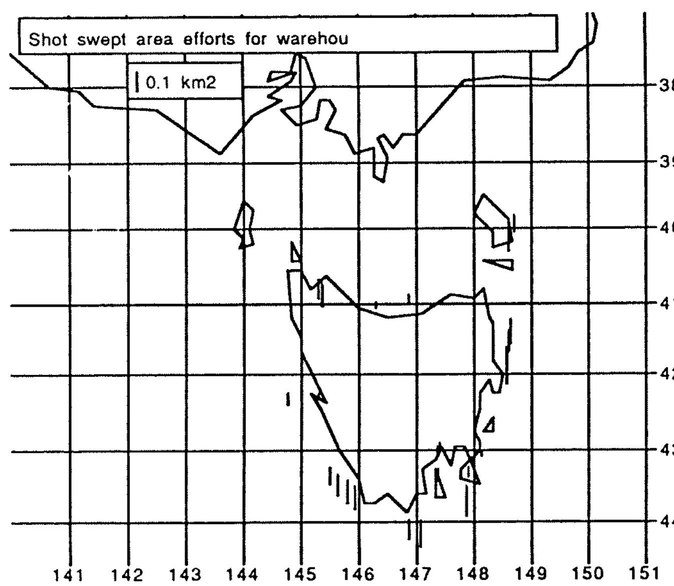


Fig. 3.52: Swept area effort for shots in which warehou were caught.

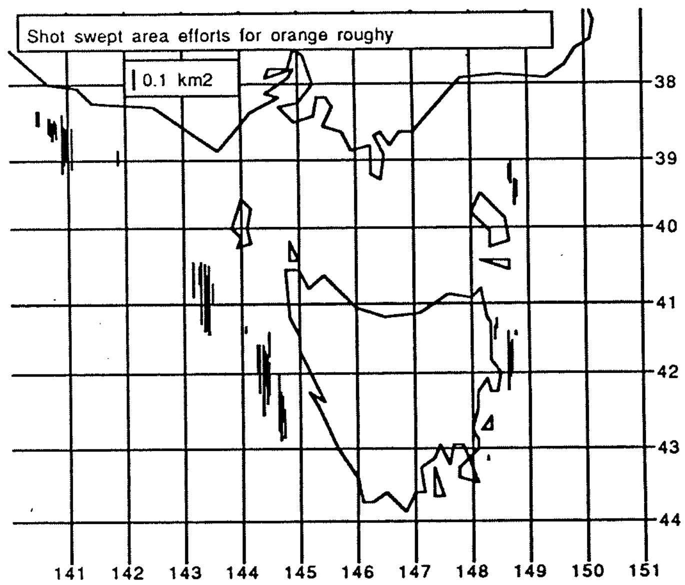


Fig. 3.53: Swept area effort for shots in which orange roughy were caught.

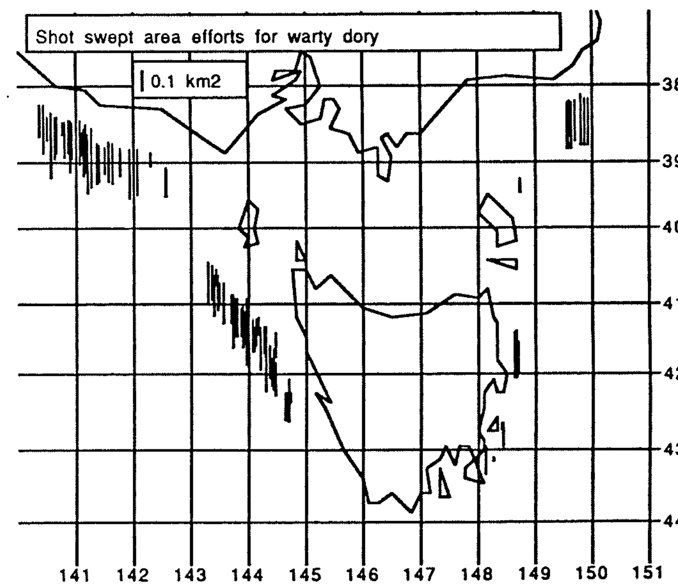


Fig. 3.54: Swept area effort for shots in which warty dory were caught.

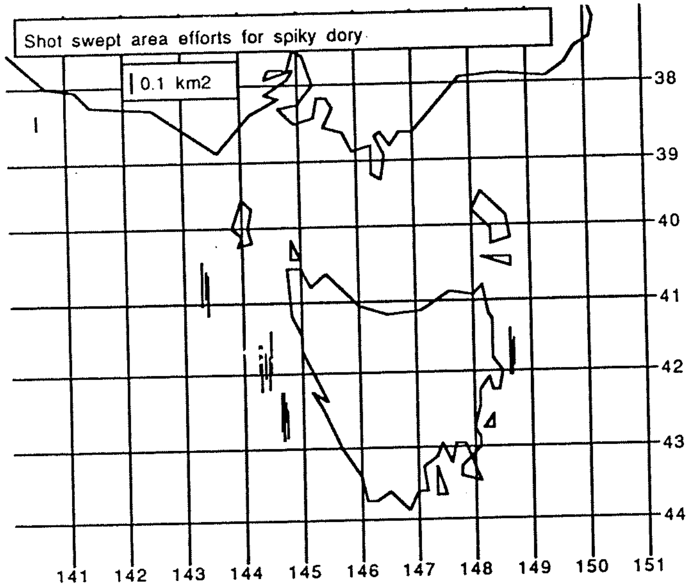


Fig. 3.55: Swept area effort for shots in which spiky dory were caught.

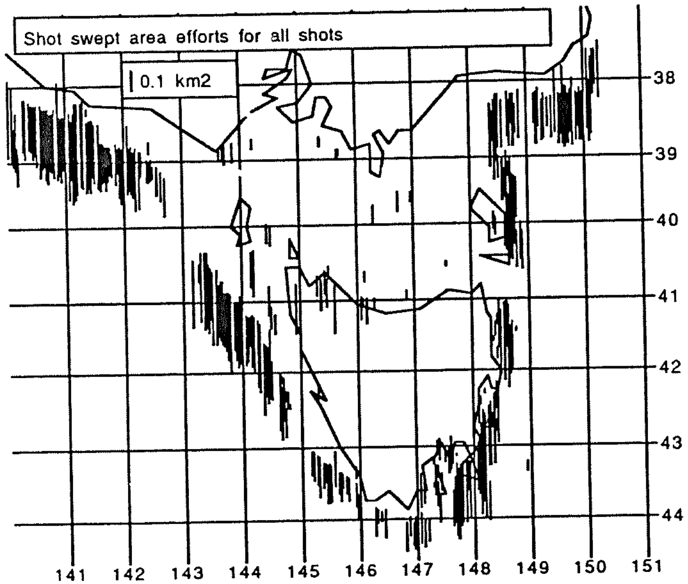


Fig. 3.56: Swept area effort for all shots.

Notes for Figs. 3.57 to 3.70.

Catch per swept area effort of individual shots (trawls only) are shown. Shot positions are located by the top of the bars. The lengths of the bars are proportional to the catch per swept area effort of the shots according to the scale shown in the legends.

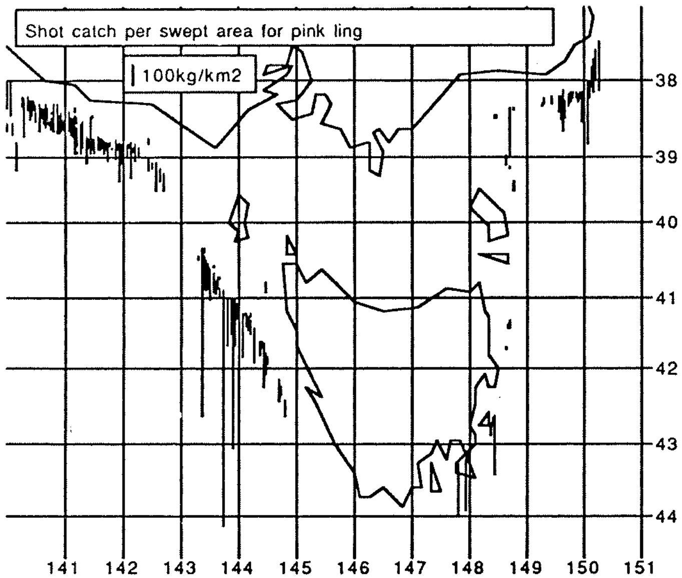


Fig. 3.57: Pink ling catch per swept area effort, excluding unsuccessful shots.

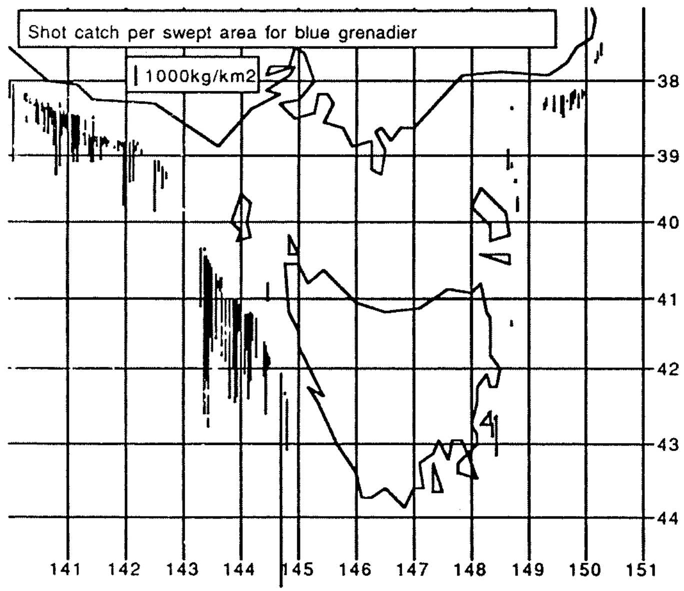


Fig. 3.58: Blue grenadier catch per swept area effort, excluding unsuccessful shots.

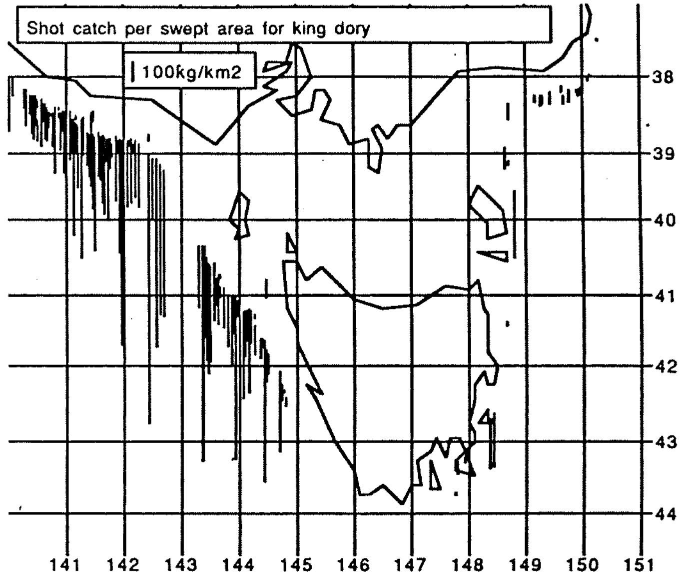


Fig. 3.59: King dory catch per swept area effort, excluding unsuccessful shots.

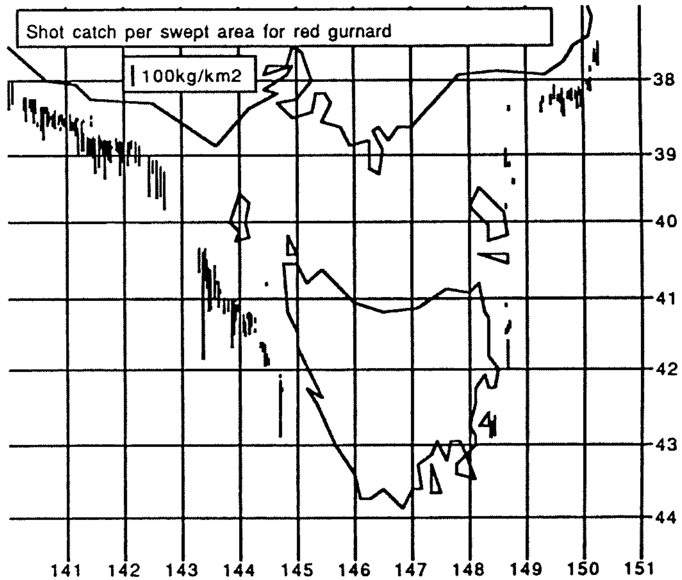


Fig. 3.60: Red gurnard catch per swept area effort, excluding unsuccessful shots.

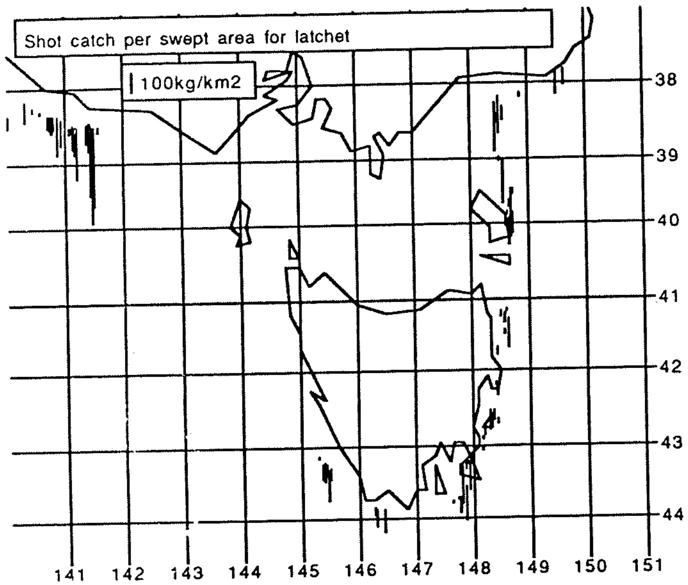


Fig. 3.61: Latchet cat^h per swept area effort, excluding unsuccessful shots.

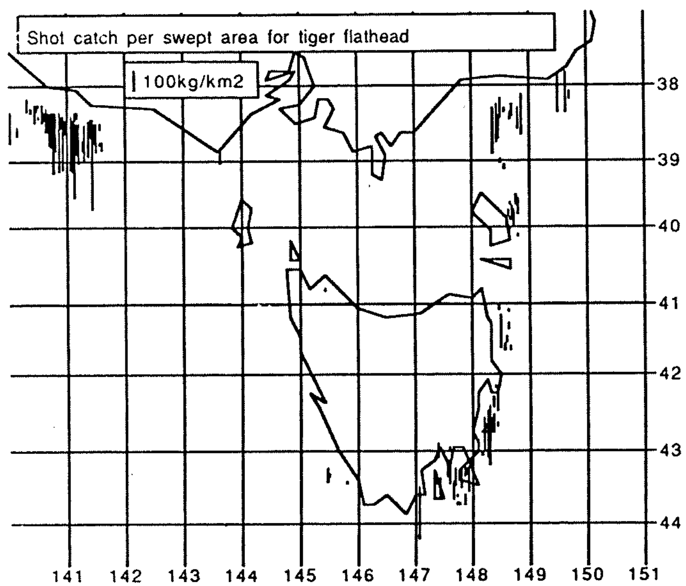


Fig. 3.62: Tiger flathead catch per swept area effort, excluding unsuccessful shots.

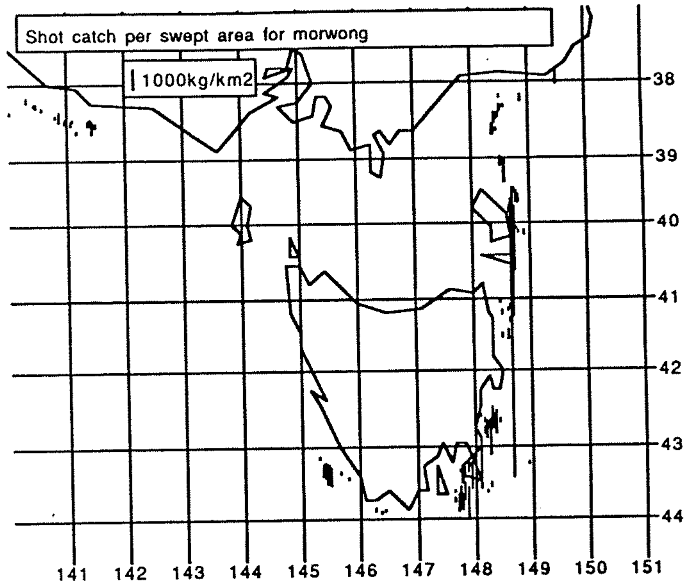


Fig. 3.63: Morwong catch per swept area effort, excluding unsuccessful shots.

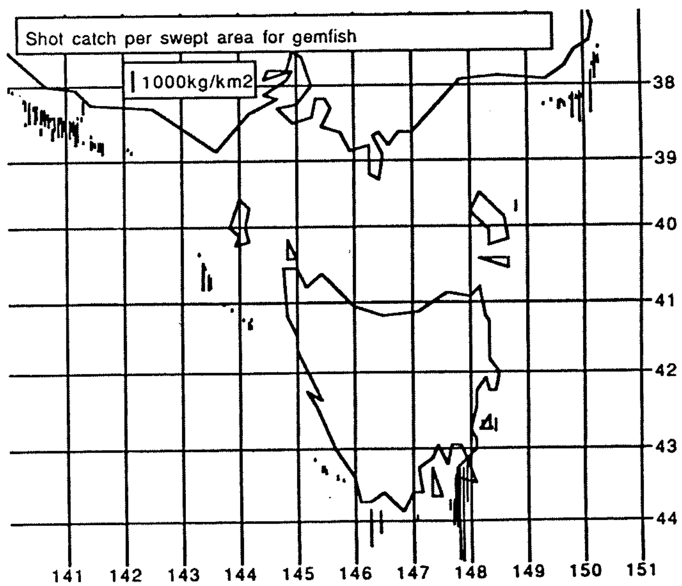


Fig. 3.64: Gemfish catch per swept area effort, excluding unsuccessful shots.

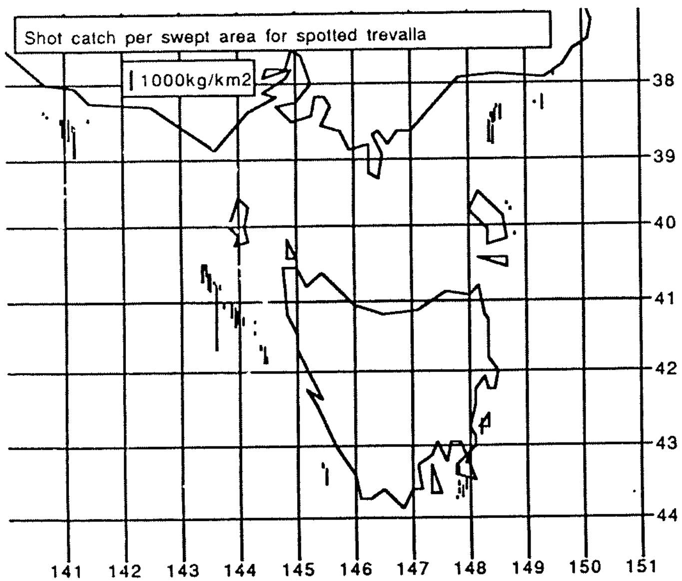


Fig. 3.65: Spotted trevalla catch per swept area effort, excluding unsuccessful shots.

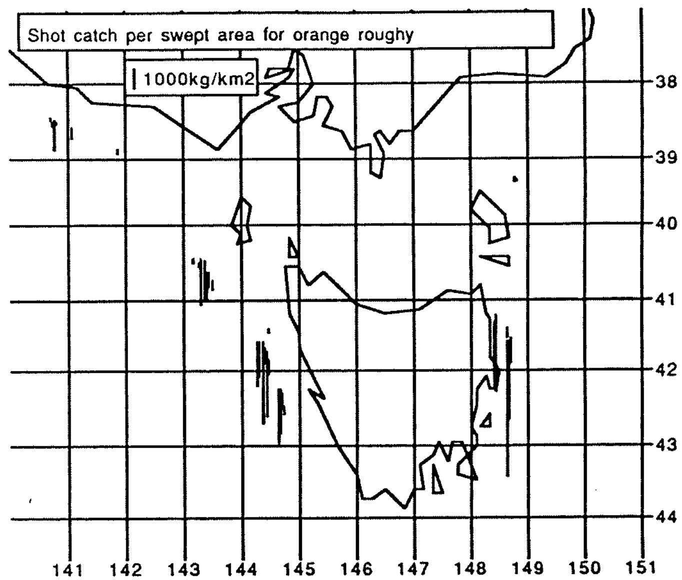


Fig. 3.67: Orange roughy catch per swept area effort, excluding unsuccessful shots.

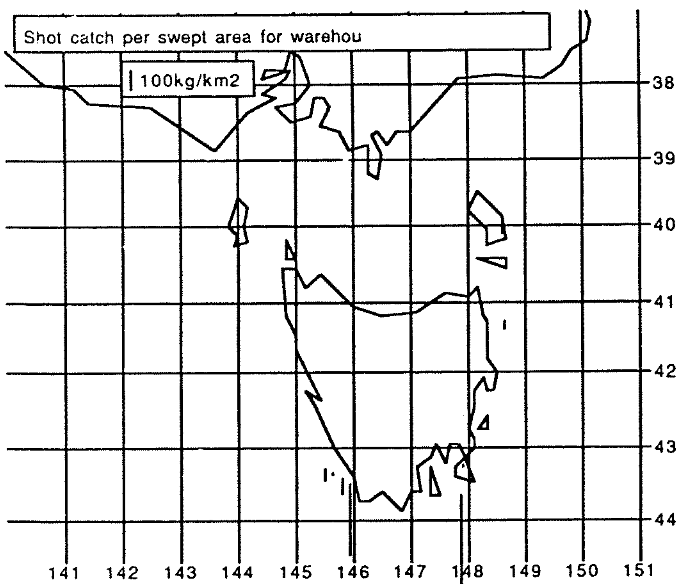


Fig. 3.66: Warehou catch per swept area effort, excluding unsuccessful shots.

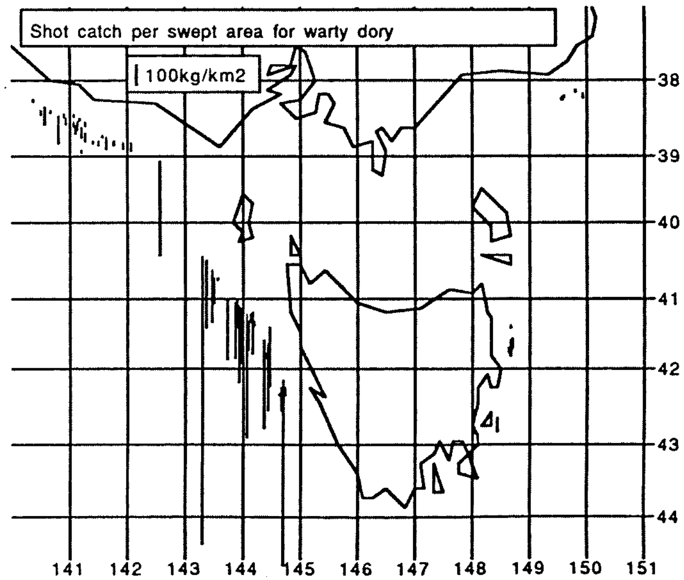


Fig. 3.68: Warty dory catch per swept area effort, excluding unsuccessful shots.

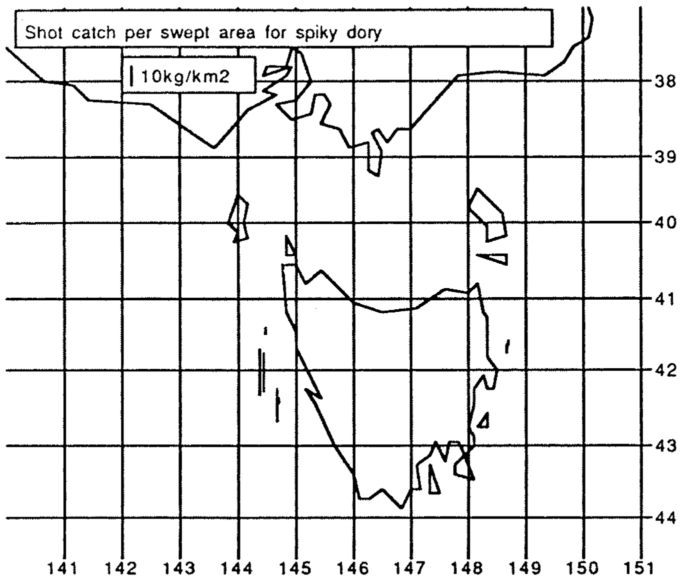


Fig. 3.69: Spiky dory catch per swept area effort, excluding unsuccessful shots.

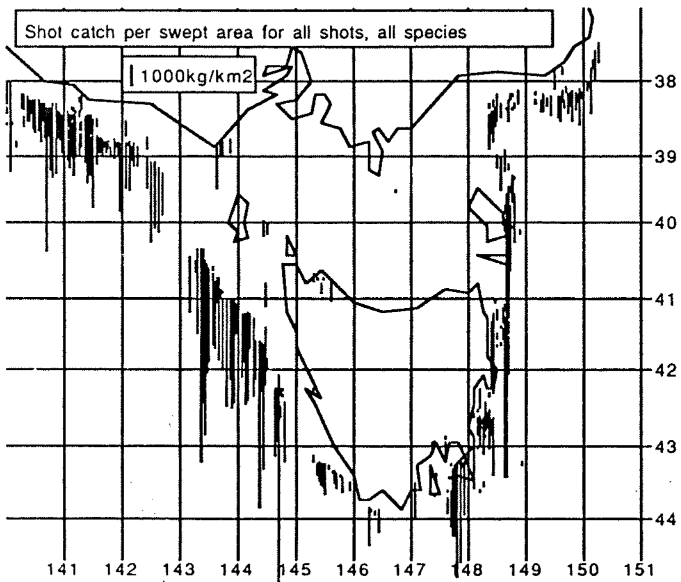


Fig. 3.70: Total catch per swept area effort, excluding unsuccessful shots.

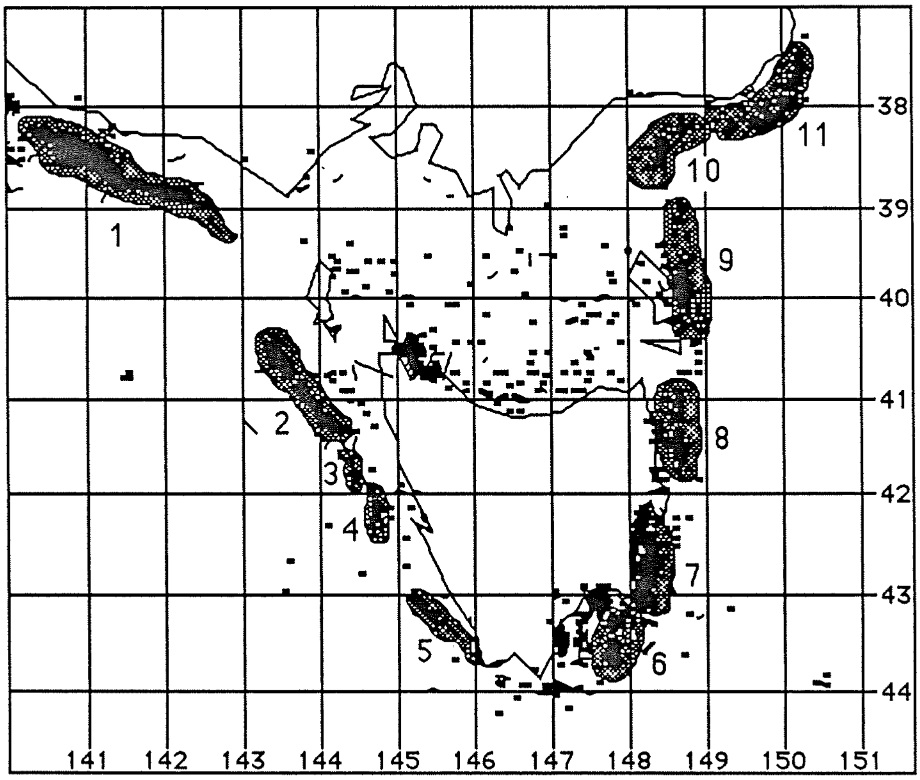


Fig. 4.0: Areas used in stratification by position.

Notes for Tables 4.1 to 4.39.

Stratified catches (kg) and catches per swept areas (kg/km^2) are compared by ANOVA. Where significant variations between the means exist, the stratifications are grouped by multiple range testing.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	42.5	47.4	1.49	1014	ii	42588	26.02
2	112.9	192.0	8.5	504	iii	56448	34.49
3	86.1	61.2	14.9	17	iii	1462	0.89
4	46.0	46.3	16.4	8	ii	368	0.22
5	-	-	-	0	-	0	0
6	239.5	133.5	47.2	8	iii	1912	1.17
7	45.1	51.2	12.4	17	ii	765	0.47
8	15.6	15.1	5.7	7	i	105	0.06
9	45.0	36.2	14.8	6	ii	270	0.16
10	55.6	102.6	24.9	17	ii	935	0.57
11	148.8	110.8	17.9	38	iii	5624	3.44
12	115.3	179.4	8.3	462	iii	53130	32.47
Total	78.6	137.3	3.0	2098			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	3.9531e+7	2097	
Groups	3.0031e+6	10	3.0031e+5
Error	3.6528e+7	2087	1.7503e+4

F=17.158 $F_{5\%}$ =1.83, hence reject Ho.

Table 4.1 (a): Comparison and grouping of catch data by area for pink ling.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	250.6	259.3	8.1	1014	i	253500	26.09
2	672.9	1302.9	58.0	504	ii	338688	34.87
3	656.9	656.2	159.2	17	ii	11152	1.15
4	799.9	837.8	296.2	8	ii	6392	0.66
5	-	-	-	0	-	0	0
6	1619.9	882.4	312.0	8	iv	12952	1.33
7	686.2	670.1	162.5	17	ii	11662	1.20
8	164.0	146.6	55.4	7	iii	1148	0.12
9	238.0	211.0	86.2	6	iii	1428	0.15
10	320.4	610.7	148.1	17	iii	5440	0.56
11	869.9	655.5	106.3	38	ii	33022	3.40
12	640.3	1033.0	48.1	462	ii	295680	30.44
Total	463.46	863.5	18.9	2098			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	1.5637e+9	2097	
Groups	1.0314e+8	10	1.0314e+7
Error	1.4606e+9	2087	6.9984e+5

F=14.738 $F_{5\%}$ =1.83, hence reject Ho.

Table 4.1 (b): Comparison and grouping of catch per swept area data by area for pink ling.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	147.7	169.2	6.8	625	iv	91875	36.29
2	150.6	170.2	7.3	542	iv	81300	32.12
3	142.8	125.9	29.7	18	iii	2556	1.01
4	117.9	123.3	43.7	8	iii	936	0.37
5	-	-	-	0	-	0	0
6	37	35.9	14.7	6	i	222	0.09
7	48.8	35.8	8.7	17	i	833	0.33
8	33.0	38.9	19.4	4	i	132	0.05
9	117.1	93.2	35.2	7	ii	819	0.32
10	90.0	61.4	16.4	14	ii	1260	0.50
11	27.9	20.2	5.8	12	i	336	0.13
12	191.7	237.8	12.2	380	v	72580	28.67
Total	155.5	186.3	4.6	1633			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	5.6648e+7	1632	
Groups	1.1668e+6	10	1.1668e+5
Error	5.5481e+7	1622	3.4205e+4

F= 3.411 $F_{5\%}$ =1.83, hence reject Ho.

Table 4.3(a): Comparison and grouping of catch data by area for king dory.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	934.5	1062.1	42.5	625	iii	583750	36.89
2	807.7	901.3	38.7	542	iii	437394	27.64
3	1430.5	2013.8	474.6	18	vi	25740	1.33
4	1540.1	1408.6	498.0	8	vi	12320	0.78
5	-	-	-	0	-	0	0
6	241.8	234.4	95.7	6	i	1446	0.09
7	1006.8	799.7	193.9	17	iv	17102	1.08
8	696.7	1105.3	552.7	4	iv	2784	0.18
9	980.5	1220.8	461.4	7	iv	6860	0.43
10	440.6	267.9	71.7	14	ii	6160	0.39
11	126.3	72.6	21.0	12	i	1512	0.09
12	1265.8	1778.3	91.2	380	v	460700	30.38
Total	969.0	1242.4	30.7	1633			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	2.5195e+9	1632	
Groups	7.0669e+7	10	7.0669e+6
Error	2.4489e+9	1622	1.5098e+6

F= 4.681 $F_{5\%}$ =1.83, hence reject Ho.

Table 4.3 (b): Comparison and grouping of catch per swept area data by area for king dory.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	412.3	882.5	28.4	967	iii	398404	20.40
2	1653.9	2210.2	93.8	555	vi	917415	46.97
3	775.6	1378.6	275.7	25	iv	19375	0.99
4	1719.0	2885.9	870.1	11	iv	18909	0.97
5	52.9	31.3	11.8	7	i	364	0.02
6	1123.0	1420.4	820.1	3	iv	3369	0.17
7	155.3	226.0	47.1	23	i	3565	0.18
8	38.4	71.4	20.6	12	i	456	0.02
9	415.7	335.5	126.8	7	ii	2905	0.15
10	520.1	596.4	154.0	15	ii	7800	0.40
11	209.4	357.5	60.4	35	ii	7315	0.37
12	1237.7	1980.3	92.0	463	v	57273	29.32
Total	920.3	1690.9	36.7	2123			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	6.0670e+9	2122	
Groups	6.5247e+8	11	5.9316e+7
Error	5.4145e+9	2111	2.5649e+6

F=23.126 $F_{5\%}$ =1.79, hence reject Ho.

Table 4.2 (a): Comparison and grouping of catch data by area for blue grenadi

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	2326.3	4995.0	160.6	967	ii	2249242	20.45
2	8714.0	11492.2	487.8	555	v	4836270	43.98
3	5562.2	9361.4	1872.3	25	vi	139050	1.26
4	25250.3	40541.4	12223.7	11	vi	277750	2.53
5	382.6	206.3	77.9	7	i	2674	0.02
6	22619.2	28615.9	16521.4	3	vi	67857	0.62
7	3201.6	4728.4	986.0	23	iii	73623	0.67
8	550.6	1045.8	301.9	12	i	6600	0.06
9	2657.3	2704.9	1022.3	7	iii	18599	0.17
10	2649.7	2731.4	705.2	15	iii	39735	0.36
11	1125.6	1603.8	271.1	35	i	39375	0.36
12	7014.5	11839.9	550.3	463	iv	3247482	29.53
Total	5180.8	9850.1	213.8	2123			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	2.058e+11	2122	
Groups	2.293e+10	11	2.0851e+9
Error	1.829e+11	2111	8.6665e+7

F= 24.059 $F_{5\%}$ =1.79, hence reject Ho.

Table 4.2 (b): Comparison and grouping of catch per swept area data by area fo grenadier.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	44.1	47.1	2.0	566	iii	24904	33.38
2	47.5	53.4	2.5	446	iii	20962	28.09
3	41.1	20.4	5.3	15	ii	615	0.82
4	44.6	62.9	28.1	5	ii	220	0.29
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	16.7	12.3	3.2	15	i	255	0.34
8	25.3	21.6	6.2	12	i	300	0.40
9	60.0	44.1	15.6	8	iv	480	0.64
10	70.4	46.0	12.7	13	iv	910	1.22
11	83.6	70.5	13.1	29	iv	2436	3.27
12	63.5	73.6	3.8	383	iv	24129	32.34
Total	50.7	57.6	1.5	1492			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	4.9544e+6	1491	
Groups	1.5575e+5	9	1.7305e+4
Error	4.7987e+6	1482	3.2380e+3

F= 5.345 $F_{5\%}$ =1.88, hence reject Ho.

Table 4.4 (a): Comparison and grouping of catch data by area for red gurnard.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	281.4	308.0	12.9	566	ii	159046	34.84
2	260.4	298.0	14.1	446	i	115960	25.40
3	345.3	263.2	68.0	15	iv	5175	1.13
4	712.0	1250.6	559.3	5	iv	3560	0.78
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	338.0	224.9	58.0	15	iv	5070	1.11
8	304.9	419.1	121.0	12	iv	3660	0.80
9	426.3	453.2	160.2	8	iv	3408	0.75
10	360.8	176.1	48.8	13	iii	4680	1.03
11	429.8	343.7	63.8	29	iii	12441	2.72
12	373.5	434.8	22.2	383	iii	142859	31.29
Total	305.9	352.1	9.1	1492			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	1.8479e+8	1491	
Groups	4.4770e+6	9	4.9744e+5
Error	1.8032e+8	1482	1.2167e+5

F= 4.088 $F_{5\%}$ =1.88, hence reject Ho.

Table 4.4 (b): Comparison and grouping of catch per swept area data by area for gurnard.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	57.9	80.1	4.6	303	i	17574	46.32
2	30.0	-	-	1	i	30	0.08
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	64.4	54.5	8.7	39	i	2496	6.58
6	82.1	67.4	8.6	61	i	5002	13.18
7	27.6	16.3	3.7	19	i	513	1.35
8	24.9	23.1	5.6	17	i	425	1.12
9	69.7	44.8	7.8	33	i	2310	6.09
10	102.3	93.3	20.9	20	i	2040	5.38
11	69.3	29.9	11.3	7	i	483	1.27
12	61.4	128.7	12.2	112	i	6832	10.01
Total	61.7	86.0	3.5	612			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	4.5216e+6	611	
Groups	1.1166e+5	9	1.2407e+4
Error	4.4099e+6	602	7.3255e+3

F= 1.694 $F_{5\%}$ =1.88, hence accept Ho.

Table 4.5(a): Comparison and grouping of catch data by area for latchet.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	581.9	927.0	53.3	303	i	176346	50.64
2	589.7	-	-	1	i	590	0.17
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	499.3	389.2	62.3	39	i	19461	5.59
6	561.9	438.1	56.1	61	i	34282	9.84
7	259.0	132.8	30.5	19	i	4921	1.41
8	277.9	304.4	73.8	17	i	4726	1.36
9	552.9	483.1	84.1	33	i	18249	5.24
10	560.7	493.0	110.2	20	i	11220	3.22
11	577.3	374.9	141.7	7	i	4039	1.16
12	665.8	2456.8	232.1	112	i	74592	21.42
Total	569.2	1257.4	50.8	612			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	9.6607e+8	611	
Groups	4.5697e+6	9	5.0775e+5
Error	9.6150e+8	602	1.5972e+6

F= 0.318 $F_{5\%}$ =1.88, hence accept Ho.

Table 4.5(b): Comparison and grouping of catch per swept area data by area for latchet.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	56.9	65.2	2.4	732	ii	41724	69.63
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	20.6	25.0	9.4	7	i	147	0.25
6	40.5	34.2	4.9	48	i	1920	3.20
7	69.5	65.6	10.5	39	iii	2691	4.49
8	32.6	48.6	14.0	12	i	396	0.66
9	39.2	22.6	4.5	25	i	975	1.63
10	105.3	64.3	9.9	42	iv	4410	7.36
11	77.3	76.2	14.5	19	iii	1463	2.44
12	43.6	50.7	4.2	146	i	6278	10.48
Total	56.2	62.6	1.9	1070			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	4.1895e+6	1069	
Groups	1.7476e+5	8	2.1845e+4
Error	4.0148e+6	1061	3.7839e+3

F= 5.773 $F_{5\%}$ =1.94, hence reject Ho.

Table 4.6 (a): Comparison and grouping of catch data by area for tiger flathead.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	399.7	512.2	18.9	732	ii	292800	65.47
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	185.5	269.1	101.7	7	i	1295	0.29
6	333.5	293.4	42.3	48	i	15984	3.57
7	543.6	522.6	83.7	39	iii	21177	4.73
8	343.8	471.7	136.2	12	i	4116	0.92
9	344.2	204.1	40.8	25	i	8600	1.92
10	636.5	419.8	64.8	42	iii	26712	5.97
11	680.4	753.2	172.8	19	iii	12920	2.89
12	438.8	902.9	74.7	146	iii	63948	14.30
Total	418.2	572.9	17.5	1070			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	3.5089e+8	1069	
Groups	5.1602e+6	8	6.4503e+5
Error	3.4573e+8	1061	3.2585e+5

F= 1.980 $F_{5\%}$ =1.94, hence reject Ho.

Table 4.6(b): Comparison and grouping of catch per swept area data by area for flathead.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	59.4	89.9	4.9	342	i	20178	8.10
2	35.0	44.9	22.5	4	i	140	0.06
3	-	-	-	0	-	0	0
4	30.0	-	-	1	i	30	0.01
5	370.3	319.5	39.9	64	iii	23680	9.50
6	253.0	274.0	17.8	237	ii	59961	24.06
7	253.6	462.0	57.7	64	ii	16192	6.50
8	138.0	133.4	25.7	27	ii	3726	1.50
9	1144.8	3270.9	453.6	52	iv	59488	23.87
10	213.1	194.7	32.4	36	ii	7668	3.08
11	129.9	186.0	41.6	20	ii	2600	1.04
12	257.9	656.3	44.4	218	ii	56244	22.57
Total	234.9	832.6	25.5	1065			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	7.3758e+8	1064	
Groups	5.5667e+7	10	5.5667e+6
Error	6.8191e+8	1054	6.4697e+5

F= 8.604 $F_{5\%}$ =1.83, hence reject Ho.

Table 4.7(a): Comparison and grouping of catch data by area for morwong.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	490.5	808.7	43.7	342	i	167580	8.86
2	485.9	611.3	305.7	4	i	1944	0.10
3	-	-	-	0	-	0	0
4	510.6	-	-	1	i	511	0.03
5	3040.0	2612.4	326.6	64	iii	194560	10.29
6	1798.0	1812.3	117.7	237	ii	426126	22.53
7	2029.4	3765.9	470.7	64	ii	129856	6.87
8	1374.8	1333.9	256.7	27	ii	37098	1.96
9	8241.8	21329.0	2957.8	52	iv	428532	22.66
10	1302.6	1235.7	206.0	36	ii	46872	2.48
11	937.3	1553.7	347.4	20	ii	18740	0.99
12	2017.7	4517.0	305.9	218	ii	439706	23.25
Total	1776.5	5568.3	170.6	1065			

ANOVA Ho. all means are equal.

Source	SS	DF	MS
Total	3.299e+10	1064	
Groups	2.893e+9	10	2.8931e+8
Error	3.009e+10	1054	2.8555e+7

F= 10.132 $F_{5\%}$ =1.83, hence reject Ho.

Table 4.7 (b): Comparison and grouping of catch per swept area data by area for morwong.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	191.5	265.5	7.5	1258	iii	240278	42.34
2	61.6	147.0	7.1	425	ii	25925	4.57
3	28.2	18.0	5.0	13	i	364	0.06
4	38.6	77.2	27.3	8	i	304	0.05
5	183.5	272.8	40.7	45	iii	8235	1.45
6	702.8	865.0	59.0	215	v	151145	26.64
7	94.5	194.0	37.3	27	ii	2538	0.45
8	42.8	34.9	8.7	16	i	672	0.12
9	69.6	72.3	12.8	32	ii	2240	0.39
10	68.4	58.1	12.1	23	ii	1564	0.28
11	641.2	1524.9	235.3	42	iv	26922	4.74
12	212.5	433.0	19.4	499	iv	105788	18.64
Total	217.9	448.5	8.8	2603			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	5.2340e+8	2602	
Groups	7.2250e+7	11	6.5682e+6
Error	4.5115e+8	2591	1.7412e+5

F= 37.722 $F_{5\%}$ =1.79, hence reject Ho.

Table 4.8 (a): Comparison and grouping of catch data by area for gemfish.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	1001.3	1316.5	37.1	1258	iii	1259258	36.99
2	325.1	775.9	37.6	425	i	138125	4.06
3	171.9	101.2	28.1	13	i	2236	0.07
4	421.0	570.6	201.7	8	i	3368	0.09
5	1377.1	1786.1	266.3	45	iii	61965	1.82
6	5061.8	6477.8	441.8	215	v	1088115	31.96
7	957.9	1590.7	306.1	27	ii	25866	0.76
8	441.7	394.3	98.6	16	ii	7056	0.21
9	561.5	881.2	155.8	32	ii	17952	0.53
10	368.5	331.0	69.0	23	ii	8464	0.25
11	3567.3	8339.1	1286.8	42	iv	149814	4.40
12	1286.0	2543.9	113.9	499	iv	641714	18.85
Total	1308.0	2879.5	56.4	2603			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	2.157e+10	2602	
Groups	3.849e+9	11	3.4999e+8
Error	1.772e+10	2591	6.8410e+6

F= 51.160 $F_{5\%}$ =1.79, hence reject Ho.

Table 4.8(b): Comparison and grouping of catch per swept area data by area for gemfish.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	152.8	698.2	42.3	273	i	41496	21 13
2	186 2	568.3	29.3	376	i	69936	35.61
3	270.7	241.3	69.6	12	i	3240	1.65
4	26.8	19.7	8.1	6	i	156	0.08
5	197.7	274 4	66.6	17	i	3349	1.71
6	164.3	217.9	29.9	53	i	8692	4.43
7	116.4	356.1	91.9	15	i	1740	0.89
8	39.4	54.2	16.3	11	i	429	0.22
9	65.4	51.7	11.6	20	i	1300	0.66
10	400.8	563.5	96.6	34	i	13600	6.93
11	621.5	1413.2	324.2	19	i	11799	6.01
12	169 3	400.8	25.7	243	i	41067	20.91
Total	182.8	571.1	17.4	1079			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	3.5158e+8	1078	
Groups	6.3955e+6	11	5.8141e+5
Error	3.4518e+8	1067	3.2351e+5

F= 1.797 $F_{5\%}$ =1.79, hence choose to accept Ho.

Table 4.9 (a): Comparison and grouping of catch data by area for spotted trevalla.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	935.5	4931.6	298.5	273	i	255255	21.66
2	1017.5	3020.7	155.8	376	i	382392	32.45
3	2014.1	2072.9	598.4	12	i	24168	2.05
4	370.0	293.2	119.7	6	i	2220	0.19
5	1391.1	1890.5	458.5	17	i	23647	2.00
6	1077.3	1391.2	191.1	53	i	57081	4.84
7	855.4	2067.0	533.7	15	i	12825	1.09
8	357.3	430.2	129.7	11	i	3927	0.33
9	498.2	380.3	85.0	20	i	9960	0.85
10	2171.5	2861.9	490.8	34	i	73814	6.26
11	4048.0	9381.6	2152.3	19	i	76912	6.53
12	1052.2	2278.8	146.2	243	i	255636	21.70
Total	1092.0	3559.9	1084.4	1079			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	1.366e+10	1078	
Groups	2.434e+8	11	2.2136e+7
Error	1.341e+10	1067	1.2576e+7

F= 1.760 $F_{5\%}$ =1.79, hence accept Ho.

Table 4.9 (b): Comparison and grouping of catch per swept area data by area for spotted trevalla.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	55.0	40.9	23.6	3	i	165	4.67
6	452.5	632.9	447.5	2	i	904	25.57
7	-	-	-	0	-	0	0
8	9.3	6.1	3.5	3	i	27	0.76
9	160.0	-	-	1	i	160	4.52
10	-	-	-	0	-	0	0
11	-	-	-	0	-	0	0
12	326.0	587.1	221.9	7	i	2282	64.54
Total	221.3	438.0	109.5	16			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	2.8773e+6	15	
Groups	4.0520e+5	4	1.0130e+5
Error	2.4721e+6	11	2.2474e+5

F= 0.45 $F_{5\%}$ =3.36, hence accept Ho.

Table 4.10 (a): Comparison and grouping of catch data by area for warehou.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	560.1	341.7	197.3	3	i	1680	4.76
6	5260.2	7290.8	5155.4	2	i	10520	29.82
7	-	-	-	0	-	0	0
8	181.8	148.6	85.8	3	i	543	1.54
9	921.3	-	-	1	i	921	2.61
10	-	-	-	0	-	0	0
11	-	-	-	0	-	0	0
12	3089.4	4950.0	1870.9	7	i	21623	61.29
Total	2205.8	4054.9	1013.7	16			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	2.4664e+8	15	
Groups	4.6189e+7	4	1.1547e+7
Error	2.0045e+8	11	1.8223e+7

F= 0.634 $F_{5\%}$ =3.36, hence accept Ho.

Table 4.10 (b): Comparison and grouping of catch per swept area data by area fo warehou.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	251 1	276.7	50 6	29	i	7279	4.55
2	946.7	795.2	134.4	35	iii	33110	20.72
3	901.3	1050.3	188.6	31	iii	27931	17.48
4	1112.3	1273 2	353.1	13	iii	14456	9.05
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	-	-	-	0	-	0	0
8	597.3	1041.8	122 8	72	ii	42984	26.89
9	215.0	163.4	81.1	4	i	860	0.54
10	-	-	-	0	-	0	0
11	-	-	-	0	-	0	0
12	663 7	917.8	129.8	50	ii	33150	20.74
Total	683.2	944.1	61.7	234			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	2.0775e+8	233	
Groups	1.3140e+7	6	2.1900e+6
Error	1.9461e+8	227	8.5729e+5

F= 2.555 $F_{5\%}$ =2.14, hence reject Ho.

Table 4.11 (a): Comparison and grouping of catch data by area for orange roughy.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	2013.8	3101.2	575.9	29	i	58377	4.44
2	4772.3	4147.8	701.1	35	i	167020	12.69
3	7848 3	9437.3	1695.0	31	i	243288	18.49
4	8200.5	7646.9	2120.9	13	i	106600	8.10
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	-	-	-	0	-	0	0
8	6512.9	10441.3	1230 5	72	i	468864	35.63
9	2355.7	1975.7	987.6	4	i	9420	0.72
10	-	-	-	0	-	0	0
11	-	-	-	0	-	0	0
12	5242.5	8272.8	1169.9	50	i	262100	19.92
Total	5623 1	8308.3	543.1	234			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	1 608e+10	233	
Groups	7 499e+8	6	1.2499e+8
Error	1.533e+10	227	6.7549e+7

F= 1.850 $F_{5\%}$ =2.14, hence accept Ho

Table 4.11 (b): Comparison and grouping of catch per swept area data by area for orange roughy.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	43.3	55.6	6.8	66	ii	2838	9.43
2	266.6	515.2	62.5	68	v	18088	60.09
3	80.1	77.8	17.9	19	iii	1520	5.05
4	118.2	164.8	49.7	11	iii	1298	4.31
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	22.0	14.7	8.5	3	i	66	0.22
8	23.3	24.2	6.7	13	i	299	0.99
9	-	-	-	0	-	0	0
10	-	-	-	0	-	0	0
11	20.0	-	-	1	i	20	0.07
12	194.5	264.2	47.5	31	iv	6014	19.98
Total	142.6	327.1	22.5	212			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	2.2571e+7	211	
Groups	2.1043e+6	7	3.0062e+5
Error	2.0467e+7	204	1.0033e+5

F= 2.996 $F_{5\%}$ =2.06, hence reject Ho.

Table 4.12 (a): Comparison and grouping of catch data by area for warty dory.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	262 5	317.5	39.1	66	ii	17292	8.11
2	1569.9	2182.0	264 6	68	iv	106692	50.03
3	914.2	1076 7	247.0	19	iv	17366	8.14
4	1887.8	3203 2	965.8	11	iv	20757	9.73
5	-	-		0	-	0	0
6	-	-	-	0	-	0	0
7	343.4	310.6	179.3	3	iii	1029	0.48
8	236.2	243.1	67.4	13	iii	3068	1.44
9	-	-	-	0	-	0	0
10	-	-	-	0	-	0	0
11	[illegible]	-	-	1	i	87	0.04
12	1516.6	2788.1	500.8	31	iv	46996	22.04
Total	1006.7	1907.7	131.0	212			

<u>ANOVA</u> Ho: all means are equal.

Source	SS	DF	MS
Total	7.6789e+8	211	
Groups	8.4767e+7	7	1.2110e+7
Error	6.8313e+8	204	3.3487e+6

F= 3.616 $F_{5\%}$ =2.06, hence reject Ho.

Table 4.12 (b): Comparison and grouping of catch per swept area data by area for warty dory.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	5.0	-	-	0	i	5	5.21
3	11.0	5.5	2.4	5	i	55	57.29
4	10.7	9.0	5.2	3	i	30	31.25
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	-	-	-	0	-	0	0
8	2.7	2.9	1.7	3	i	9	9.38
9	-	-	-	0	-	0	0
10	-	-	-	0	-	0	0
11	-	-	-	0	-	0	0
12	-	-	-	0	-	0	0
Total	8.3	6.5	1.9	12			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	4.4625e+2	10	
Groups	1.4643e+2	2	7.3214e+1
Error	2.9982e+2	8	3.7477e+1

F= 1.954 $F_{5\%}$ =4.46, hence accept Ho.

Table 4.13 (a): Comparison and grouping of catch data by area for spiky dory.

Area	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	39.2	-	-	1	i	39	3.92
3	121.8	76.2	34.1	5	i	605	60.74
4	92.6	77.6	44.8	3	i	276	27.71
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	-	-	-	0	-	0	0
8	25.9	15 3	8.8	3	i	75	7.53
9	-	-	-	0	-	0	0
10	-	-	-	0	-	0	0
11	-	-	-	0	-	0	0
12	-	-	-	0	-	0	0
Total	83.7	70.8	20.5	12			

ANOVA Ho: all means are equal.

Source	SS	DF	MS
Total	5.5236e+4	11	
Groups	1.9498e+4	3	6.4995e+3
Error	3.5737e+4	8	4.4672e+3

F= 1.455 $F_{5\%}$ =4.07, hence accept Ho.

Table 4.13(b): Comparison and grouping of catch per swept area data by area for spiky dory.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	42.3	71.2	26.9	7	i	294	0.18
2	2.0	-	-	1	i	2	0.001
3	41.3	96.4	12.4	60	i	2460	1.48
4	33.6	43.6	2.2	393	i	12969	7.82
5	92.6	153.2	3.9	1565	ii	145545	87.81
6	53.6	59.3	7.1	70	ii	3780	2.28
7	65.0	35.4	25.0	2	i	130	0.08
Total	78.6	137.3	3.0	2098			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	3.9520e+7	2097	
Groups	1.2452e+6	6	2.0754e+5
Error	3.8275e+7	2091	1.8305e+4

F= 11.338 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.14 (a): Comparison and grouping of catch data by depth for pink lir

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	274.2	462.7	174.9	7	i	1918	0.20
2	90.8	-	-	1	i	90	0.01
3	296.5	680.2	87.8	60	i	17760	1.83
4	191.6	259.6	13.1	393	ii	75456	7.77
5	546.5	965.2	24.4	1565	ii	854490	87.97
6	301.2	336.2	40.2	70	ii	21070	2.17
7	422.1	365.3	258.3	2	I	844	0.09
Total	463.5	863.5	18.9	2098			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	1.5637e+9	2097	
Groups	4.3746e+7	6	7.2910e+6
Error	1.5200e+9	2091	7.2691e+5

F= 10.030 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.14 (b): Comparison and grouping of catch per effort data by depth for pink ling.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	1693.7	1590.5	649.3	6	v	10158	0.09
2	4.0	-	-	1	i	4	0.0002
3	50.0	105.7	18.4	33	i	1650	0.02
4	457.5	879.9	42.9	420	iii	191940	1.75
5	1106.1	1876.5	47.5	1561	iv	1726466	15.70
6	277.8	356.4	41.1	75	ii	20775	0.19
7	89.1	382 9	73.7	27	i	2403	0.02
Total	920.3	1690.9	36.7	2123			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	6.0667e+9	2122	
Groups	2.2288e+8	6	3.7147e+7
Error	5.8438e+9	2116	2.7617e+6

F= 13 451 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.15 (a): Comparison and grouping of catch data by depth for blue grenadier.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	9059.8	8315.2	3394.7	6	iv	54354	0.49
2	181.6	-	-	1	i	181	0.002
3	431 5	870.3	151.5	33	i	14223	0.13
4	2520.8	5149 8	251.3	420	ii	1058400	9 62
5	6231.5	10941.9	276.9	1561	iii	9726591	88.45
6	1757 7	2679.4	309.4	75	ii	131775	1.20
7	452.9	1576.4	303.4	27	i	12204	0.11
Total	5180.8	9850.1	213.8	2123			

ANOVA Ho. all means are equal

Source	SS	DF	MS
Total	2.058e+11	2122	
Groups	7.037e+9	6	1.1728e+9
Error	1.988e+11	2116	9.3974e+7

F= 12.480 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.15 (b): Comparison and grouping of catch per effort data by depth for blue grenadier.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	156.4	60.0	26.9	5	ii	780	0.31
2	-	-	-	0	-	0	0
3	83.6	104.8	34.9	9	ii	756	0.30
4	45.5	51.2	6.0	72	i	3240	1.28
5	162.0	190.9	5.0	1480	iii	239760	94.72
6	142.2	152.3	19.0	64	iii	9088	3.59
7	78.3	74.2	42.9	3	ii	234	0.09
Total	155.5	186.3	4.6	1633			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	5.6669e+7	1632	
Groups	1.0095e+6	5	2.0189e+5
Error	5.5660e+7	1627	3.4210e+4

F= 5.902 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.16 (a): Comparison and grouping of catch data by depth for king dory.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	919.8	345.7	154.6	5	ii	4595	0.29
2		-	-	-	0	-	03
	588.6	770.4	256.8	9	ii	5292	0.33
4	333.5	498.0	58.7	72	i	23976	1 52
5	1012.9	128 6	33.3	1480	iv	1497760	94.65
6	746.5	685.9	85.7	64	iii	47744	3.02
7	553.4	568.6	328.3	3	ii	1659	0.10
Total	969 0	1242.4	30.7	1633			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	1.1451e+8	1632	
Groups	3.6931e+7	5	7.3862e+6
Error	7.7580e+7	1627	4.7683e+4

F= 154 904 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.16 (b): Comparison and grouping of catch per effort data by depth for king dory.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	42.5	26.4	10.8	6	i	252	0.34
2	6	-	-	1	i	6	0.01
3	23.7	32.0	9.2	12	i	288	0.39
4	26.0	26.9	2.5	119	i	3094	4.15
5	52.9	60.0	1.7	1285	ii	68105	91.29
6	60.2	43.4	5.3	66	ii	3960	5.31
7	33.3	40.7	23.5	3	i	99	0.13
Total	50.7	57.6	1.5	1492			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	4.9451e+6	1491	
Groups	9.6833e+4	6	1.6139e+4
Error	4.8483e+6	1485	3.2648e+3

F= 4.943 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.17 (a): Comparison and grouping of catch data by depth for red gurnard.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	241.0	144.2	58.9	6	i	1446	0.32
2	68.7	-	-	1	i	68	0.01
3	181.5	210.5	60.8	12	i	2172	0.48
4	150.3	157.1	14.4	119	i	17850	3.91
5	318.8	365.0	10.2	1285	ii	408630	89.50
6	357.2	278.3	34.3	66	ii	23562	5.16
7	584.7	855.7	494.0	3	i	1752	0.38
Total	305.9	352.1	9.1	1492			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	1.8483e+8	1491	
Groups	3.7691e+6	6	6.2818e+5
Error	1.8106e+8	1485	1.2193e+5

F= 5.152 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.17 (b): Comparison and grouping of catch per effort data by depth for red gurnard.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	23.5	13.3	5.4	6	i	138	0.36
2	37.1	44.1	11.0	16	i	592	1.56
3	73.2	93.0	4.3	458	ii	33434	88.11
4	25.7	47.3	4.2	129	i	3225	8.50
5	47.5	31.8	22.5	2	i	94	0.25
6	-	-	-	0	-	0	0
7	70.0	-	-	1	i	70	0.18
Total	61.7	86.0	3.5	612			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	4.5167e+6	611	
Groups	2.4666e+5	5	4.9333e+4
Error	4.2700e+6	606	7.0463e+3

F= 7.001 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.18 (a): Comparison and grouping of catch data by depth for latchet.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	172.2	78.6	32.1	6	i	1032	0.30
2	615.0	1518.5	379.6	16	ii	9840	2.83
3	693.1	1397.6	65.3	458	ii	317394	91.15
4	149.6	246.0	21.7	129	i	19221	5.52
5	181.7	48.1	34.0	2	i	364	0.10
6	-	-	-	0	-	0	0
7	413.6	-	-	1	ii	413	0.12
Total	569.2	1257.4	50.8	612			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	9.6607e+8	611	
Groups	3.1047e+7	5	6.2094e+6
Error	9.3502e+8	606	1.5429e+6

F= 4.024 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.18 (b): Comparison and grouping of catch per effort data by depth for latchet.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	17.8	19.8	8.1	6	i	108	0.18
2	52.1	75.2	12.2	38	i	1976	3.30
3	60.6	58.8	2.7	472	i	28320	47.26
4	53.8	65.8	2.9	521	i	27613	46.08
5	38.2	36.9	6.6	31	i	1178	1.96
6	-	-	-	0	-	0	0
7	112.5	137.9	97.5	2	i	224	0.37
Total	56.2	62.6	1.9	1070			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	4.1889e+6	1069	
Groups	3.8008e+4	5	7.6017e+3
Error	4.1509e+6	1064	3.9012e+3

F= 1.949 $F_{5\%}$= 2.21, hence accept Ho.

Table 4.19 (a): Comparison and grouping of catch data by depth for tiger flathead.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	313.0	198.2	80.9	6	iii	1878	0.42
2	743.6	1650.9	267.8	38	iii	28234	6.31
3	507.3	489.5	22.5	472	ii	239304	53.50
4	330.2	483.3	21.2	521	iii	171930	38.44
5	141.4	139.1	25.0	31	i	4371	0.98
6	-	-	-	0	-	0	0
7	767.9	669.0	473.0	2	iii	1534	0.34
Total	418.2	572.9	17.5	1070			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	3.5088e+8	1069	
Groups	1.4492e+7	5	2.8983e+6
Error	3.3638e+8	1064	3.1615e+5

F= 9.167 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.19 (b): Comparison and grouping of catch per effort data by depth for tiger flathead.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	100.8	153.6	76.8	4	iii	400	0.16
2	202.5	366.7	78.2	22	iii	4444	1.78
3	294.8	951.4	33.7	798	iv	234612	94.14
4	41.0	70.4	4.7	225	ii	9225	3.70
5	14.2	11.9	3.3	13	i	182	0.07
6	-	-	-	0	-	0	0
7	196.7	160.4	92.6	3	iii	588	0.24
Total	234.9	832.6	25.5	1065			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	7.3753e+8	1064	
Groups	1.2055e+7	5	2.4110e+6
Error	7.2547e+8	1059	6.8505e+5

F= 3.519 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.20 (a): Comparison and grouping of catch data by depth for morwong.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	755.8	1069.0	534.5	4	iii	3020	0.16
2	2597.1	5223.8	1113.7	22	iv	57134	3.02
3	2207.9	6300.7	223.0	798	iv	1761984	93.16
4	277.3	492.7	32.8	225	ii	62325	3.30
5	60.2	46.6	12.9	13	i	780	0.04
6	-	-	-	0	-	0	0
7	2235.5	1814.4	1047.5	3	iii	6705	0.35
Total	1776.5	5568.3	170.6	1065			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	3.299e+10	1064	
Groups	7.121e+8	5	1.4243e+8
Error	3.227e+10	1059	3.0479e+7

F= 4.673 $F_{5\%}$= 2.21, hence reject Ho.

Table 4.20 (b): Comparison and grouping of catch per effort data by depth for morwong.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	98.4	91.3	32.3	8	ii	784	0.14
2	55.0	40.2	20.1	4	ii	220	0.04
3	391.1	690.5	30.4	516	iv	201756	35.55
4	303.1	481.2	16.3	872	iii	264216	46.56
5	84.8	165.6	4.8	1169	ii	99365	17.51
6	23.5	47.0	8.6	30	i	690	0.12
7	16.3	15.9	7.9	4	i	64	0.01
Total	217.9	448.5	8.8	2603			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	5.2342e+8	2602	
Groups	4.4035e+7	6	7.3392e+6
Error	4.7939e+8	2596	1.8466e+5

F= 39.743 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.21 (a): Comparison and grouping of catch data by depth for gemfish.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	635.4	461.6	163.2	8	ii	5080	0.15
2	566.6	424.9	212.4	4	ii	2264	0.07
3	2794.5	5021.4	221.1	516	iv	1441704	42.34
4	1641.1	2540.3	86.0	872	iii	1430952	42.03
5	443.9	829.4	24.3	1169	ii	519036	15.24
6	153.7	298.5	54.5	30	i	4590	0.13
7	197.7	264.4	132.2	4	i	788	0.02
Total	1308.0	2879.5	56.4	2603			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	2.157e+10	2598	
Groups	2.155e+9	5	4.3112e+8
Error	1.941e+10	2593	7.4872e+6

F= 57.581 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.21 (b): Comparison and grouping of catch per effort data by depth for gemfish.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	174.4	251.3	83.8	9	ii	1566	0.79
2	99.8	81.7	33.3	6	ii	600	0.30
3	267.9	811.7	52.7	237	iii	63279	32.05
4	104.4	404.8	30.3	178	ii	18512	9.38
5	177.1	508.0	20.2	634	ii	112218	56.83
6	13.0	14.3	4.5	10	i	130	0.07
7	113.0	90.5	40.5	5	ii	565	0.29
Total	182.8	571.1	17.4	1079			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	3.5161e+8	1078	
Groups	3.1857e+6	6	5.3095e+5
Error	3.4842e+8	1072	3.2502e+5

F= 1.634 $F_{5\%}$= 2.10, hence accept Ho.

Table 4.22 (a): Comparison and grouping of catch data by depth for spotted trevalla.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	1598.7	2022.0	674.0	9	i	14382	1.22
2	2710.8	3451.9	1409.2	6	i	16260	1.38
3	1811.8	5874.7	381.6	237	i	429207	36.43
4	488.8	1679.2	125.9	178	i	86864	7.37
5	987.7	2725.0	108.2	634	i	625758	53.11
6	80.5	86.6	27.4	10	i	800	0.07
7	837.9	622.5	278.4	5	i	4190	0.36
Total	1092.0	3559.9	108.4	1079			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	1.366e+10	1078	
Groups	2.230e+8	6	3.7174e+7
Error	1.343e+10	1072	1.2536e+7

F= 2.965 $F_{5\%}$= 2.10, hence reject Ho.

Table 4.22 (b): Comparison and grouping of catch per effort data by depth for spotted trevalla.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	3.0	2.8	2.0	2	i	6	0.17
2	653.3	820.1	473.5	3	i	1959	55.40
3	143.1	284.5	85.8	11	i	1573	44.49
4	-	-	-	0	-	0	0
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	-	-	-	0	-	0	0
Total	221.3	438.0	109.5	16			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	2.8770e+6	15	
Groups	7.2245e+5	2	3.6122e+5
Error	2.1545e+6	13	1.6573e+5

F= 2.180 $F_{5\%}$= 3.81, hence accept Ho.

Table 4.23 (a): Comparison and grouping of catch data by depth for warehou.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	44.6	20.0	14.1	2	i	88	0.25
2	6162.4	6572.9	3794.9	3	i	18486	52.40
3	1519.7	3142.4	947.5	11	i	16709	47.36
4	-	-	-	0	-	0	0
5	-	-	-	0	-	0	0
6	-	-	-	0	-	0	0
7	-	-	-	0	-	0	0
Total	2205.8	4054.9	1013.7	16			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	2.4664e+8	15	
Groups	6.1484e+7	2	3.0742e+7
Error	1.8515e+8	13	1.4243e+7

F= 2.158 $F_{5\%}$= 3.81, hence accept Ho.

Table 4.23 (b): Comparison and grouping of catch per effort data by depth for warehou.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	1200.0	282.8	200.0	2	i	2400	1.50
2	511.0	408.7	289.0	2	i	1022	0.64
3	184.5	6.4	4.5	2	i	368	0.23
4	120.0	141.4	100.0	2	i	240	0.15
5	660.0	723.5	361.8	4	i	2640	1.65
6	457.4	545.8	88.5	38	i	17366	10.87
7	738.1	1020.5	75.2	184	i	135792	84.96
Total	683.2	944.1	61.7	234			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	2.0766e+8	233	
Groups	4.2194e+6	6	7.0324e+5
Error	2.0344e+8	227	8.9621e+5

F= 0.785 $F_{5\%}$= 2.13, hence accept Ho.

Table 4.24 (a): Comparison and grouping of catch data by depth for orange roughy.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	16099.2	16149.2	11419.2	2	i	32198	2.45
2	2681.6	2218.0	1568.4	2	i	5362	0.41
3	1273.6	209.2	147.9	2	i	2546	0.19
4	895.5	1170.9	828.0	2	i	1790	0.14
5	6155.6	8583.1	4291.7	4	i	24620	1.87
6	5616.7	8182.8	1327.4	38	i	213408	16.22
7	5629.6	8362.5	616.5	184	i	1035736	78.72
Total	5623.1	8308.3	543.1	234			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	1.608e+10	233	
Groups	3.204e+8	6	5.3414e+7
Error	1.576e+10	227	6.9441e+7

F= 0.769 $F_{5\%}$= 2.13, hence accept Ho.

Table 4.24 (b): Comparison and grouping of catch per effort data by depth for orange roughy.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	40.5	40 4	7.1	32	i	1280	4.25
5	191.3	395.2	34.8	129	ii	24639	81.85
6	132.8	292.2	67.0	19	ii	2527	8.39
7	54.0	58.0	10.2	32	i	1728	5.74
Total	142.6	327.1	22.5	212			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	2.2576e+7	211	
Groups	8.9255e+5	3	2.9752e+5
Error	2.1683e+7	208	1.0425e+5

F= 2.854 $F_{5\%}$= 2.65, hence reject Ho.

Table 4.25 (a): Comparison and grouping of catch data by depth for warty dory.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	231.4	257.0	45.4	32	i	7392	3.46
5	1252.3	1979.8	174.3	129	iii	161508	75.65
6	1481 0	3465.8	795.1	19	iii	28139	13.18
7	510.0	531.6	94.0	32	ii	16320	7.64
Total	1006.7	1907.7	131.0	212			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	7.6791e+8	211	
Groups	3.9185e+7	3	1.3062e+7
Error	7.2873e+8	208	3.5035e+6

F= 3.728 $F_{5\%}$= 2.65, hence reject H0.

Table 4.25 (b): Comparison and grouping of catch per effort data by depth for warty dory.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	-	-	-	0	-	0	0
6	8.0	2.8	2.0	2	i	16	16
7	8.4	7.1	2.2	10	i	84	84
Total	8.3	6.5	1.9	12			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	4.6180e+2	11	
Groups	2.6667e-1	1	2.6667e-1
Error	4.6153e+2	10	4.6153e+1

F= 0.006 $F_{5\%}$= 4.96, hence accept Ho.

Table 4.26 (a): Comparison and grouping of catch data by depth for spiky dory.

Depth	Mean	S.D.	S.E.	N	Group	Total	%
1	-	-	-	0	-	0	0
2	-	-	-	0	-	0	0
3	-	-	-	0	-	0	0
4	-	-	-	0	-	0	0
5	-	-	-	0	-	0	0
6	59.3	26.9	19.0	2	i	118	11.85
7	88.5	76.8	24.3	10	i	885	88.86
Total	83.7	70.8	20.5	12			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	5.5229e+4	11	
Groups	1.4211e+3	1	1.4211e+3
Error	5.3808e+4	10	5.3808e+3

F= 0.264 $F_{5\%}$= 4.96, hence accept Ho.

Table 4.26 (b): Comparison and grouping of catch per effort data by depth for spiky dory.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	96.5	126 8	7.9	257	iii	24672	15 08
Feb	62.2	61.7	3.4	329	ii	20398	12.46
Mar	56.7	50 4	3.2	253	ii	14168	8.66
Apr	56.4	57 5	3.7	245	ii	13720	8.38
May	43.7	36 4	2.8	170	i	7480	4.57
Jun	57 9	101.3	10 6	91	ii	5278	3.23
Jul	27 9	47 5	5.9	64	i	1792	1.09
Aug	69.2	77.5	6.9	128	ii	8832	5.40
Sep	67.9	66.1	6.8	94	ii	6392	3.90
Oct	67.4	65 6	5.2	158	ii	10586	6.47
Nov	202.0	346.8	24.9	194	iv	39188	23.95
Dec	102.9	147.6	13.8	115	iii	11845	7.24
Total	78.6	137.3	3.0	2098			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	3.9529e+7	2097	
Groups	3.8874e+6	11	3.5340e+5
Error	3.5642e+7	2086	1.7086e+4

F= 20.684 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.27 (a): Comparison and grouping of catch data by month for pink ling.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	490 7	654 0	40.8	257	iii	125930	12.96
Feb	370.4	422.2	23 3	329	ii	121730	12.53
Mar	338 8	309 7	19.5	253	ii	85514	8.80
Apr	336.8	380 0	24.3	245	ii	82320	8.47
May	256 1	209.9	16.1	170	i	43520	4.48
Jun	369 6	573.7	60 1	91	ii	33579	3.46
Jul	216.2	332 2	41 5	64	i	*3324	1.42
Aug	401 9	451.6	39 9	128	ii	51328	5.28
Sep	348 4	331 5	34.2	94	ii	32712	3.37
Oct	418 1	440 0	35 3	158	ii	66044	6.80
Nov	1269 2	2252 9	161.8	194	iv	246186	25.34
Dec	597 1	901 3	84 0	115	iii	68655	7.07
Total	463 5	863.5	18.9	2098			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	1.5631e+9	2097	
Groups	1.5298e+8	11	1 3908e+7
Error	1 4101e+9	2086	6 7598e+5

F= 20.574 $F_{5\%}$= 1 79, hence reject Ho.

Table 4.27 (b): Comparison and grouping of catch per effort data by month for pink ling.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	1453.7	1961.8	115.4	289	iii	2150449	19.55
Feb	1427.3	2072.8	112.2	341	iii	2837461	25.80
Mar	960.6	1525.9	94.1	263	ii	1515932	13.78
Apr	974.4	1633.5	102.9	252	ii	1245384	11.32
May	407.6	532.0	39.1	185	i	416805	3.79
Jun	420.5	516.8	50.9	103	i	279027	2.54
Jul	2093.1	3356.7	433.4	60	iv	846000	7.69
Aug	610.9	1193.4	115.4	107	i	326564	2.97
Sep	402.3	990 9	107.5	85	i	148410	1.35
Oct	384.3	1895.8	161.4	138	i	266202	2.42
Nov	392.7	765.2	56.4	184	i	450064	4.09
Dec	686.4	1259.9	117.0	116	i	515504	4.69
Total	920.3	1690.9	36.7	2123			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	6.0668e+9	2122	
Groups	4.5819e+8	11	4.1654e+7
Error	5.6086e+9	2111	2.6569e+6

F= 15.678 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.28 (a): Comparison and grouping of catch data by month for blue grenadier.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	7441.3	10254.7	603.2	289	iii	2150449	19.55
Feb	8321.7	12732.7	689.5	341	iii	2837461	25.80
Mar	5764 5	9274.9	571.9	263	ii	1515932	13.78
Apr	4942.6	7799.3	491.3	252	ii	1245384	11.32
May	2253.5	2688.4	197.7	185	i	416805	3.79
Jun	2709 3	3210.8	316.4	103	i	279027	2.54
Jul	14100.8	25092.1	3239.4	60	iv	846000	7.69
Aug	3052 8	5710.7	552.1	107	i	326564	2.97
Sep	1746.7	3957.9	429.3	85	i	148410	1.35
Oct	1929.2	7907.9	673.2	138	i	266202	2.42
Nov	2446.9	5042.9	371.8	184	i	450064	4 09
Dec	4443 6	8764.1	813.7	116	i	515504	4.69
Total	5180.8	9850.1	213.8	2123			

<u>ANOVA</u> Ho: all means are equal

Source	SS	DF	MS
Total	2.058e+11	2122	
Groups	1.631e+10	11	1 4834e+9
Error	1.895e+11	2111	8.9801e+7

F= 16 519 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.28(b): Comparison and grouping of catch per effort data by month for blue grenadier.

Month	Mean	S.D	S.E.	N	Group	Total	%
Jan	133.0	198.2	13.7	209	ii	27797	10.91
Feb	125.7	143.5	8.1	317	ii	39625	15.55
Mar	207.5	227.3	14.9	233	iv	48231	18.93
Apr	260.4	235.3	16.8	195	iv	50700	19.90
May	171.1	186.5	17.0	120	iii	20520	8.06
Jun	102.9	132.8	18.8	50	ii	5150	2.02
Jul	137.1	133.4	19.5	47	ii	6439	2.53
Aug	132.6	184.6	19.5	90	ii	11880	4.66
Sep	121.1	194.4	26.7	53	ii	6413	2.52
Oct	122.6	142.4	13.6	110	ii	13530	5.31
Nov	128.6	105.8	9.2	133	ii	17157	6.73
Dec	79.8	92.8	10.6	76	i	6004	2.36
Total	155.5	186.3	4.6	1633			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	5.6666e+7	1632	
Groups	4.1073e+6	11	3.7339e+5
Error	5.2559e+7	1621	3.2424e+4

F= 11.516 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.29 (a): Comparison and grouping of catch data by month for king dory.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	747.8	1154.1	79.8	209	ii	156123	9.87
Feb	818.4	1095.9	61.5	317	ii	259306	16.39
Mar	1340.8	1537.5	100.7	233	iv	312220	19.73
Apr	1604.9	1711.3	122.5	195	iv	312780	19.77
May	1025.4	1096.8	100.1	120	iii	123000	7.77
Jun	890.4	991.8	140.3	50	ii	44500	2.81
Jul	819.0	763.0	111.3	47	ii	38493	2.43
Aug	669.0	783.9	82.6	90	ii	60210	3.81
Sep	565.3	797.2	109.5	53	ii	29945	1.89
Oct	841.1	1168.4	111.4	110	ii	92510	5.85
Nov	871.9	854.6	74.1	133	ii	115843	7.32
Dec	481.7	600.4	68.9	76	i	36556	2.31
Total	969.0	1242.4	30.7	1633			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	2.5193e+9	1632	
Groups	1.6806e+8	11	1.5278e+7
Error	2.3512e+9	1621	1.4505e+6

F= 10.533 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.29 (b): Comparison and grouping of catch per effort data by month for king dory.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	43.1	54.4	4.1	178	i	7654	10.26
Feb	58.4	57.5	3.5	265	ii	15370	20.60
Mar	63.0	85.5	5.8	216	ii	13608	18.24
Apr	44.0	42.1	3.1	190	i	8360	11.21
May	40.9	38.6	3.7	107	i	4387	5.88
Jun	39.0	33.8	3.9	75	i	2925	3.92
Jul	30.7	30.0	5.2	34	i	1054	1.41
Aug	47.3	55.4	6.2	80	i	3760	5.04
Sep	49.1	47.4	6.4	55	i	2695	3.61
Oct	54.0	45.2	4.6	98	ii	5292	7.09
Nov	59.5	47.9	4.1	134	ii	7906	10.60
Dec	41.5	81.3	10.5	60	i	2460	3.30
Total	50.7	57.6	1.5	1492			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	4.9515e+6	1491	
Groups	1.1893e+5	11	1.0812e+4
Error	4.8326e+6	1480	3.2653e+3

F= 3.311 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.30 (a): Comparison and grouping of catch data by month for red gurnard.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	237.0	312.6	23.4	178	i	42186	9.24
Feb	248.3	330.8	20.3	265	i	92220	20.20
Mar	388.7	502.1	34.2	216	ii	83808	18.36
Apr	272.3	309.0	22.4	190	i	51680	11.32
May	222.5	190.2	18.4	107	i	23754	5.20
Jun	259.1	228.2	26.4	75	i	19425	4.25
Jul	272.5	497.1	85.3	34	i	9248	2.03
Aug	270.2	346.5	38.7	80	i	21600	4.73
Sep	245.2	231.5	31.2	55	i	13475	2.95
Oct	353.5	301.9	30.5	98	ii	34595	7.58
Nov	384.9	344.5	29.8	134	ii	51456	11.27
Dec	208.9	359.3	46.4	60	i	12540	2.75
Total	305.9	352.1	9.1	1492			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	1.8473e+8	1491	
Groups	5.8278e+6	11	5.2980e+5
Error	1.7890e+8	1480	1.2088e+5

F= 4.383 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.30 (b): Comparison and grouping of catch per effort data by month for red gurnard.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	48.5	58.1	8.4	48	i	2352	6.20
Feb	57.4	57.7	7.5	59	i	3363	8.86
Mar	82.1	69.1	12.6	30	ii	2460	6.48
Apr	50.7	47.0	8.1	34	i	1700	4.48
May	43.6	34.1	5.2	43	i	1892	4.99
Jun	97.6	179.4	23.8	57	ii	5586	14.72
Jul	79.6	76.6	10.8	50	ii	4000	10.54
Aug	39.5	47.5	7.0	46	i	1840	4.85
Sep	51.5	53.1	7.6	49	i	2499	6.59
Oct	80.4	105.4	10.0	111	ii	8880	23.40
Nov	39.6	36.2	4.6	63	i	2520	6.64
Dec	30.9	37.3	8.0	22	i	682	1.80
Total	61.7	86.0	3.5	612			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	4.5190e+6	611	
Groups	2.4785e+5	11	2.2532e+4
Error	4.2711e+6	600	7.1186e+3

F= 3.165 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.31 (a): Comparison and grouping of catch data by month for latchet.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	355.3	389.4	56.2	48	i	17040	4.89
Feb	458.8	395.9	51.5	59	i	27022	7.76
Mar	566.3	438.5	80.1	30	i	16980	4.88
Apr	353.0	318.3	54.6	34	i	12002	3.45
May	436.9	360.1	54.9	43	i	18748	5.38
Jun	1631.5	3532.6	467.9	57	ii	92967	26.70
Jul	783.8	729.0	103.1	50	ii	39150	11.24
Aug	408.6	949.0	139.9	46	i	18768	5.39
Sep	360.8	381.0	54.4	49	i	17689	5.08
Oct	568.6	800.3	76.0	111	i	63048	18.11
Nov	290.2	351.3	44.3	63	i	18270	5.25
Dec	291.9	391.7	83.5	22	i	6402	1.84
Total	569.2	1257.4	50.8	612			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	49.660e+8	611	
Groups	8.1794e+7	11	7.4358e+6
Error	48.842e+8	600	1.4738e+6

F= 5.045 $F_{5\%}$= 1.79, hence reject Ho

Table 4.31 (b): Comparison and grouping of catch per effort data by month for latchet.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	42.4	45.3	4.9	87	i	3654	6.10
Feb	34.1	57.6	8.4	47	i	1598	2.67
Mar	29.8	34.8	4.9	51	i	1530	2.55
Apr	36.1	44.6	5.4	68	i	2448	4.09
May	54.1	62.4	8.2	58	ii	3132	5.23
Jun	49.4	40.0	5.1	61	ii	2989	4.99
Jul	73.6	62.0	7.4	71	iii	5254	8.77
Aug	64.5	58.7	6.4	83	iii	5395	9.00
Sep	82.0	73.3	8.0	84	iii	6888	11.50
Oct	79.8	85.2	5.9	210	iii	16800	28.04
Nov	46.8	48.0	3.6	179	ii	8413	14.04
Dec	29.2	26.9	3.2	71	i	2059	3.44
Total	56.2	62.6	1.9	1070			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	44.189e+6	1069	
Groups	3.7328e+5	11	3.3935e+4
Error	43.816e+6	1058	3.6071e+3

F= 9.408 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.32 (a): Comparison and grouping of catch data by month for tiger flathead.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	325.0	416.7	44.7	87	ii	28275	6.32
Feb	298.8	489.7	71.4	47	ii	14006	3.13
Mar	194.6	220.5	30.9	51	i	9894	2.21
Apr	350.9	1215.4	147.4	68	i	23868	5.34
May	470.0	595.4	78.2	58	iii	27260	6.09
Jun	496.6	323.8	41.5	61	iii	30256	6.76
Jul	585.0	485.1	57.6	71	iii	41535	9.29
Aug	507.9	612.2	67.2	83	iii	42164	9.43
Sep	547.6	550.6	60.1	84	iii	46032	10.29
Oct	566.8	635.8	43.9	210	iii	119070	26.62
Nov	287.2	310.8	23.2	179	ii	51373	11.49
Dec	193.4	199.1	23.6	71	i	13703	3.06
Total	418.2	572.9	17.5	1070			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	43.508e+8	1069	
Groups	2.0161e+7	11	1.8328e+6
Error	43.306e+8	1058	3.1256e+5

F= 5.864 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.32 (b): Comparison and grouping of catch per effort data by month for tiger flathead.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	186.6	262.9	26.7	97	i	18139	7.28
Feb	201.6	228.9	24.3	89	i	17978	7.21
Mar	226.5	207.2	28.7	52	i	11804	4.74
Apr	236.8	292.7	37.2	62	i	14694	5.90
May	215.8	255.8	29.0	78	i	16848	6.76
Jun	123.6	277.4	33.4	69	i	8556	3.43
Jul	268.2	609.5	73.9	68	i	18224	7.31
Aug	352.2	1251.4	149.6	70	i	24640	9.89
Sep	361.9	993.3	120.5	68	i	24616	9.88
Oct	272.7	1837.5	153.1	144	i	39312	15.77
Nov	207.4	321.4	24.8	168	i	34776	13.95
Dec	206.7	241.4	24.1	100	i	20600	8.27
Total	234.9	832.6	25.5	1065			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	47.375e+8	1064	
Groups	3.7597e+6	11	3.4179e+5
Error	47.338e+8	1053	6.9689e+5

F= 0.490 $F_{5\%}$= 1.79, hence accept Ho.

Table 4.33 (a): Comparison and grouping of catch data by month for morwong.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	1350.4	1765.4	179.2	97	i	130950	6.92
Feb	1518.5	1643.4	174.2	89	i	135102	7.14
Mar	1622.7	1720.3	238.6	52	i	86424	4.57
Apr	1879.0	2215.4	281.4	62	i	116498	6.16
May	1773.3	2306.4	261.2	78	i	138294	7.31
Jun	1246.2	2835.5	341.4	69	i	85974	4.55
Jul	2161.2	5481.5	664.7	68	i	147016	7.77
Aug	2635.3	7872.3	940.9	70	i	184450	9.75
Sep	2526.5	6247.5	757.6	68	i	171768	9.08
Oct	1881.6	12026.5	1002.2	144	i	270864	14.32
Nov	1590.4	2415.1	186.3	168	i	267120	14.12
Dec	1572.0	1822.9	182.3	100	i	157200	8.31
Total	1776.5	5568.3	170.6	1065			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	43.29e+10	1064	
Groups	1.5635e+8	11	1.4214e+7
Error	43.28e+10	1053	3.1181e+7

F= 0.456 $F_{5\%}$= 1.79, hence accept Ho.

Table 4.33 (b): Comparison and grouping of catch per effort data by month for morwong.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	208.3	414.8	21.6	369	iii	76752	13.53
Feb	144.7	260.2	13.6	368	iii	52992	9.34
Mar	179.2	310.8	19.3	259	iii	46361	8.17
Apr	186.2	224.0	13.6	273	iii	50778	8.95
May	144.9	220.9	17.5	159	iii	22896	4.03
Jun	341.6	599.0	66.1	82	iv	27962	4.93
Jul	38.6	51.3	6.9	56	i	2184	0.38
Aug	79.9	256.0	23.6	118	ii	9440	1.66
Sep	323.9	1040.5	102.5	103	iv	33372	5.88
Oct	125.9	294.8	19.9	220	ii	27720	4.88
Nov	288.2	462.1	24.7	350	iii	100800	17.76
Dec	468.1	697.3	44.5	246	v	115128	20.29
Total	217.9	448.5	8.8	2603			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	45.234e+8	2602	
Groups	2.8966e+7	11	2.6333e+6
Error	44.943e+8	2591	1.9083e+5

F= 13.799 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.34 (a): Comparison and grouping of catch data by month for gemfis

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	1261.3	2887.4	150.3	369	iii	465309	13.67
Feb	881.1	1637.3	85.4	368	iii	324208	9.52
Mar	1079.1	1909.6	118.7	259	iii	279461	8.21
Apr	986.0	1150.5	69.6	273	iii	269178	7.91
May	834.8	1449.0	114.9	159	iii	132765	3.90
Jun	1844.9	2914.7	321.9	82	iv	151208	4.44
Jul	201.4	258.2	34.5	56	i	11256	0.33
Aug	493.9	1511.5	139.1	118	ii	58292	1.71
Sep	1622.5	5496.1	541.6	103	iii	167169	4.91
Oct	647.6	1314.3	88.6	220	ii	142340	4.18
Nov	1897.1	3093.9	165.4	350	iv	663950	19.50
Dec	3004.6	5299.1	337.9	246	v	738984	21.70
Total	1308.0	2879.5	56.4	2603			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	42.15e+10	2602	
Groups	1.2515e+9	11	1.1377e+8
Error	42.03e+10	2591	7.8438e+6

F= 14.504 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.34 (b): Comparison and grouping of catch per effort data by month for gemfish.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	166.4	398.8	30.9	167	iii	27722	14.12
Feb	232.8	697.9	53.2	172	iii	39904	20.32
Mar	69.6	111.6	11.5	94	ii	6580	3.35
Apr	36.4	34.0	3.7	83	i	2988	1.52
May	382.3	1423.0	201.2	50	iv	19100	9.73
Jun	79.7	194.3	30.3	41	ii	3280	1.67
Jul	159.4	503.6	60.0	71	ii	11289	5.75
Aug	310.3	720.9	70.7	104	iv	32240	16.42
Sep	252.9	754.7	89.6	71	iii	17963	9.15
Oct	85.8	160.5	18.3	77	ii	6622	3.37
Nov	167.6	303.7	35.1	75	iii	12525	6.38
Dec	226.6	389.5	45.3	74	iii	16798	8.55
Total	182.8	571.1	17.4	1079			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	43.515e+8	1078	
Groups	8.8464e+6	11	8.0422e+5
Error	43.426e+8	1067	3.2117e+5

F= 2.504 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.35 (a): Comparison and grouping of catch data by month for spotted trevalla.

Month	Mean	S.D	S.E	N	Group	Total	%
Jan	893.9	2[illegible]57.0	166.9	157	iii	149298	12.67
Feb	1355.5	3865.6	[illegible]94.8	172	iii	233060	19.78
Mar	439.2	740.4	76.4	94	ii	41266	3.50
Apr	198.1	220.5	24.2	83	i	16434	1.39
May	3050.6	10897.6	1541.2	50	iv	152500	12.94
Jun	578.1	1351.4	211.1	41	ii	23698	2.01
Jul	802.1	2203.3	261.5	71	ii	56942	4.83
Aug	1929.9	4575.7	448.7	104	iv	200720	17.04
Sep	1172.9	3224.0	382.6	71	iii	83283	7.07
Oct	573.4	1147.7	130.8	77	ii	44121	3.74
Nov	1086.4	1977.2	228.3	75	iii	81450	6.91
Dec	1287.7	2167.4	[illegible]	74	iii	95238	8.08
Total	1092.0	3559.9	10[illegible]4	1079			

ANOVA Ho. all means are equal

Source	SS	DF	MS
Total	41.36e+10	1078	
Groups	4.3050e+[illegible]	11	[illegible]9137e+7
Error	41.32e+10	1067	1.2400e+7

F= 3.156 $F_{5\%}$= 1.79, hence reject Ho.

Table 4.35 (b): Comparison and grouping of catch per effort data by month for spotted trevalla.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	1.0	-	-	1	i	0.03	
Feb	-	-	-	0	-	0	0
Mar	160.0	-	-	1	i	160	4.52
Apr	5.0	-	-	1	i	5	0.14
May	4.0	-	-	1	i	4	0.11
Jun	10.0	7.1	5.0	2	i	20	0.57
Jul	74.7	108.6	62.7	3	i	222	6.28
Aug	-	-	-	0	-	0	0
Sep	-	-	-	0	-	0	0
Oct	230.5	324.6	229.5	2	i	460	13.01
Nov	32.5	17.7	12.5	2	i	64	1.81
Dec	866.7	750.6	433.3	3	i	2601	73.56
Total	221.3	438.0	109.5	16			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	42.877e+6	15	
Groups	1.6211e+6	8	2.0264e+5
Error	41.256e+6	7	1.7945e+5

F= 1.129 $F_{5\%}$= 3.73, hence accept Ho.

Table 4.36 (a): Comparison and grouping of catch data by month for warehou.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	30.5	-	-	1	i	30	0.09
Feb	-	-	-	0	-	0	0
Mar	921.3	-	-	1	i	921	2.61
Apr	104.8	-	-	1	i	105	0.30
May	21.3	-	-	1	i	21	0.06
Jun	105.7	66.4	46.9	2	i	210	0.60
Jul	1517.7	2175.4	1255.9	3	i	4551	12.90
Aug	-	-	-	0	-	0	0
Sep	-	-	-	0	-	0	0
Oct	1909.1	2651.3	1874.7	2	i	3818	10.82
Nov	414.6	326.1	230.6	2	i	828	2.35
Dec	8267.9	6609.9	3816.2	3	i	24804	70.31
Total	2205.8	4054.9	1013.7	16			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	41.826e+8	6	
Groups	8.8270e+7	3	2.9423e+7
Error	49.441e+7	3	3.1470e+7

F= 0.935 $F_{5\%}$= 9.28, hence accept Ho.

Table 4.36 (b): Comparison and grouping of catch per effort data by month for warehou.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	621.5	514.4	124.8	17	i	10557	6.61
Feb	463.9	486.7	111.7	19	i	8797	5.50
Mar	963.3	976.5	325.5	9	i	8667	5.42
Apr	691.1	533.1	177.7	9	i	6219	3.89
May	987.0	1756.2	453.4	15	i	14805	9.26
Jun	508.9	542.1	115.6	22	i	11198	7.01
Jul	588.1	795.0	102.6	60	i	35280	22.07
Aug	487.3	619.1	113.0	30	i	14610	9.14
Sep	364.4	285.8	62.4	21	i	7644	4.78
Oct	1770.9	1659.2	362.1	21	ii	37170	23.26
Nov	390.0	346.9	122.7	8	i	3120	1.95
Dec	576.7	653.2	377.1	3	i	1728	1.08
Total	683.2	944.1	61.7	234			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	42.076e+8	233	
Groups	3.3133e+7	11	3.0121e+6
Error	41.745e+8	222	7.8623e+5

F= 3.831 $F_{5\%}$= 1.84, hence reject Ho.

Table 4.37 (a): Comparison and grouping of catch data by month for orange roughy.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	3522.1	2973.5	721.2	17	i	59874	4.55
Feb	2754.1	4185.5	960.2	19	i	52326	3.98
Mar	4448.5	4100.8	1367.0	9	i	40032	3.04
Apr	9020.9	10918.8	3639.6	9	iii	81180	6.17
May	14174.8	19424.4	5015.4	15	iii	212610	16.16
Jun	7008.0	10553.6	2250.0	22	ii	154176	11.72
Jul	5135.7	6200.6	800.5	60	ii	308100	23.42
Aug	3578.8	3968.7	724.6	30	i	107340	8.16
Sep	2092.8	1417.7	309.4	21	i	43932	3.34
Oct	10513.9	8980.9	1959.8	21	iii	220773	16.78
Nov	2771.1	2979.2	1053.3	8	i	22168	1.68
Dec	4389.2	2844.2	1642.1	3	i	13167	1.00
Total	5623.1	8308.3	543.1	234			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	41.60e+10	233	
Groups	2.4602e+9	11	2.2366e+8
Error	41.36e+10	222	6.1366e+7

F= 3.645 $F_{5\%}$= 1.84, hence reject Ho.

Table 4.37 (b): Comparison and grouping of catch per effort data by month for orange roughy.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	320.4	897.7	200.7	20	i	6400	21.26
Feb	164.4	228.1	47.6	23	i	3772	12.53
Mar	163.7	202.2	35.2	33	i	5412	17.98
Apr	200.0	244.3	141.1	3	i	600	1.99
May	41.5	36.1	10.0	13	i	546	1.81
Jun	40.0	52.2	12.3	18	i	720	2.39
Jul	68.6	102.0	18.9	29	i	1972	6.55
Aug	58.3	56.6	16.3	12	i	696	2.31
Sep	35.0	15.0	8.7	3	i	105	0.35
Oct	189.1	292.1	62.3	22	i	4158	13.81
Nov	135.2	140.6	27.1	27	i	3645	12.11
Dec	240.9	271.4	90.5	9	i	2169	7.21
Total	142.6	327.1	22.5	212			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	42.257e+7	211	
Groups	1.4049e+6	11	1.2772e+5
Error	42.116e+7	200	1.0584e+5

F= 1.207 $F_{5\%}$= 1.84, hence accept Ho.

Table 4.38 (a): Comparison and grouping of catch data by month for warty dory.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	1535.3	3429.0	766.8	20	i	30700	14.39
Feb	1182.2	1565.5	326.4	23	i	27186	12.75
Mar	1056.9	1316.2	229.1	33	i	34848	16.34
Apr	1924.9	2647.2	1528.4	3	i	5772	2.71
May	223.0	163.4	45.3	13	i	2899	1.36
Jun	286.8	395.6	93.2	18	i	5148	2.41
Jul	904.6	1907.6	354.2	29	i	26245	12.31
Aug	401.8	387.7	111.9	12	i	4824	2.26
Sep	283.4	135.1	78.0	3	i	849	0.39
Oct	1744.5	3336.1	711.3	22	i	38368	17.99
Nov	880.1	909.6	175.1	27	i	23760	11.14
Dec	1416.9	1271.3	423.8	9	i	12753	5.98
Total	1006.7	1907.7	131.0	212			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	47.679e+8	211	
Groups	4.6408e+7	11	4.2189e+6
Error	47.214e+8	200	3.6075e+6

F= 1.169 $F_{5\%}$= 1.84, hence accept Ho.

Table 4.38 (b): Comparison and grouping of catch per effort data by month for warty dory.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	-	-	-	0	-	0	0
Feb	-	-	-	0	-	0	0
Mar	-	-	-	0	-	0	0
Apr	-	-	-	0	-	0	0
May	-	-	-	0	-	0	0
Jun	10.3	9.5	5.5	3	i	30	31.02
Jul	7.7	5.7	1.9	9	i	69	69.58
Aug	-	-	-	0	-	0	0
Sep	-	-	-	0	-	0	0
Oct	-	-	-	0	-	0	0
Nov	-	-	-	0	-	0	0
Dec	-	-	-	0	-	0	0
Total	8.3	6.5	1.9	12			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	44.556e+2	11	
Groups	1.5210e+1	1	1.5210e+1
Error	44.404e+2	10	4.4042e+1

F= 0.345 $F_{5\%}$= 4.96, hence accept Ho.

Table 4.39 (a): Comparison and grouping of catch data by month for spiky dory.

Month	Mean	S.D.	S.E.	N	Group	Total	%
Jan	-	-	-	0	-	0	0
Feb	-	-	-	0	-	0	0
Mar	-	-	-	0	-	0	0
Apr	-	-	-	0	-	0	0
May	-	-	-	0	-	0	0
Jun	144.6	101.4	58.6	3	i	432	43.37
Jul	63.4	49.7	16.6	9	i	567	56.92
Aug	-	-	-	0	-	0	0
Sep	-	-	-	0	-	0	0
Oct	-	-	-	0	-	0	0
Nov	-	-	-	0	-	0	0
Dec	-	-	-	0	-	0	0
Total	83.7	70.8	20.5	12			

ANOVA Ho: all means are equal

Source	SS	DF	MS
Total	45.516e+4	11	
Groups	1.4835e+4	1	1.4835e+4
Error	44.032e+4	10	4.0325e+3

F= 3.679 $F_{5\%}$= 4.96, hence accept Ho.

Table 4.39 (b): Comparison and grouping of catch per effort data by month for spiky dory.

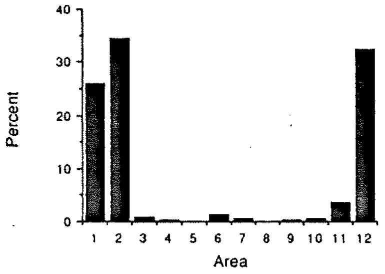


Fig. 4.1 (a): Relative proportions of catch by area for pink ling.

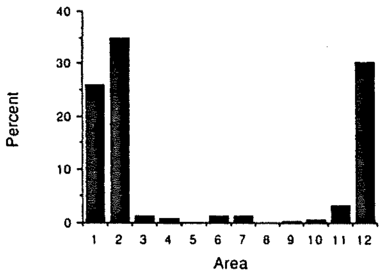


Fig. 4.1 (b): Relative proportions of catch per swept area effort by area for pink ling.

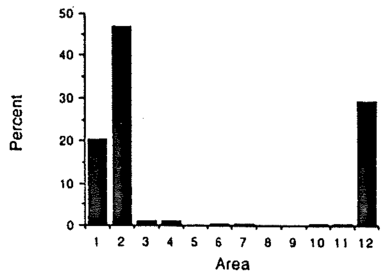


Fig. 4.2 (a): Relative proportions of catch by area for blue grenadier.

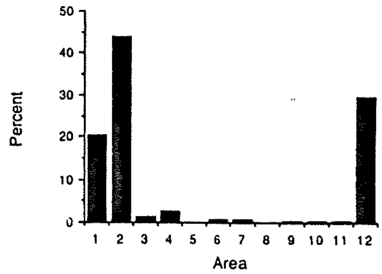


Fig. 4.2 (b): Relative proportions of catch per swept area effort by area for blue grenadier.

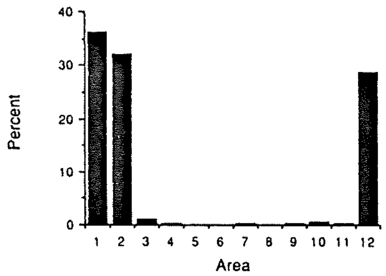


Fig. 4.3 (a): Relative proportions of catch by area for king dory.

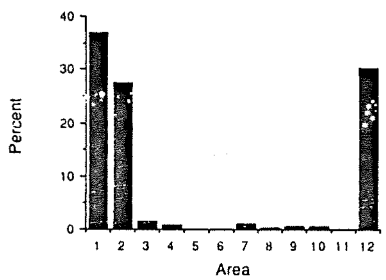


Fig. 4.3 (b): Relative proportions of catch per swept area effort by area for king dory.

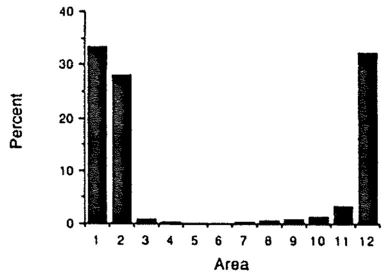


Fig. 4.4 (a): Relative proportions of catch by area for red gurnard.

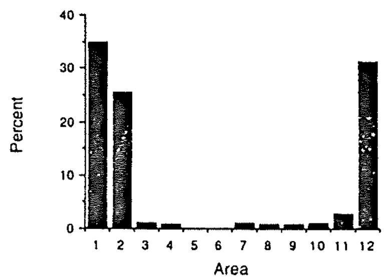


Fig. 4.4 (b): Relative proportions of catch per swept area effort by area for red gurnard.

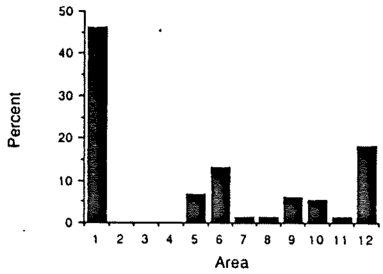


Fig. 4.5 (a): Relative proportions of catch by area for latchet.

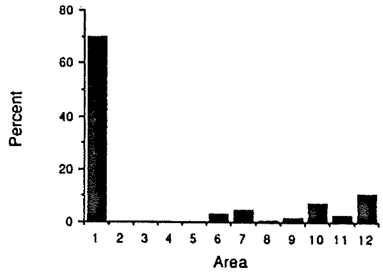


Fig. 4.6 (a): Relative proportions of catch by area for tiger flathead.

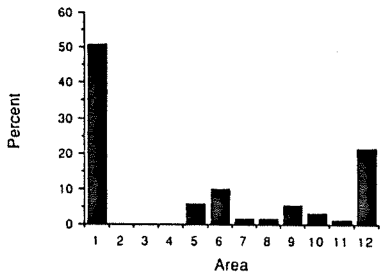


Fig. 4.5 (b): Relative proportions of catch per swept area effort by area for latchet.

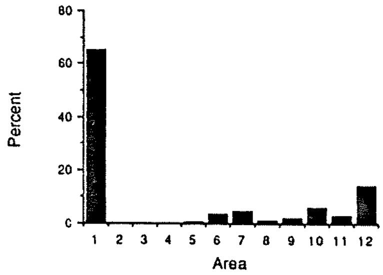


Fig. 4.6 (b): Relative proportions of catch per swept area for tiger flathead.

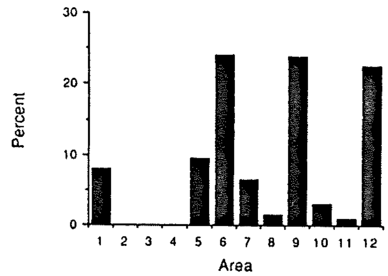


Fig. 4.7 (a): Relative proportions of catch by area for morwong.

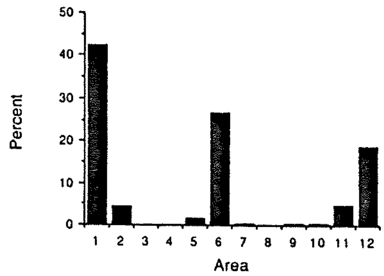


Fig. 4.8 (a): Relative proportions of catch by area for gemfish.

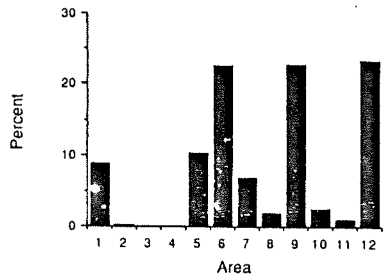


Fig. 4.7 (b): Relative proportions of catch per swept area effort by area for morwong.

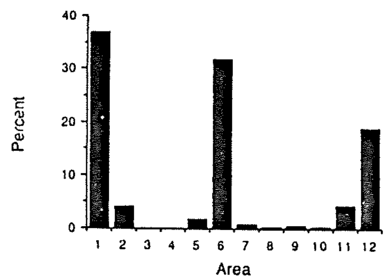


Fig. 4.8 (b): Relative proportions of catch per swept area effort by area for gemfish.

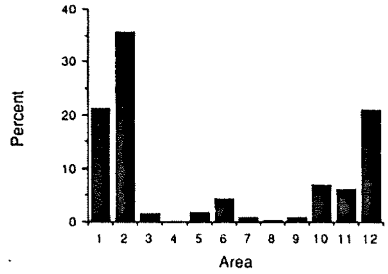


Fig. 4.9 (a): Relative proportions of catch by area for spotted trevalla.

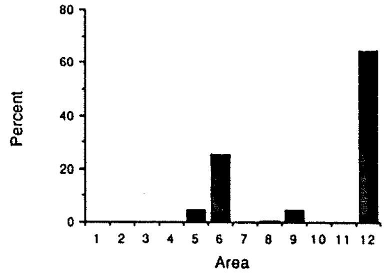


Fig. 4.10 (a): Relative proportions of catch by area for warehou.

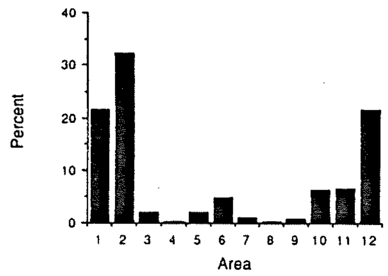


Fig. 4.9 (b): Relative proportions of catch per swept area effort by area for spotted trevalla.

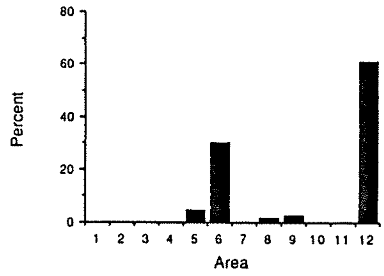


Fig. 4.10 (b): Relative proportions of catch per swept area effort by ar for warehou.

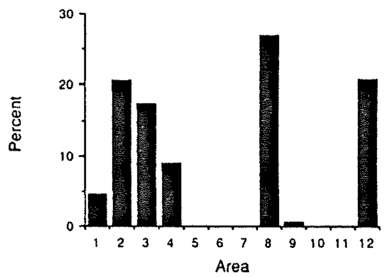


Fig. 4.11 (a): Relative proportions of catch by area for orange roughy.

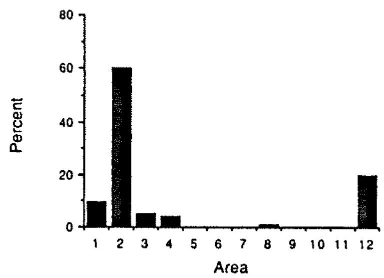


Fig. 4.12 (a): Relative proportions of catch by area for warty dory.

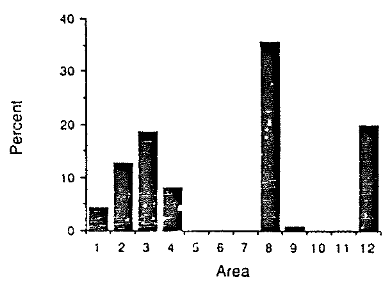


Fig. 4.11 (b): Relative proportions of catch per swept area effort by area for orange roughy.

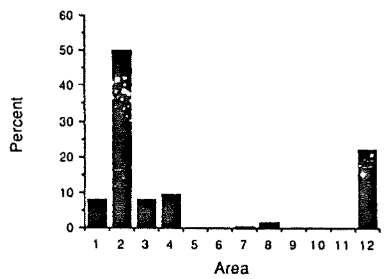


Fig. 4.12 (b): Relative proportions of catch per swept area effort by a for warty dory.

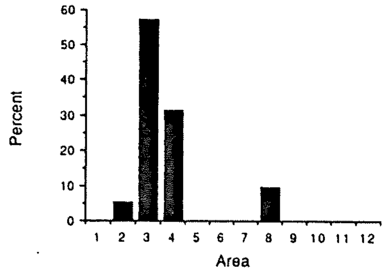


Fig. 4.13 (a): Relative proportions of catch by area for spiky dory.

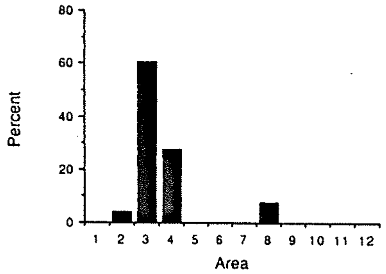


Fig. 4.13 (b): Relative proportions of catch per swept area effort by area for spiky dory.

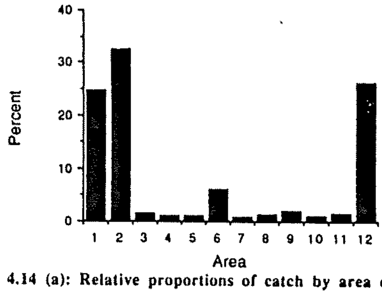


Fig. 4.14 (a): Relative proportions of catch by area overall.

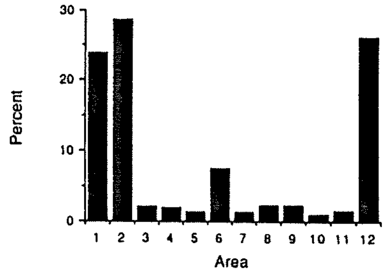


Fig. 4.14 (b): Relative proportions of catch per swept area effort by area overall.

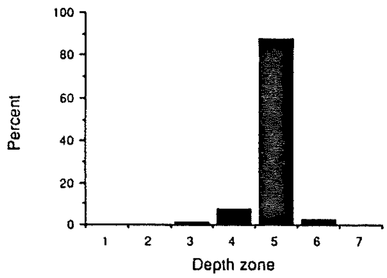


Fig. 4.15 (a): Relative proportions of catch by depth for pink ling.

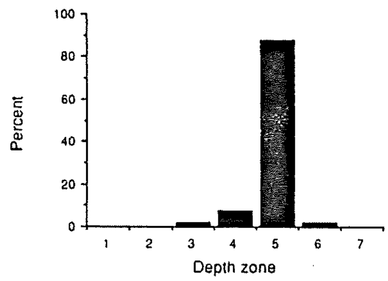


Fig. 4.15 (b): Relative proportions of catch per swept area effort by depth for pink ling.

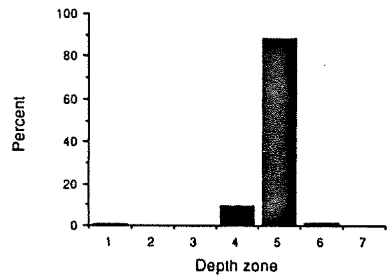


Fig. 4.16 (a): Relative proportions of catch by depth for blue grenadier.

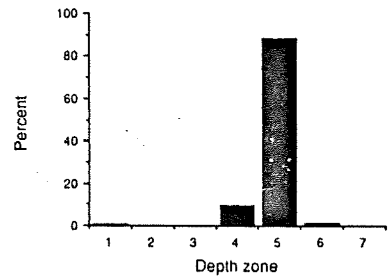


Fig. 4.16 (b): Relative proportions of catch per swept area effort by depth for blue grenadier.

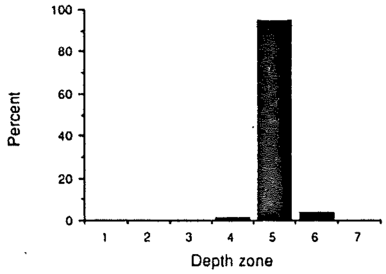


Fig. 4.17 (a): Relative proportions of catch by depth for king dory.

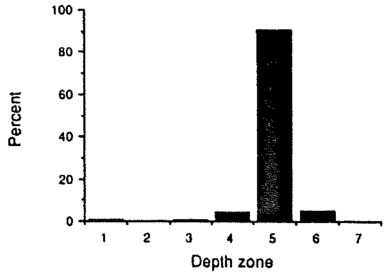


Fig. 4.18 (a): Relative proportions of catch by depth for red gurnard.

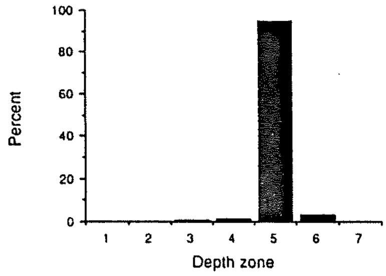


Fig. 4.17 (b): Relative proportions of catch per swept area effort by depth for king dory.

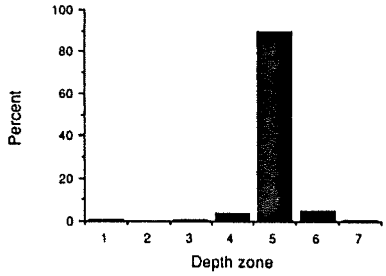


Fig. 4.18(b): Relative proportions of catch per swept area effort by depth for red gurnard.

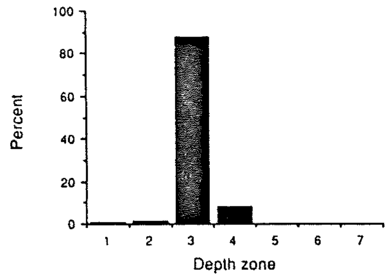


Fig. 4.19 (a): Relative proportions of catch by depth for latchet.

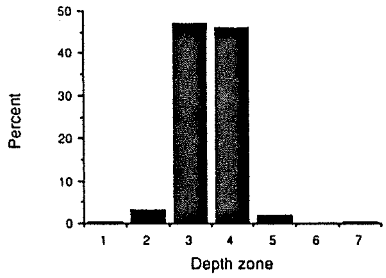


Fig. 4.20 (a): Relative proportions of catch by depth for tiger flathead.

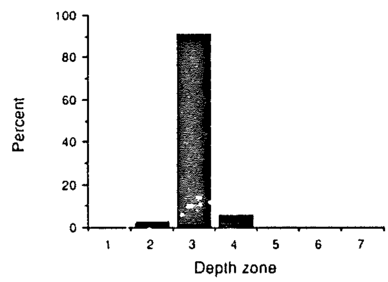


Fig. 4.19 (b): Relative proportions of catch per swept area effort by depth for latchet.

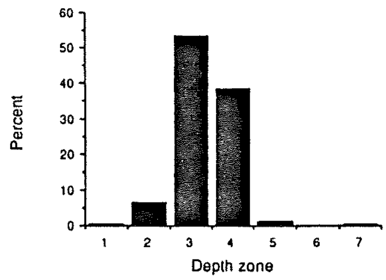


Fig. 4.20 (b): Relative proportions of catch per swept area effort by depth for tiger flathead.

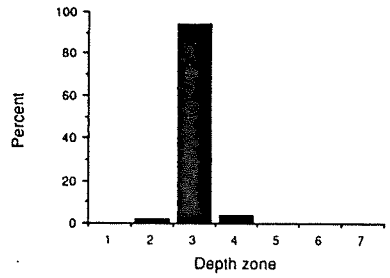


Fig. 4.21 (a): Relative proportions of catch by depth for morwong.

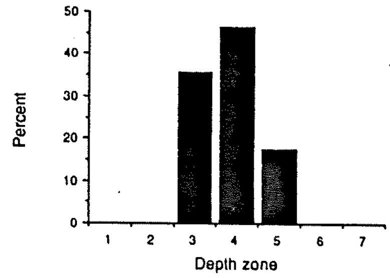


Fig. 4.22 (a): Relative proportions of catch by depth for gemfish.

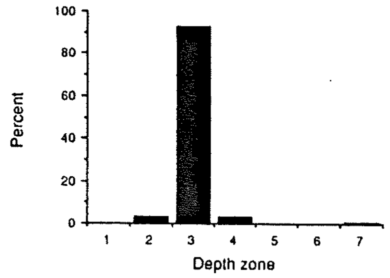


Fig. 4.21 (b): Relative proportions of catch per swept area effort by depth for morwong.

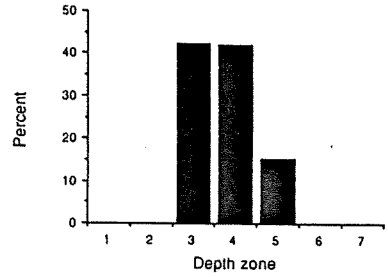


Fig. 4.22 (b): Relative proportions of catch per swept area effort by depth for gemfish.

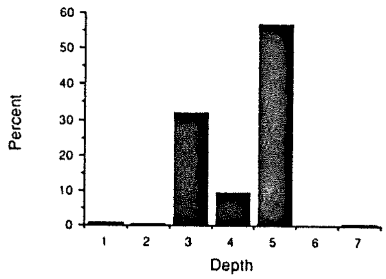


Fig. 4.23 (a): Relative proportions of catch by depth for spotted trevalla.

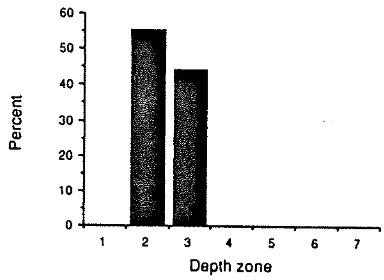


Fig. 4.24 (a): Relative proportions of catch by depth for warehou.

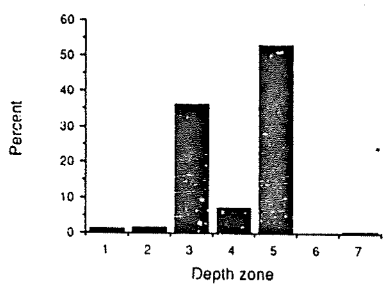


Fig. 4.23 (b): Relative proportions of catch per swept area effort by depth for spotted trevalla.

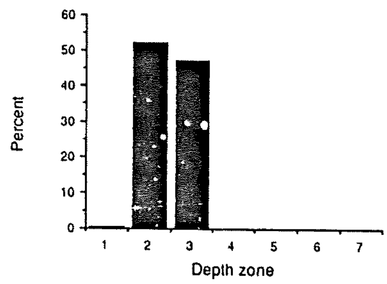


Fig. 4.24 (b): Relative proportions of catch per swept area effort by depth for warehou.

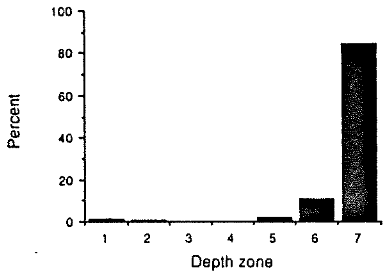


Fig. 4.25 (a): Relative proportions of catch by depth for orange roughy.

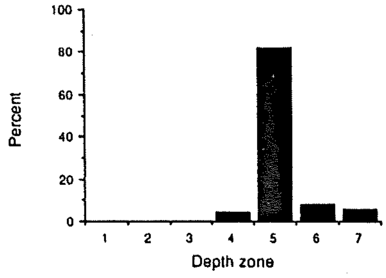


Fig. 4.26 (a): Relative proportions of catch by depth for warty dory.

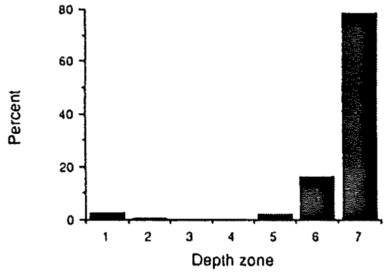


Fig. 4.25 (b): Relative proportions of catch per swept area effort by depth for orange roughy.

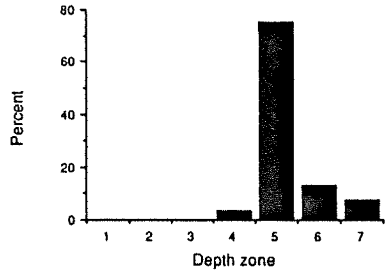


Fig. 4.26 (b): Relative proportions of catch per swept area effort by depth for warty dory.

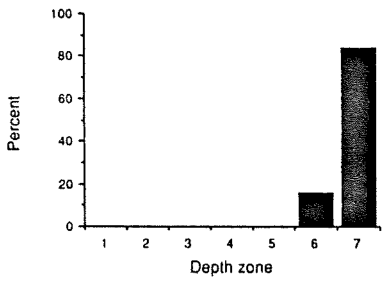


Fig. 4.27 (a): Relative proportions of catch by depth for spiky dory.

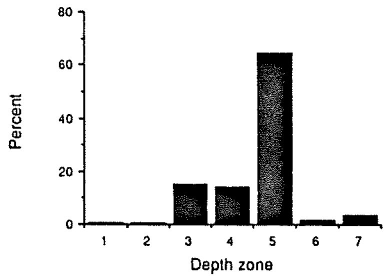


Fig. 4.28 (a): Relative proportions of catch by depth overall.

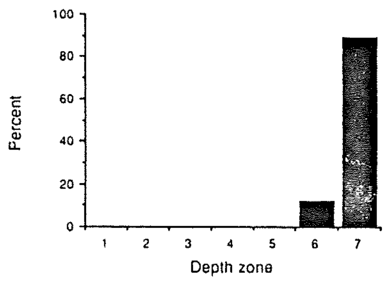


Fig. 4.27 (b): Relative proportions of catch per swept area effo.t ' y Jepth for spiky dory.

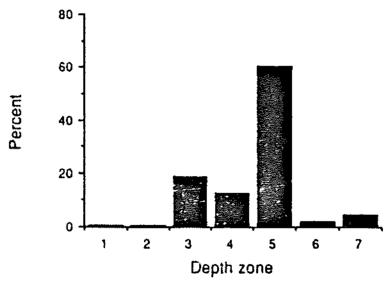


Fig. 4.28 (b): Relative proportions of catch per swept area effort by depth for overall.

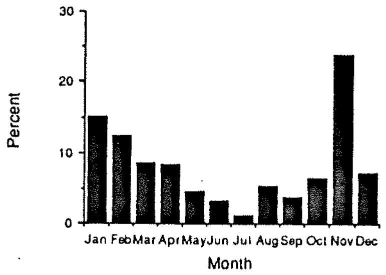


Fig. 4.29 (a): Relative proportions of catch by month for pink ling.

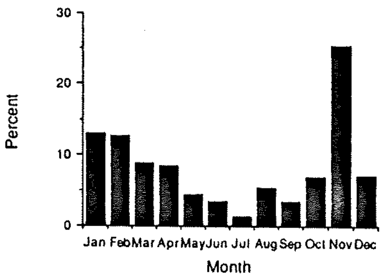


Fig. 4.29 (b): Relative proportions of catch per swept area effort by month for pink ling.

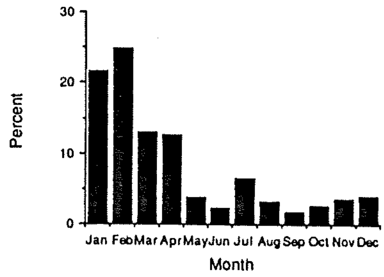


Fig. 4.30 (a): Relative proportions of catch by month for blue grenadie

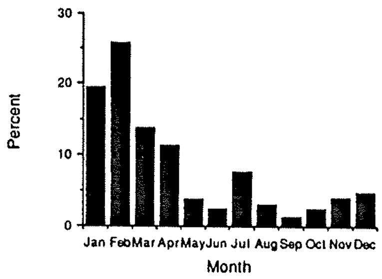


Fig. 4.30 (b): Relative proportions of catch per swept area effort by month for blue grenadier.

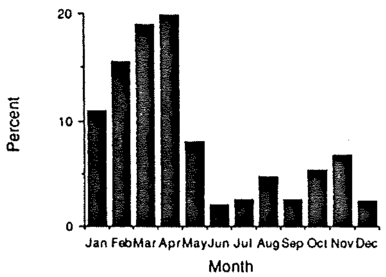


Fig. 4.31 (a): Relative proportions of catch by month for king dory.

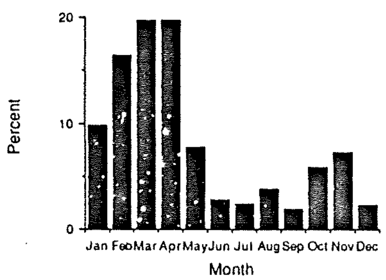


Fig. 4.31 (b): Relative proportions of catch per swept area effort by month for king dory.

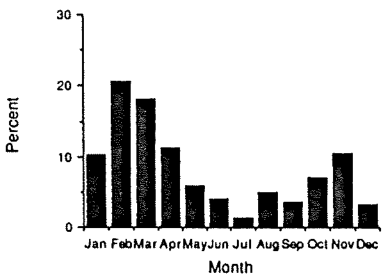


Fig. 4.32 (a): Relative proportions of catch by month for red gurnard.

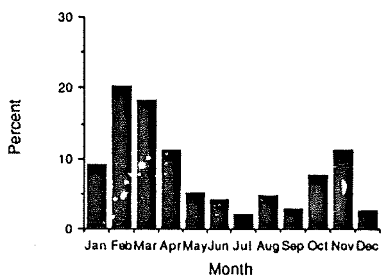


Fig. 4.32 (b): Relative proportions of catch per swept area effort by month for red gurnard.

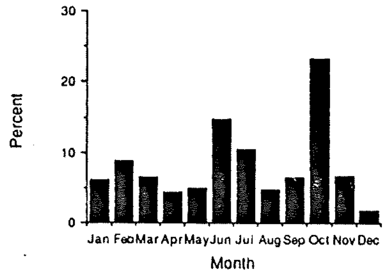


Fig. 4.33 (a): Relative proportions of catch by month for latchet.

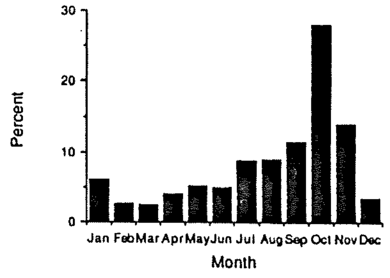


Fig. 4.34 (a): Relative proportions of catch by month for tiger flathead.

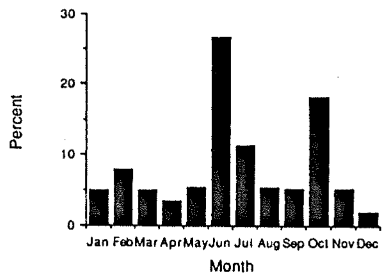


Fig. 4.33 (b): Relative proportions of catch per swept area effort by month for latchet.

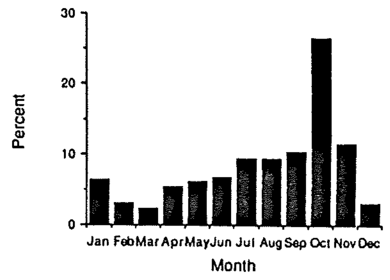


Fig. 4.34 (b): Relative proportions of catch per swept area effort by month for tiger flathead.

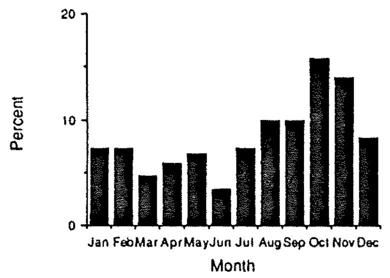


Fig. 4.35 (a): Relative proportions of catch by month for morwong.

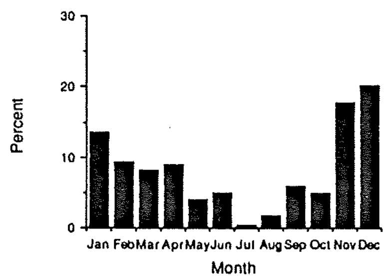


Fig. 4.36 (a): Relative proportions of catch by month for gemfish.

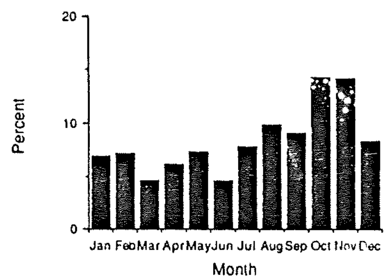


Fig. 4.35 (b): Relative proportions of catch per swept area effort by month for morwong.

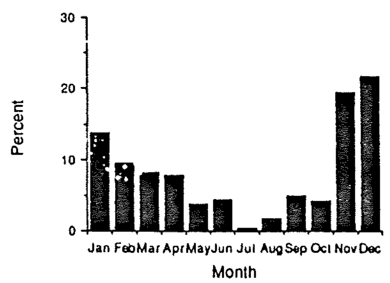


Fig. 4.36 (b): Relative proportions of catch per swept area effort by month for gemfish.

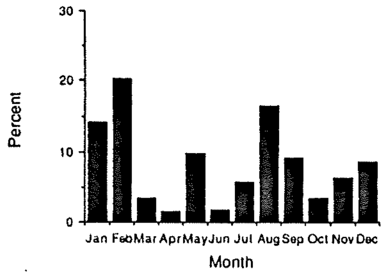


Fig. 4.37 (a): Relative proportions of catch by month for spotted trevalla.

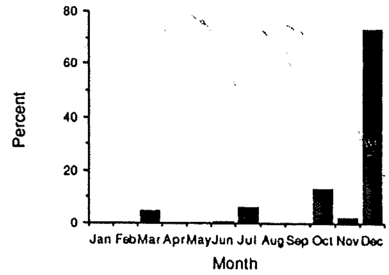


Fig. 4.38 (a): Relative proportions of catch by month for warehou.

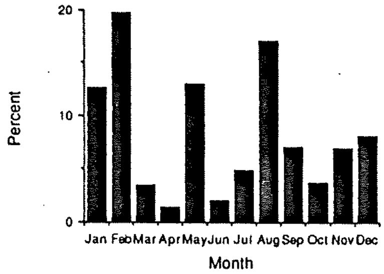


Fig. 4.37 (b): Relative proportions of catch per swept area effort by month for spotted trevalla.

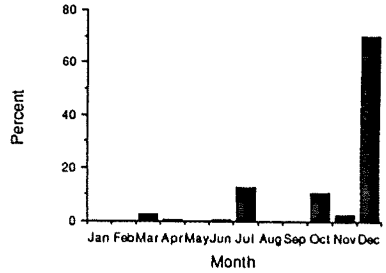


Fig. 4.38 (b): Relative proportions of catch per swept area effort by month for warehou.

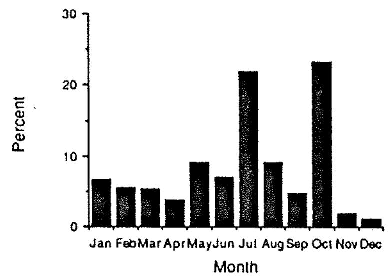


Fig. 4.39 (a): Relative proportions of catch by month for orange roughy.

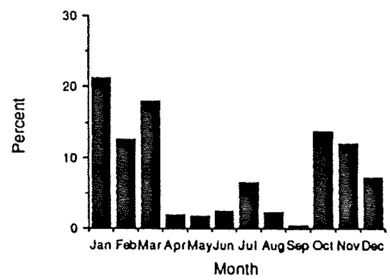


Fig. 4.40 (a): Relative proportions of catch by month for warty dory.

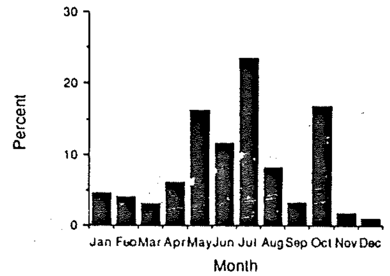


Fig. 4.39 (b): Relative proportions of catch per swept area effort by month for orange roughy.

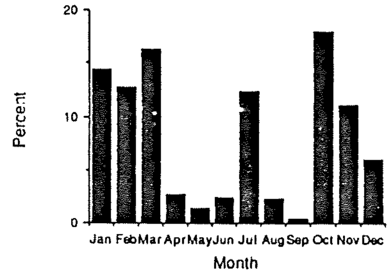


Fig. 4.40 (b): Relative proportions of catch per swept area effort by month for warty dory.

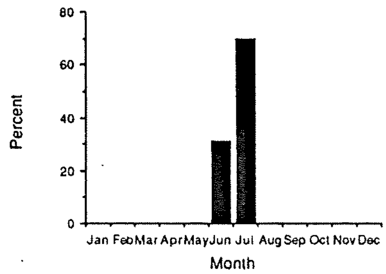


Fig. 4.41 (a): Relative proportions of catch by month for spiky dory.

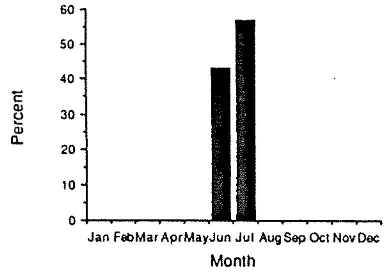


Fig. 4.41 (b): Relative proportions of catch per swept area effort by month for spiky dory.

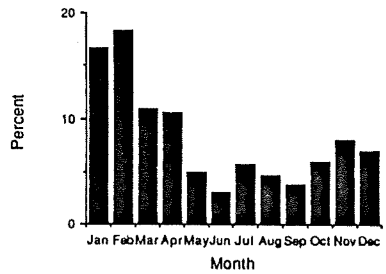


Fig. 4.42 (a): Relative proportions of catch by month overall.

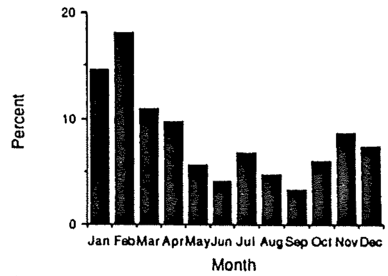


Fig. 4.42 (b): Relative proportions of catch per swept area effort by month overall.

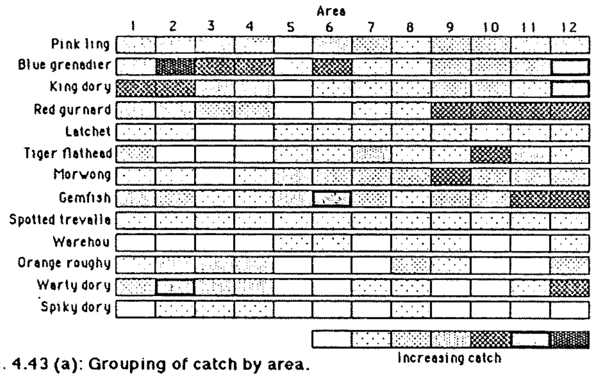


Fig. 4.43 (a): Grouping of catch by area.

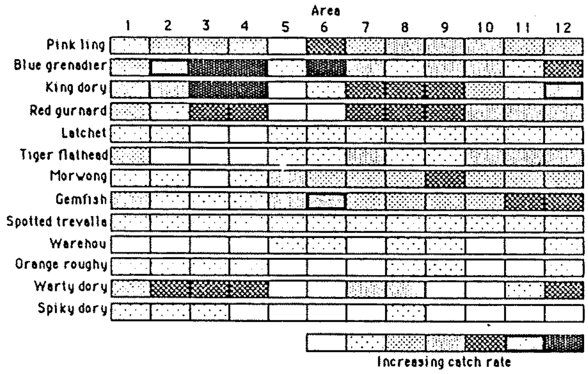


Fig. 4.43 (b): Grouping of catch per swept area effort by area.

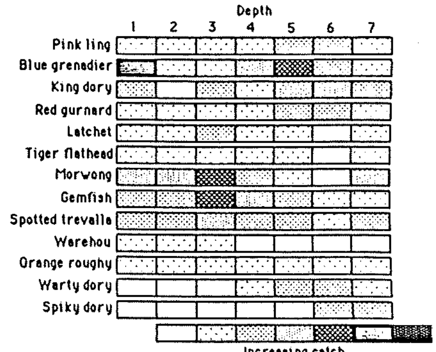


Fig. 4.44 (a): Grouping of catch by depth.

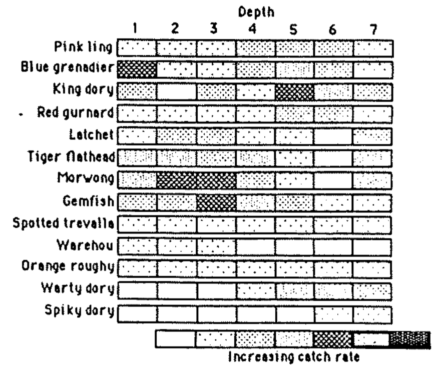


Fig. 4.44 (b): Grouping of catch per swept area effort by depth.

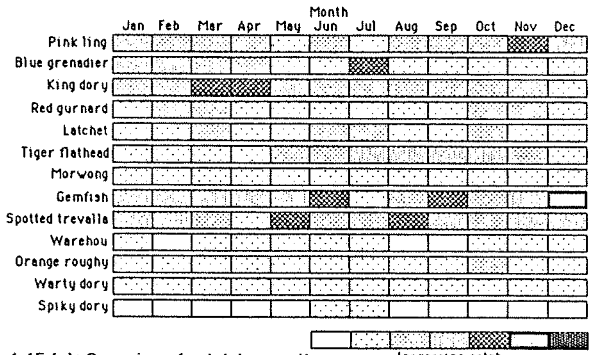


Fig. 4.45 (a): Grouping of catch by month.

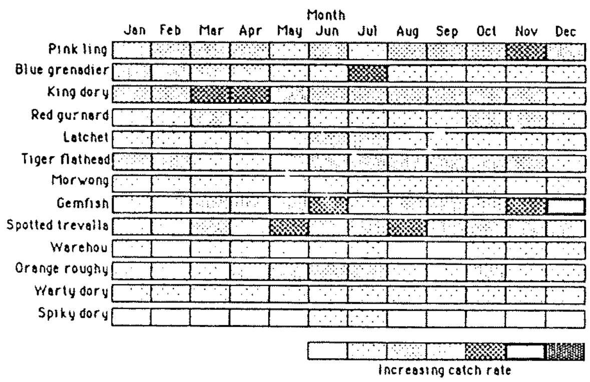


Fig. 4.45 (b): Grouping of catch per swept area effort by month.

OTHER TITLES IN THIS SERIES.

Report Number	
1	Cuthbertson, A. (1978) *The Abalone Culture Handbook*
2	Hortle, M. (1981) *Sea Water Culture of Rainbow Trout*
3	Thomson, J. D., Sumner, C. E. and Harris, J. G. K. (1982) *Temperature and Salinity Records from an Aquaculture Monitoring Program in Tasmania 1961-1981*
4	McMullen, J. and Sumner, C. E. (1983) *Abalone Culture Production Costs*
5	Cropp, D. A. (1985) *Economic Feasability of Scallop Culture in Tasmania*
6	Cropp, R. A. (1986) *An Introduction to Abalone Farming; A Synopsis of Procedures and Requirements for the Farming of Small Abalone*
7	Zacharin, W. (1986) *Reports on the Size Composition and abundance of the Scallop Fishing Grounds off North-Eastern Tasmania*
8	Williams, H. (1986) *Collection and Storage of Data in the Trawl, Purse Seine and Drop-line Fisheries*
9	Zacharin, W. (1986) *D'Entrecasteaux Channel Scallop Survey, 1986*
10	Williams, H. and Pullen, G. (1986) *A Synopsis of Biological Data on the Jack Mackerel Trachurus declivis Jenyns*
11	Cropp, D. A. (1986) *Diving Survey of Scallops in Great Oyster Bay, Tasmania*
12	Evans, K. R. (1986) *Arrow Squid Behaviour and Vulnerability to Netting Techniques*
13	Williams, H., Kirkwood, R., Pullen, G. and Kucerans, I. G. (1986) *The Jack Mackerel Purse Seine Fishery in Tasmania, 1985 - 86*
14	Collins, S. (1986) *An Evaluation of AFZ Squid Logbook Data and Samples Collected by AFZ Observers*
15	Cropp, R. A. (1987) *Feasability of Scallop Culture in Tasmania*
16	Zacharin, W. (1987) *D'Entrecasteaux Channel Scallop Survey, 1987*
17	Hortle, M. E. (1987) *The Use of Artificial Hatching Substrates in a Salmon Hatchery*
18	Zacharin, W. (1987) *Tasmanian Zone Scallop Survey, 1987*
19	Williams, H., Pullen, G., Kucerans, G. and Waterworth, C. (1987) *The Jack Mackerel Purse Seine Fishery in Tasmania, 1986 - 87*
20	Hortle, M. E. (Ed) (1987) *The Tasmanian Aquaculture Industry - Proceedings of the First Tasmanian Aquaculture Conference*
21	Sanderson, J. C. (1987) *A Survey of the Macrocystis pyrifera (L.) C. Agardh Stocks on the East Coast of Tasmania*
22	Sanderson, J. C. (1987) *Macroalgal Study, George III Reef*