A data management and reporting system and historical analysis of catch records in the South Australian abalone fishery

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FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Project number 94/167

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Objectives

1. Develop a system of data management protocols to ensure long term integrity of the database and allow timely analysis and reporting.

2. Automate generation of detailed annual reports (including maps and graphs) showing individual (confidential) and combined activity in catch and effort on a small spatial scale.

3. Automate generation of detailed annual reports for research purposes to enable analysis of trends in catch, effort, size composition and fishing patterns to assist in annual stock assessments of abalone.

4. Produce a comprehensive resource document describing and illustrating catch and effort history of each of the 196 areas since 1983 and on a larger scale (by 22 sub-zones) using data collected between 1968 and 1982.

5. Produce detailed analysis of trends and spatial and temporal interactions in the fishery from the above data. This will include an analysis of catch size structure and fishing patterns.

6. Produce a "history of fishing" document of the activity of each licence holder in the fishery for confidential use by that licence holder.

NON TECHNICAL SUMMARY

Abalone stocks exist as a large number of metapopulations or sub-stocks each with peculiar growth and mortality characteristics. Hence different populations respond differently to exploitation through fishing. The sustainability of this fishery is linked to effective management of these meta-populations. For this reason, abalone catch and effort data should be collected on as fine a spatial scale as possible.

South Australia's catch and effort data is collected on the finest spatial scale of any abalone fishery in Australia. However, to date, analysis of the fine scale components of the data has been superficial simply as a result of the lack of tools to rapidly summarize and present data visually. Spatial and temporal analyses of these data will assist in the assessment of how individual sub-stocks have responded to fishing.

Across South Australia there are 35 abalone fishers fishing 7 different Total Allowable Catches (TAC's) on two species across 196 reporting areas. While the complexity of the data has to date precluded comprehensive analysis it also offers the potential for powerful insights into the dynamics of the fishery after more than 10 years of quota management.

In all fisheries, levels of catch and catch rates are two indicators used to attempt to evaluate and assess the response of stocks to exploitation through fishing. Declines in catches or catch rates are often

interpreted as indicators of recruitment or growth overfishing and similarly increases in catches and catch rates may be interpreted as providing evidence that stocks are being sustained in the face of fishing or may even be under-exploited.

In practice, however the situation is far more complex with any number of factors affecting these indicators. The dominant factor affecting diver behaviour is to maximise their catch but this is modified on a range of other factors.

In fisheries such as abalone, the dynamics of diver behaviour can be affected by weather, experience, economic considerations and lifestyle preferences affecting how fast they can, need or desire to catch their quota. Other factors such as where they live and how far they want to travel to fish will affect where they fish. Such factors make it difficult to interpret fishery dependent catch data aggregated over groups of fishers.

The high mobility of abalone fishers also makes interpretation of catch data difficult. In abalone fishing it is possible to move quickly from one abalone aggregation to the next, serially depleting metapopulations without a corresponding drop in catch rate being evident. These factors make it difficult to interpret fishery dependent catch data aggregated over large spatial scales.

This project does not carry out the detailed analysis and modelling required to account for all these factors in interpreting abalone catch and effort data. The Abalone Data Management and Reporting System (ADMRS) developed through this project is a tool to assist in this analysis and an application adaptable to other fisheries. Furthermore the project outcomes provide a summary of the broad temporal and spatial patterns of abalones catches in this fishery.

The South Australian abalone fishery is a limited entry, quota managed fishery comprising two species *Haliotis laevigata* Donovan (greenlip) and *H. rubra* Leach (blacklip). The fishery is separated into 3 zones; Western , Southern and Central.

Analysis of the greenlip catches shows that in the Western Zone the most important areas are Thorny Passage, Ward Island, The Hotspot, Pearson Island, Baird Bay, Sheringa and the Avoid Point/Avoid Bay area. Other areas including the Whidbey Isles, Golden and Price Islands and Coffin Bay Peninsula show declining catches in recent years. Analysis of the blacklip catches within this zone shows that the most important areas are Ward Island, Sheringa, High Cliff, Point Labatt and Venus Bay. Since the introduction of quotas in this zone, catches taken from the Watchers, Drummond and Fishery Bay have declined.

Analysis of greenlip catches in the Central Zone shows that up to 1984 significant catches came from the Edithburgh area however, since 1985 the catches from this area have been almost zero. Similarly declining catches from Cape Jervis are also evident. Since 1985 fishing grounds near Point Turtin and Tiparra Reef, Spencer Gulf have become more important in sustaining the fishery. Analysis of blacklip catches within this zone demonstrates the importance of southern Kangaroo Island, particularly the area from Cape Bedout to Cape Bouger, to the fishery.

Greenlip abalone have never been a major component of the catch in the Southern Zone. The main areas for catch of this species have been Ringwood Reef and south of Carpenters rocks. Whilst catches of blacklip ablone are made throughout the Southern Zone, the largest component of the catch comes from south of Cape Martin especially in Ringwood Reef and Lipson Rock areas.

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1.1. BACKGROUND

Australian abalone stocks were virtually unexploited before 1963 (Prince and Shepherd, 1992) and with the increase in popularity of recreational scuba diving the ability to exploit abalone increased. The establishment of markets between 1965 and 1968 for the product saw a number of divers professionally fishing for the resource. The Australian abalone fishery has now grown to a major fishery worth over $100 million annually. In South Australia the catch of the fishery is valued between $30 million to $40 million annually. The two species commercially exploited in South Australia are *Haliotis laevigata* Donovan (greenlip) and *H. rubra* Leach (blacklip).

During the past 35 years our knowledge of the biology of *Haliotis laevigata* and *H. rubra* has increased and hopefully the requirements to manage the resource sustainably are better understood. Abalone stocks exist as a large number of metapopulations or sub-stocks each with peculiar growth and mortality characteristics. Hence different populations respond differently to exploitation through fishing. The sustainability of this fishery is linked to effective management of these meta-populations. Commonwealth and state government legislation and policies require that management strategies for sustainable use of the resource are based on quantitative data. Hence the need to collect and analyse abalone catch and effort and population data at as fine a spatial scale as possible.

South Australia's catch and effort data is collected on the finest spatial scale (see attached maps in Section 3) of any abalone fishery in Australia, probably the world. However, to date, analysis of the fine scale components of the data has been superficial simply as a result of the lack of tools to rapidly summarise and present data visually. The complexity of the data structure stems from having 35 fishers fishing 7 different TAC's on two species across 196 different reporting areas. While the complexity of the data has to date precluded comprehensive analysis it also offers the potential for powerful insights into the dynamics of the fishery after more than 10 years of quota management

In all fisheries, levels of catch and catch rates are two indicators used to attempt to evaluate and assess the response of stocks to exploitation through fishing. Declines in catches or catch rates are often interpreted as indicators of recruitment or growth overfishing and similarly increases in catches and catch rates may be interpreted as providing evidence that stocks are being sustained in the face of fishing or may even be under-exploited.

In practice, however the situation is far more complex with any number of factors affecting these indicators. The dominant factor affecting diver behaviour is to maximise their catch but this is modified on a range of other factors that are discussed below. More and more fisheries scientists are understanding that in limited entry, quota manged fisheries, the behaviour of fishers as a group and as individuals are the primary factors determining patterns of catches and catch rates in fisheries.

In fisheries such as abalone, the dynamics of diver behaviour can be affected by weather, experience, economic considerations and lifestyle preferences affecting how fast they can, need or desire to catch their quota. Other factors such as where they live and how far they want to travel to fish will affect where they fish. Such factors make it difficult to interpret fishery dependent catch data aggregated over groups of fishers.

The high mobility of abalone fishers also makes interpretation of catch data difficult. In abalone fishing it is possible to move quickly from one abalone aggregation to the next, serially depleting metapopulations without a corresponding drop in catch rate being evident. These factors make it difficult to interpret fishery dependent catch data aggregated over large spatial scales.

1.2. NEED

To date, analysis of abalone catch and effort statistics in South Australia has been undertaken only over very large spatial scales of 10's to 100's of kilometres. However, since 1983, this information (together with catch gradings) has been collected on a daily basis from 196 individual (metapopulation) areas (<10 km) across the state. There is a need to carry out detailed spatial and temporal analysis of this data to determine how individual sub-stocks (metapopulations) have responded to fishing since the introduction of quota management.

There is also a need for a reporting system to deal with future analyses and to provide feedback to the fishers who have provided the data. Regular analysis of this information on a much finer spatial scale than previously done also requires the development of long term data management and handling protocols because of the very large amounts of data.

Furthermore the development of a data management tool that can assist in the collection, storage and analysis of spatial and temporal catch and effort data will assist in reporting on annual stock assessments as well as providing a model that can be applied to other fisheries.

1.3 OBJECTIVES

The objectives of this study were to:

1 Develop a system of data management protocols to ensure long term integrity of the database and allow timely analysis and reporting.

2 Automate generation of detailed annual reports (including maps and graphs) showing individual (confidential) and combined activity in catch and effort on a small spatial scale.

3 Automate generation of detailed annual reports for research purposes to enable analysis of trends in catch, effort, size composition and fishing patterns to assist in annual stock assessments of abalone.

4 Produce a comprehensive resource document describing and illustrating catch and effort history of each of the 196 areas since 1983 and on a larger scale (by 22 sub-zones) using data collected between 1968 and 1982.

5 Produce detailed analysis of trends and spatial and temporal interactions in the fishery from the above data. This will include an analysis of catch size structure and fishing patterns.

6 Produce a "history of fishing" document of the activity of each licence holder in the fishery for confidential use by that licence holder.

2 SECTION TWO

The Abalone Data Management and Reporting System (ADMRS)

Objectives

- Develop a system of data management protocols to ensure long term integrity of the database and allow timely analysis and reporting.

- Automate generation of detailed annual reports (including maps and graphs) showing individual (confidential) and combined activity in catch and effort on a small spatial scale.

- Automate generation of detailed annual reports for research purposes to enable analysis of trends in catch, effort, size composition and fishing patterns to assist in annual stock assessments of abalone.

The overall objective is to develop a data management and reporting system

This study has produced a new data entry, storage and management system which not only protects and archives the valuable long term data set but links all historical data since the emergence of the fishery in the 1960's and enables rapid retrieval, analysis, summary and reporting of the data. The system is described in this section. A CD containing the ADMRS system, but empty of data, is included in the back cover sleeve of this report.

2.1 INTRODUCTION

The Abalone Data Management and Reporting System (ADMRS) provides a computer based archive and data analysis system for the South Australian abalone catch and effort data. ADMRS is a entry, storage and management system which not only protects and archives the valuable lont term data set bu tlinks all historical data since the emergence of the fishery in the 1960's. It enables rapid retrieval, analysis, summary and reporting of data.

This section describes the use of the various on screen menus to interrogate the database.

START UP SCREEN

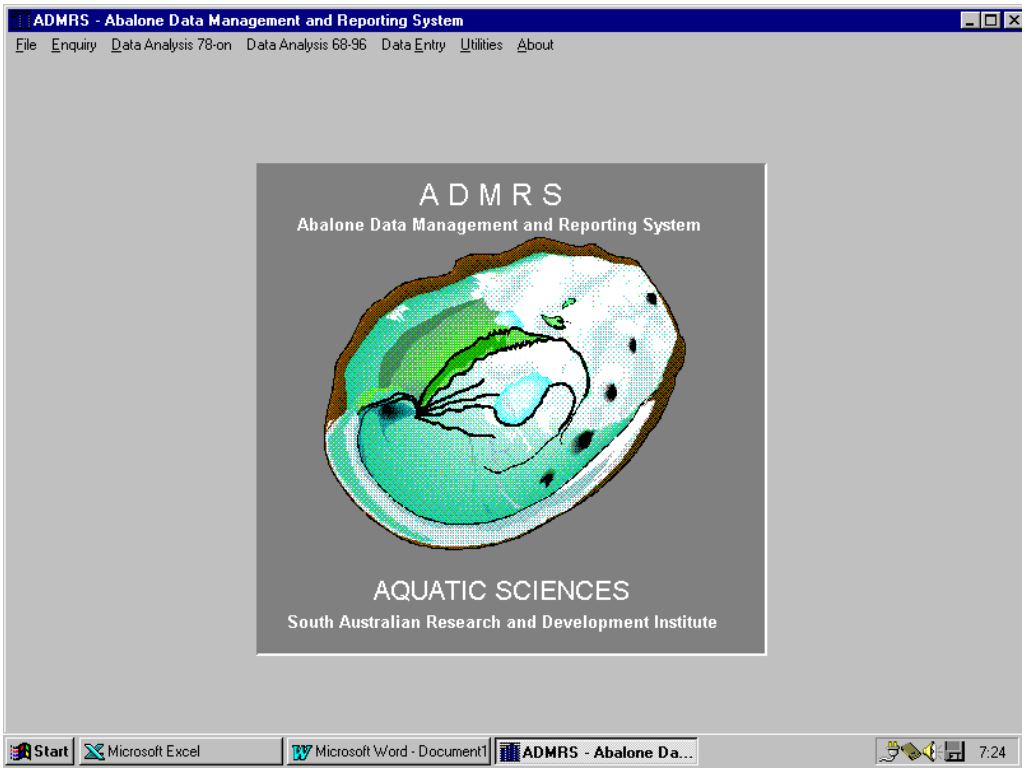


Figure 2.1: Start up screen for ADMRS showing menu choices

The Start Up Screen (Figure 2.1) provides the following options:

- File: used to close ADMRS.
- Enquiry: used to interrogate database, find individual records, etc.
- Data Analysis 78-on: enables on screen analysis of data sorted by various fields and presented as graphs or tables for data aggregated or disaggregated over various spatial and temporal scales back to 1978.
- Data Analysis 68-96: enables on screen analysis of data sorted by various fields and presented as graphs or tables for data on an enlarged spatial scale from 1968 to 1996.
- Data Entry: provides access to the data entry module.
- Utilities: enables download of data from old SA Department of Fisheries and SARDI databases and creates copies of data submitted by individual abalone license holders.
- About: About ADMRS.

DATABASE ENQUIRY

The database enquiry menu is the start point to be able to look at and search for individual records within the 1978 to 1998 database. There is no search facility for the earlier 1968 to 1978 database but individual records can be viewed under the data entry facility.

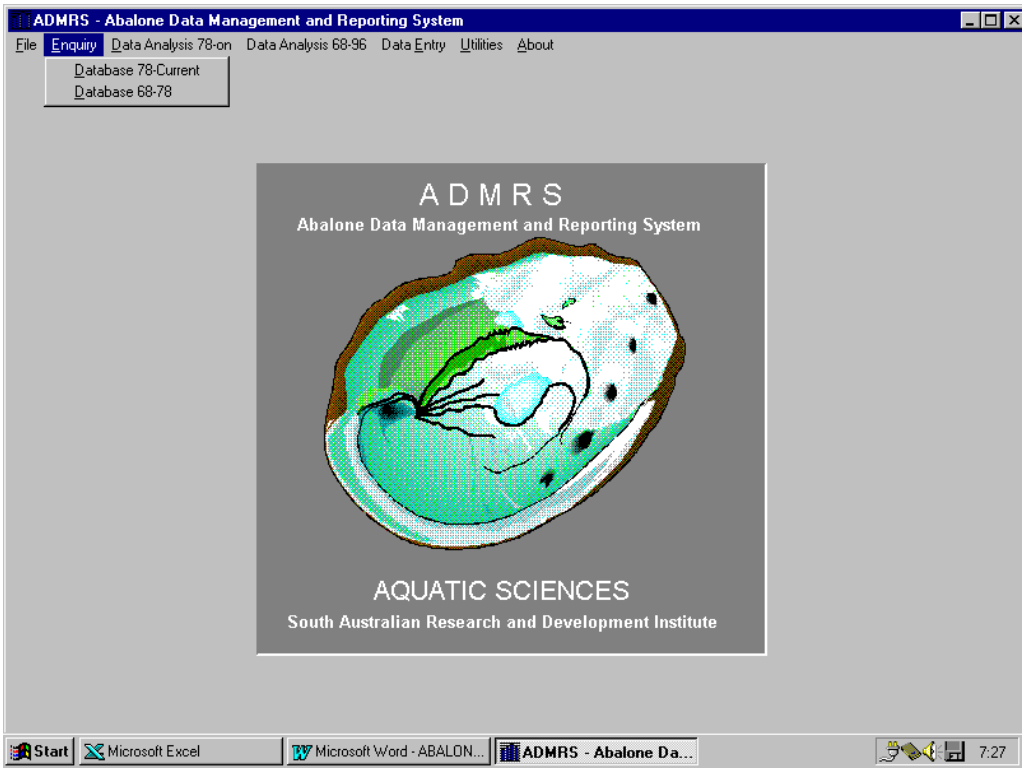
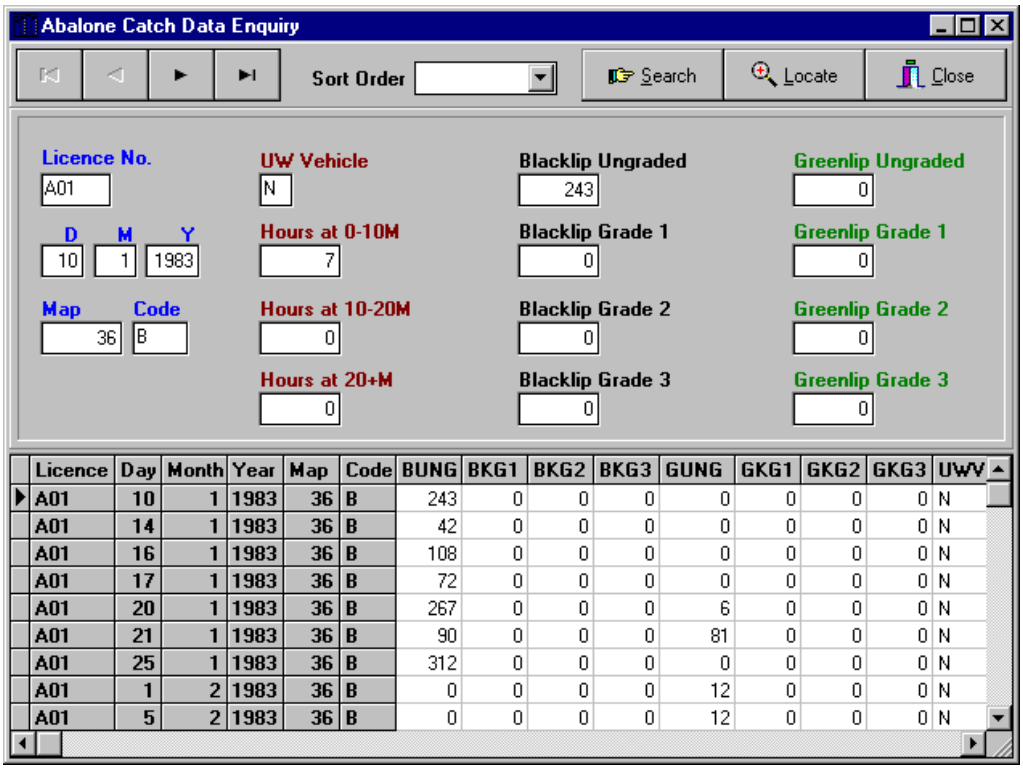


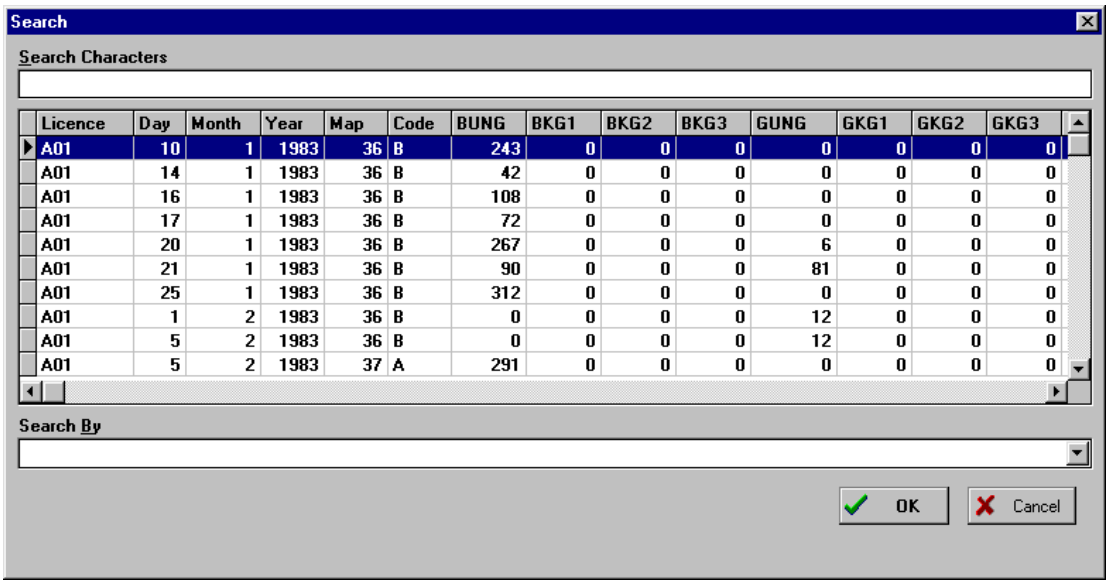
Figure.2.2: Database enquiry menu

The menu at figure 2.2 opens the Data enquiry screen (figure 2.3). The user can scroll through the entire database or use the searching tools to sort in different ways by using the "Sort Order" drop down menu to sort by Year, Month, Licence No. or Map or by using the "Search" or "Locate" menus (see below).



Licence	Day	Month	Year	Map	Code	BUNG	BKG1	BKG2	BKG3	GUNG	GKG1	GKG2	GKG3	UWV
A01	10	1	1983	36	B	243	0	0	0	0	0	0	0	N
A01	14	1	1983	36	B	42	0	0	0	0	0	0	0	N
A01	16	1	1983	36	B	108	0	0	0	0	0	0	0	N
A01	17	1	1983	36	B	72	0	0	0	0	0	0	0	N
A01	20	1	1983	36	B	267	0	0	0	6	0	0	0	N
A01	21	1	1983	36	B	90	0	0	0	81	0	0	0	N
A01	25	1	1983	36	B	312	0	0	0	0	0	0	0	N
A01	1	2	1983	36	B	0	0	0	0	12	0	0	0	N
A01	5	2	1983	36	B	0	0	0	0	12	0	0	0	N

Figure 2.3 : Data enquiry screen showing actual data records by row (lower section), individual data points within a single record (middle section) and searching tools (upper section)



Licence	Day	Month	Year	Map	Code	BUNG	BKG1	BKG2	BKG3	GUNG	GKG1	GKG2	GKG3
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A01	16	1	1983	36	B	108	0	0	0	0	0	0	0
A01	17	1	1983	36	B	72	0	0	0	0	0	0	0
A01	20	1	1983	36	B	267	0	0	0	6	0	0	0
A01	21	1	1983	36	B	90	0	0	0	81	0	0	0
A01	25	1	1983	36	B	312	0	0	0	0	0	0	0
A01	1	2	1983	36	B	0	0	0	0	12	0	0	0
A01	5	2	1983	36	B	0	0	0	0	12	0	0	0
A01	5	2	1983	37	A	291	0	0	0	0	0	0	0

Figure 2.4: Search menu

The “Search” menu is opened by clicking on the button in the top right part of the data enquiry menu (figure 2.3) and enables the user to move quickly within the database searching for records of interest. The databases can be searched by Year, Month, Licence No. and Map by clicking on the down arrow on the “Search By” bar and the characteristics of the record sought can be entered on the “Search Characters” bar.

The “Locate Field Value” menu can be opened by clicking on the button in the top right part of the data einquiry menu (figure 2.3) and enables the user to move quickly to the section of the database of interest. For the example shown in figure 2.5, the field being searched is Licence No. and the user can enter the licence number of interest at the top under “Field Value” and then click “Next”.

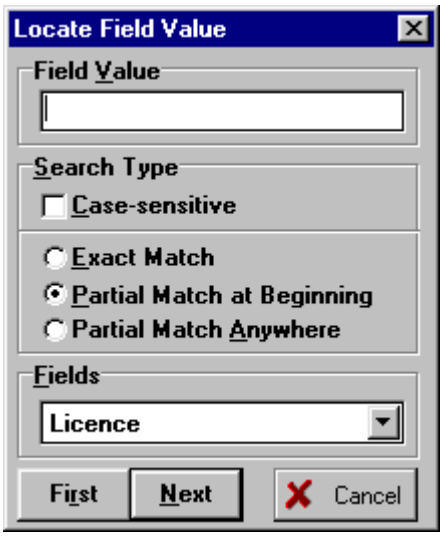


Figure 2.5: The Locate Field Value menu

UTILITIES MENU

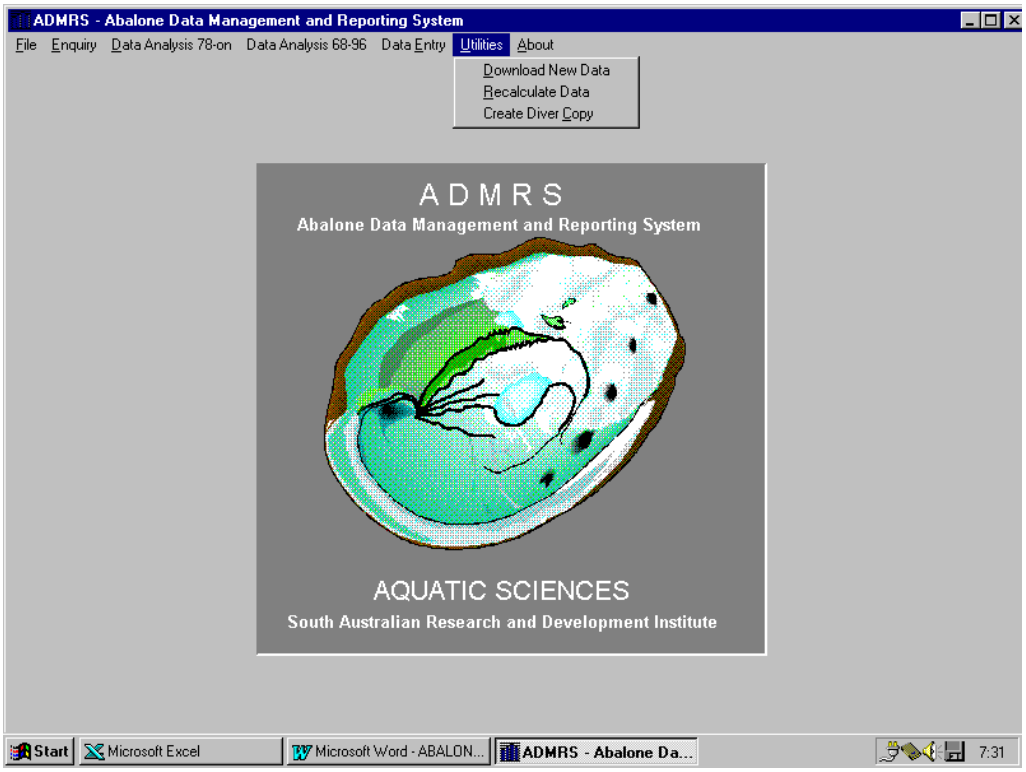


Figure 2.6: Utilities menu

The Utilities menu provides three functions. The first "Download New Data" was used to enable historical data records from the old databases held by SARDI to be loaded into the ADMRS. This process has already been carried out with all the historical data downloaded into the new ADMRS. The "Recalculate Data" was also used to generate new data columns not present in the older database and now is only used after any manual change is made (e.g. historical data error correction) to any records in the database. Secondly it enables copies of the ADMRS to be made for each Licence holder which contains a copy of their data only.

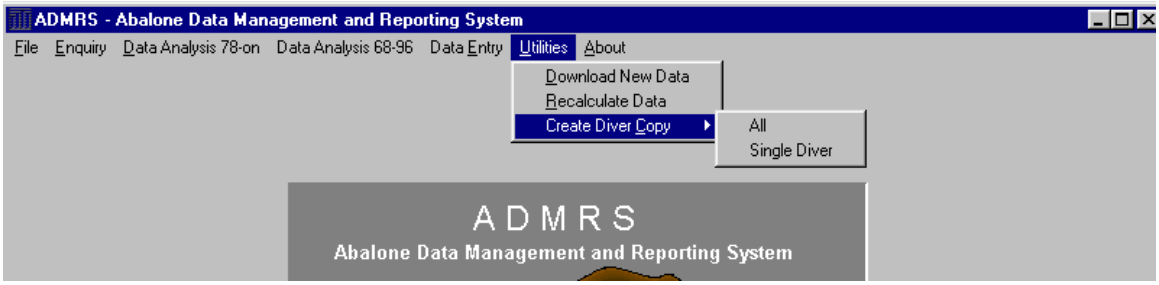


Figure 2.7: Create Diver Copy menu

The Utilities menu gives two options under the "Create Diver Copy" heading (Figure 2.7); to create "All" the diver copies in one go or to create a "Single Diver" copy.

If you choose "All" this automatically creates diver copies from 1978-1998. However, when creating a "Single Diver Copy" (Figure 2.8) it allows the user to choose the individual divers licence eg. A01, A02 etc and allows selection of the year in which the current licence holder started fishing. Then click on "Diver Copy" with the tick. This may be 1982-1998 for example.

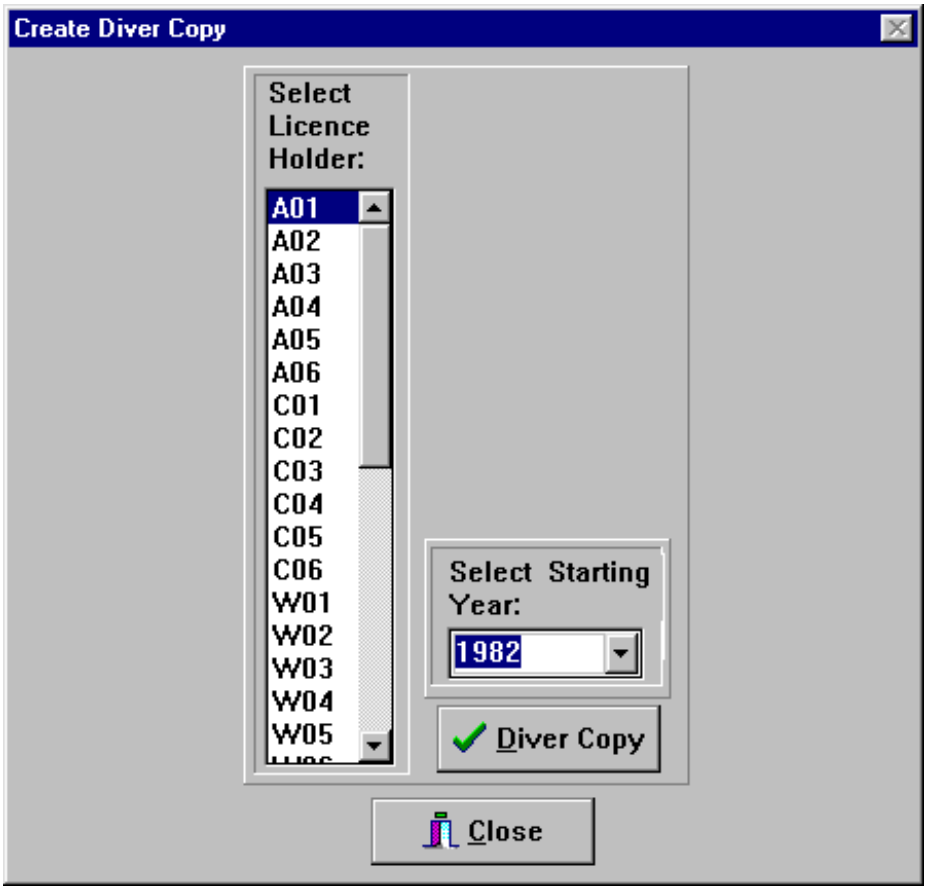


Figure 2.8: Menu to create a Single Diver Copy

When this is finished the ADMRS needs to be closed down before using the Wise Installation System. This is important to remember, otherwise the system will not work.

WISE INSTALLATION SYSTEM

Wise Installation System Version 6.0 (Enterprise Edition) which runs on Windows 3.1x, Windows 95 and Windows NT needs to be installed to create diver copies. The start-up screen for the Wise Installation System is shown in Figure 2.9.

Clicking on “File” then “Open” allows the user to look in the ADMRS directory.

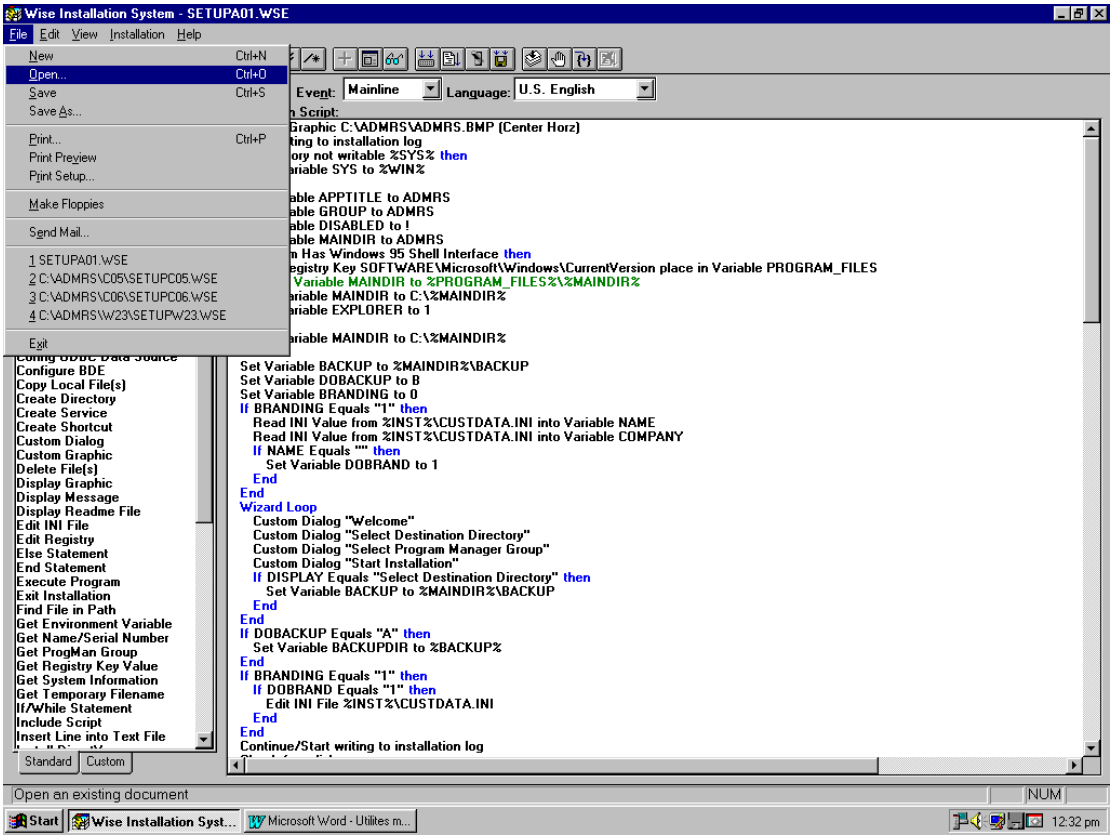


Figure 2.9: Start up menu for Wise Installation System

Once in the ADMRS directory, the folder for which ever licence holder (eg. A01, A02 etc) can be located for each required Diver Copy (Figure 2.10).

Within each folder a setup script will be shown. The setup script will look like the following setupA01.WSE, with A01 being the licence holder and will vary. Double click on the setupA01.WSE or click on the “OK” button.

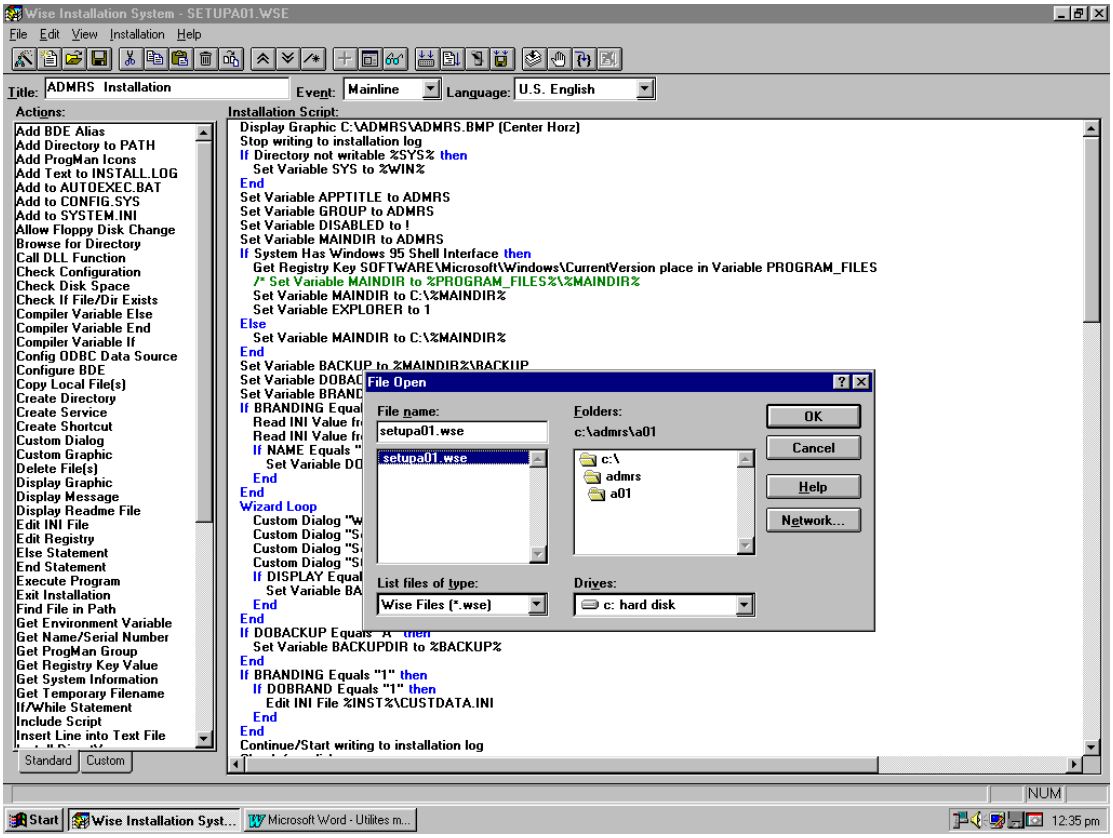


Figure 2.10: Opening License Holder Directory in Wise

Then using the toolbar find the “Compile” button and click on this. This button looks like a small bar with two arrows above it.

By using the Wise Installation System this creates setupA01.exe which is located in ADMRS\A01. SetupA01.exe is a single exe file which contains all the relevant information to load a copy of ADMRS (Figure 2.11).

It can then be copied to a CD for distribution to the diver.

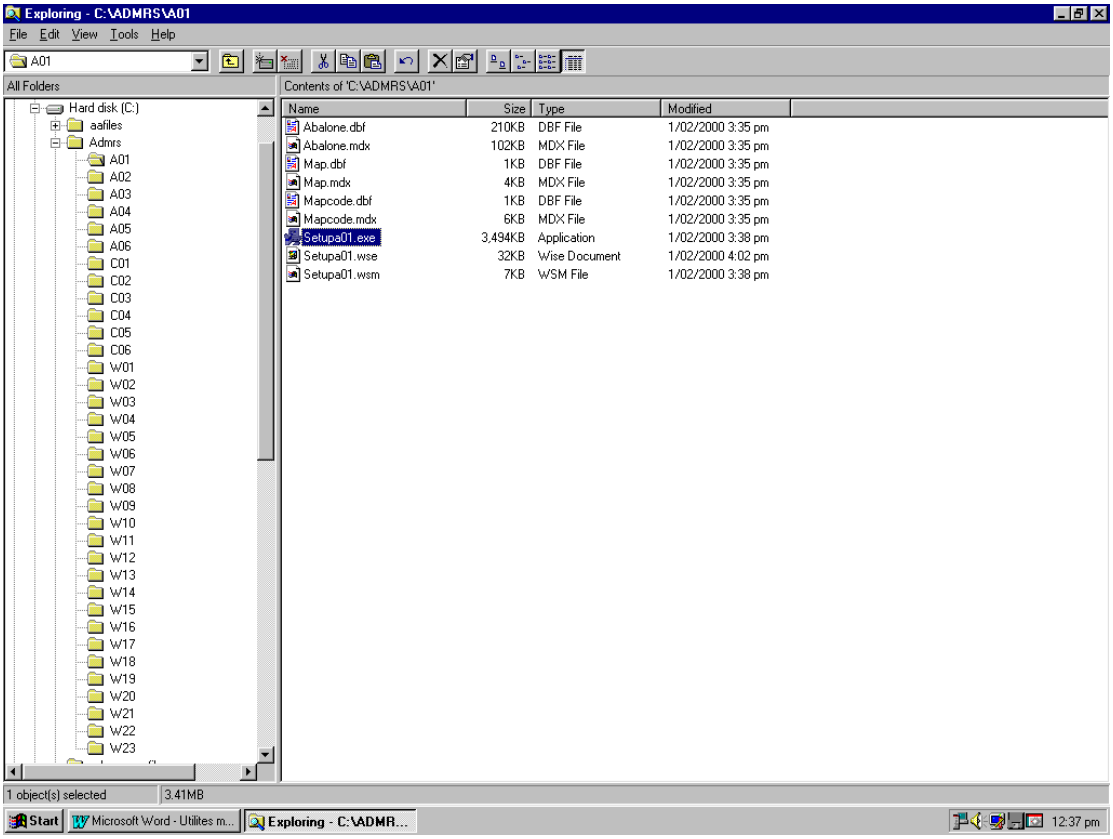


Figure 2.11: Contents of Directory following successful creation of Single Diver Copy

2.2 INTERROGATING ADMRS

2.2.1 Analysis at Subzone and Block Level (1968 onwards)

2.2.1.1 Data Analysis Menu (1968 - 1996)

The Data Analysis 1968-1996 module provides the principal capability of the ADMRS to anaylse data from the very early part of the South Australian abalone fishery. The spatial aggregation of data is more coarse than can be examined using the Data Analysis 1978 – Current module, but provides a longer running data set. The opening menu is shown in figure 2.12 and the catch and effort data can be analysed by year or by month within year.

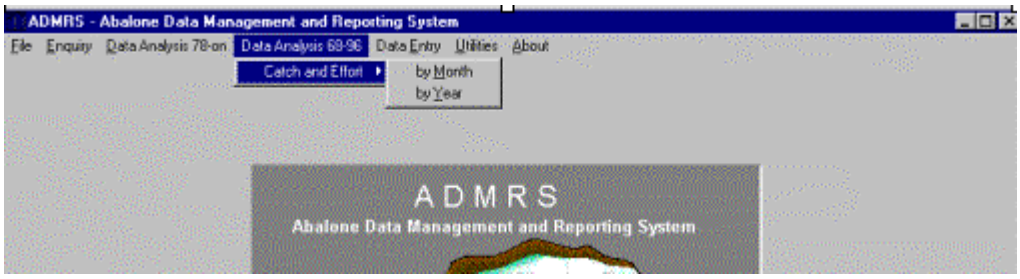


Figure 2.12: Data analysis menu for analysing data series back to 1968

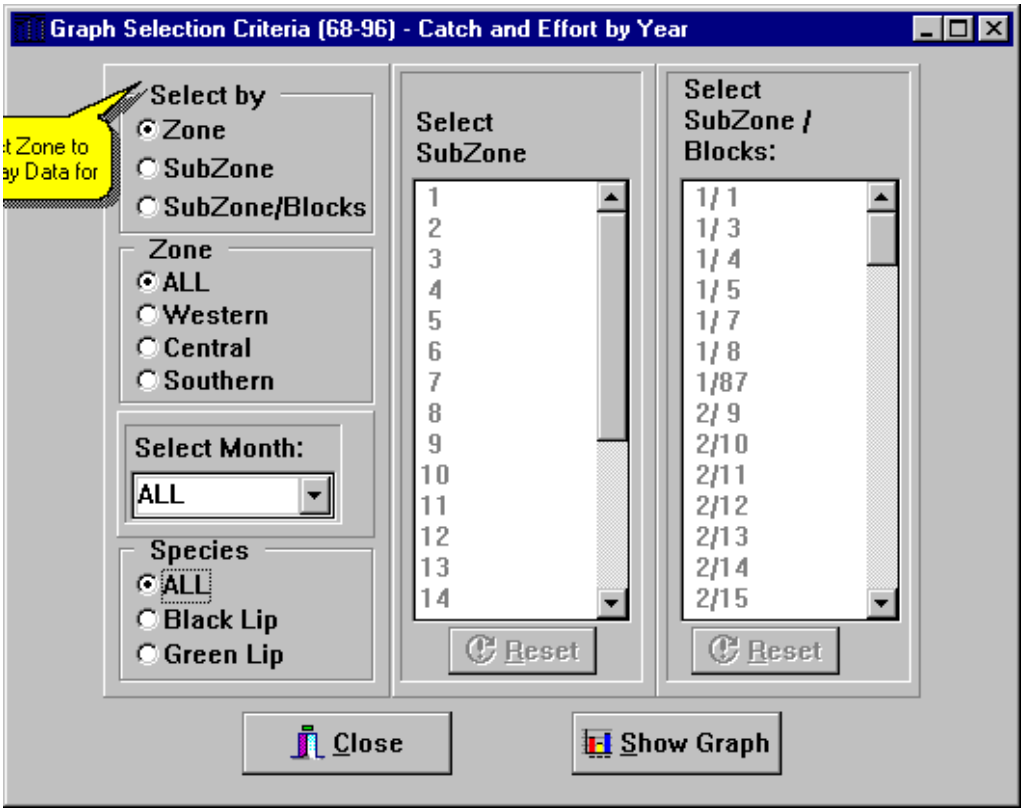


Figure 2.13: Data analysis screen for analysing data series back to 1968

This module enables the user to graph the catch and catch rate details for any single zone, subzone or block or aggregates of blocks, subzones or zones. The data may be viewed by year (to see how an area has performed in each year) or by month (to see how the catch is distributed throughout any given year). To use this module the user first selects whether data analysis is sought by year or by month (figure 2.13).

2.2.1.2 Catch and Effort by Year

Selecting to analyse data by year, the screen shown in figure 2.13. presents a number of options as to how to compose the analysis that is required.

The first choice is to determine the spatial scale over which the analysis is required.

The options are:

-analysis of an entire zone (click on “Zone” in the top left hand box)

-analysis of a single subzone area within a zone (click on “SubZone”)

-analysis of a single block within a Sub Zone map (click on SubZone/Blocks”)

2.2.1.3 Selecting by Zone

If you choose “Zone” you will then need to select which of the three zones you wish to analyse from the second box down on the left hand side. Choosing “All” will analyse the catch and catch rate from the entire fishery across all zones.

2.2.1.4 Selecting by SubZone

Choosing to select by SubZone will highlight the middle column as shown in Figure 2.14. If you know which SubZone or SubZones you wish to analyse you can highlight them by clicking with the mouse (eg figure 2.14. has selected SubZone 1). It is possible to select one SubZone or any combination of SubZones. If you select more than one SubZone you will get a combined analysis for all maps selected not a separate analysis for each map selected.

If you do not know which map corresponds to which piece of coast, then you will need to check the maps shown in Section 3 of this report.

2.2.1.5 Choosing the species to display (lower left-hand box)

The ADMRS can select to display data for either of the two fishery species (click on “greenlip” or “blacklip”) or both species combined (click on “ALL”). For the example (Figures 2.14, 2.15) we have chosen “ALL”.

2.2.1.6 Choosing the months to display (second to bottom left hand box)

The ADMRS can display the data for all months combined by year (i.e. annual data) or it can select a single month. The default is “ALL” (Figure 2.14). Leaving this option will display the combined data for all months in each year (i.e. annual data). To choose another time frame, click on the down arrow and select a month. It is not possible to select multiple months (i.e. you cannot select January to March). For the example in Figure 2.15 we have selected “ALL”.

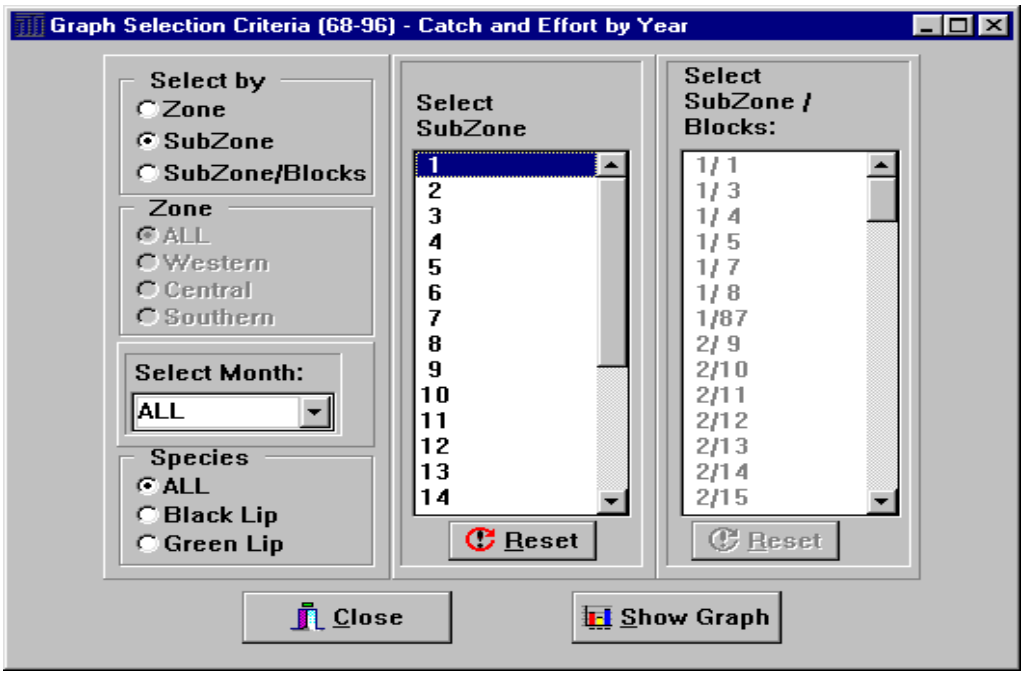


Figure 2.14: Data analysis screen for analysing data series back to 1968 with selection for analysis of catch for all species by year for Subzone 1.

2.2.1.7 Seeing the graph

Having made the above selections, you are now ready to look at the graph for both greenlip and blacklip abalone combined caught in SubZone 1 (Far West Coast) from all months in each year from 1968 to 1996. Click on “Show Graph”.

The graph will appear in a few seconds (it will take longer if you had chosen multiple SubZones). The graph (Figure 2.15.) shows the pattern of abalone catches (coloured bars read against the left-hand axis) for each year. These are easy to interpret. For example the bar for 1970 shows a catch of about 15 tonnes. If you want to know exactly, you can put the cursor over the bar and “right” click your mouse and a box will appear telling you it is exactly 15.510 tonnes. Note that there may be gaps in the data, for example between 1976 and 1979 indicating the area was not fished in 1977 and 1978.

Interpreting the catch rate data (line on graph read against right hand axis) is also straightforward. Figure 2.15 shows the catch rate as fluctuating between 50 and 100 kg per hour except between 1979 and 1996. This is actually the catch rate for both species combined. This is because when the divers record their effort (hours dived) they do not differentiate between hours spent looking for blacklip and hours spent looking for greenlip. This is for practical reasons as often both species are caught together. You will see the same catch rate data line whether you choose greenlip, blacklip or “ALL”.

There are of course some catches for some areas, which consist only of one species in which case the catch rate will represent the catch rate for that species alone.

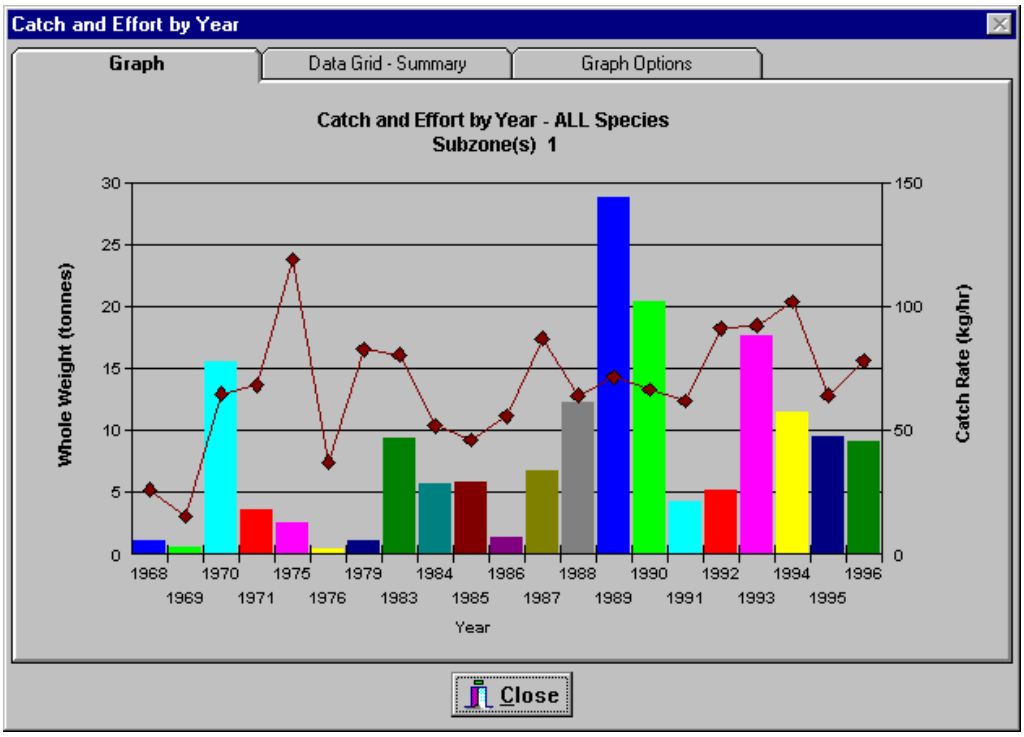


Figure 2.15: Catch and catch rate graph for all species by year for Subzone 1

2.2.1.8 Selecting by SubZone/Blocks

If you wish to select the spatial area to be analysed by a smaller area than that taken up by a whole SubZone, then select "SubZone/Block" from the top left hand box. This will dim the Zone options and highlight the right hand column (Figure 2.16).

Similarly for that described above for SubZones, if you know the Block to be analysed, simply click on that SubZone/Block. If you are unsure you will need to check the maps shown in Section 3 of this report.

For the example shown in figures 2.16 and 2.17 we have chosen to look at all species fished in Block 8 from the Far West Coast (SubZone 1) for each year (all months in each year). The catch and catch rate data can be read the same way as for the previous example.

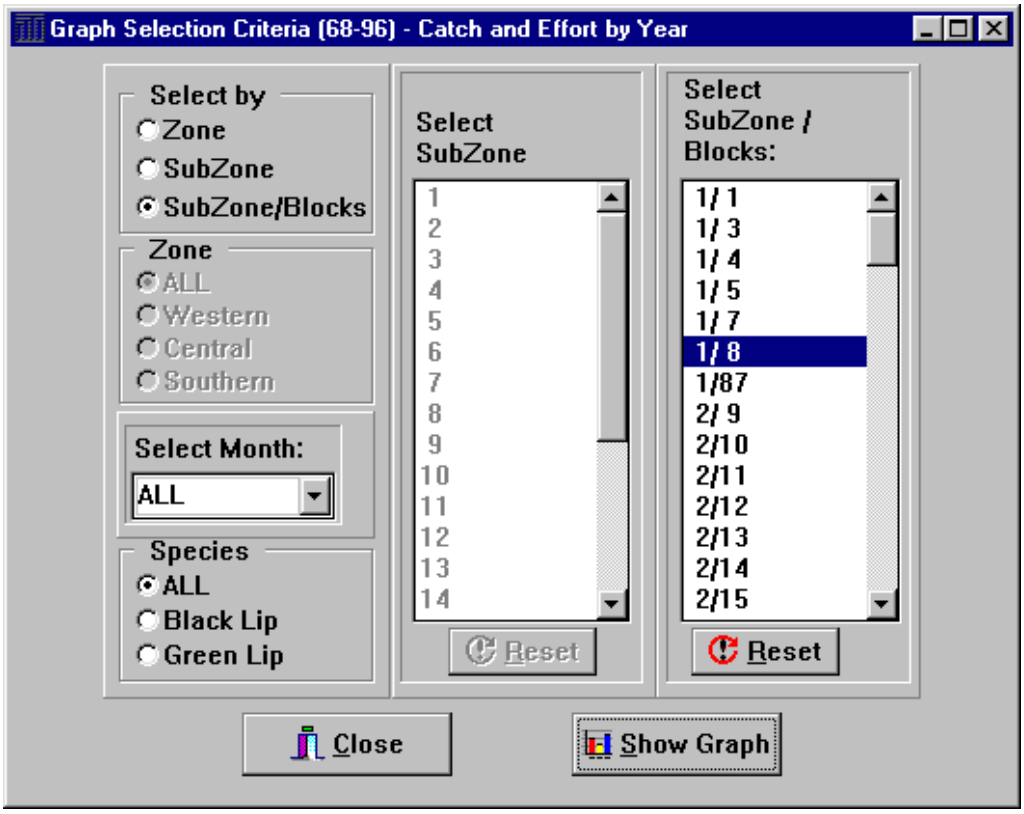


Figure 2.16: Data analysis screen for analysing data series back to 1968 with selection for analysis of catch for all species by year for Block 8 within Subzone1

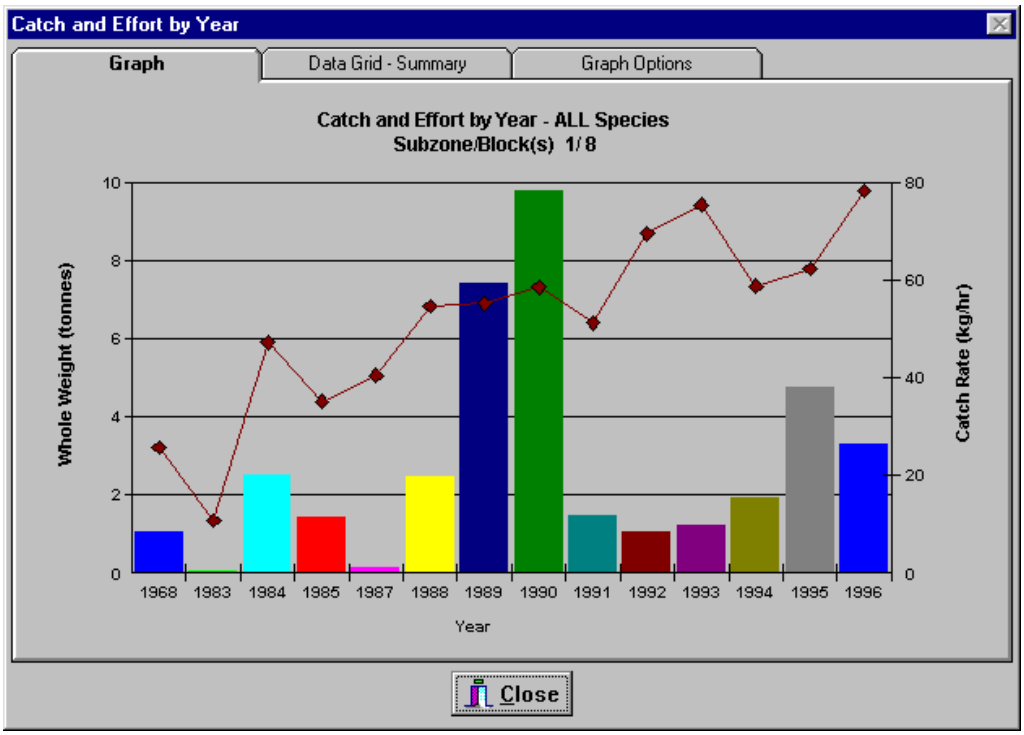


Figure 2.17: Catch and catch rate graph for all species by year for Block 8 within Subzone 1

2.2.1.9 Graph Options Menu

The graph options menu (Figure 2.18.) allows the user to alter attributes of the graph as it appears on screen or to print the graph, save it to disk or copy it to the Windows clipboard enabling it to be put directly into a document or spreadsheet.

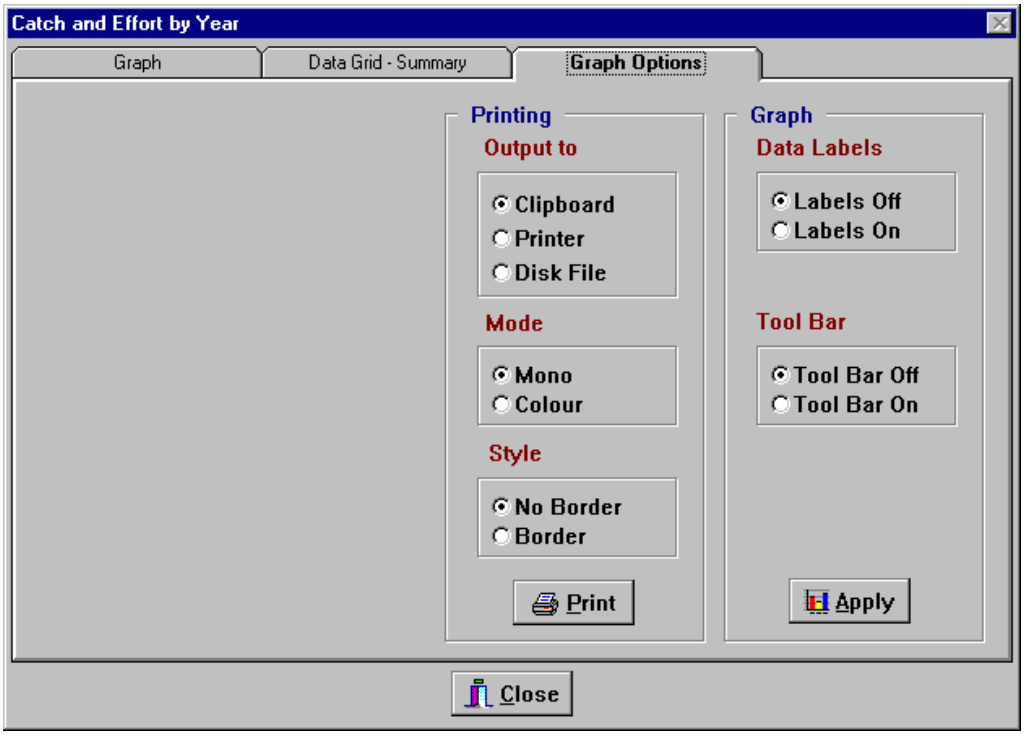


Figure 2.18: Graph options menu

2.2.1.10 Data Grid - Summary

Clicking on the "Data Grid – Summary" tab will display the Summary data used to compose the graph (Figure 2.17.). Note the column headings have the following meanings for 1968:

TOTCATCH - combined total kg of blacklip and greenlip for all days fished in the selected area is 1059 kg

HOURS – total effort in fishing for both species for all days fished in the selected area is 41 hours

SPECCATCH – total kg of the species selected caught for all days fished in the selected area is 1059 kg (note this is the same as for TOTCATCH, because we selected both species. If we had selected just blacklip, the amount shown in this column would be the catch of blacklip only).

To understand the usage of these data in the graphs, consider the catch rate in Figure 2.17 for 1987 is 40.5 kg per hour, which is derived from 162/4. The data in the table can be printed or saved as a Microsoft Excel spreadsheet. Clicking on the "All" button displays the raw data, i.e. each data records for all days fishing in Block 8 in SubZone 1 for all years.

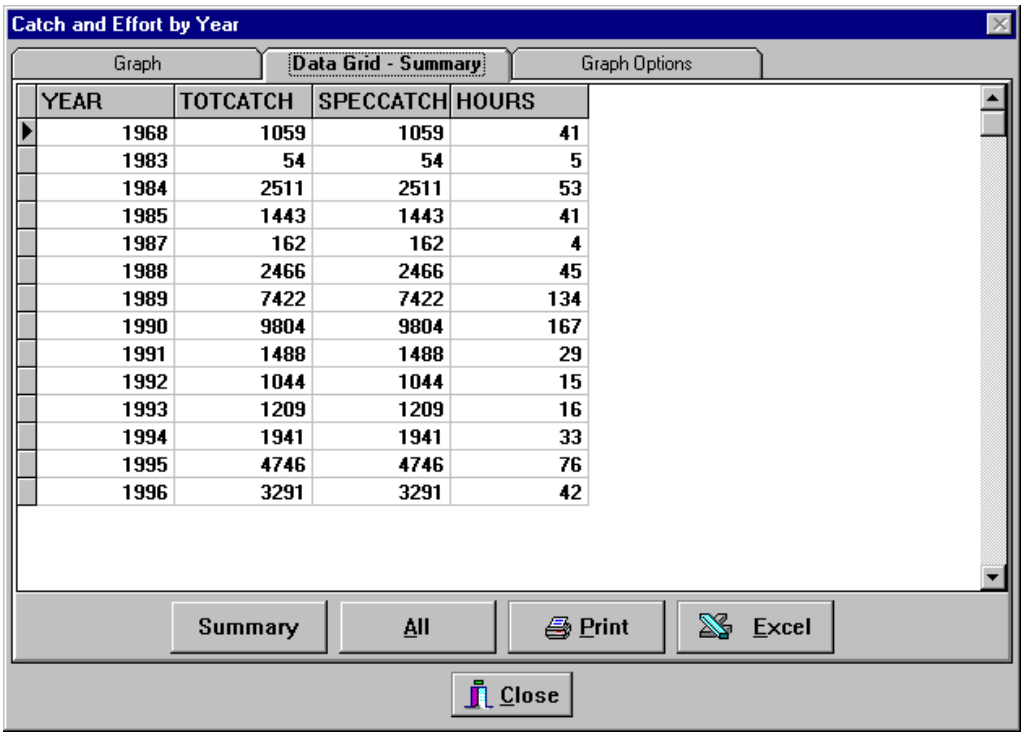


Figure 2.19: Data grid summaries for graph shown in Figure 2.2.6

2.2.1.11. Catch and Effort by Month

If analysis of the distribution of catches between months within any given year is desired, then "by month" is selected from the main "Catch and Effort" menu (Figure 2.12) and then the same procedures are followed as described above, with the exception that you must choose the actual year you wish to analyse in detail. More detail on this function of the ADMRS can be found later in this section associated with discussion of figures 2.38 and 2.39.

2.2.2 Analysis at Map and Mapcode Level (1978 onwards).

The main capability provided by the ADMRS is the data interrogation capacity of the DataAnalysis 78 on module. The module is accessed from the start up screen and presents two output options: screen or as a Microsoft Word compatible file (see figure 2.20.).

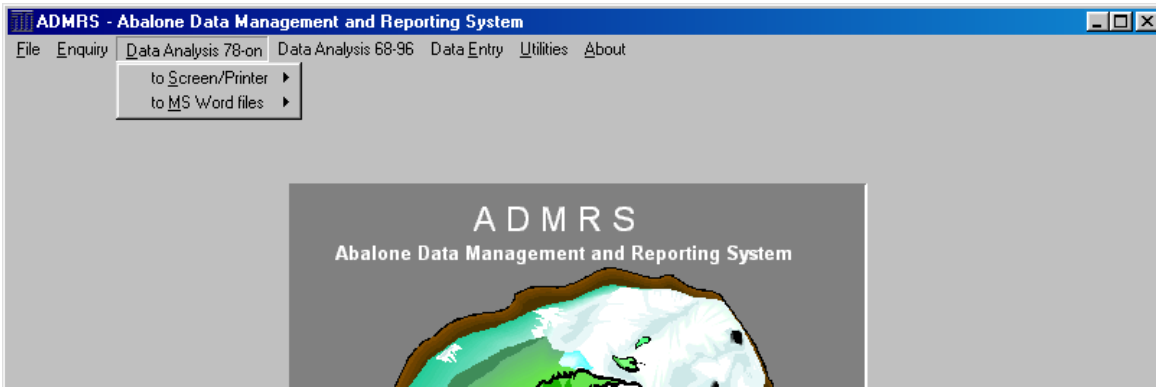


Figure 2.20: Menu used to open Data Analysis module for 1978 onwards

Figure 2.21: Shows the data analysis options, each of which is explained below.

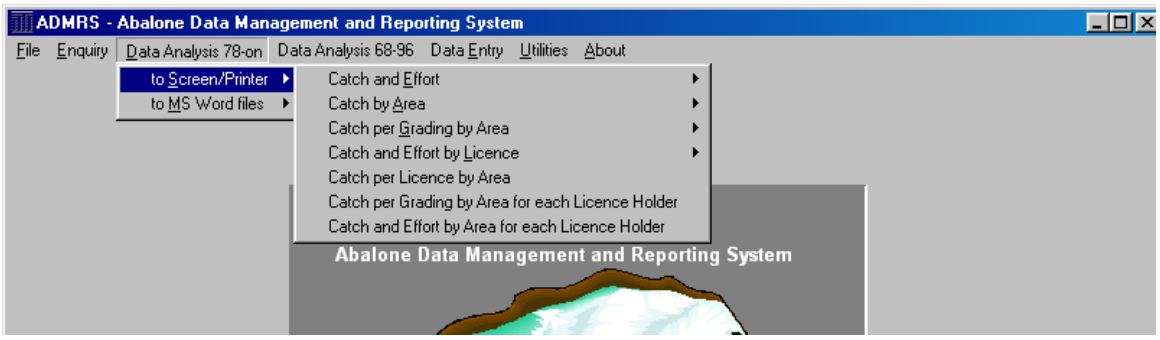


Figure 2.21. Menu options for Data Analysis 1978 onwards

Catch and Effort. This option enables the user to graph the catch and catch rate details for any single zone, map or mapcode area or aggregates of mapcode, map or zone. The data may be viewed by year (to see how an area has performed in each year) or by month (to see how the catch is distributed throughout any given year).

To use this module the user first selects whether data analysis is sought by year or by month (figure 2.22.).

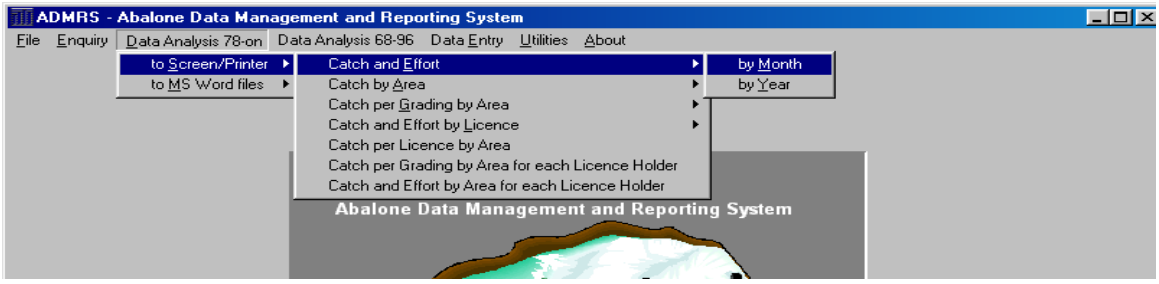


Figure 2.22: Extended menu options for Data Analysis 1978 onwards for Catch and Effort by Month of Year

2.2.2.1 Catch and Effort by Year

Selecting to analyse data by year, the screen shown in figure 2.23., presents a number of options as to how to compose the analysis that is required.

The first choice is to determine the spatial scale over which the analysis is required.

The options are:

- analysis of an entire zone (click on “Zone” in the top left hand box)
- analysis of a single map area within a zone (click on “Map”)
- analysis of a single reef or mapcode area within a map (click on “Map/Codes”)

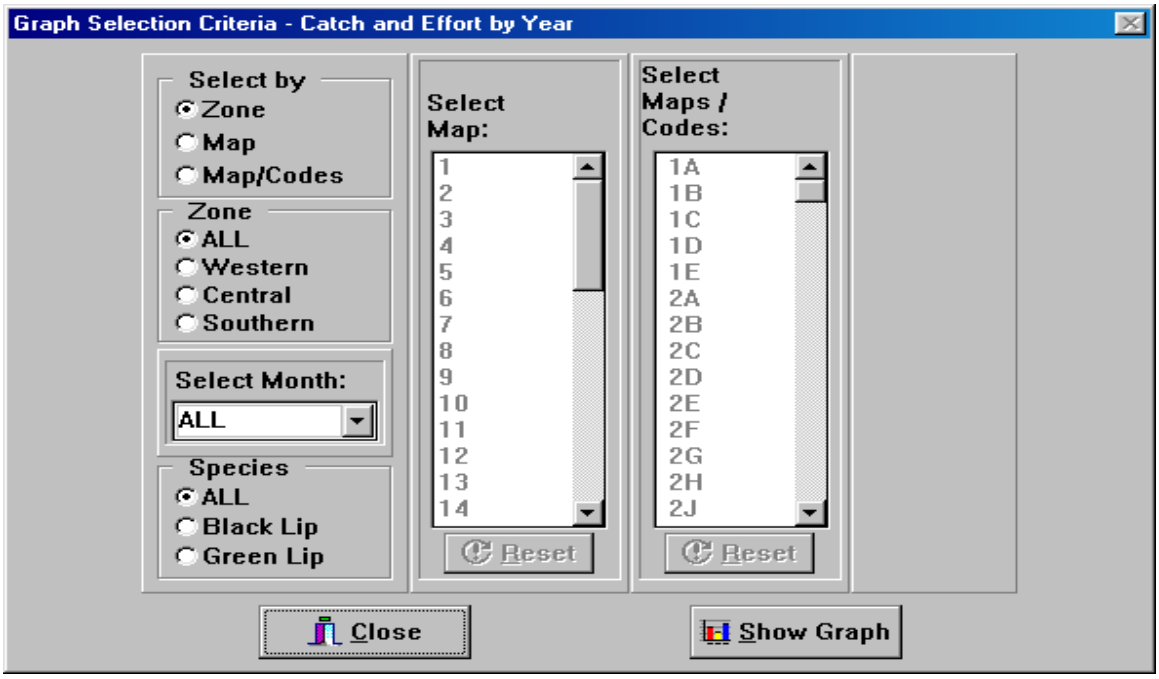


Figure 2.23: Options menu for Catch and Effort by Year Analysis

2.2.2.2 Selecting by Zone

If you choose “Zone” you will then need to select which of the three zones you wish to analyse from the second box down on the left hand side. Choosing “All” will analyse the catch and catch rate from the entire fishery across all zones.

2.2.2.3 Selecting by Map

Selecting “Map” will dim the Zone options and highlight the central panel (see figure 2.24.). A little map of South Australia will appear at the top of this panel.

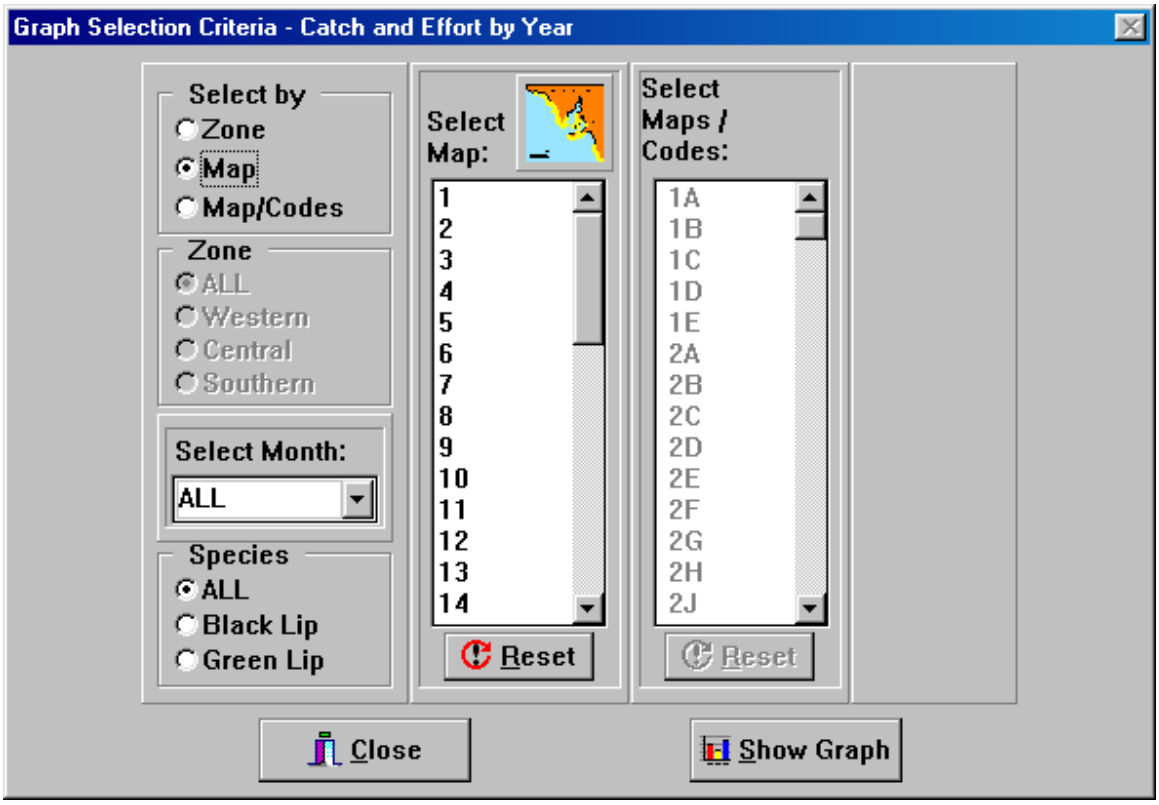


Figure 2.24: Options menu for Catch and Effort by Year analysis - selecting by Map

If you know which map or maps you wish to analyse you can highlight them by clicking with mouse (eg figure 2.25. has selected maps 3 and 6. It is possible to select one map or any combination of maps. If you select more than one map you will get a combined analysis for all maps selected not a separate analysis for each map selected.

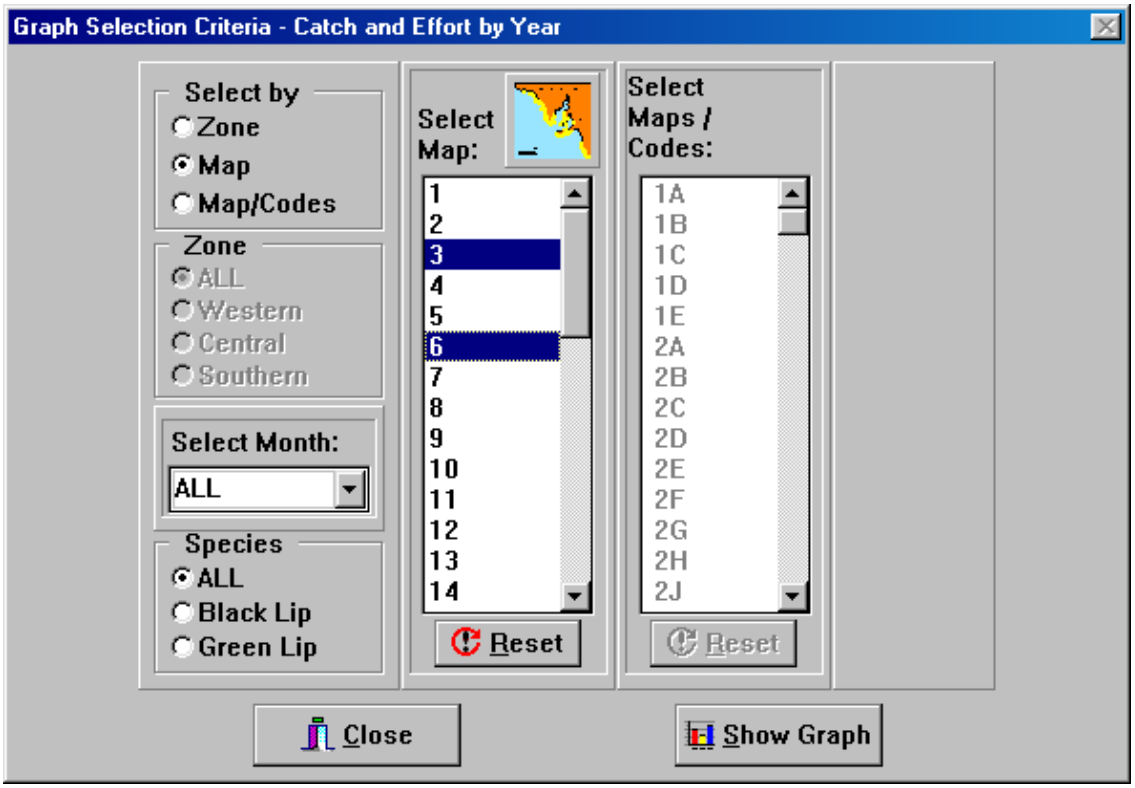


Figure 2.25: Options menu for Catch and Effort by Year analysis - selecting by Map

If you do not know which map corresponds to which piece of coast, then rather than selecting a map number to analyse click on the small map of South Australia. This brings up a large map of South Australia showing the location of each map (figure 2.26.).

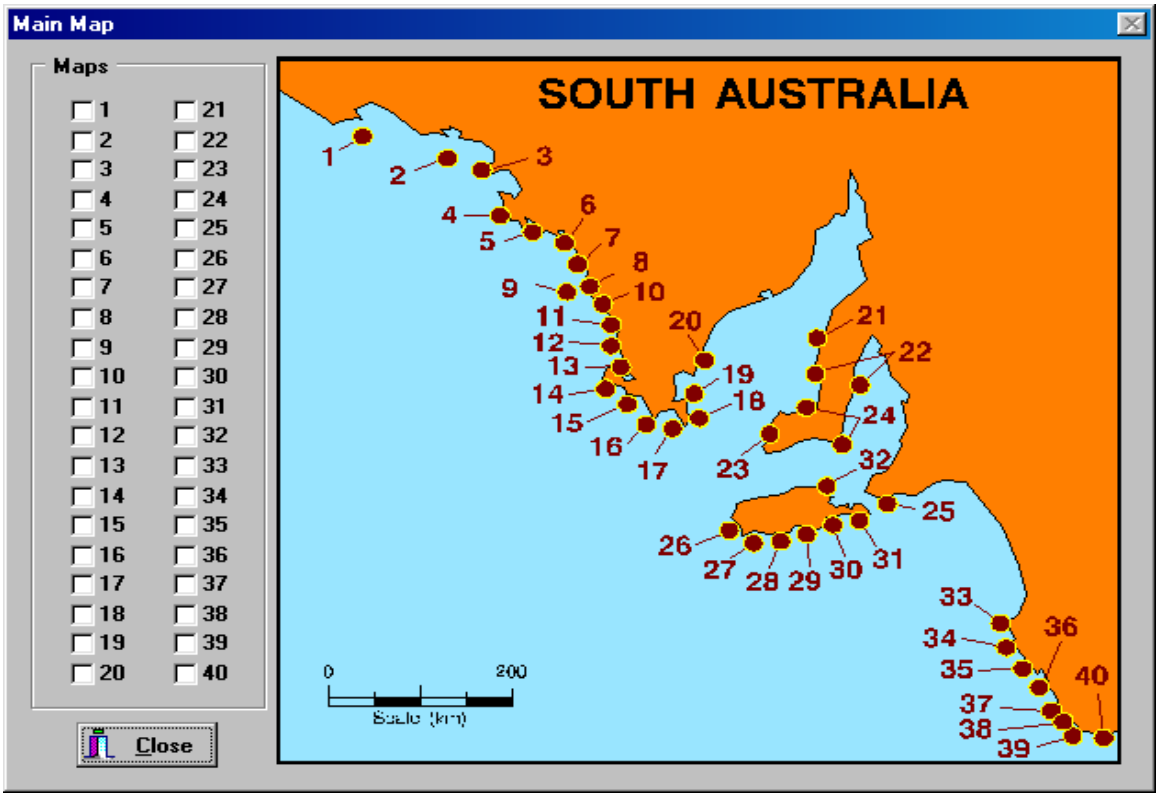


Figure 2.26: Map Selection Index

The required map or combination of maps can then be selected by either clicking on the number on the map or on the corresponding box for each map on the left-hand side. Close the map screen once you have finished your selection(s) and it will return to the previous screen showing you choices highlighted as in figure 2.25.

2.2.2.4 Selecting by Map/Code

If you wish to select the spatial area to be analysed by a smaller area than that taken up by a whole map, then select "Map/Code" from the top left hand box. This will dim the Zone options and highlight the right hand box (Figure 2.27.).

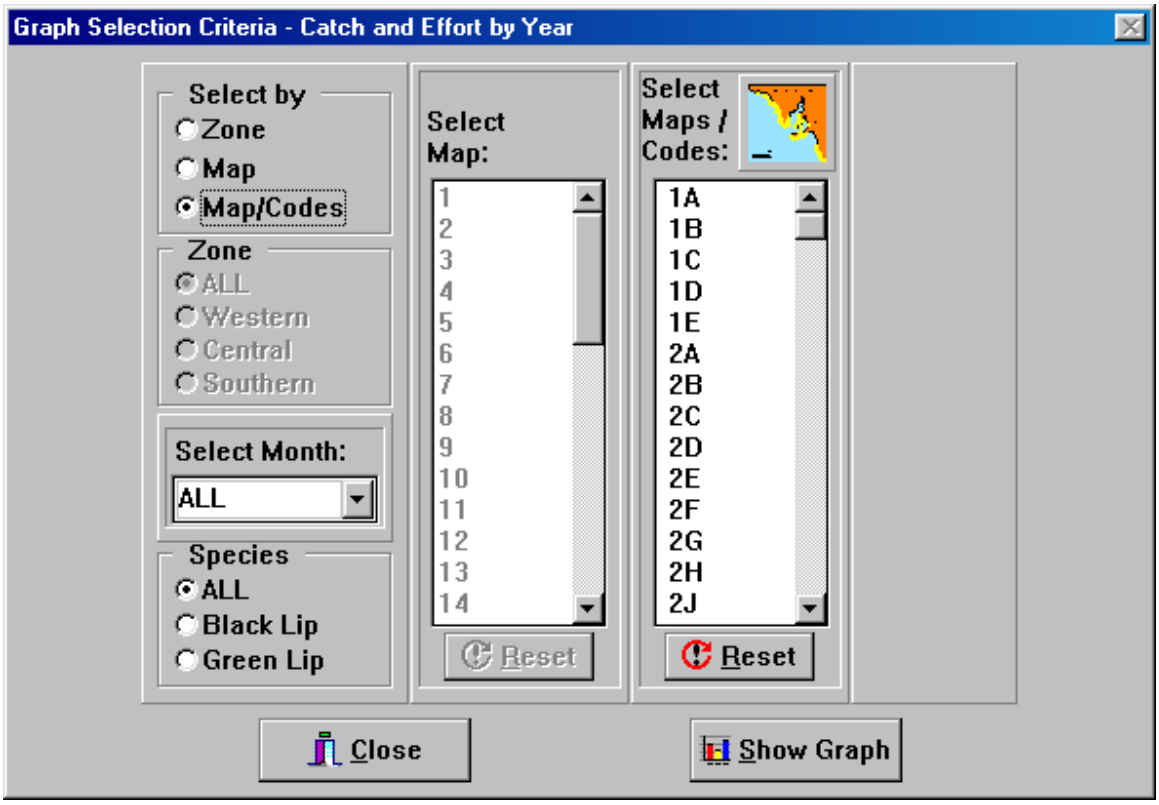


Figure 2.27: Options Menu for Catch and Effort by Year analysis - selecting by Map/Code

Similarly for that described above for maps, if you know the mapcode to be analysed, simply click on that mapcode. If you are unsure click on the small map of South Australia at the top of the box. It will show you an enlarged map of South Australia (Figure 2.28.).

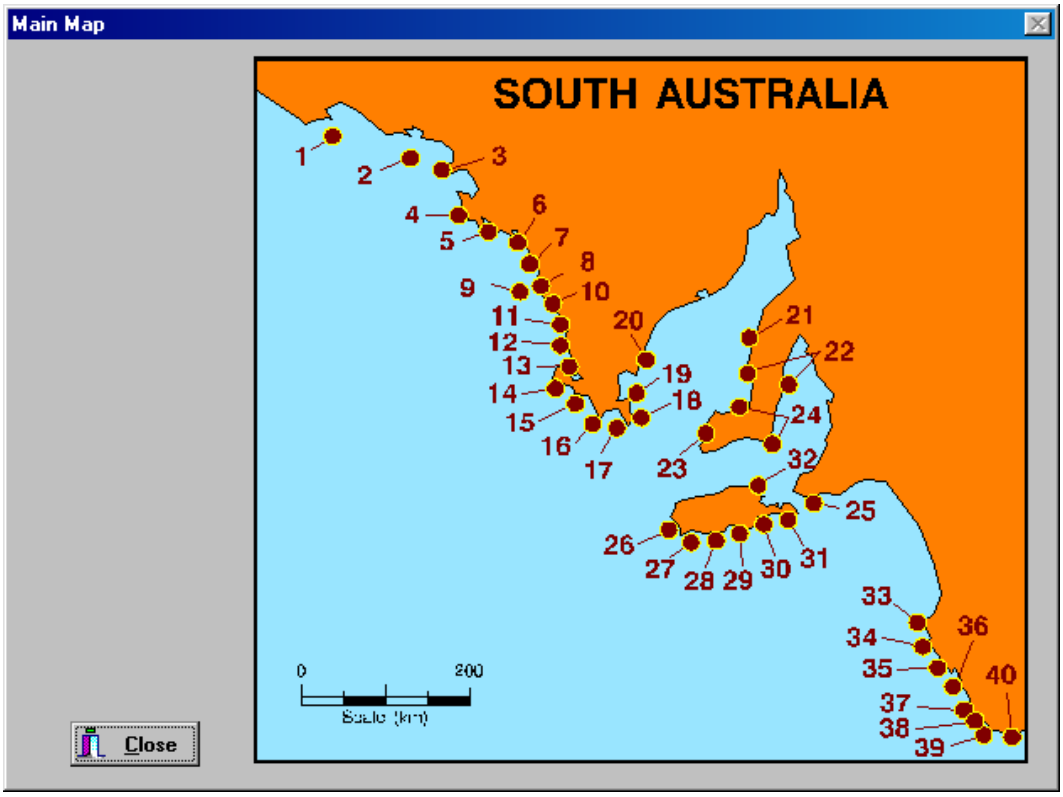


Figure 2.28: Map Selection Index to access more detailed maps

This time there are no boxes to choose from. You must choose the area of the coast (map) that is of interest. For this example we will choose map 18 (Figure 2.29.) providing us with a detailed map of the coast in this area and having broken the map down into smaller areas called mapcodes.

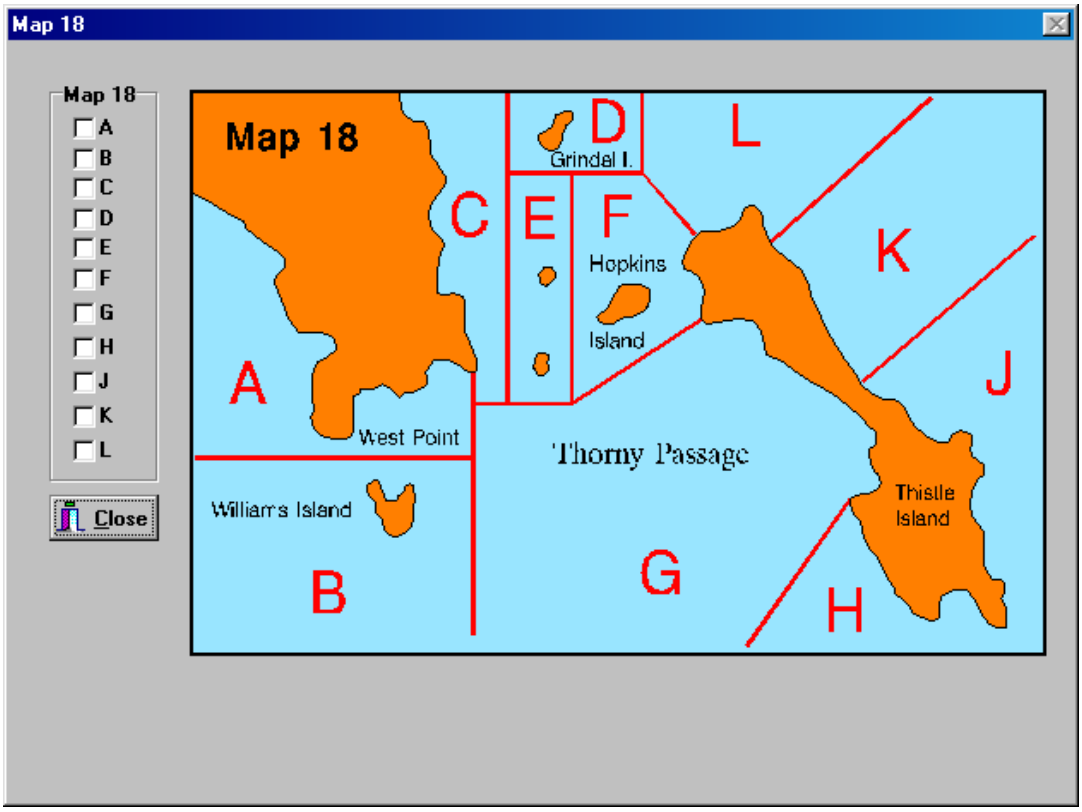


Figure 2.29: Detail of Map 18

From this map it is possible to select one or more areas from the map to be analysed. Again this maybe done by clicking on the map in the areas required or in the box on the left-hand side. Closing the map will return you to the large map of South Australia from which you can choose to close or select another map to examine in more detail. Remember it is possible to select any mapcode from any map area and analyse the areas in combination. This may be useful if you wish to examine the data from contiguous areas covered by two maps.

For the purposes of illustration we have selected just mapcode 18F (Hopkins Island) (Figure 2.30.). The next step is to click on “Close”. This takes you back to the map of South Australia (Figure 2.31.). Again click on “Close”. This returns you to the main Catch and Effort menu where mapcode 18F will be highlighted (figure 2.32.).

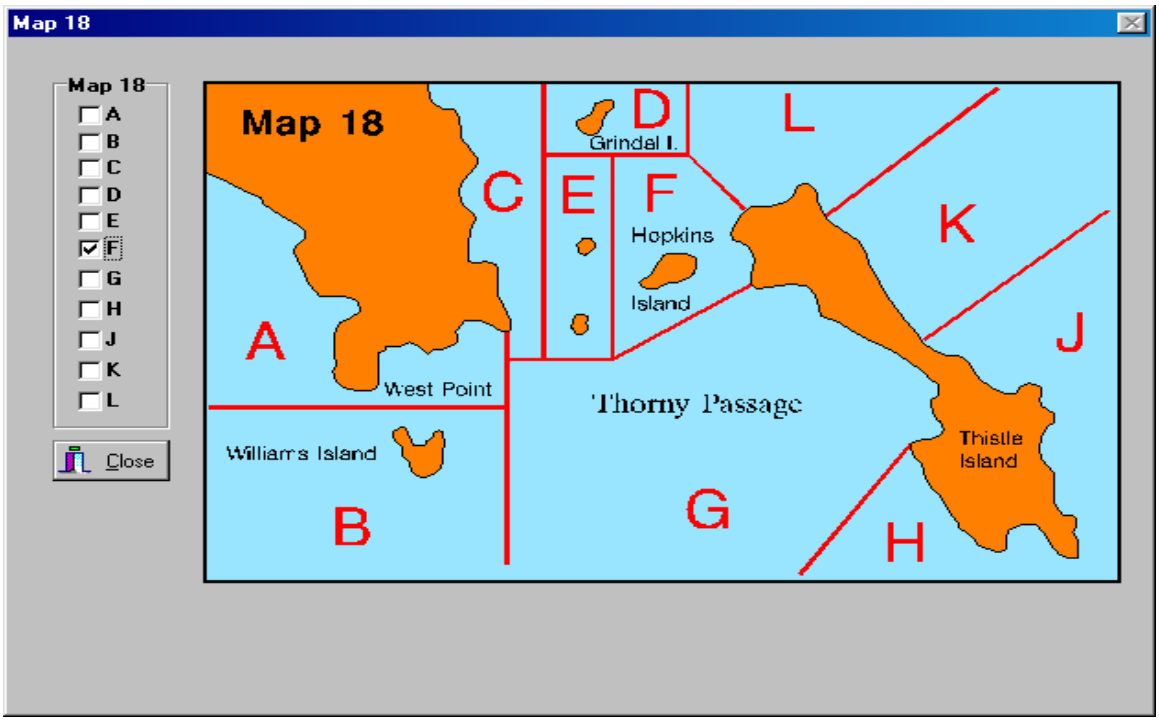


Figure 2.30: Detail of Map 18 showing how to select one Map Code

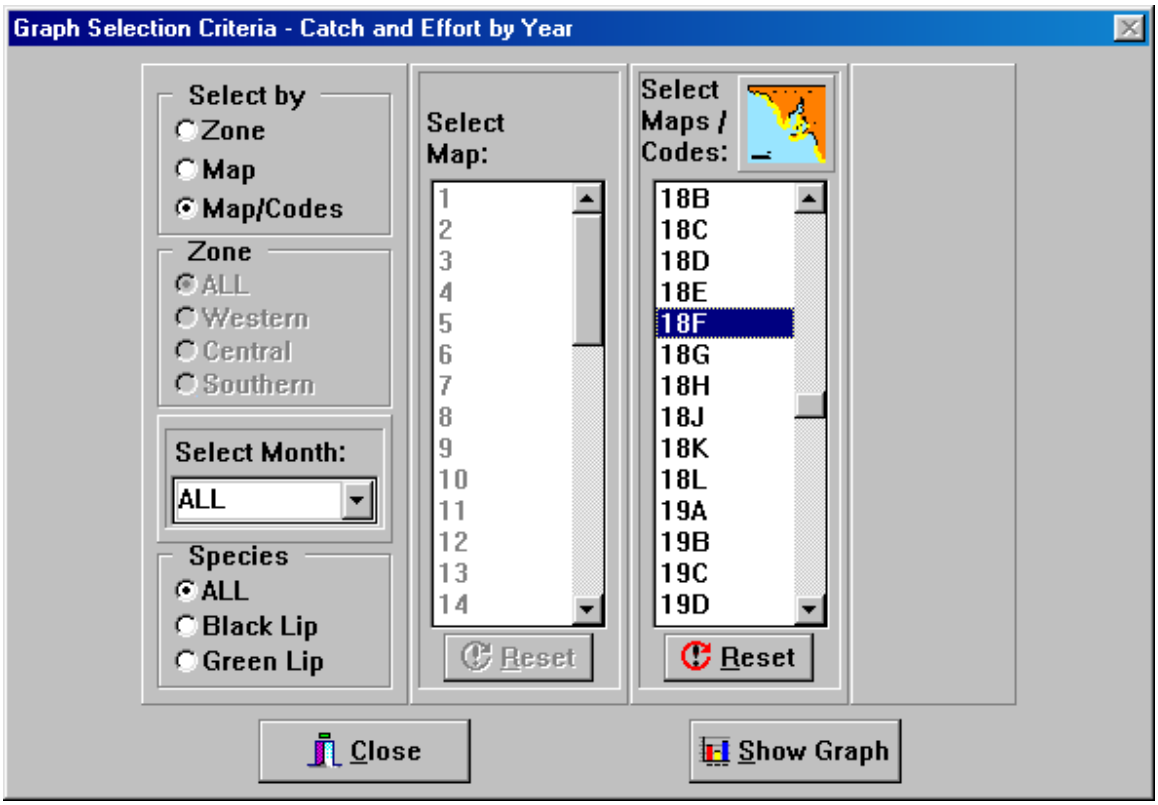


Figure 2.31: Catch and Effort by Year analysis menu with map Code selected

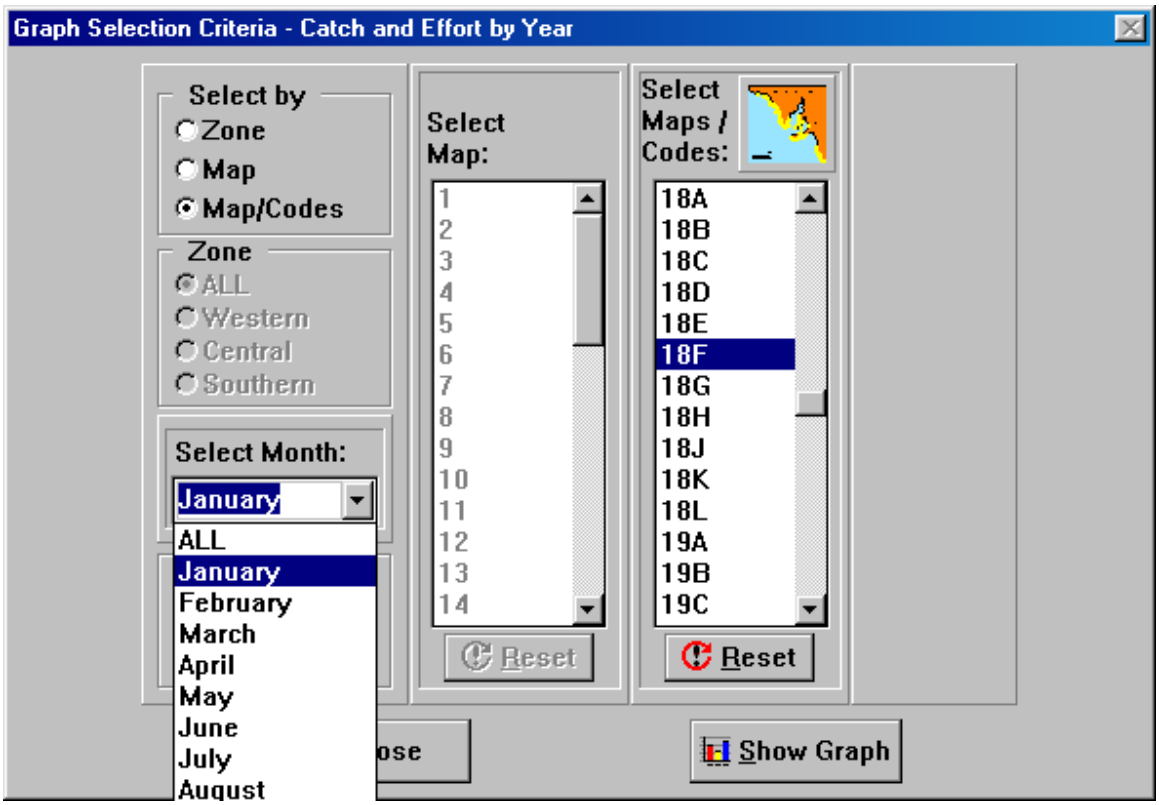


Figure 2.32: Catch and Effort by Year analysis menu showing how to select individual months in each year

2.2.2.5 Choosing the months to display (second to bottom left hand box)

The ADMRS can display the data for all months combined by year (i.e. annual data) or it can select a single month. The default is "ALL" (Figure 2.31.). Leaving this option will display the combined data for all months in each year (i.e. annual data). To choose another time frame, click on the down arrow and select a month. In this case we have chosen "January" (Figure 2.33.). It is not possible to select multiple months (i.e. you cannot select January to March).

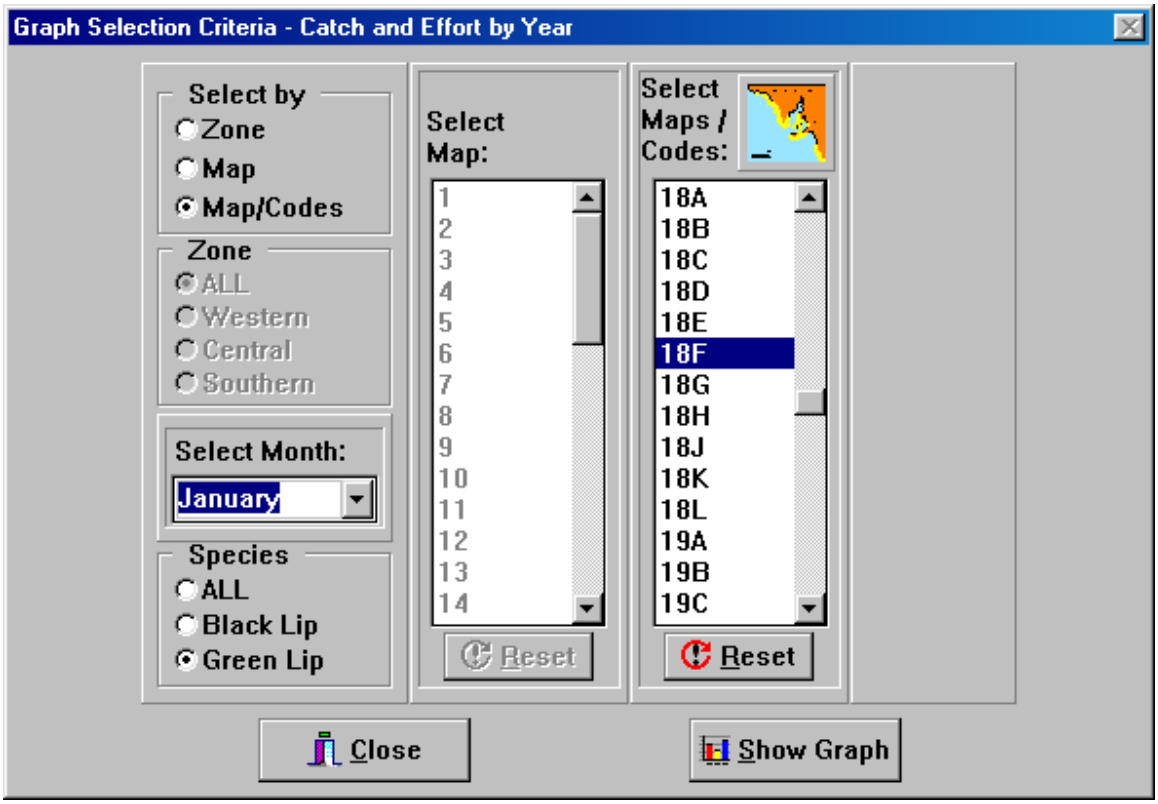


Figure 2.33: Catch and Effort by Year analysis menu - January has been chosen as the month to display

2.2.2.6 Choosing the species to display (lower left-hand box)

The ADMRS can select to display data for either of the two fishery species (click on "greenlip" or "blacklip") or both species combined (click on "ALL"). For the example (Figure 2.33.) we have chosen "greenlip".

2.2.2.7 Seeing the graph

Having made the above selections, you are now ready to look at the graph for greenlip abalone caught at Hopkins Island in January from 1978 onwards. Click on "Show Graph".

The graph will appear in a few seconds (it will take longer if you had chosen multiple species, months and mapcodes). The graph (Figure 2.34.) shows the pattern of greenlip catches (coloured bars read against the left-hand axis) in January for each year. These are easy to interpret. For example the bar for 1991 shows a catch of about 8 tonnes. If you want to know exactly, you can put the cursor over the bar and "right" click your mouse and a box will appear telling you it is exactly 8.643 tonnes (Figure 2.35.).

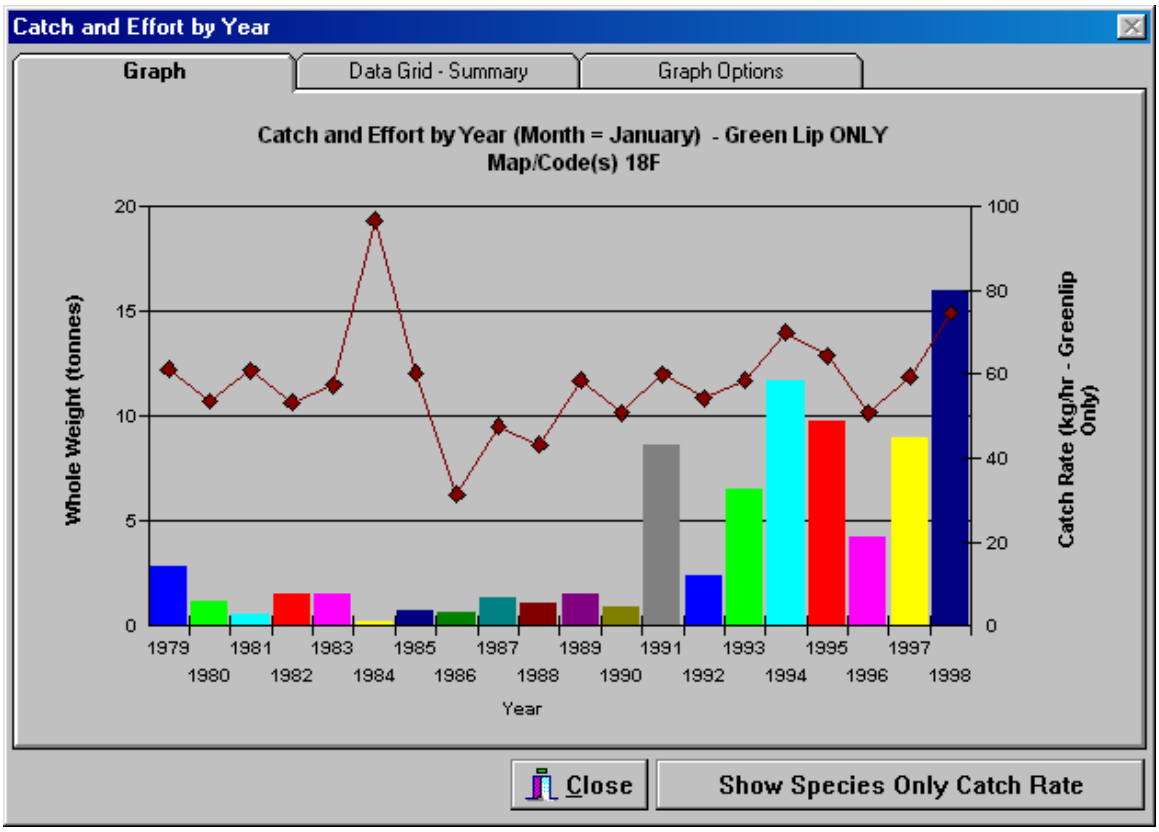


Figure 2.34: Output of Catch and Catch Rate for MapCode 18

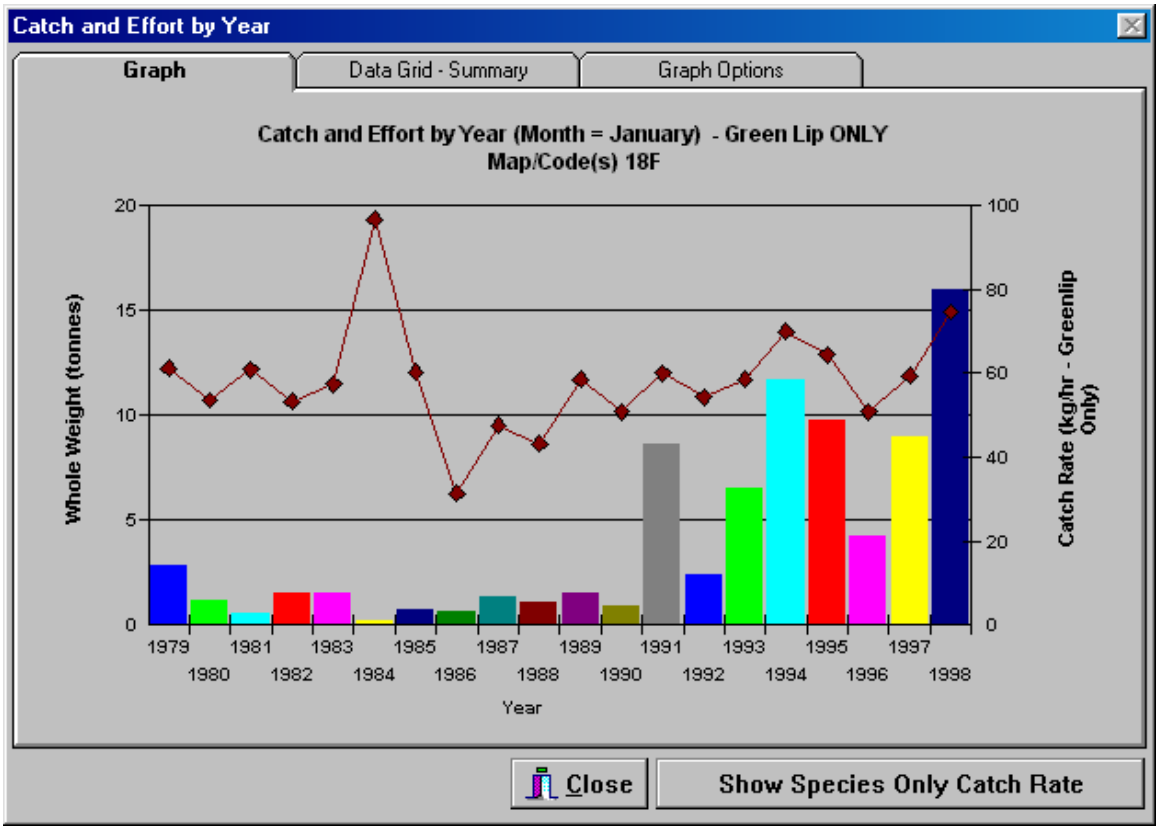


Figure 2.35: Information boxes show exact magnitude of data bars or points

Interpreting the catch rate data (line on graph read against right hand axis) is a little more complicated. Figure 2.34. shows the catch rate as fluctuating between 50 and 80 kg per hour except in 1984 and 1986. This is actually the catch rate for both species combined. This is because when the divers record their effort (hours dived) they do not differentiate between hours spent looking for blacklip and hours spent looking for greenlip. This is for practical reasons as often both species are caught together.

There are of course some catches for some areas which consist only of one species. In such cases it is possible to calculate what is called the "species only catch rate". In the case of the example we are looking at, if you click on the button on the bottom right hand side "Show Species Only Catch Rate" the line on the graph changes to use only data points where only greenlip abalone was caught (Figure 2.36.). The line is more erratic, fluctuating between zero and 70 kg per hour, because in this example there are few data points where only greenlip were caught in one day in the area around Hopkins Island.

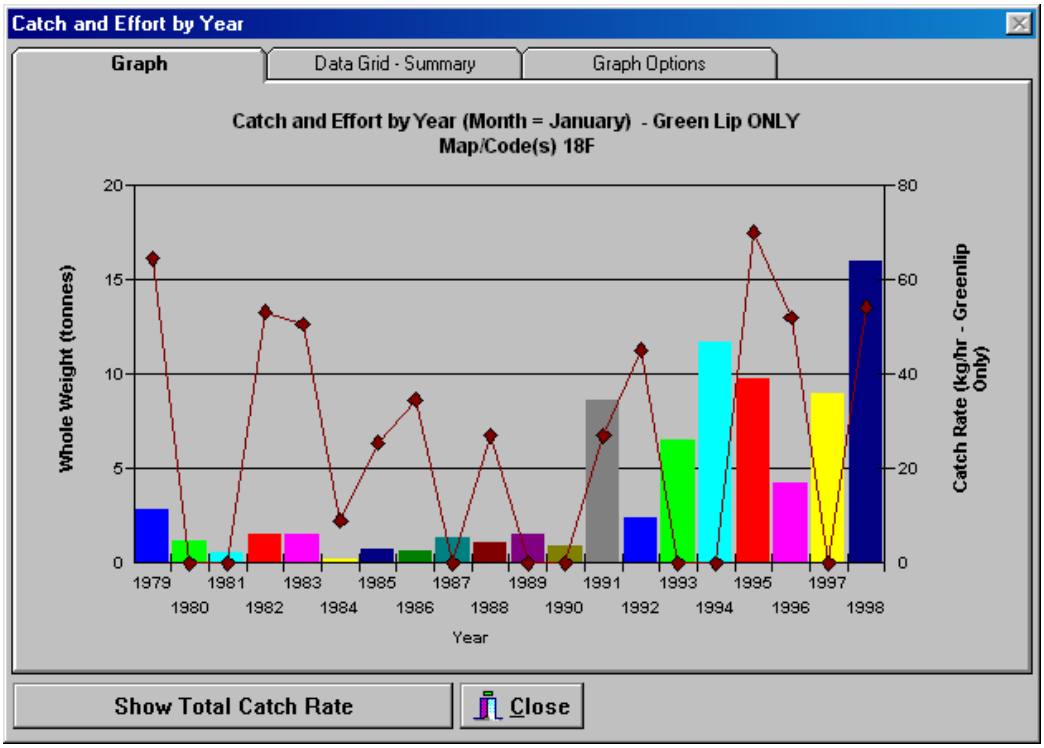
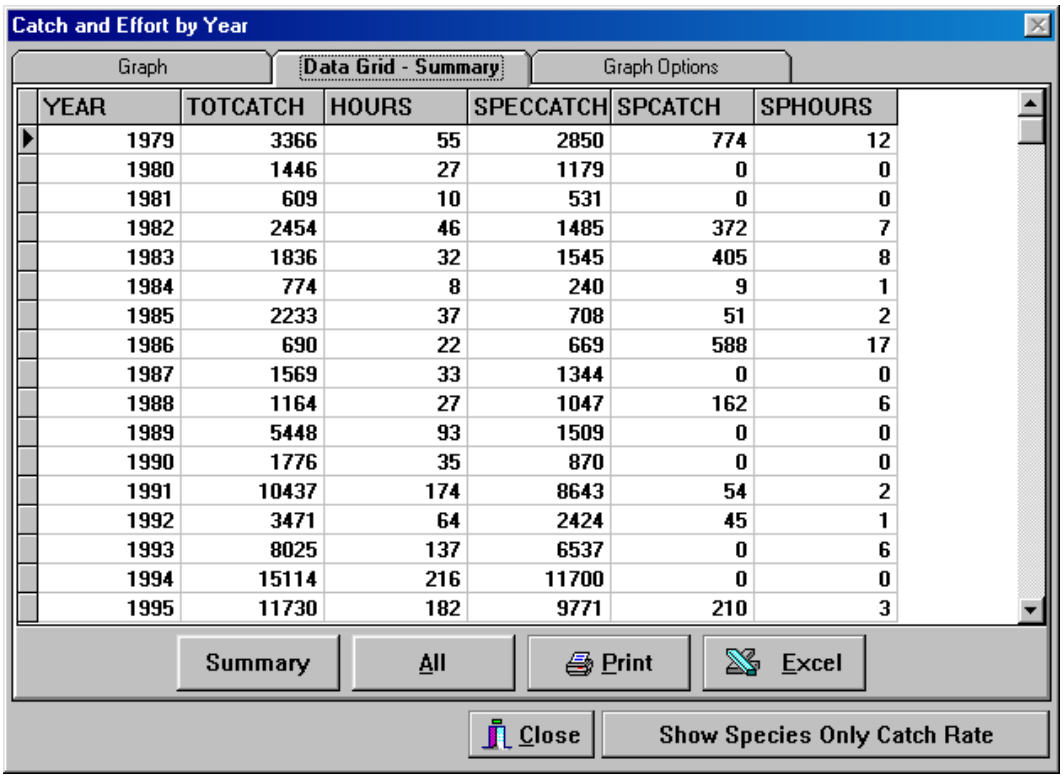


Figure 2.36: Output for species only Catch Rate

2.2.2.8 Data Grid – Summary

Clicking on the "Data Grid – Summary" tab will display the Summary data used to compose the graph (Figure 2.37.). Note the column headings have the following meanings for 1979:



YEAR	TOTCATCH	HOURS	SPECCATCH	SPCATCH	SPHOURS
1979	3366	55	2850	774	12
1980	1446	27	1179	0	0
1981	609	10	531	0	0
1982	2454	46	1485	372	7
1983	1836	32	1545	405	8
1984	774	8	240	9	1
1985	2233	37	708	51	2
1986	690	22	669	588	17
1987	1569	33	1344	0	0
1988	1164	27	1047	162	6
1989	5448	93	1509	0	0
1990	1776	35	870	0	0
1991	10437	174	8643	54	2
1992	3471	64	2424	45	1
1993	8025	137	6537	0	6
1994	15114	216	11700	0	0
1995	11730	182	9771	210	3

Figure 2.37: Data grid for graph output in figures 2.34 and 2.36

TOTCATCH - combined total kg of blacklip and greenlip for all days fished in the selected area is 3366 kg

HOURS – total effort in fishing for both species for all days fished in the selected area is 55 hours

SPECCATCH – total kg of greenlip caught for all days fished in the selected area is 2850 kg (note this is 516 kg less than TOTCATCH, meaning this was the blacklip component of the total catch).

SPCATCH – total kg of greenlip caught in the selected area for days when only greenlip (i.e. no blacklip) were caught is 774 kg

SPHOURS – total effort in fishing for days when only greenlip (i.e. no blacklip) were caught is 12 hours

To understand the usage of these data in the graphs, consider the catch rate in Figure 2.34. (Total Catch Rate) for 1979 is 61.2 kg per hour which is derived from 3366/55 and the catch rate in figure 2.36. (Species Only Catch Rate) is 64.5 derived from 774/12.

The data in the table can be printed or saved as an MS Excel spreadsheet. Clicking on the "All" button displays the raw data, i.e. each data records for all days fishing at Hopkins Island in all years.

2.2.2.9 Graph Options Tabs Menu

These can be used in the same way as described above in Figure 2.18 (Section 2.2.1.9).

2.2.2.10 Catch and Effort by Month

If analysis of the distribution of catches within any given year is desired, then "by month" is selected from the main "Catch and Effort" menu (Figure 2.22.). Using the same selections as above for mapcode, species and selecting 1998 from the drop down menu which displays various years available (Figure 2.38.) gives the graph shown in figure 2.39. This indicates that in 1998 the vast majority of the catch of greenlip from Hopkins Island was taken in January.

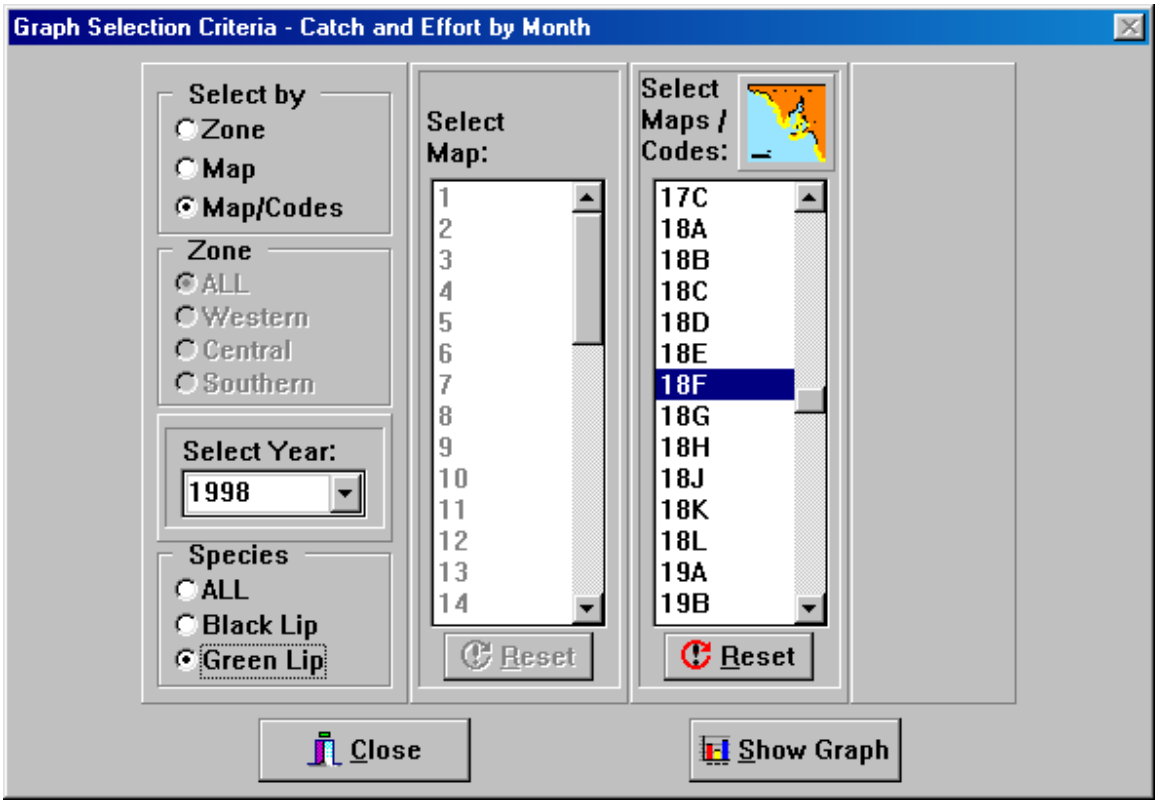


Figure 2.38: Catch and Effort by Month within year analysis menu

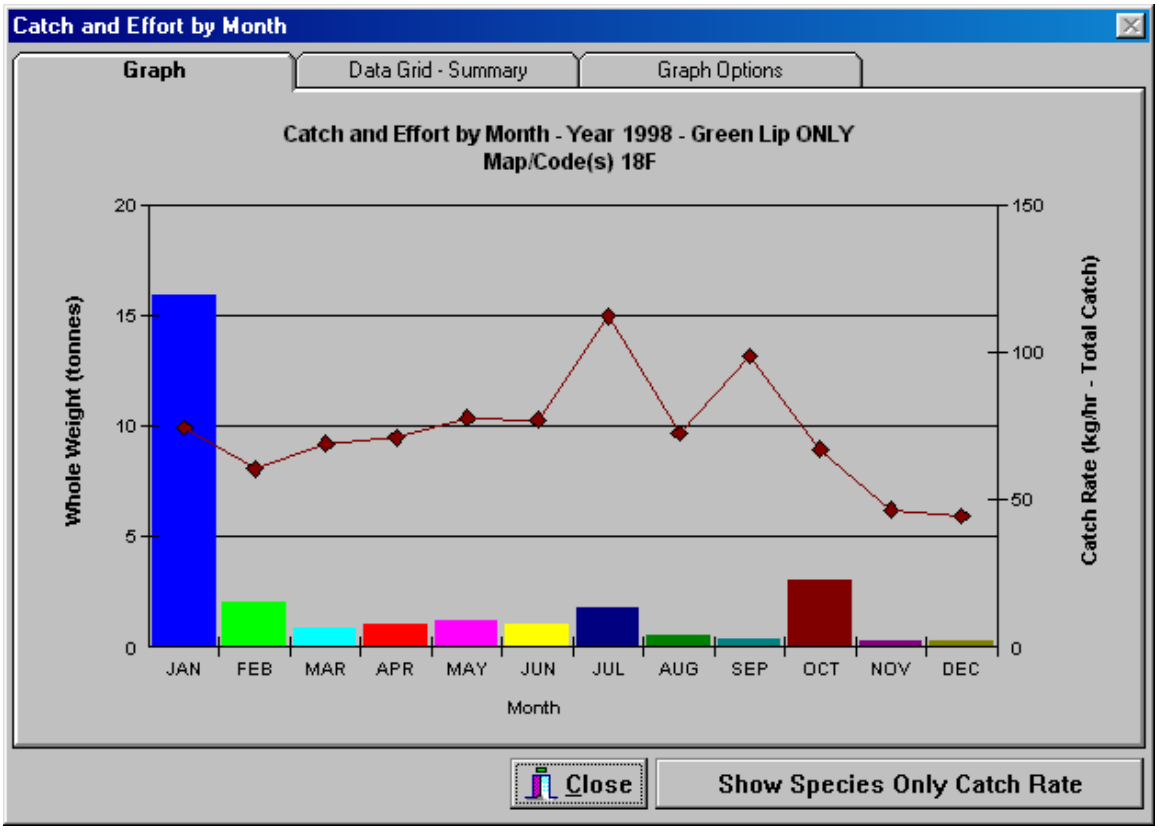


Figure 2.39: Output for Map Code 18F in 1998

Catch by Area. This option is exactly the same as the Catch and Effort option described above except that it does not display any catch rate information. The menu and first screen are shown in figures 2.40. and 2.41. Instructions for use of this option are exactly the same as for the Catch and Effort option.

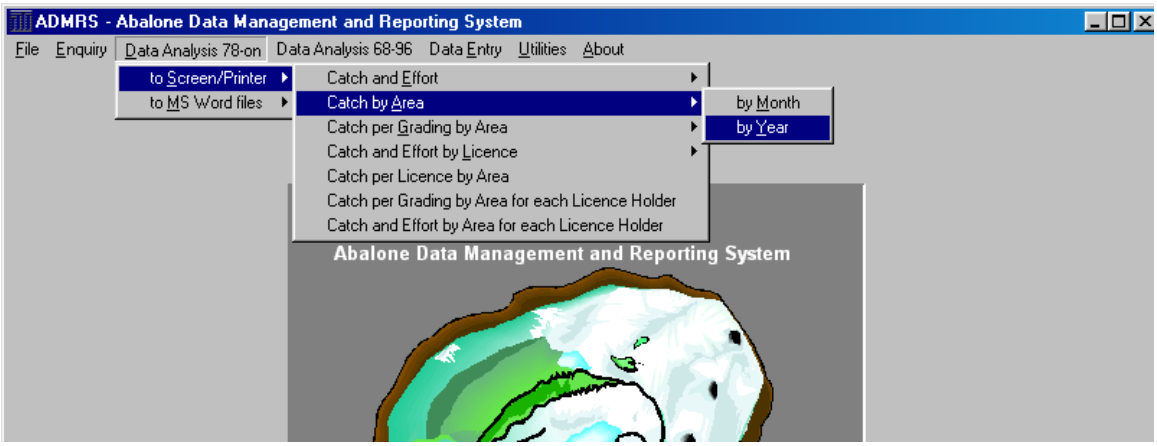


Figure 2.40: Extended menu options for Data Analysis 1978 onwards for Catch by Area

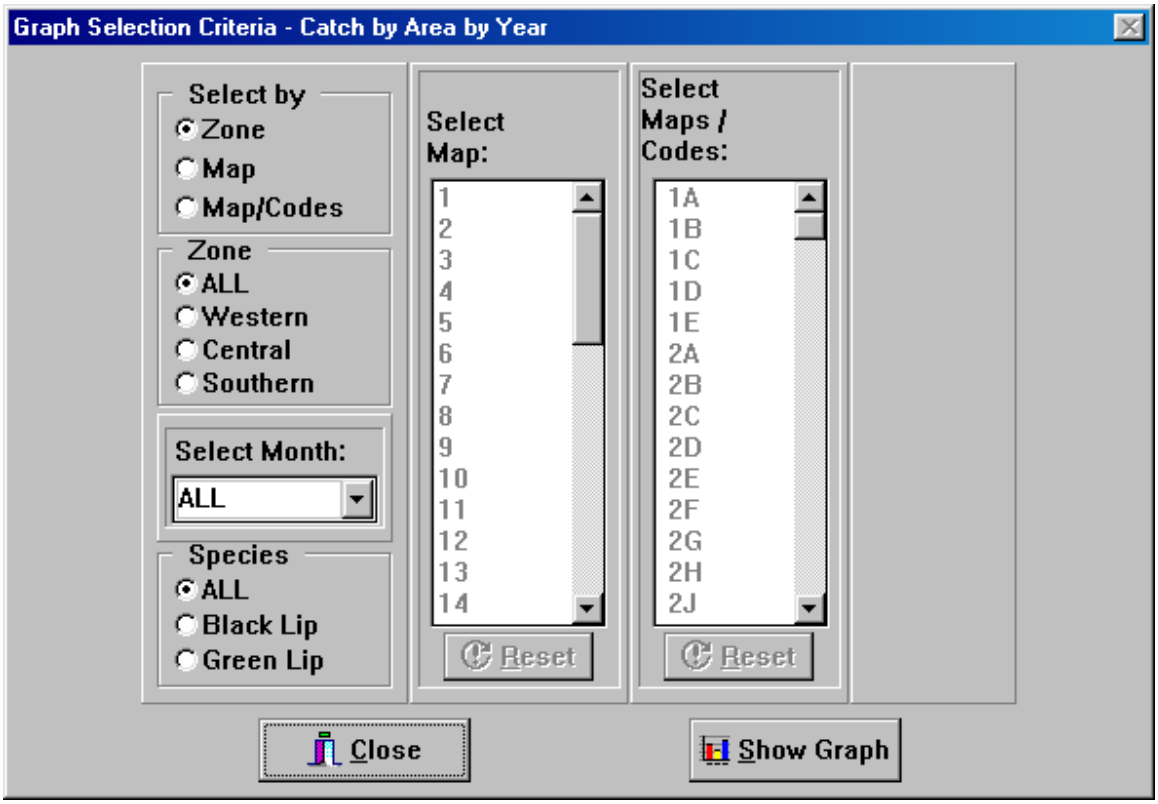
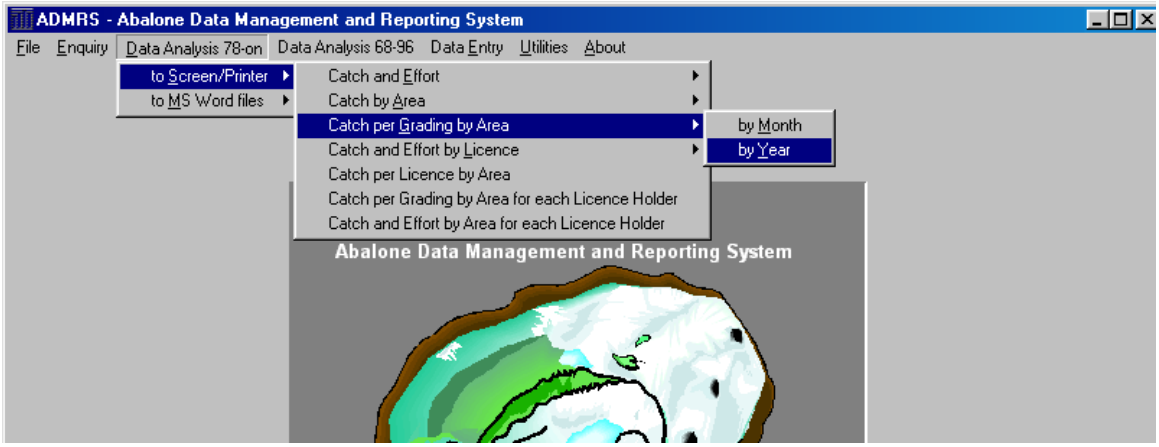


Figure 2.41:Options menu for Catch by Area by Year analysis

Catch per Grading. This option enables analysis of the size composition of the catch from any area of the fishery over time on either an annual (any one or all months combined) or monthly (within a single year) basis. The menu and first screen are shown in figures 2.42. and 2.43. Instructions for selecting the area and species of this option are exactly the same as for the Catch and Effort option. For the example shown here, we have selected to examine the size composition of blacklip abalone from map 11 by year (Figure 2.44.).

Figure 2.42: Extended menu options for Data Analysis 1978 onwards for Catch per Grading by Area



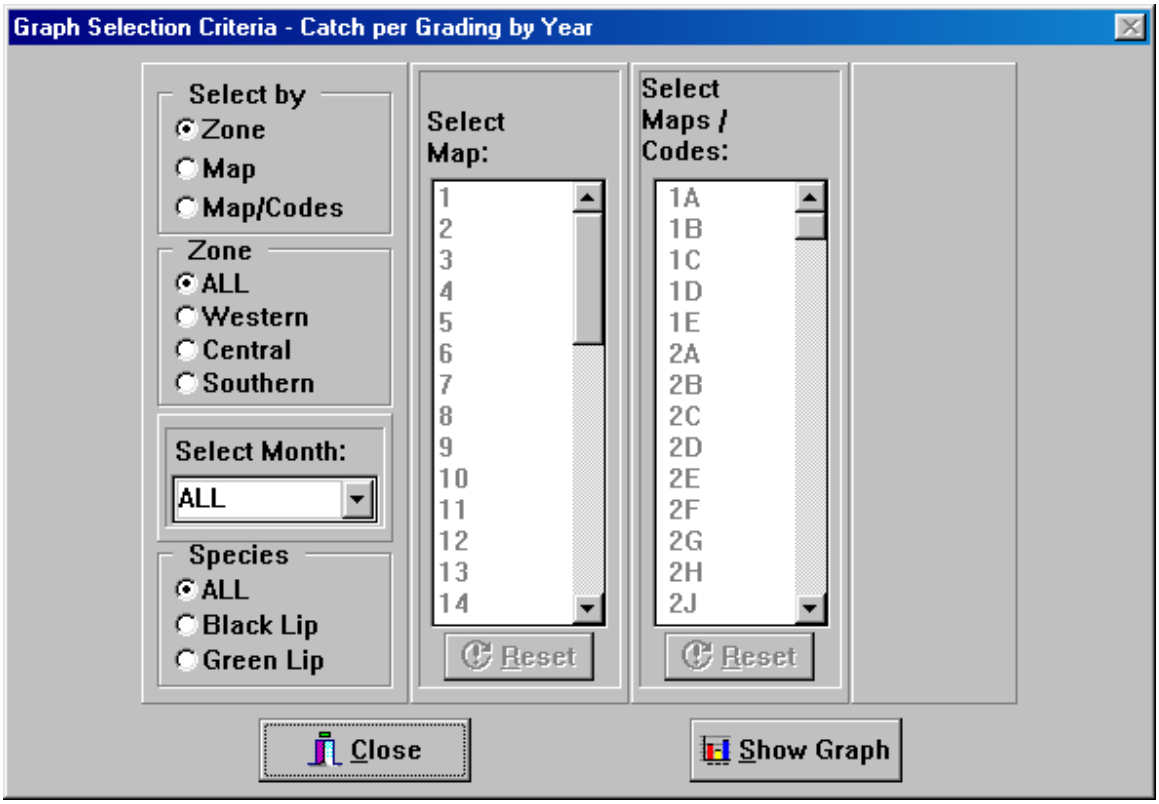


Figure 2.43: Options menu for catch per Grading by Year

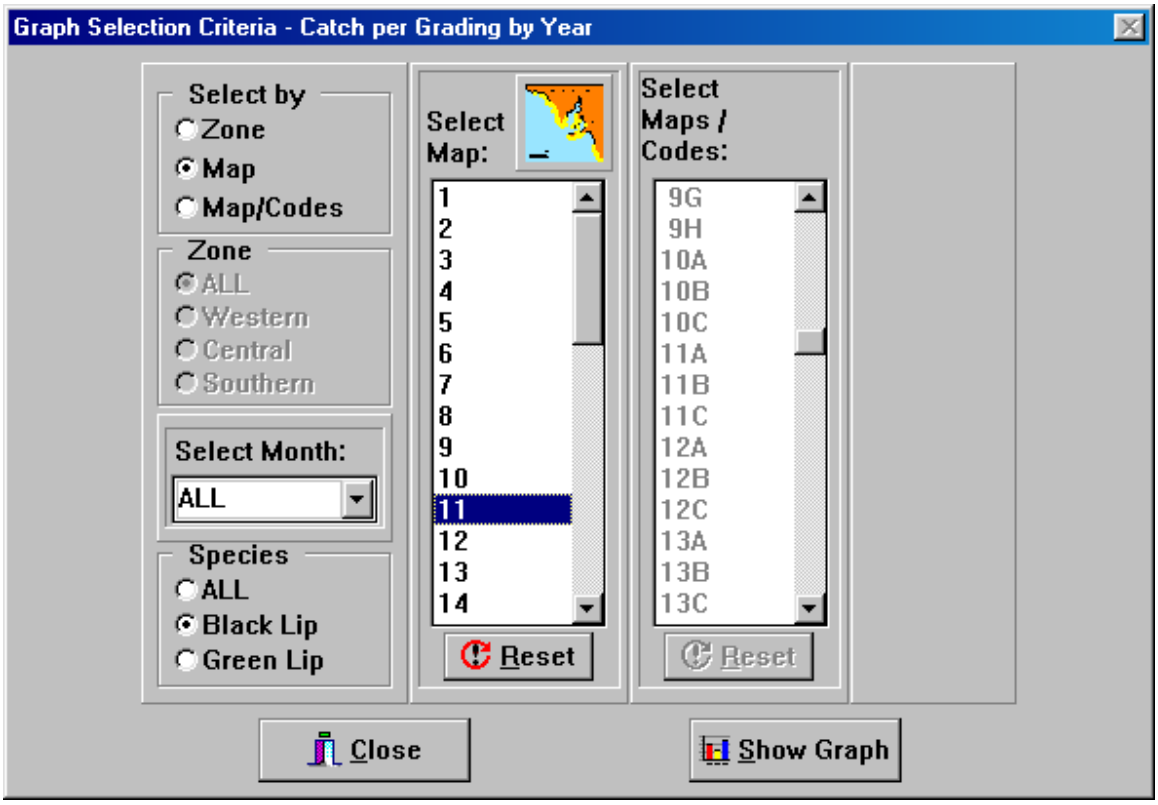


Figure 2.44: Options menu for Catch per Grading by Year with selection made for Greenlip from Map 11

The graphical output is shown in figure 2.45. The three coloured lines track the percentage of the graded catch in each of three categories: small abalone (3-5 pieces per pound), medium sized abalone (2-3 pieces per pound) and large abalone (1-2 pieces per pound). In the example shown from Sheringa, the trend is for a reduction in abundance of large abalone in the catch over time and an increase in the proportion of small abalone over time. Note that the graph shows the percentage of the total graded catch made up by each size class. Because not all the catch is graded, the figures shown will only be indicative of the total catch where a fairly high proportion of the total catch is graded. It is possible to check this by “right clicking” your mouse on any data point. In the example in figure 2.46. we have clicked on the 1996 data point (which sits at about 20 %) for the small sized abalone. It shows that small abalone made up exactly 20.61 % of the catch that was graded and that over 96 % of the total catch was graded. Thus the figure can be given a high degree of reliability relative to say the 1981 data point when only 44 % of the total catch was graded.

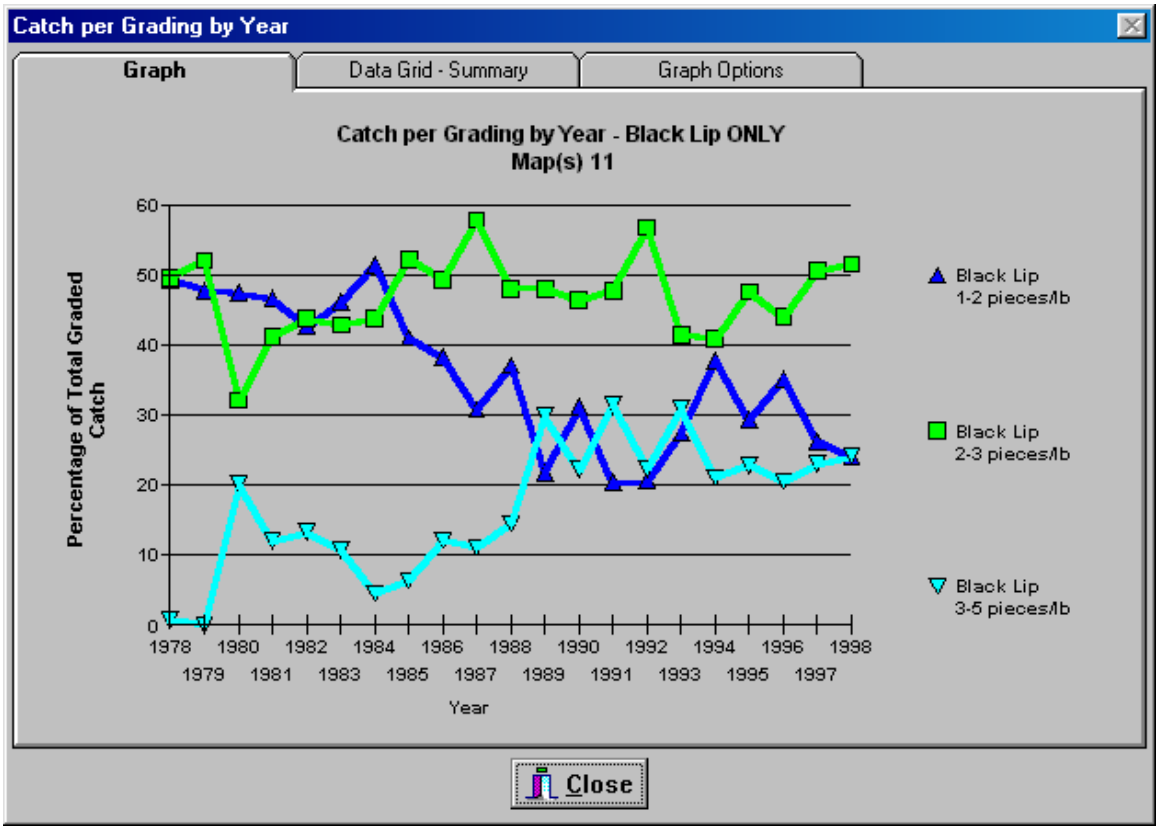


Figure 2.45: Output showing size grading structure of catch

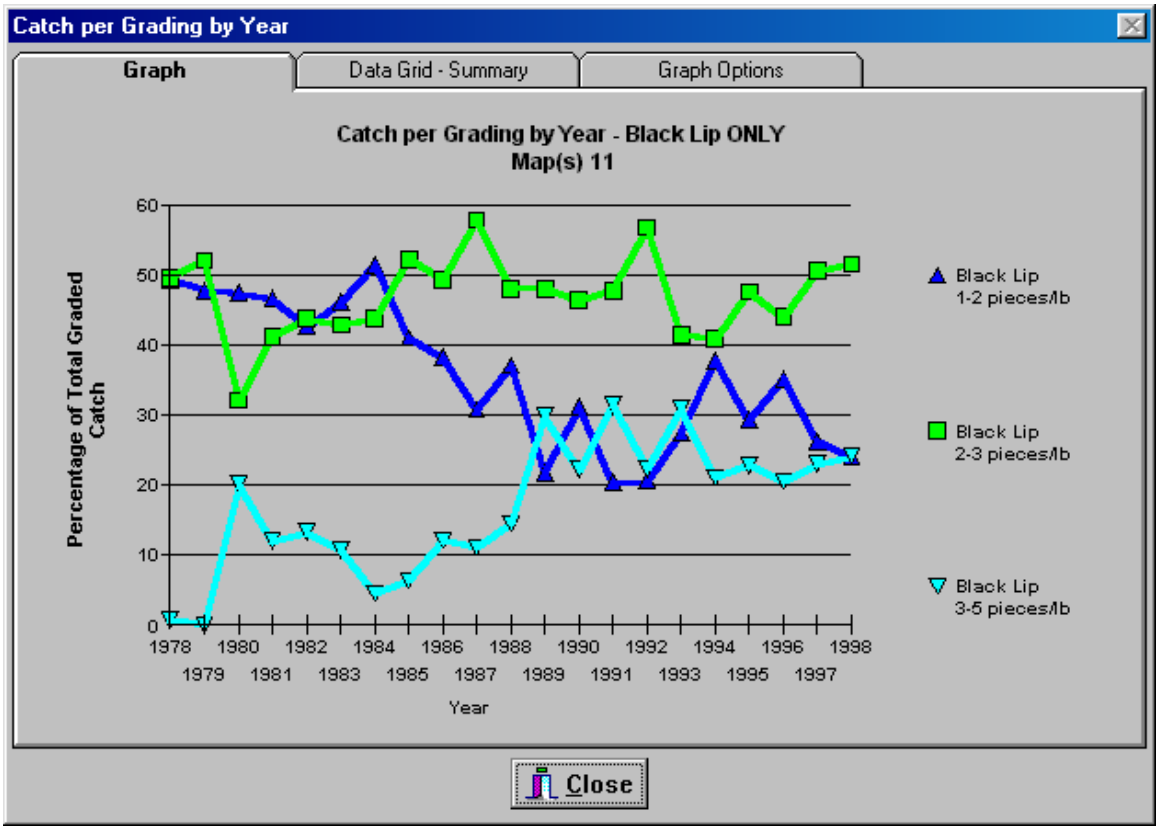
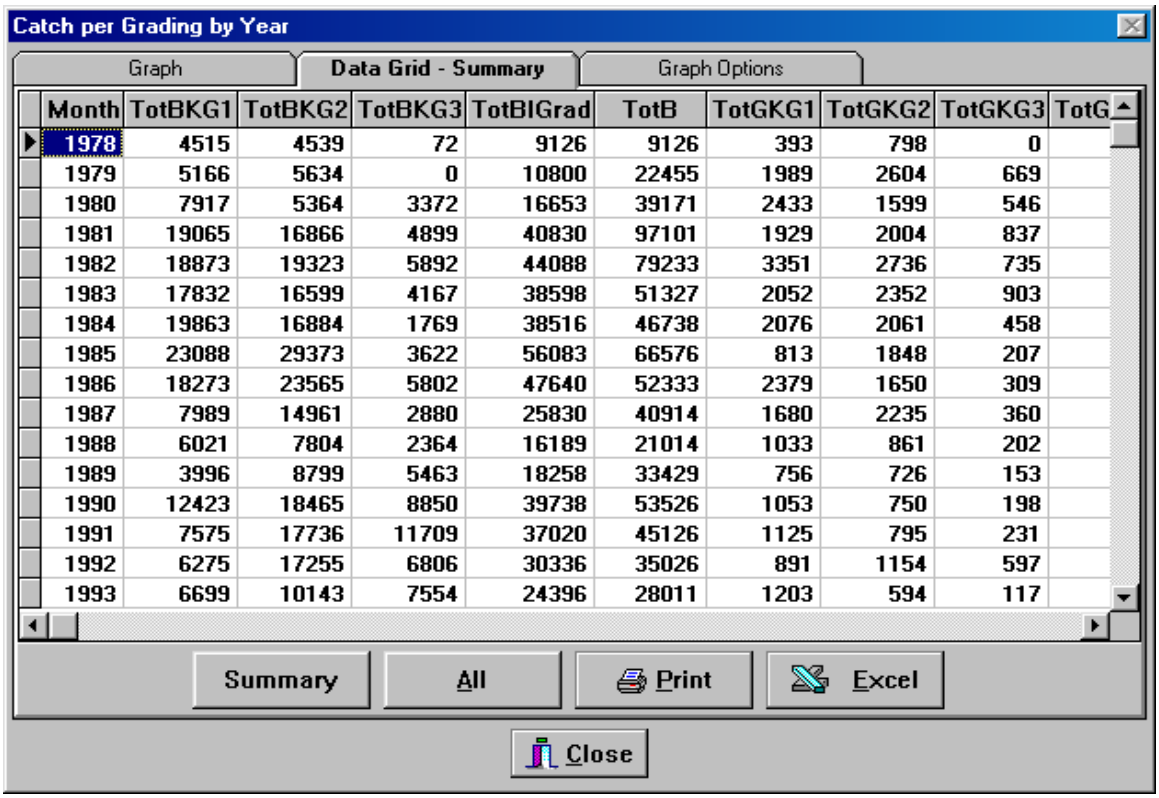


Figure 2.46: information boxes show exact percentage and reliability indicated by percent of total catch graded.

Clicking on the "Data Grid – Summary" tab brings up the table of data used to compose the graph (figure 2.47.). Note the column headings have the following meanings:



Month	TotBKG1	TotBKG2	TotBKG3	TotBIGrad	TotB	TotGKG1	TotGKG2	TotGKG3	TotG
1978	4515	4539	72	9126	9126	393	798	0	
1979	5166	5634	0	10800	22455	1989	2604	669	
1980	7917	5364	3372	16653	39171	2433	1599	546	
1981	19065	16866	4899	40830	97101	1929	2004	837	
1982	18873	19323	5892	44088	79233	3351	2736	735	
1983	17832	16599	4167	38598	51327	2052	2352	903	
1984	19863	16884	1769	38516	46738	2076	2061	458	
1985	23088	29373	3622	56083	66576	813	1848	207	
1986	18273	23565	5802	47640	52333	2379	1650	309	
1987	7989	14961	2880	25830	40914	1680	2235	360	
1988	6021	7804	2364	16189	21014	1033	861	202	
1989	3996	8799	5463	18258	33429	756	726	153	
1990	12423	18465	8850	39738	53526	1053	750	198	
1991	7575	17736	11709	37020	45126	1125	795	231	
1992	6275	17255	6806	30336	35026	891	1154	597	
1993	6699	10143	7554	24396	28011	1203	594	117	

Figure 2.47: Data grid summary for output shown in Figure 2.46

TotBKG1 - kg of large blacklip graded

TotBKG2 - kg of medium blacklip graded

TotBKG3 - kg of small blacklip graded

TotBIGrad – total kg of blacklip in all size grades

TotB – total kg blacklip. Note: Subtract the TotBIGrad from TotB will equal the ungraded component of the catch.

TotGKG1 - kg of large greenlip graded

TotGKG2 - kg of medium greenlip graded

TotGKG3 - kg of small greenlip graded

TotGIGrad – total kg of greenlip in all size grades

TotG – total kg greenlip. Note: Subtract the TotGIGrad from TotG will equal the ungraded component of the catch.

Catch – total abalone catch (TotB plus TotG)

Figure 2.48. shows the catch grading data output for a single year by month. In this case we have chosen greenlip for map 19, a heavily fished area near Port Lincoln and the graph shows the percentage of large abalone in the catch decreasing from the start of the season (January).

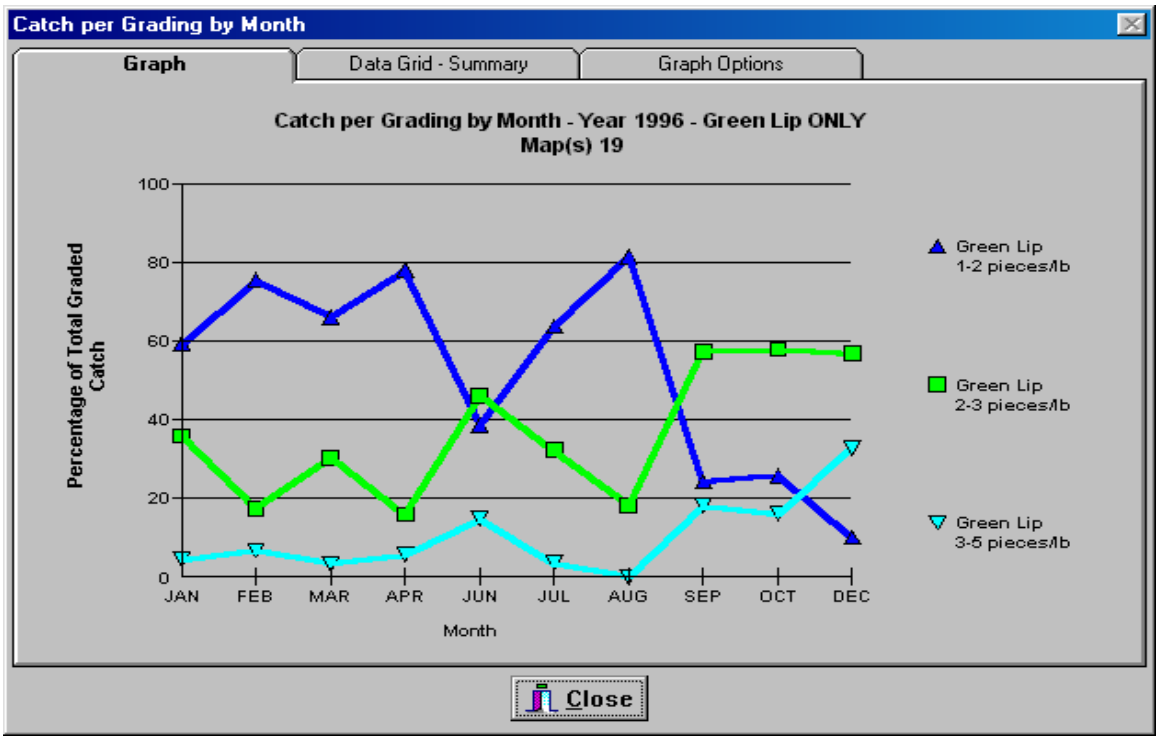


Figure 2.48: Output showing change in size grading structure of catch within a single year

Catch and Effort by Licence. This module works the same way as the Catch and Effort module described above, however in this case it is possible to analyse the data by either a single licence holder within a zone or a group of licence holders within a zone.

The menu is shown in figure 2.49. and once again the data can be analysed by year or by month within a year and the first screen is shown in figure 2.50. It can be seen that the first screen is the same as for the Catch and Effort module except an extra column listing the available licence numbers appears on the right.

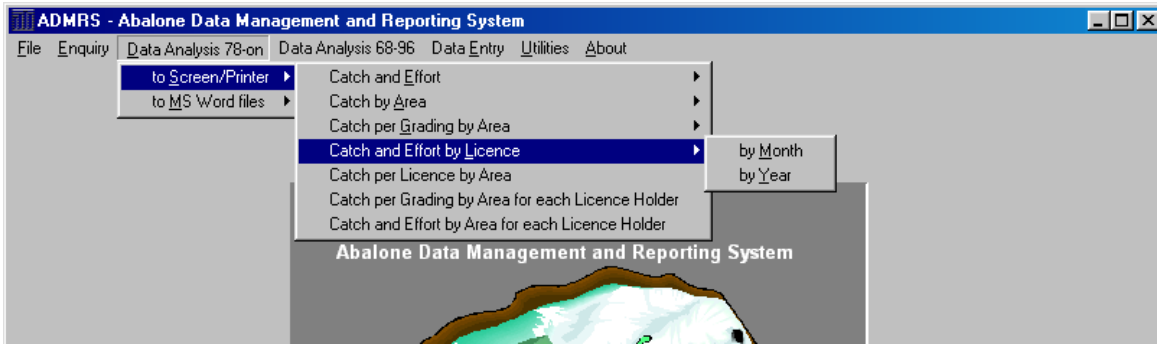


Figure 2.49: Extended menu options for Data Analysis 1978 onwards for Catch and Effort by Licence by Month or Year

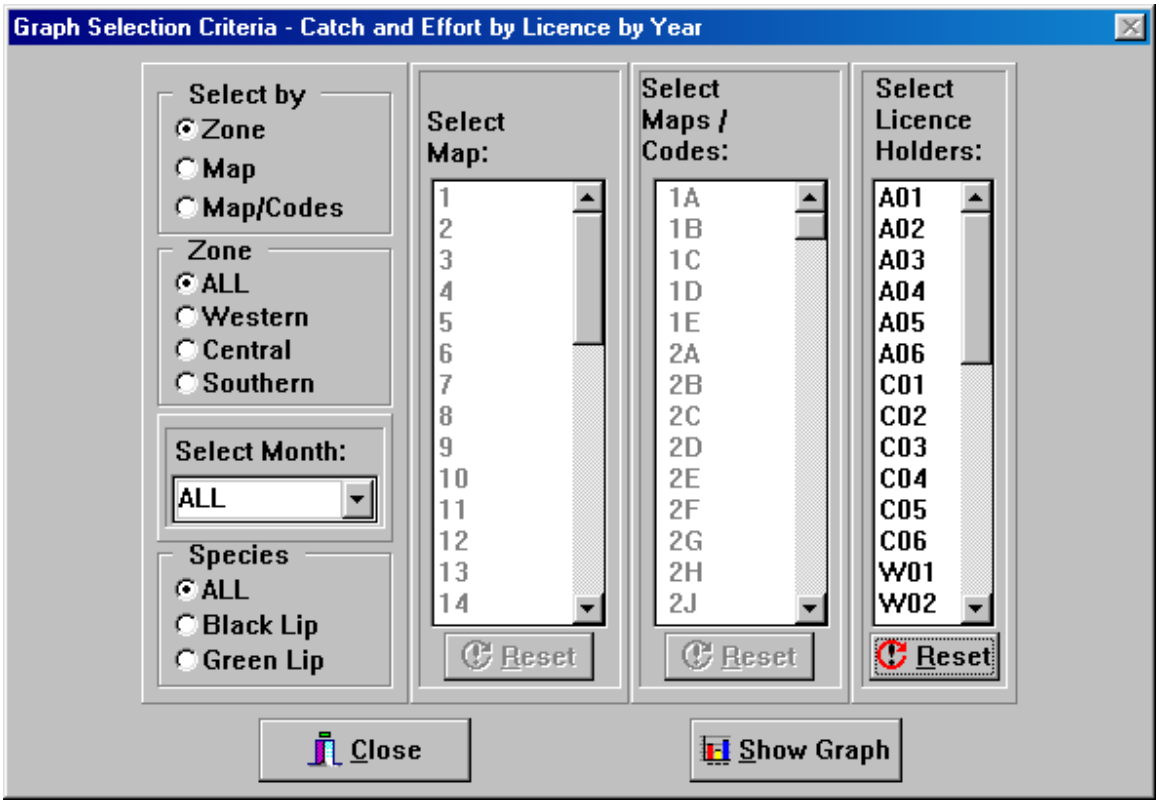


Figure 2.50: Menu options for Catch and Effort by Licence by Year

Instructions for selecting the area and species of this option are exactly the same as for the Catch and Effort option. For the example shown here, we have selected to examine the catch and catch rate of blacklip abalone from map 11 by year for all the Western Zone licence holders with odd numbers (Figure 2.51.). Note that we could have chosen just one or chosen all the ones that fit a particular attribute we wished to analyse (eg. those who live in a particular town, or those who have been diving less than five years). The output is shown in figure 2.52.

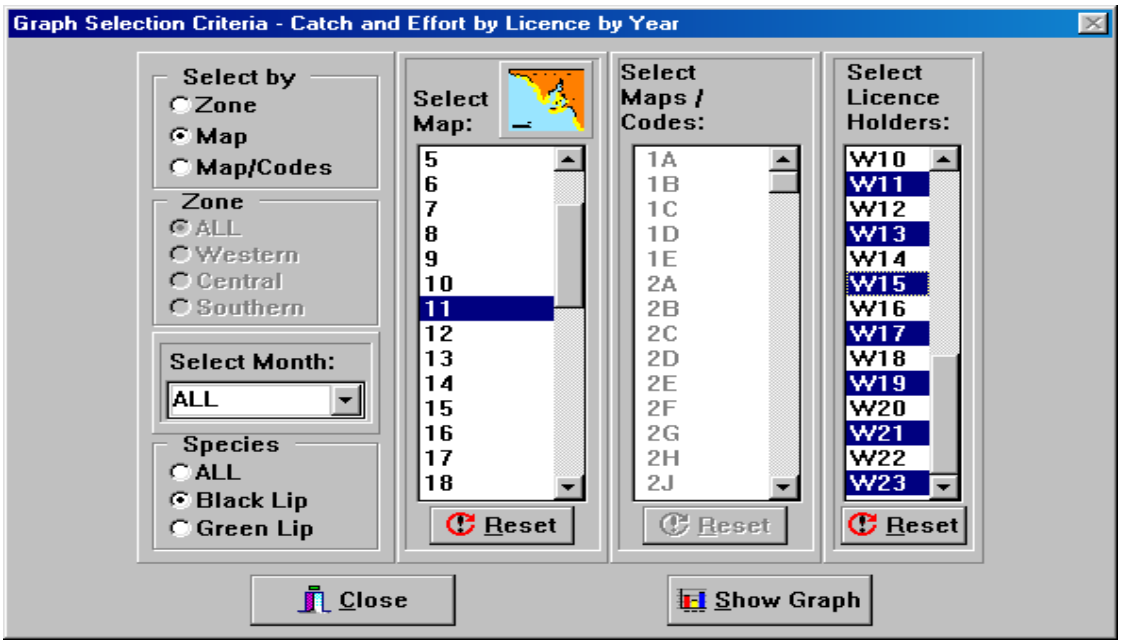


Figure 2.51: Selection of Blacklip in Map 11 for selected Western Zone divers

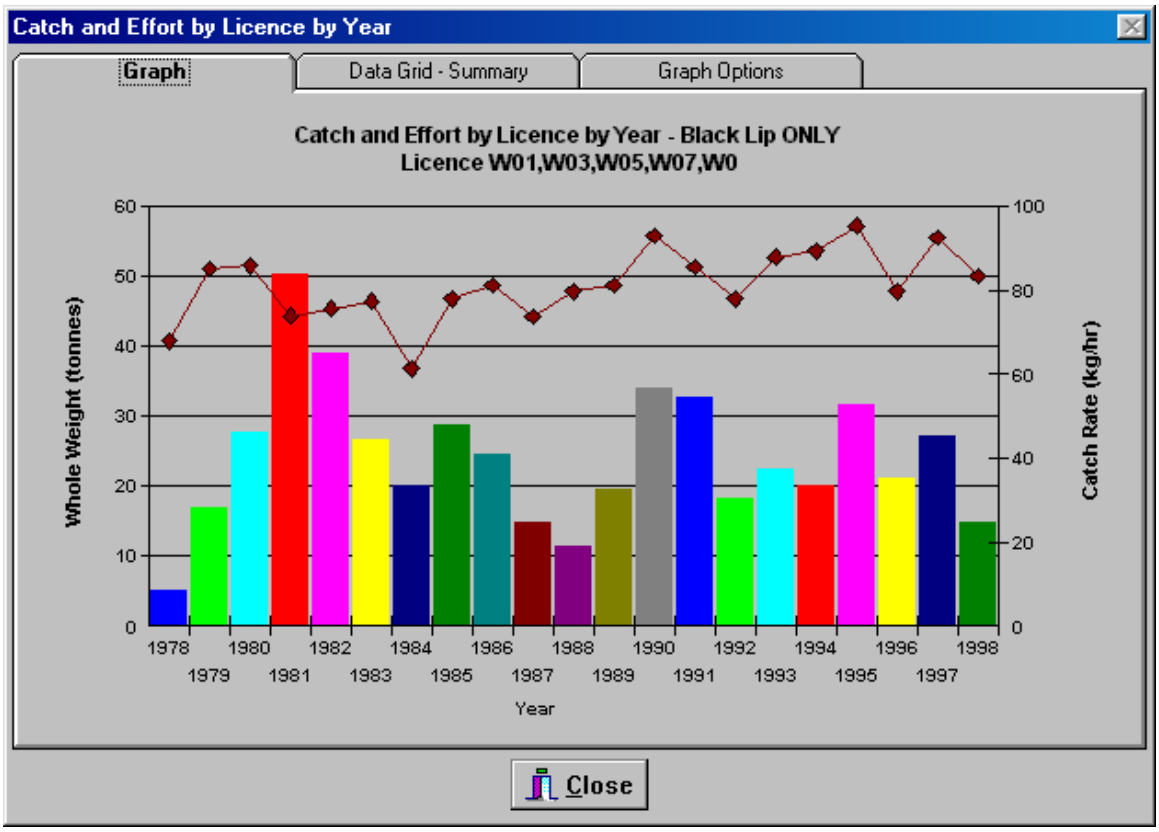


Figure 2.52: Output from menu options shown in figure 1.51

Catch per Licence by Area. This module enables comparisons of variations in catch among licence holders for different areas of the fishery. The menu and start up screens are shown in figures 2.53. and 2.54. Data can be analysed by any selected year. For reasons of data confidentiality, the example we have selected to look at is blacklip catch data from 1997 in the whole Central Zone. Figure 2.56. shows the output and as would be expected if each of the six licence holders in the Central Zone caught the same amount each (ca. 7 tonnes). It is however possible with this module to select any spatial scale down to individual map/codes and examine which licence holders fished the area and how much they caught. Figure 2.51. shows an output for blacklip in 1997 for somewhere in the Western Zone. From the graph it is evident that in that year, 11 of the 23 Western Zone Licence Holders fished the area catching up to 3 tonnes each.

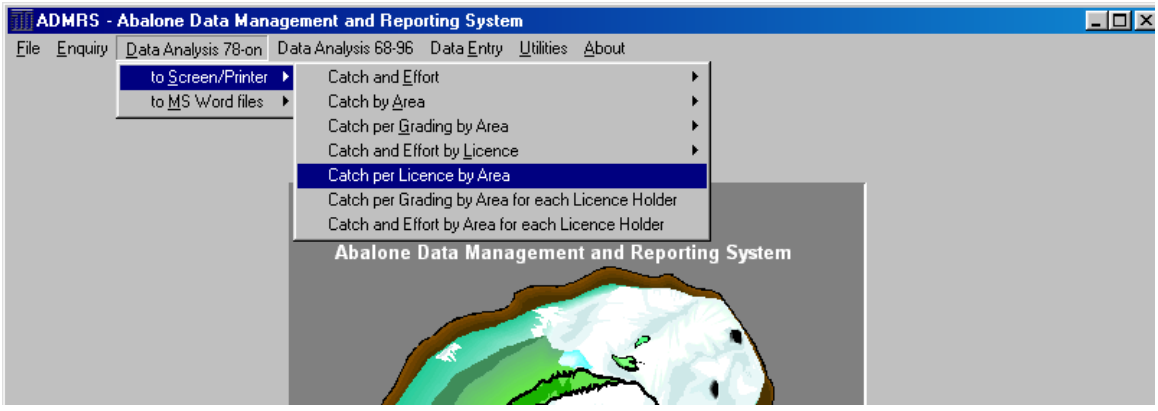


Figure 2.53: Catch by Licence by Area

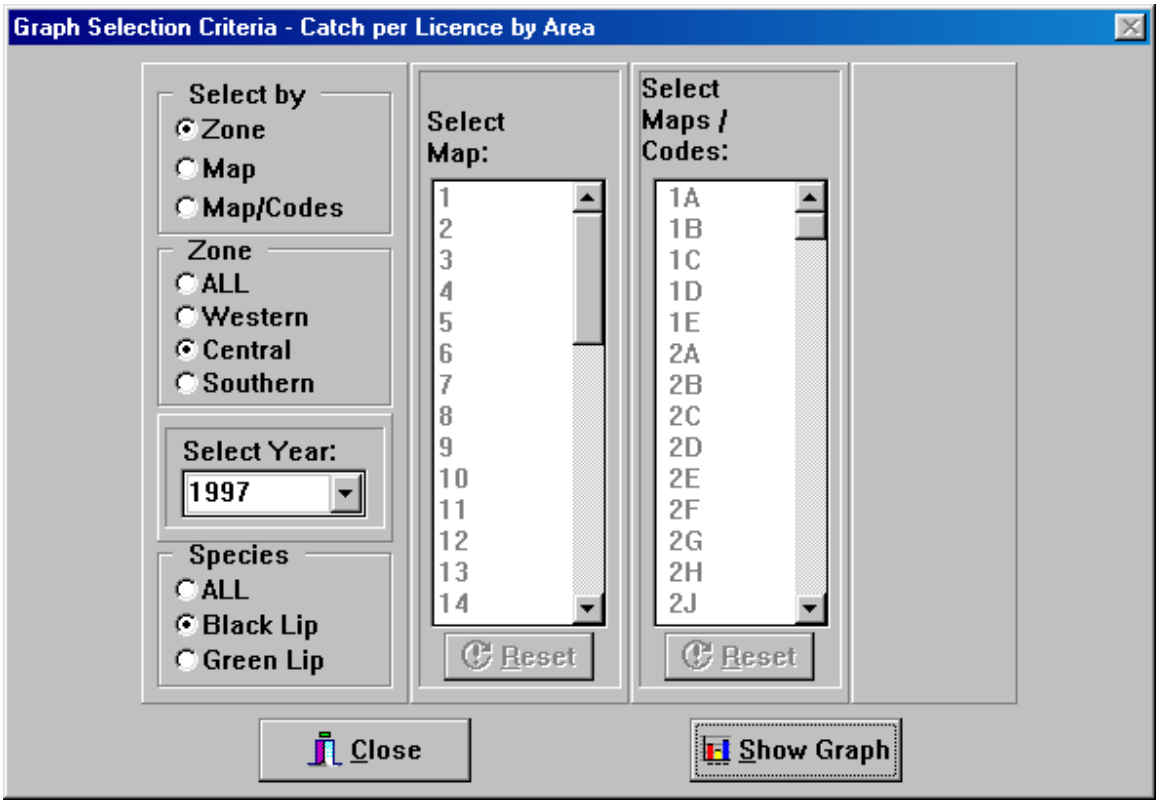


Figure 2.54: Options menu for Catch per Licence by Area

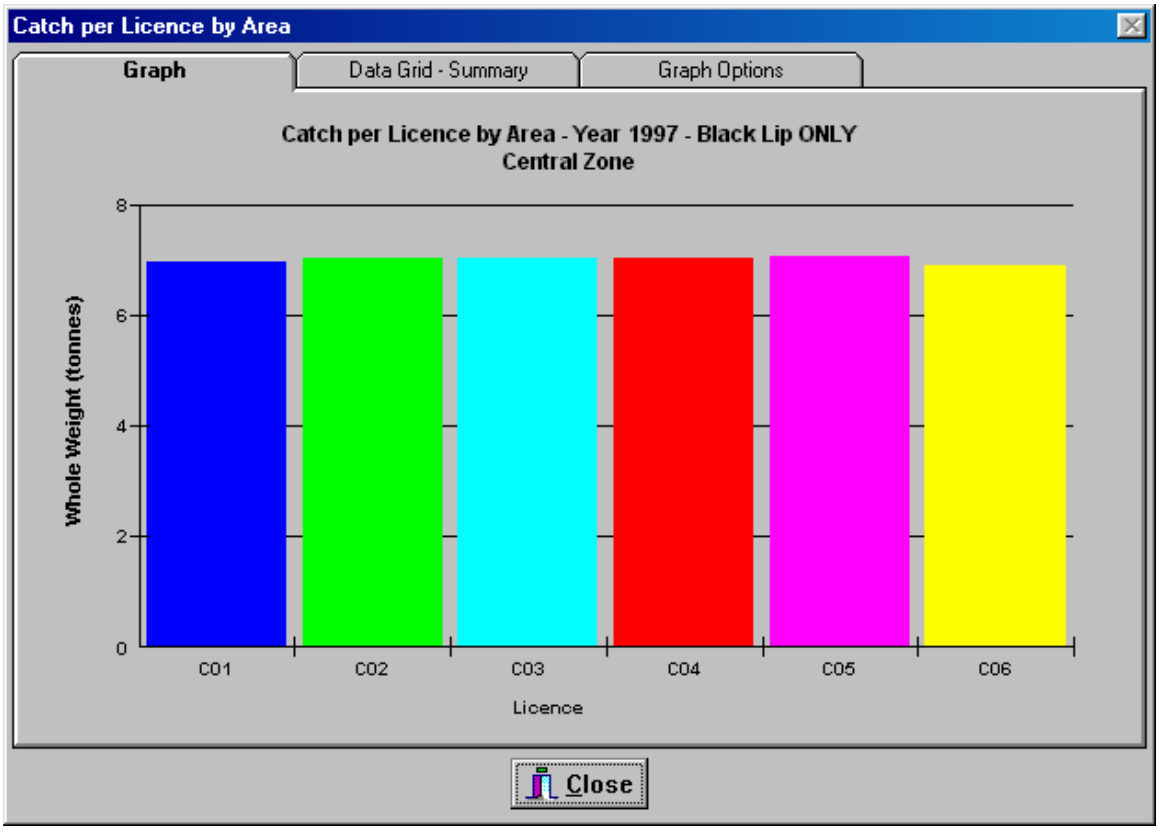


Figure 2.55: Output from Figure 2.54

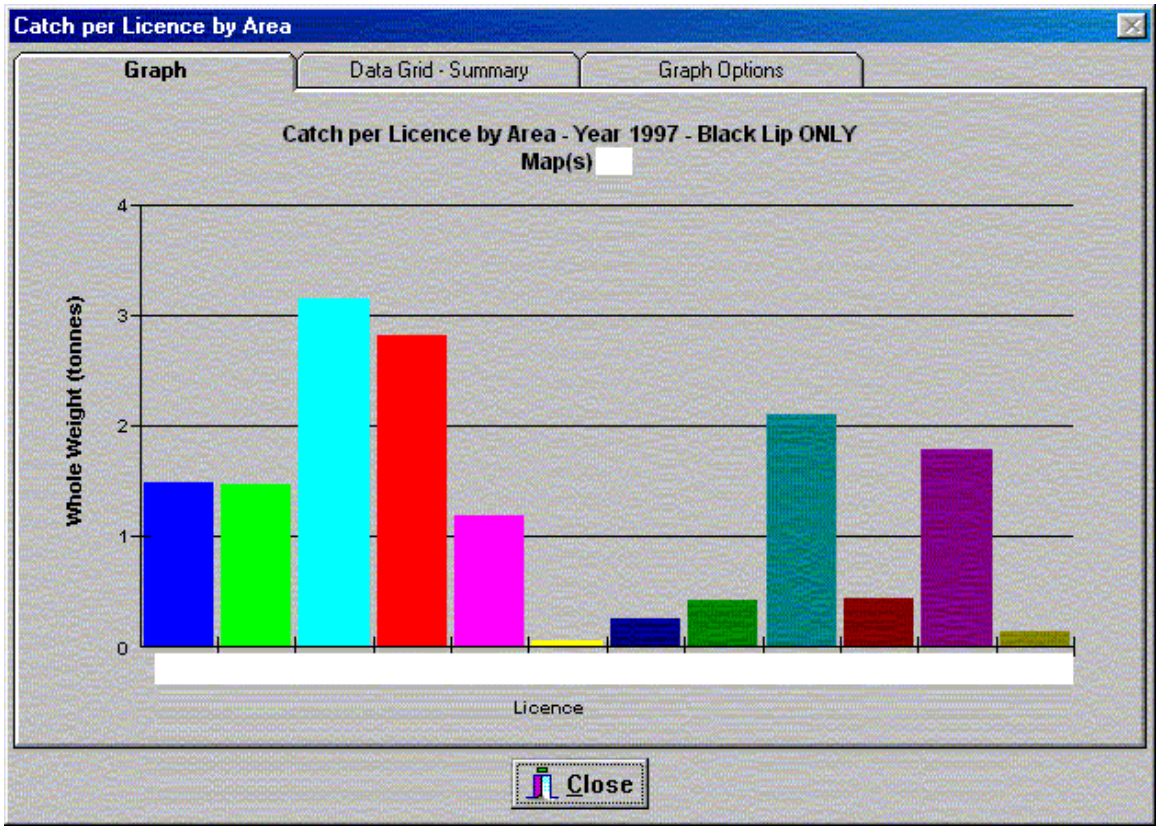


Figure 2.56: Catch per Licence by Area from Blacklip in 1997. The licence numbers and map code have been blanked out

Catch per Grading by Area for each Licence Holder. This module enables the pattern of size composition of the catch by individual licence holder to be analysed. The menu screen is shown in figure 2.57. Data is selected by species and by year along with the licence holder number (see figure 1.58.). The output for an individual licence holder for blacklip is shown in figure 2.59. The graph shows the percentage of size class in the graded catch for each map/code area fished by that licence holder in that year.

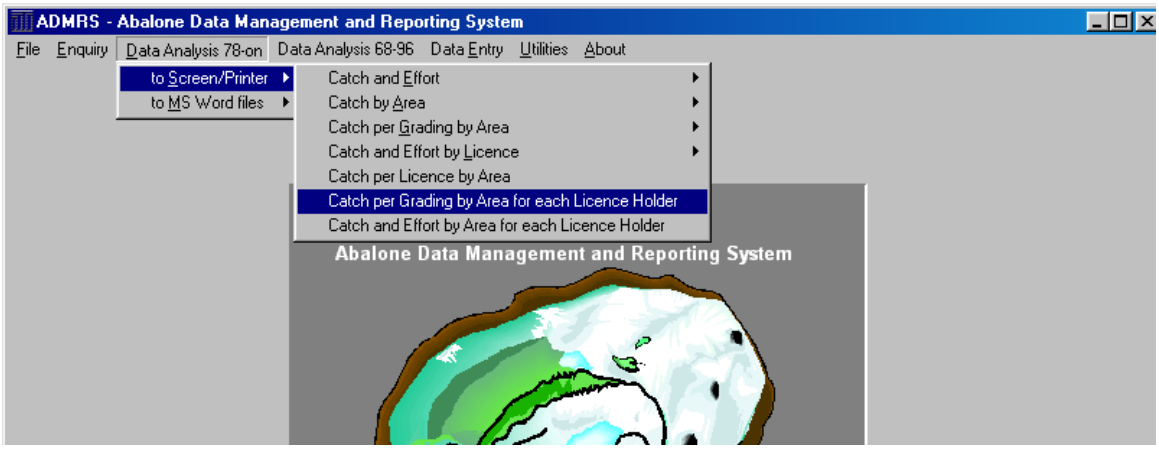


Figure 2.57: Menu for Data Analysis 1978 onwards for Catch per Grading by Area for each licence holder

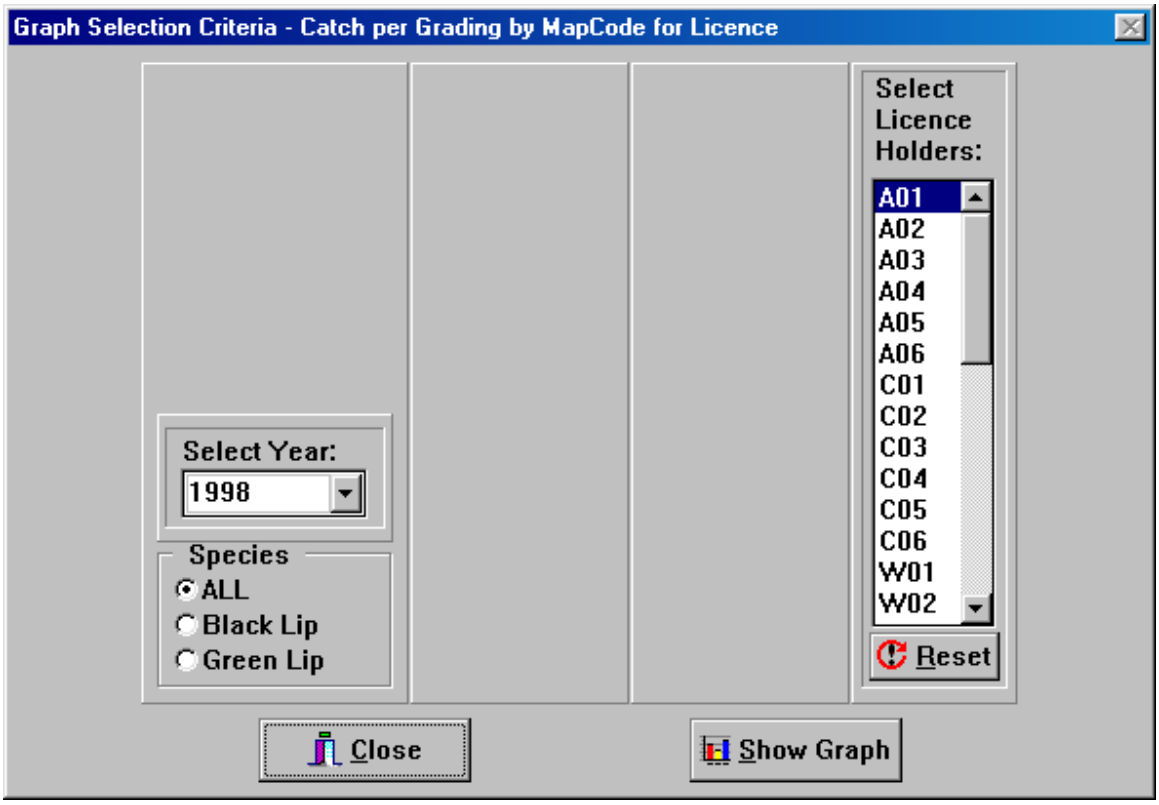


Figure 2.58: Options menu for Catch per Grading by Mapcode for each licence holder

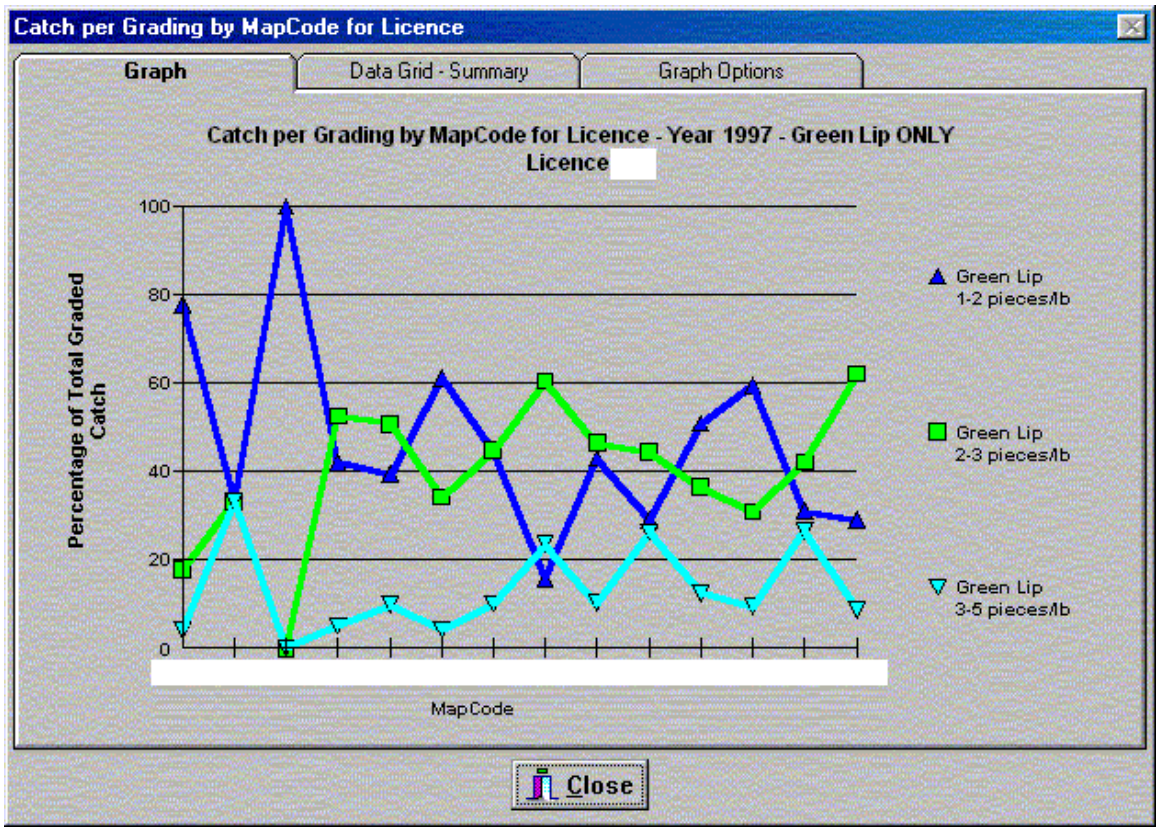


Figure 2.59:Output from figure 2.58. The MapCode and Licence Number have been blanked out).

Catch and Effort by Area for each Licence Holder. This module enables an analysis of the fishing pattern of one or more licence holders in a zone. The menu for this module is shown in figure 2.60. The start up screen (see figure 2.61.) and options for this module is the same as that described above for Catch and Effort by Licence. An output from this module is shown in figure 2.62. for blacklip abalone in 1997. It shows that for a selected group of licence holders what their catch and catch rate was for each of the map/code areas fished.

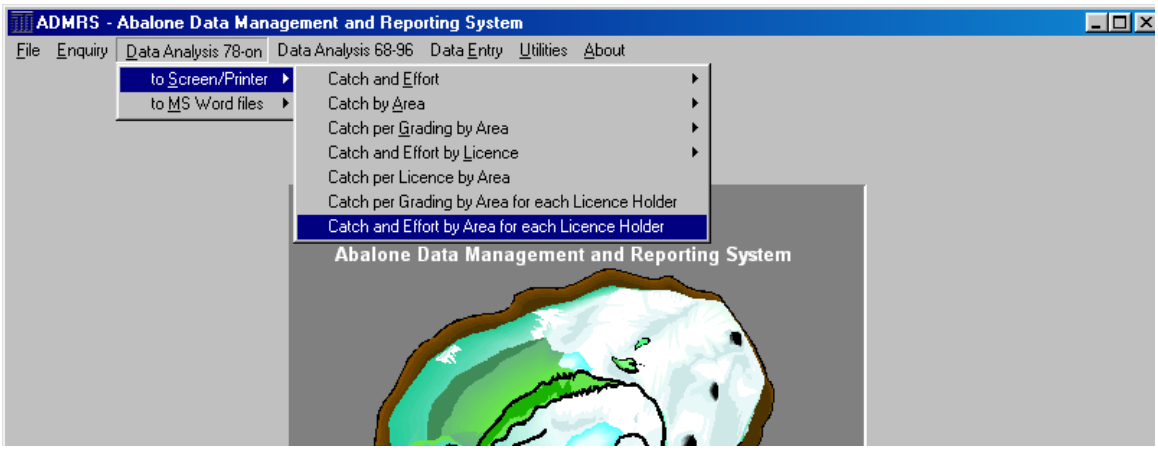


Figure 2.60: Menu for Data Analysis 1978 onwards for Catch or Effort by Area for each Licence Holder

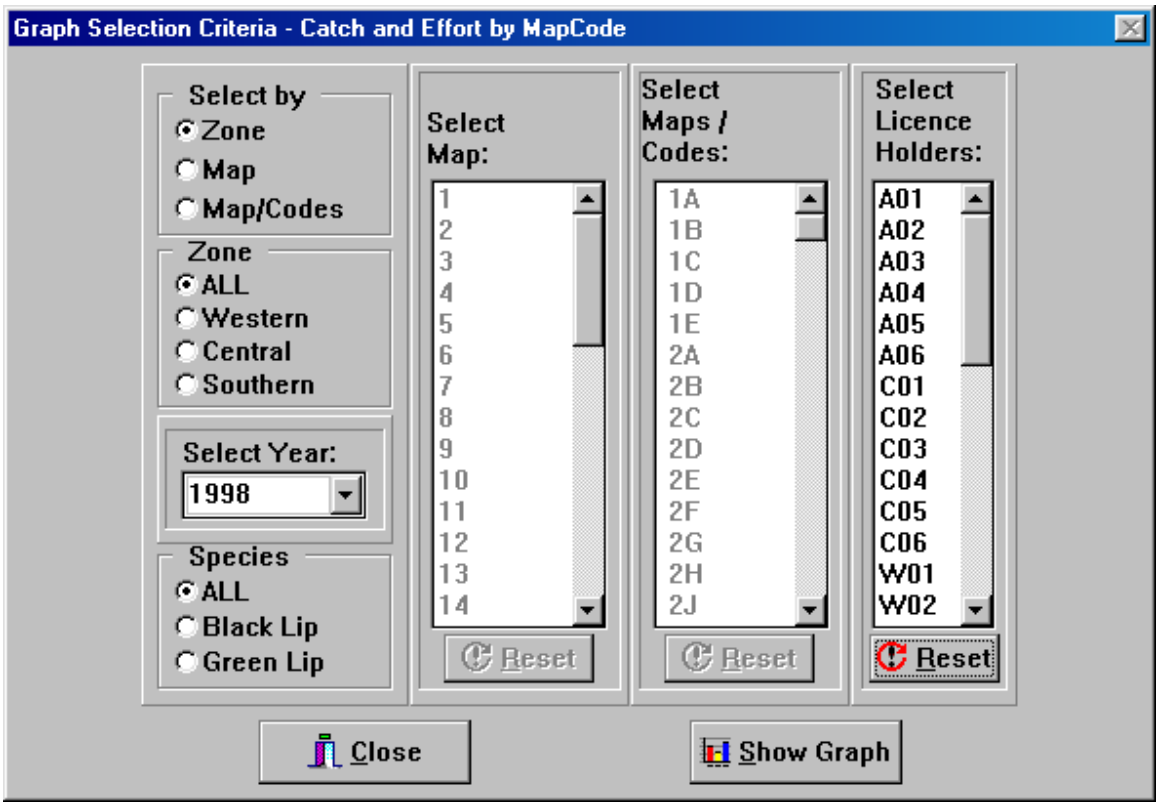


Figure 2.61: Options menu for Catch and Effort by MapCode for each Licence Holder

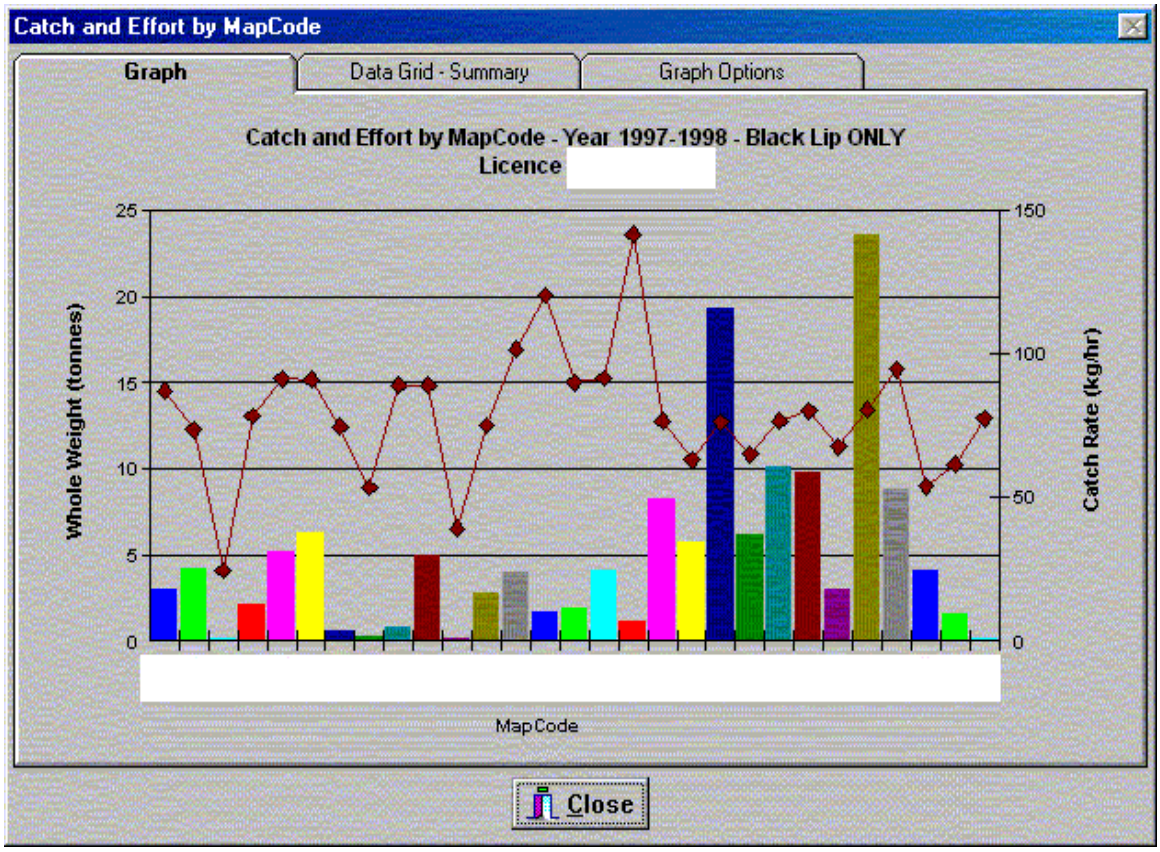


Figure 2.62: Output from Figure 2.61. (MapCodes and Licence Number have been blanked out).

2.3 DATA ENTRY

The Data Entry module is opened from the main screen (Figure 2.2.). The first data entry screen (Figure 2.63.) prompts entry of a license number, month and year. Only valid entries are permitted reducing the incidence of data entry error. The program automatically shows the relevant zone in the green box. The system will default to shell weight entry for the Southern Zone and meat weight for the Central Zone (Figure 2.64.), but this can be selected manually if the data is not in this form.

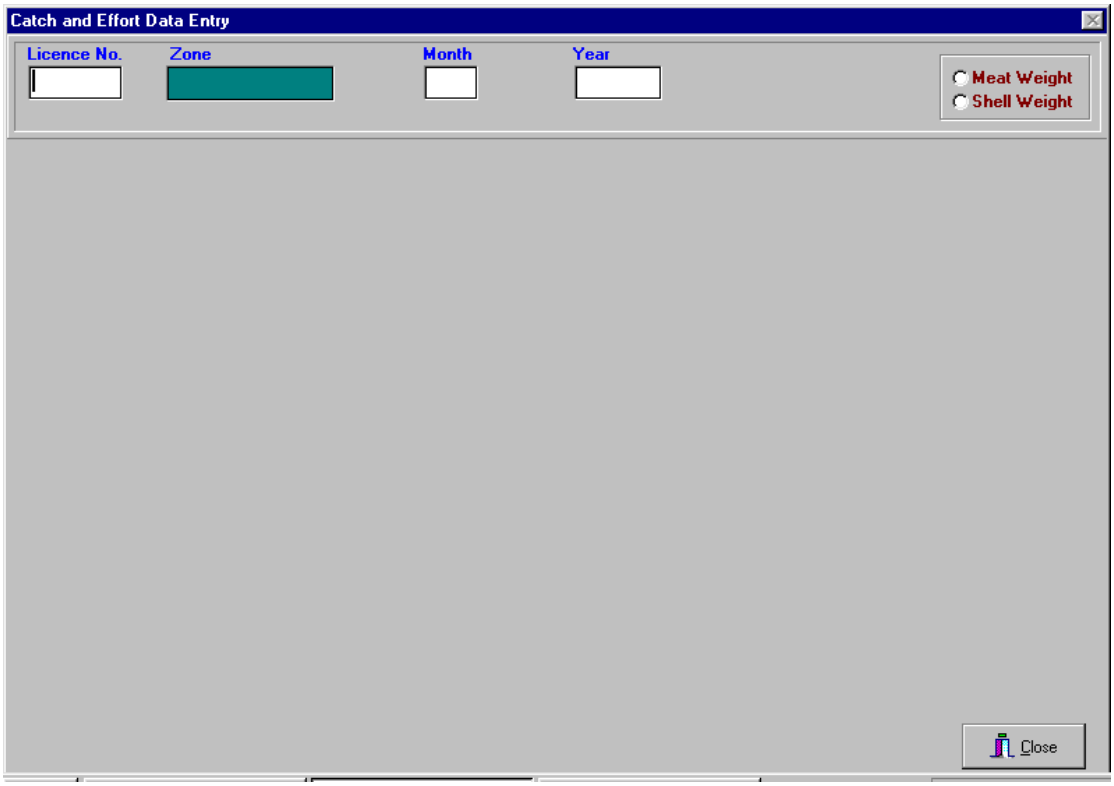


Figure 2.63: First data entry screen

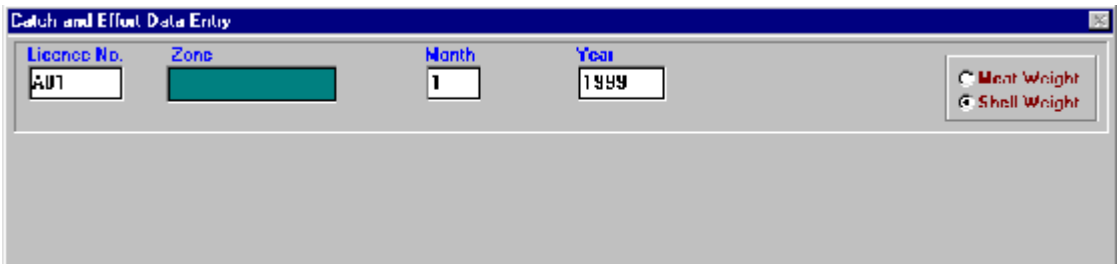


Figure 2.64: Entering data in the Catch and Effort Data Entry screen

Clicking the left mouse button on the green box showing the zone will bring up the rest of the data entry screen as long as valid data has been entered in relation to Licence Number, Month and Year (Figure 2.64.).

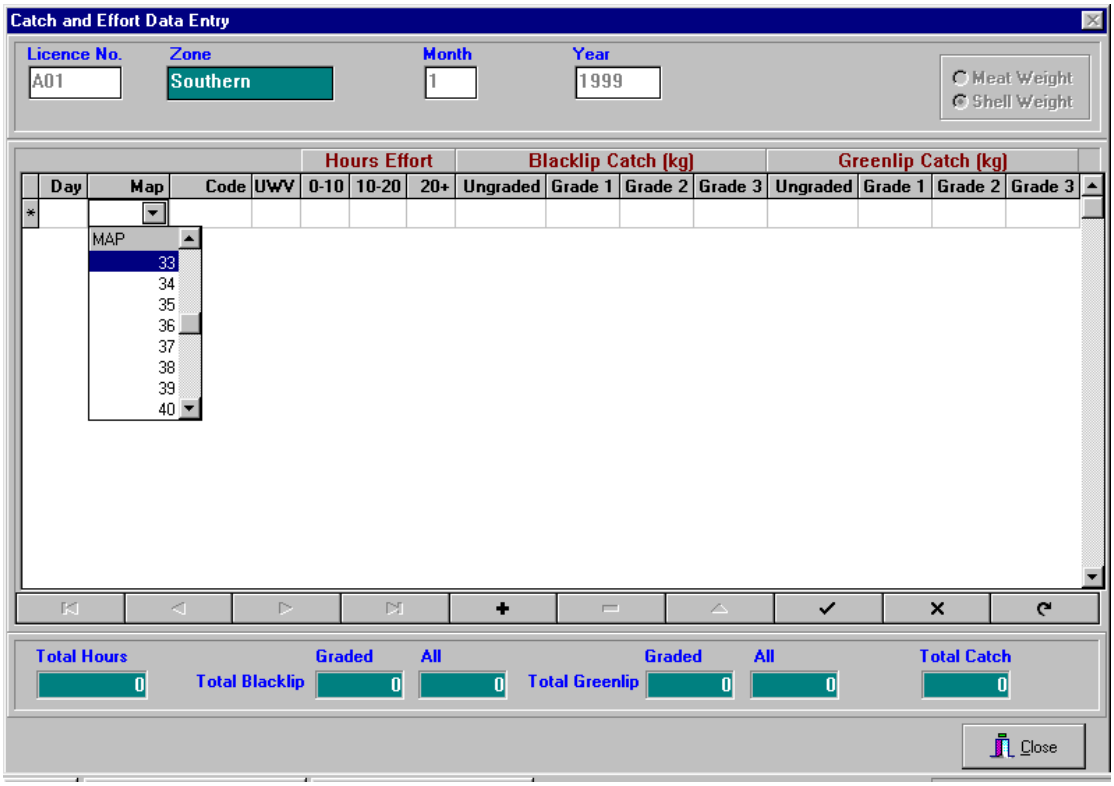


Figure 2.65: Data entered

Data is then entered directly into each of the fields. Pull down menus are provided for map and codes. Again the system only presents potentially valid data options, such that if data for the Southern Zone is being entered only maps 33 to 40 are shown (Figure 2.65.) as options. Once a map is selected only valid code options for that map are presented. All fields take numeric data except for the underwater vehicle field which allows a yes or no (Y or N) option depending on whether an underwater vehicle was used in the fishing.

Along the bottom menu are a range of symbols which have the following options:

Plus: accept new data entry

Minus: reject new data entry

Tick: accepts edits

Up arrow: choose to edit record

Circular arrow: previous screen

3 SECTION THREE.

Descriptive Summary of Catch and Effort in the South Australian Abalone Fishery since 1968.

Objective

Produce a comprehensive resource document describing and illustrating catch and effort history of each of the 196 areas since 1983 and on a larger scale (by 22 sub-zones) using data collected between 1968 and 1982.

This objective was achieved and the description of the overall catch and effort histories for each of the 196 areas are presented in this section.

NB. Some presentation of the data in this report (particularly for catches in the Central and Southern Zones) is restricted. To provide these data would comprise the confidentiality policy of commercial catch data currently in place within Primary Industries and Resources SA (SARDI).

These data were extracted from ADMRS in order to demonstarte the capabilities of the system.

3.1 INTRODUCTION TO THE SOUTH AUSTRALIAN ABALONE FISHERY

The South Australian abalone fishery is a limited entry, quota-managed fishery comprising two species *Haliotis laevigata* Donovan (greenlip) and *H. rubra* Leach (blacklip). The fishery is separated into three zones (Figure 3.1), which together cover the entire South Australian coastline. There are 6 licences in each of the Southern and Central Zones, and 23 licences in the Western Zone. A Total Allowable Catch (TAC), set annually for each species in each zone, is divided equally between all license holders in each zone. Licences are transferable and have a high capital value. The total catch for the fishery averages about 270 tonnes meat weight (810 tonnes whole weight), with an unprocessed catch value of A$40 million during 2000/01. Different minimum sizes apply to each of the species in the different zones. Recreational fishers may take up to 5 abalone per day, and their impact on the total catch of abalone is unknown, but believed to be low. The amount of illicit catch is not known.

In compiling the catch and catch rate summary for areas in the Western, Central and Southern Zones not only was the historical information on diver catch and effort analysed but the following commentary includes some information on mean catches for the period 1971-8 derived from the report of Lewis et al. (1984), numerous published and unpublished data from research surveys and information from unpublished interviews of divers in 1979 by one of us (SAS). Some of the commentaries include information on the physical properties of the habitat and estimated reef areas provided by divers to SAS in 1979 and, where relevant, reference to biological studies undertaken in each area. In some cases comment is made on the likely status of abalone populations.

3.2 CHARACTERISTICS OF SOUTH AUSTRALIAN ABALONE CATCH AND EFFORT DATA

Catch and effort information has been collected on the fishery since 1967. There were initially 110 licences and these have been reduced to 35 since 1976 (Lewis et al, 1984). The spatial

resolution of collected data increased after 1979, from 20 blocks across all zones to a new system of 40 maps with a number of reef codes within each map. The reef codes are based on a system of islands, reefs and headlands (Figure 3.1). There are 110 reef codes on 20 maps in the Western Zone, 43 reef codes on 12 maps in the Central Zone and 42 reef codes on 7 maps in the Southern Zone.

Under the current system, the catch and effort database discriminates catch, effort and size composition of catch over small spatial scales (i.e. 196 separate reef complexes defined along the 1700 km fished length of the coast). The reef complexes are of varying sizes and, most importantly, are not based on a uniform grid, but on practical geographic reef areas delineated according to the distribution of suitable habitat. These reef complexes were identified in consultation with fishers. The reef-based system of data collection has now been operating since 1979.

Catches are reported by fishers every month, on statutory logbook return forms, which detail the daily fishing trips in that month. For each day fished, divers provide details of catch of each species, as well as the combined fishing effort for both species in hours dived, separated into different depth categories.

Where processors provide fishers with size gradings (number of abalone meats per unit weight), that information is also recorded. Greater details on the South Australian abalone catch and effort data collection system can be found in Sluczanowski (1979). The only previous analysis of the spatial characteristics of catch and effort in the fishery was undertaken in 1984 (Lewis et al,. 1984, unpublished).

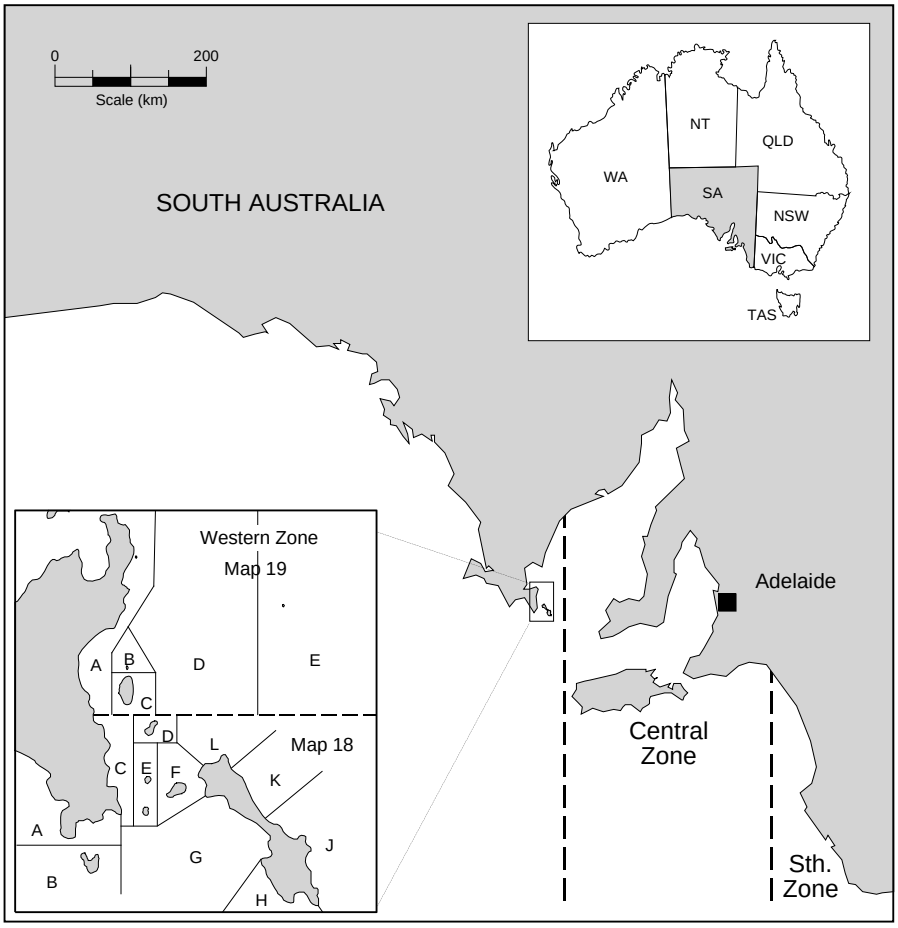


Figure 3.1: Map showing three fishing zones within the South Australian abalone fishery and an example of the further breakdown into map and reef codes which make up the statistical reporting areas for the fishery dependent catch and effort data.

3.3 WESTERN ZONE

3.3.1 Introduction

The Western Zone extends around southern Eyre Peninsula and westwards to the Great Australian Bight.

The fishery for both greenlip and blacklip abalone developed rapidly in the 1960's and catch records are available from 1968. The principal focus during the early part of the fishery was on greenlip abalone with over 1,000 tonnes of greenlip abalone caught in 1968. The catch history for the greenlip fishery shows a very typical pattern of exploitation of virgin biomass with catches falling to 200 tonnes in 1973, followed by increased catches through to 1983 as fishers began to explore more fishing grounds and broaden the scope of the fishery. Following this time, the fishery is being managed by quotas which have stabilised the catch at around 230 tonnes per annum.

The fishery for blacklip abalone in the Western Zone followed a similar pattern with catches peaking at 380 tonnes in 1969 and declining to 100 tonnes in 1977. The fishery expanded again from about 1979 as demand for blacklip abalone increased and catches returned to fluctuate between about 300 and 350 tonnes between 1981 and the present time. Quotas for both greenlip and blacklip abalone were introduced in 1985.

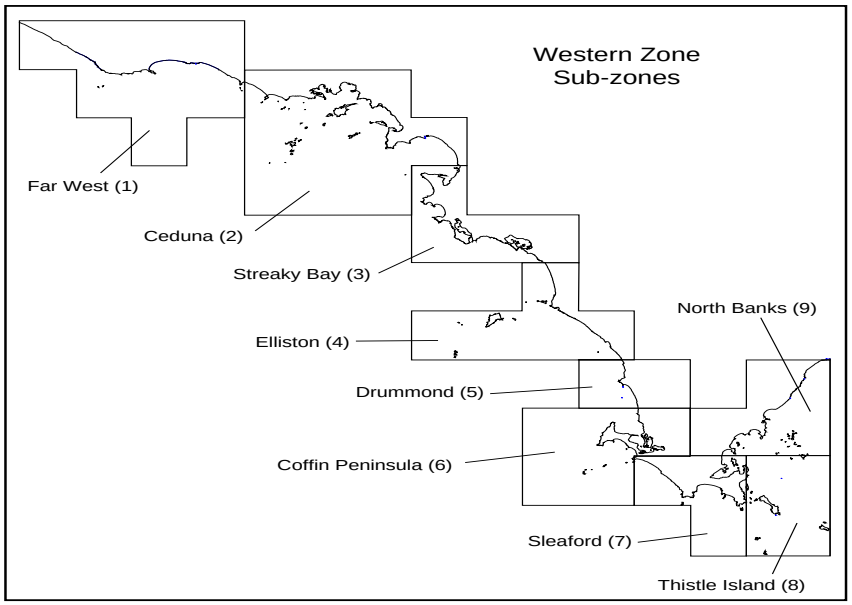


Figure 3.2: Map showing nine sub-zones within the Western Zone of the South Australian abalone which made up the statistical reporting areas for the fishery dependent catch and effort data between 1968 to 1978.

3.3.2 Summary of patterns of catches and catch rates for the Western Zone

Before 1979 catch and effort data were obtained from fishers on a 1º grid each divided into 9 square sub-blocks. These catches and catch rates of abalone in the Western Zone from 1968 were examined from each of the 9 subzones shown in figure 3.2. Catches and catch rates from 1979 and onwards were examined at a much finer spatial scale comprising 110 individual mapcodes. These have been aggregated into 53 fishing or metapopulation areas.

3.3.2.1 Far West (Subzone 1), Map Code 1A-E)

Virgin stocks of greenlip were removed in 1970-1 and of blacklip much later in 1988-90. Catches are now fairly stable at about 5 tonnes blacklip and 3-4 tonnes greenlip.

3.3.2.2 Ceduna (Subzone 2), Map Codes 2A-J, 3A,B)

As for the Far West, virgin stocks of greenlip were removed in 1968-70 and those of blacklip some 10 years later. Fluctuating catches reflect periodic visits by divers to the region.

3.3.2.3 Streaky Bay (Subzone 3), Map Codes 3C, 4-6, figure3.3)

The increasing catch of blacklip over time and the increasing trend in total effort until 1985 show the gradual transfer of effort in the fishery to this region from further south. The changes in the greenlip catch reflect the stagnation in the fishery until 1978, the increase in effort after licence transferability was granted in 1980 and the gradual decline in productivity since.

3.3.2.4 Elliston (Subzone 4), Map Codes 7-10, 11A,B, figure3.4)

This region is the main abalone-producing area in the Zone. Greenlip virgin stocks were removed mainly from 1968-70 and blacklip from 1968-73. Overall catches have been stable since then, with the exception of smaller inshore stocks.

3.3.2.5 Drummond (Subzone 5), Map Codes 11C, 12A-C, figure3.5)

Early exploitation of abalone was erratic depending on the state of the boat ramp. Since then the populations of both species have seriously declined to low levels.

3.3.2.6 Coffin Peninsula (Subzone 6), Map Codes 13,14,15A, figure 3.6)

Greenlip stocks were exploited from 1968, with later discovery of new areas, whereas exploitation of blacklip has increased gradually. The decline of greenlip is widespread over the whole peninsula.

3.3.2.7 Sleaford (Subzone 7), Map Codes 15B, 16, 17A,B, 18A,B, figure 3.7)

Over three decades blacklip has shown steady exploitation levels whereas greenlip has shown a slow long-term decline.

3.3.2.8 Thistle Island (Subzone 8), Map Codes 17C, 18C-L, 19, figure 3.8)

Abalone production for both species has shown little change over three decades.

3.3.2.9 North Banks (Subzone 9), Map Codes 20A-C

Numerous small populations of blacklip and greenlip were exploited in the early days of the fishery but never recovered after removal of virgin stocks. More recent surveys of divers as far north as Cowell showed some small stocks off Cowell and to the south off Point Driver.

3.3.2.10Far West (Mapcode = 1A, 1B, 1C, 1D, 1E)

The main reefs fished are D'Entrecasteaux Reef and Nuyts Reef. These are mainly gneissic with limestone caps on some islands. Blacklip, but rarely greenlip, occurs on mainland coasts.

During the 1970s, surveys along the mainland coast as far as Eucla were conducted by divers. Populations of stunted abalone were found at depths of 10-25 m on sheet limestone off Eucla. Small catches of greenlip have been taken off Point Bell and Pt Sinclair but greenlip populations are largely limited to the offshore islands probably because colder, more productive bottom waters do not reach the mainland coast (Vaux 1970).

The mean annual catches from 1971-8 were 1.5 tonnes greenlip, but no blacklip, indicating a low level of exploitation before 1983. The catches of both species show cyclic changes in catch, possibly related to cycles of recruitment.

3.3.2.11D'Entrecasteaux Reef (Mapcode = 1D)

A large area of submerged gneissic reef. Estimated productive reef area is 1.5 km^2 mainly on the northern side of the main reef at depths of 10-20 m. The reef is 45 km from the nearest launching point at Fowlers Bay, so is lightly exploited. The greenlip population was surveyed last in 1980. No trends in the catch of blacklip or greenlip are evident and current catches appear sustainable at current levels.

3.3.2.12 Denial Bay (Mapcode = 2A, 2B, 2G, 2H, 2F)

Greenlip catches are about 5 tonnes per year and have declined from the 1980's. Blacklip catches have fluctuated markedly between about 1-10 tonnes with catches increasing in recent years.

3.3.2.13 St Francis Isles (Mapcode = 2C, 2D, 2E, 2J)

The main exploited reefs are around St Francis Is. and isles to the north, with an estimated reef area of 1.5 km^2 on gneissic bottom. A small population is off Masillon Is. The reefs were last surveyed for greenlip in 1980. There are extensive areas of low relief rock and sand at 15-20 m depth, colonised by *Amphibolis* seagrass beds which evidently supply an abundance of drift epiphytic algal food.

Mean annual catches for 1971-8 were 4.5 tonnes greenlip, but no blacklip. Catches fluctuate with an apparent 6-yr cycle but without evidence of a long-term decline.

3.3.2.14 North of Point Brown (Mapcode = 3A)

The main populations are at Pt Brown and Eyre Is. Mean catches for 1971-8 were 0.3 tonnes blacklip and 0.5 tonnes greenlip. Exploitation was low before 1985. Blacklip catches, historically low, have declined since the mid-1980s. Greenlip catches have been sporadic without a long-term trend.

3.3.2.15 Franklin Isles (Mapcode = 3B)

Substratum is gneissic. Greenlip are mostly taken along the weedline at depths of 10-16 m (reef area <1 km^2). Mean annual catches in 1971-8 were 0.6 tonnes blacklip and 1.7 tonnes greenlip. Since then catches have been irregular and possibly cyclic, but apparently sustained.

3.3.2.16 Cape Bauer – Olives Island (Mapcode = 3C)

The mean annual catch for 1971-8 was 0.2 tonnes blacklip and 0.7 tonnes greenlip over a reef area of <1 km^2. The blacklip catch since then has been sustained but the greenlip catch has shown a long-term decline to a current level of <1 t yr^{-1}.

3.3.2.17 High Cliff (Mapcode = 4A, 4B, 4C)

Reef is gneissic with an area of <1 km^2. Mean annual catches for 1971-8 were 0.7 tonnes blacklip and 9.5 tonnes greenlip. The catch of blacklip then increased substantially. However, whereas the blacklip catch has been sustained, that of greenlip has declined by 73%.

3.3.2.18 Sceale Bay (Yanerbie) (Mapcode = 4D, 4E)

Reef is gneissic with a reef area of about 1 km^2. The mean annual catch in 1971-8 was 1.6 tonnes for blacklip and 2.8 tonnes for greenlip. Close inshore at Yanerbie there are extensive areas of stunted greenlip. The catches for both blacklip and greenlip have declined substantially in the last two decades, blacklip by 70% and greenlip by 90%. Growth rates and fecundity of greenlip are described from Yanerbie and the southern side of Sceale Bay off Cape Blanche on limestone bottom by Shepherd et al. (1992a,b). Egg-per-recruit (EPR) analyses by Shepherd and Baker (1998) suggest that overfishing of the greenlip stocks has occurred in Sceale Bay.

3.3.2.19 Cape Blanche (Mapcode = 4F, 4G, 4H,Illustrated summary available)

Reef is gneissic with a reef area of <2 km^2. The mean annual catch in 1971-8 was 3.6 tonnes for blacklip and 5.6 tonnes for greenlip. Catches of both species increased substantially in the early 1980s but that of greenlip has declined sharply since the high catches of 1987-90; by 1998 the decline was 65%. Divers report that the population of greenlip at the Cape itself declined steeply after about 1991.

3.3.2.20 Point Labatt (Mapcode = 5A)

Gneissic reef extends to about 15 m depth with a reef area of < 1 km^2. A marine reserve over a section of the area comprising mainly blacklip habitat was declared in 1988. The mean annual catch of blacklip from 1971-8 was 1.7 tonnes and of greenlip was 2.8 tonnes. Blacklip catches have been stable since then but greenlip catches have declined from 1986-1998 from about 5 tonnes to 1.4 tonnes.

3.3.2.21 Radstock – Baird Bay (Mapcode = 5B, 5C, 5D, 5E, 5F)

Gneissic reefs with a limestone cap extend along this coast to depths of 25 m and extending over an area of 1-2 km^2. Extensive populations of greenlip occur at the entrance of Baird Bay to shallow depths of 1-2 m. Mean annual blacklip catches in 1971-8 were 3.1 t blacklip and 11.2 tonnes greenlip. The blacklip catch has increased substantially since then and that of greenlip temporarily. The greenlip catch has declined by 35% since 1982.

3.3.2.22 Venus Bay (Mapcode = 6A, 6B, 6C, 6D)

The rocky substratum is mainly limestone extending over an area of about 1 km^2 and to a depth of about 22m. The mean annual catch from 1971-8 was 1.5 tonnes blacklip and 2.1

tonnes greenlip. Catches of both species increased sharply in the 1980s and fluctuated during the 1990s without sign of decline. The area is a significant mainstay of the blacklip fishery.

3.3.2.23 Anxious Bay (Bonanza) (Mapcode = 6E, 7A, 7B)

Blacklip habitat is confined to inshore areas whereas greenlip habitat is on extensive limestone bottom extending from the southern boundary of the area to Talia Caves in the north to a depth of 25 m and covering an area of > 10 km^2. The mean annual catch from 1971-8 was 2.9 tonnes blacklip and 9.5 tonnes greenlip. The catch of blacklip has increased and been sustained since then, but not that of greenlip. The level or undulating limestone bottom was ideal for underwater cages which were extensively used here from about 1975. By 1980 divers noted that greenlip were becoming 'thinner' and that recovery of numbers was decreasing from year to year. By 1986 the catch had declined by 80% and has remained low ever since.

3.3.2.24 "The Watchers" (Mapcode = 8C, 8D)

Reef is gneissic extending to a depth of 25 m. Blacklip habitat goes to about 18 m and greenlip habitat is mainly at 18-25 m depth on the northern and eastern side of the emergent reef. Mean annual catch from 1971-8 was 10.5 tonnes blacklip and 7.5 tonnes greenlip. Both blacklip and greenlip catches have declined during the succeeding two decades, blacklip by 80% and greenlip by 85%. Numerous divers have confirmed overfishing of the reef.

3.3.2.25 Waldegrave Area (Mapcode = 8A, 8B, 8E, 8Q, figure 3.10)

The substratum is gneissic outcropping around Waldegrave Is, but there are extensive limestone reefs in southern Anxious Bay with a reef area of about 1 km^2. The mean annual catch from 1971-8 was 8.8 tonnes blacklip and 25.9 tonnes greenlip. Since then the blacklip catch has been sustained at about the same level but the greenlip catch has declined slowly. By 1998 the greenlip decline was 65%. Recent estimates of F (=0.4) suggest that fishing intensity is still high. Growth and fecundity of greenlip in southern Anxious Bay is described by Shepherd et al. (1992a,b).

3.3.2.26 Waterloo Bay (Mapcode = 8, 8H, 8J, 8K, 8L, 8M)

The substratum in the Bay is limestone over an area of about 1.5 km^2 and comprises reef of high, moderate and low relief. The annual mean catch from 1971-8 was 5.4 tonnes blacklip and 9.5 tonnes greenlip. The collapse of the greenlip fishery in 1979, the closure from 1982-6 and the subsequent catch is described by Shepherd and Partington (1995). The Bay was closed to fishing from Oct. 1995 and has been reopened periodically since. The growth of both species is described by Shepherd and Hearn (1983). The Bay is the site for ongoing experiments to reverse an apparently fishing-induced reduction in growth rate of both species in the Bay since about 1970.

3.3.2.27 Elliston Cliffs (Mapcode = 8F, 8G, 8N)

A limestone substratum at the base of the cliffs is habitat for small populations of blacklip and greenlip. The mean annual catch from 1971-8 was 1.2 tonnes blacklip and 2.4 tonnes greenlip. The blacklip catch since then has been sustained but the greenlip catch has declined by 90%. Some divers report that abalone are stunted here. If so, it is possible that this is a sink population from larval sources within Waterloo Bay where abalone are now stunted.

3.3.2.28 Ward Islands (Mapcode = 9A, 9B)

The substratum is gneissic with some limestone in inshore areas. The main blacklip habitat is on exposed reefs on the western side and greenlip habitat is mainly on the eastern side of the islands. Greenlip reef area is 1.4 km^2. Mean annual catches for 1971-8 were 3.0 tonnes blacklip and 13.6 tonnes greenlip. Catches of blacklip have increased substantially and those of greenlip have been sustained since. The greenlip population has declined in abundance and recruitment has declined since about 1980 at monitored sites and Shepherd and Baker (1998) warned that overfishing was likely. It is possible that the catch of greenlip has been maintained due to the extension of the fishery to deeper reefs offshore and around Little Ward I. Greenlip growth is described by Shepherd et al. (1992a) and Shepherd and Triantafillos (1997), and fecundity by Shepherd (1987).

3.3.2.29 "The Hotspot" – East (Mapcode = 9D)

The substratum is gneissic and extends to a depth of 30 m for about 1 km^2 to the north east of the three breaks where the Hotspot Reef is emergent. The mean annual catch for 1971-8 was 1.3 tonnes blacklip and 20.2 tonnes greenlip.

3.3.2.30 "The Hotspot" – West (Mapcode = 9C)

The substratum is shallow gneissic reef comprising submerged valleys and hills with few abalone. The mean annual catch for 1971-8 was 0.3 tonnes blacklip and 2.9 tonnes greenlip. Catches of blacklip have increased in the last decade and those of greenlip have remained

about the same. In the 1990s additional greenlip sub-populations were found on the southern side of the Hotspot at depths of 20-30 m on offshore lumps and reefs.

3.3.2.31 "The Hotspot" (Mapcode = 9C, 9D)

Overall catches of blacklip have increased substantially whereas those of greenlip have remained about the same. Growth rates are given by Shepherd and Triantafillos (1997) and fecundity by Shepherd (1987).

3.3.2.32 Flinders Island (Gem Reef) (Mapcode = 9E, 9F, 8P)

The substratum is gneissic. Inshore reefs are blacklip habitat and offshore lumps and reefs are greenlip habitat. In some inshore areas there are a few more or less stunted greenlip populations. The mean annual catch for 1971-8 was 2.5 tonnes blacklip and 15.7 tonnes greenlip. Blacklip catches have increased over the succeeding two decades whereas that of greenlip has declined by 40%.

3.3.2.33 Flinders Island (SE Side) (Mapcode = 9G, 9H)

The substratum is gneissic. Blacklip populations occur inshore. Greenlip are limited to several small populations along the south east coast and in Groper Bay. The mean annual catch for 1971-8 was 0.5 tonnes blacklip and 7.1 tonnes greenlip. The catch of both species has increased slightly in the last two decades. Some greenlip populations are monitored annually and Shepherd et al. (1999) in the stock assessment of that year warned that abundance of spawning stock in the census areas was critically low.

3.3.2.34 Pearson Island (Mapcode = 10C)

The island is gneissic. Blacklip occur on inshore reefs and greenlip on sloping granite to depths of 40 m. The island is 60 km from the mainland and visited annually by few divers. The mean annual catch for 1971-8 was only 0.7 tonnes greenlip. Catches of blacklip are still sporadic and the catch of greenlip shows a slow decline since 1982. The growth rate is described by Shepherd and Triantafillos (1997), and fecundity by Shepherd (1987).

3.3.2.35 Tungketta (Mapcode = 10A, 10B)

The coast is aeolianite limestone and abalone habitat is close inshore below the cliffs. The mean annual catch for 1971-8 was 1.0 tonnes blacklip and 0.3 tonnes greenlip. In the last two decades the blacklip catch has been sustained whereas that of greenlip has declined to a low level.

3.3.2.36 Sheringa Bay (Mapcode = 11A, figure 3.11)

The substratum is limestone, with blacklip habitat close inshore and greenlip further offshore. The largest abundances of blacklip are at the north western and south eastern ends of the Bay. The mean annual catch for 1971-8 was 45.5 tonnes blacklip and 4.1 tonnes greenlip. The blacklip catch has declined since 1985 by 40%, and the greenlip catch by 65% since 1979.

3.3.2.37 Mt Misery – Kiana Cliffs (Mapcode = 11B , 11C)

The substratum is limestone. Abalone habitat is close inshore below the cliffs. The mean annual catch for 1971-8 was 7.8 tonnes blacklip and 3.4 tonnes greenlip. In the last two decades the catch of blacklip has been sustained but that of greenlip has declined by 90%.

3.3.2.38 Drummond (Mapcode = 12A, 12B, 12C)

The substratum is gneissic with some limestone reefs inshore and in Hall Bay. Reef area extends over about 7 km^2 to a depth of 30 m. Most abalone are taken to the west and south of the Point, but some greenlip habitat extends inshore to Kiana Cliffs. The mean annual catch from 1971-8 was 33.4 tonnes blacklip and 20.6 tonnes greenlip. Both species have suffered a major decline in catch since about 1981. Blacklip has declined by 70% since 1985 and greenlip by >90% since 1979. A recent estimate of the fishing mortality is 0.4 (unpublished data S.A.Shepherd) , indicating that fishing intensity is still high. Growth rates of greenlip are given by Shepherd and Triantafillos (1997).

3.3.2.39 Frenchmans (Mapcode = 13A, 13B, 13C)

The substratum is gneissic on Frenchman's reef but limestone elsewhere. Blacklip habitat is inshore below the cliffs and greenlip habitat mostly at 10-20 m depth offshore on flat limestone bottom. About 4 km^2 of the latter habitat occurs off Farm Beach and this habitat extends patchily to Coles Point where there is good habitat also. The mean annual catch for 1971-8 was 1.0 tonnes blacklip and 3.7 tonnes greenlip. In the last two decades the blacklip catch has been sustained at 2-3 tonnes yr^{-1}, but the greenlip catch has declined by >80%. In 1979 divers had reported that the limestone reefs off Farm Beach had been largely 'cleaned out' by divers with cages. One diver reported that the 1995 phytoplankton bloom killed many of the remaining greenlip off Farm Beach.

3.3.2.40 Sir Isaac – Reef Head (Mapcode = 13D, 13E, 13F, figure 3.12)

The substratum is gneissic and blacklip and greenlip habitat extends patchily over an area of >2 km^2 at depths to 20 m. The mean annual catch for 1971-8 was 6.8 tonnes blacklip and 13.9 tonnes greenlip. The catch of blacklip has declined by 50% since 1985 and that of greenlip by 85%. Recent reports of divers are that greenlip have nearly disappeared from deeper water and are now found mainly at 2-13 m depth.

3.3.2.41 Boardinghouse Bay – Pt Whidbey (Mapcode = 14A, 14B)

The substratum is not known. The mean annual catch for 1971-8 was 0.6 tonnes blacklip and 4.4 tonnes greenlip. In the last two decades the blacklip catch has been sustained at about 3 tonnes yr^{-1}, but the greenlip catch has declined by >85%.

3.3.2.42 Misery Bay – Black Rocks (Mapcode = 14C, 14D, figure 3.13)

The substratum in Misery Bay is gneissic. At Black Rocks where there is extensive greenlip habitat the substratum is mainly limestone but basaltic at 20 m depth. The mean annual catch from 1971-8 was 2.8 tonnes blacklip and 27.8 tonnes greenlip. The blacklip catch has increased substantially to >10 tonnes yr^{-1}, but the greenlip catch has declined by >90%. Divers report that greenlip have largely disappeared from reefs off Black Rocks, except inshore where some stunted stocks persist.

3.3.2.43 Whidbey Isles (Mapcode = 14E)

Abalone habitat is mainly around Perforated Is. Only blacklip was taken during 1971-8 with a mean annual catch of only 76 kg yr^{-1}. In 1983 a large deep reef extending south from the northern end of the island was discovered by divers G. Ford and I. Wakelin (and named Wakeford Reef). Large catches were taken in the next six years, but the catch has now almost entirely failed. Blacklip catches have also declined by 80% since 1985.

3.3.2.44 Greenly Island (Mapcode 14F)

Very few abalone have been taken historically, and none since 1993.

3.3.2.45 Pt Avoid (Mapcode 15A, figure 3.14)

The substratum is mainly gneissic with limestone reefs inshore around Golden Is. Blacklip habitat is inshore and greenlip habitat offshore mainly between Price and Golden Is extending to a depth of nearly 30 m, and also northward patchily off Pt Avoid. The total area of greenlip habitat is 13 km^2. The mean annual catch in 1971-8 was 4.8 tonnes blacklip and 49.1 tonnes greenlip. The blacklip catch has declined only slightly from historic catches of about 10 tonnes yr-1, but the greenlip catch has declined steeply by >90% and is now found only around Price Is. and Golden Is. Growth rates for greenlip are given by Shepherd and Triantafillos (1997).

3.3.2.46 D'Anville Bay – Liguanea Island (Mapcode = 15B, 16A, 16B)

The substratum is gneissic and abalone habitat is mainly at the foot of cliffs falling steeply into the sea. The mean annual catch for 1971-8 was 1.2 tonnes blacklip and 5.8 tonnes greenlip. Since then catches of blacklip have stabilised at 1-2 tonnes yr-1 but greenlip have declined by 70%. The deepest known populations of greenlip occur on the east coast of Liguana Is. where they are recorded to 48 m depth.

3.3.2.47 Fishery Bay (Mapcode = 16C, figure 3.15)

The substratum is gneissic, with blacklip at shallower depths and greenlip at depths of 10-30 m. Mean annual catches for 1971-8 were 5.5 tonnes blacklip and 18.3 tonnes greenlip. The catches of both blacklip and greenlip have declined more or less continuously since then.

Even in 1979 divers recorded that the previously populations of greenlip had by then become sparser. Greenlip have declined by 80% over the last two decades and blacklip by 75% since 1985.

3.3.2.48 Sleaford Bay (Mapcode = 17A, 17B)

The substratum is presumably gneissic. The mean annual catch for 1971-8 was 0.4 tonnes blacklip and 2.4 tonnes greenlip. The catch for blacklip has increased for blacklip to about 2 tonnes yr^{-1} and remained around 2 tonnes yr^{-1} for greenlip.

3.3.2.49 Neptune Islands (Mapcode = 17C)

The substratum is gneissic. The mean annual catch for 1971-8 was 0.6 tonnes blacklip and 3.6 tonnes greenlip. Catches over the succeeding two decades have fluctuated around the same average for blacklip and around 2-3 tonnes yr^{-1} for greenlip.

3.3.2.50 West Point (Mapcode = 18A, 18B, figure 3.16)

The substratum is gneissic. Blacklip habitat is close inshore and greenlip habitat at the base of cliffs where rock meets sand. The mean annual catch for 1971-8 was 2.0 tonnes blacklip and 8.8 tonnes greenlip. In the succeeding two decades the annual catch of blacklip has fluctuated around 3-4 tonnes and that of greenlip around 4-5 tonnes. Divers report that most greenlip now come from Area 18A; there were formerly populations in the bay on the north side of Williams Is. but these have now gone.

3.3.2.51 Southern Thorny Passage (Mapcode = 18C, 18D, 18E, 18F, figure 3.17)

The substratum is mainly gneissic with flat limestone substratum in parts of Thorny Passage and between Hopkins and Thistle Is (called the Gap). The mean annual catch for 1971-8 was 6.9 tonnes blacklip and 36.4 tonnes greenlip. The blacklip catch has increased marginally since then and the greenlip catch has remained about the same.

The overwhelming majority of the catch comes from the Gap, which is thus a substantial contributor to the Western Zone fishery for greenlip.

3.3.2.52 The Gap (Mapcode = 18F,figure 3.18)

See above for Southern Thorny Passage.

3.3.2.53 Thistle Island (Mapcode = 18G, 18H, 18J, 18K, 18L, figure 3.19)

See above for Southern Thorny Passage.

3.3.2.54 Northern Thorny passage (Mapcode = 19A, 19B, 19C)

The substratum is usually gneissic inshore with extensive limestone habitat for greenlip offshore to about 20 m depth. The mean annual catch for 1971-8 was 0.6 tonnes blacklip and 3.6 tonnes greenlip. The catch of blacklip has fluctuated in recent years due to closures during periods of high infection from Perkinsus. Most of the greenlip production has come from Taylor Is. on the south east and south west coasts. Divers report a slow decline in the catch since the high catches of 1984-8. The growth rate, fecundity and recruitment of greenlip is described from Taylor Is. by Shepherd et al. (1992a,b,c), Shepherd and Triantafillos (1997) and an EPR analysis is given by Shepherd and Baker (1998).

3.3.2.55 Dangerous Reef and Porter Rock (Mapcode = 19D, 19E)

The substratum is gneissic and the main catches have come from Porter Rock, a complex area of reef. The mean annual catch in 1971-8 was 0.7 tonnes blacklip and 0.4 tonnes greenlip. Catches have been maintained at these or slightly higher levels in the succeeding two decades.

3.3.2.56 Wedge Island (Mapcode = 19F)

The substratum is gneissic, sometimes capped with limestone. The mean annual catch for 1971-8 was 0.2 tonnes blacklip and 2.9 tonnes greenlip. The catch of blacklip is still very low but that of greenlip has slowly increased to 4-5 tonnes yr^{-1}. The greenlip catch is taken almost entirely from the north east coast and around North Is.

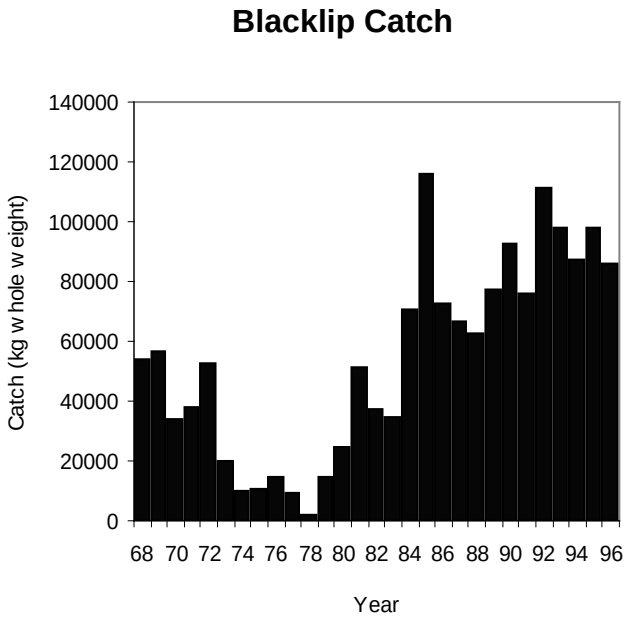
3.3.2.57 Lower West Spencer Gulf (Mapcode = 20A , 20C)

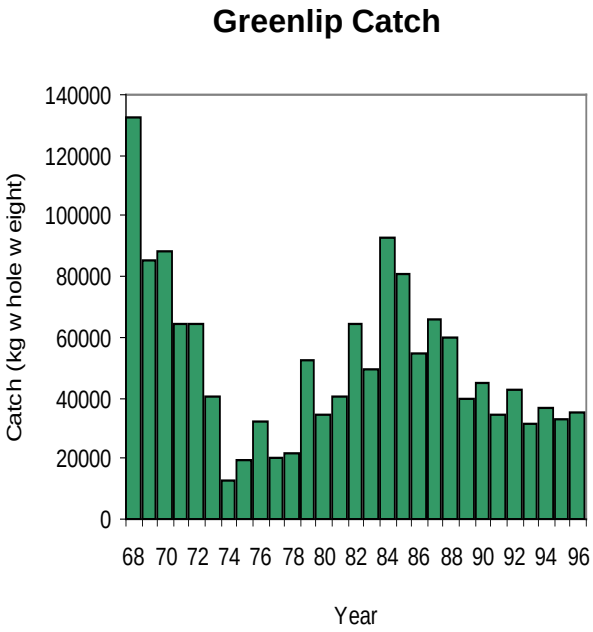
The substratum is mainly gneissic. Numerous populations of greenlip occurred along this coast but were taken in the late 1960s and never recovered. The mean annual catch for 1971-8 was 0.9 tonnes greenlip only. Blacklip are very sparse. Studies by J.King (unpublished) of a greenlip population north of Lipson Cove showed very slow growth rates and an apparent high natural mortality rate of 0.6. These populations have been surveyed by divers but are unproductive.

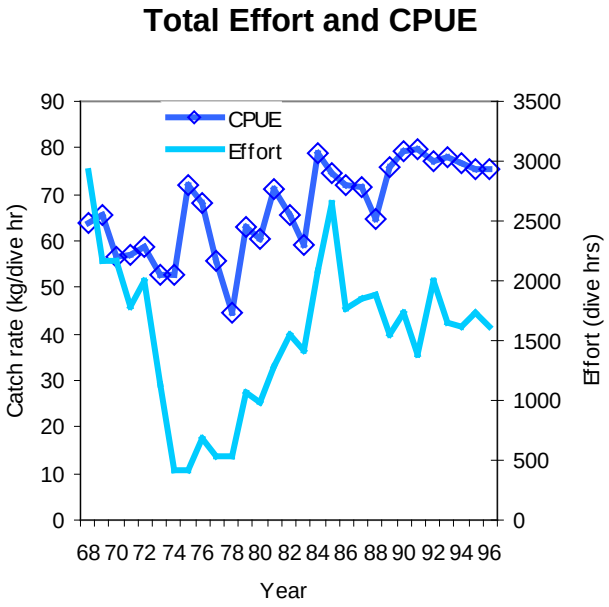
3.3.2.58 Sir Joseph Banks Group (Mapcode = 20B)

The substratum is gneissic around some islands and limestone around others. The mean annual catch was 0.7 tonnes blacklip and 3.6 tonnes greenlip for 1971-8. Catches in the succeeding two decades have been low and sporadic.

Figure 3.3: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hours) and catch per unit effort (kg per diver hr) at Streaky Bay (Subzone 3) from 1968 to 1996.

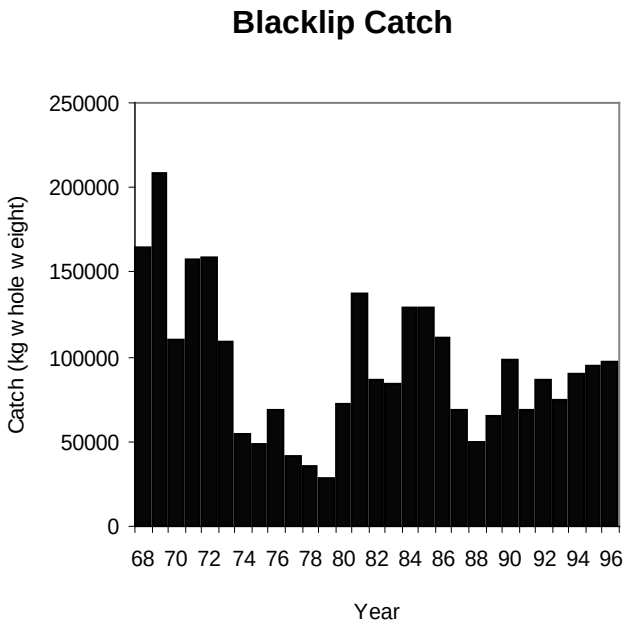


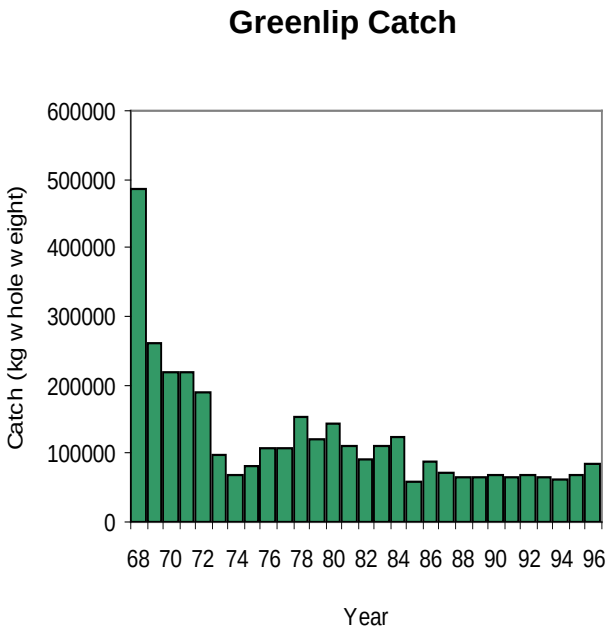


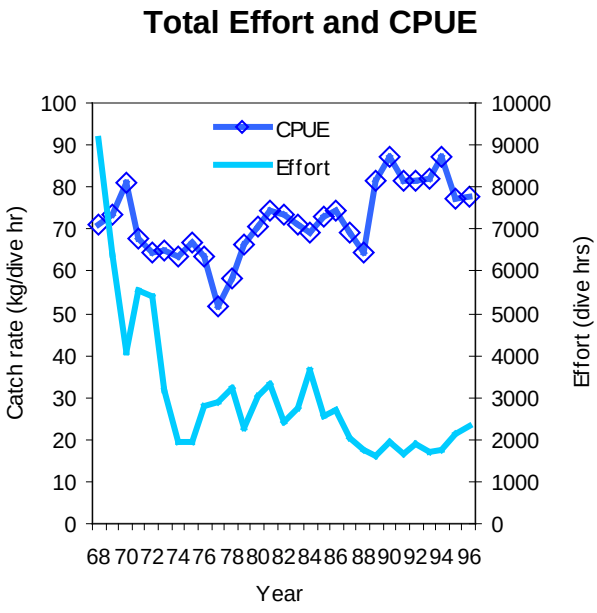


YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
68	54252	132396	186648	2925	63.8
69	56994	85185	142179	2170	65.5
70	33906	88527	122433	2165	56.6
71	37776	64086	101862	1790	56.9
72	52767	64218	116985	1993	58.7
73	19671	40329	60000	1135	52.9
74	9768	12465	22233	422	52.7
75	10476	19221	29697	412	72.1
76	14739	32373	47112	691	68.2
77	9264	20055	29319	528	55.5
78	2049	21858	23907	537	44.5
79	14718	52728	67446	1070	63.0
80	24834	34644	59478	985	60.4
81	51186	40653	91839	1291	71.1
82	37182	64461	101643	1546	65.7
83	34620	49623	84243	1424	59.2
84	70403	93060	163463	2076	78.7
85	116170	80888	197058	2650	74.4
86	72548	55025	127573	1768	72.2
87	66766	65955	132721	1851	71.7
88	62556	59770	122326	1891	64.7
89	77258	39747	117005	1543	75.9
90	92374	44912	137286	1731	79.3
91	76279	34342	110621	1388	79.7
92	111442	42304	153746	1993	77.1
93	97834	31500	129334	1656	78.1
94	87313	36320	123633	1612	76.7
95	98313	32802	131115	1741	75.3
96	86271	35304	121575	1614	75.3

Figure 3.4: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Elliston (Subzone 4) from 1968 to 1996.

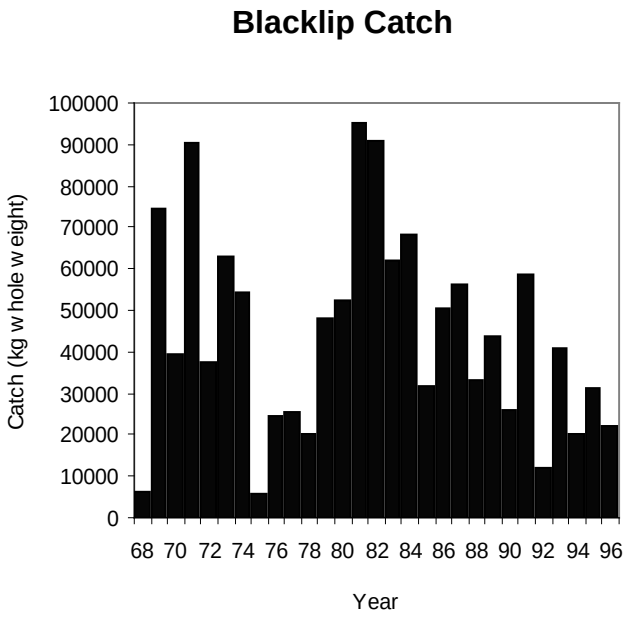


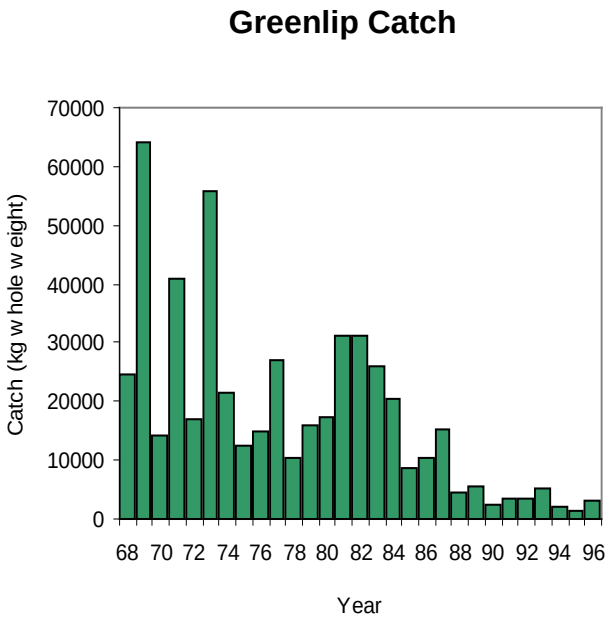


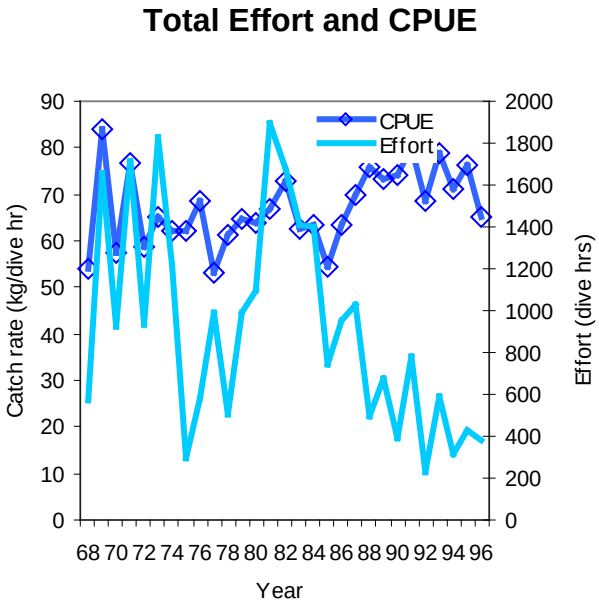


YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
68	164889	484776	649665	9142	71.1
69	209037	259368	468405	6386	73.4
70	110160	218430	328590	4060	80.9
71	157863	218019	375882	5547	67.8
72	158811	190512	349323	5403	64.7
73	108552	97791	206343	3187	64.7
74	54261	69378	123639	1943	63.6
75	48315	80598	128913	1934	66.7
76	68325	108813	177138	2781	63.7
77	41577	107478	149055	2893	51.5
78	36012	152838	188850	3235	58.4
79	28875	121968	150843	2267	66.5
80	72753	142002	214755	3037	70.7
81	137115	109692	246807	3325	74.2
82	86952	89823	176775	2412	73.3
83	83670	112230	195900	2750	71.2
84	128582	123630	252212	3640	69.3
85	128823	57462	186285	2545	73.2
86	111912	89157	201069	2701	74.5
87	69013	72498	141511	2048	69.1
88	49457	65031	114488	1775	64.5
89	65154	66294	131448	1614	81.5
90	98478	69439	167917	1927	87.1
91	68901	66322	135223	1662	81.4
92	86868	68114	154982	1904	81.4
93	74349	63789	138138	1690	81.8
94	90301	62603	152904	1755	87.1
95	94998	70026	165024	2142	77.0
96	97590	83423	181013	2324	77.9

Figure 3.5: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hours) and catch per unit effort (kg per diver hour) at Drummond (Subzone 5) from 1968 to 1996.

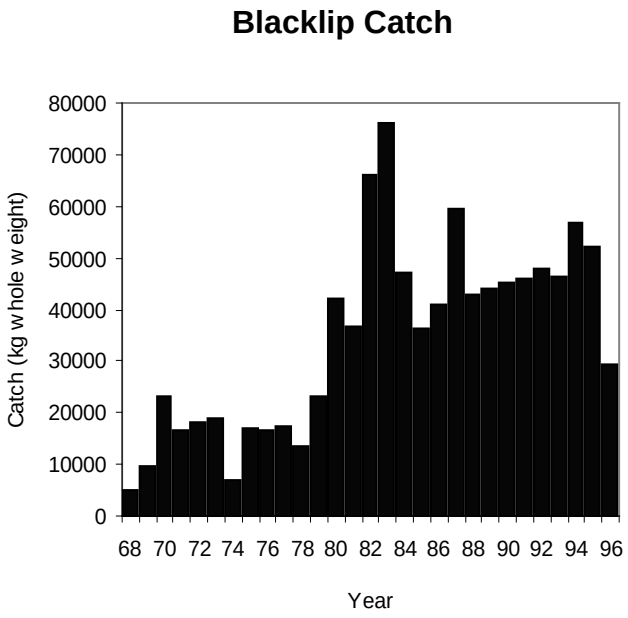


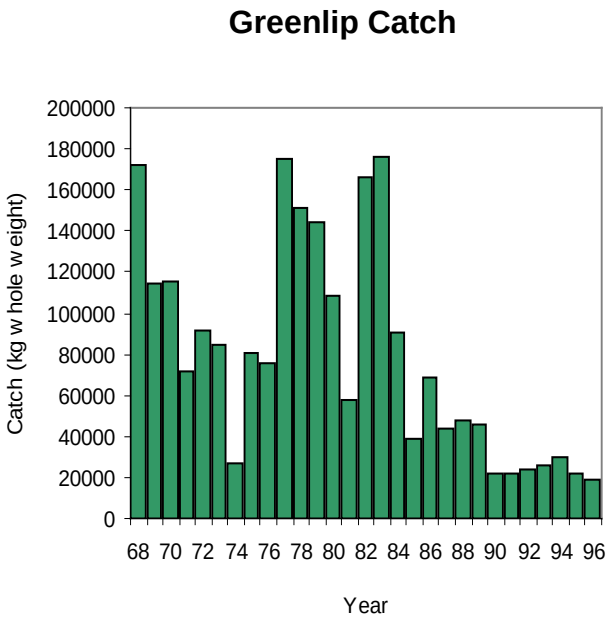


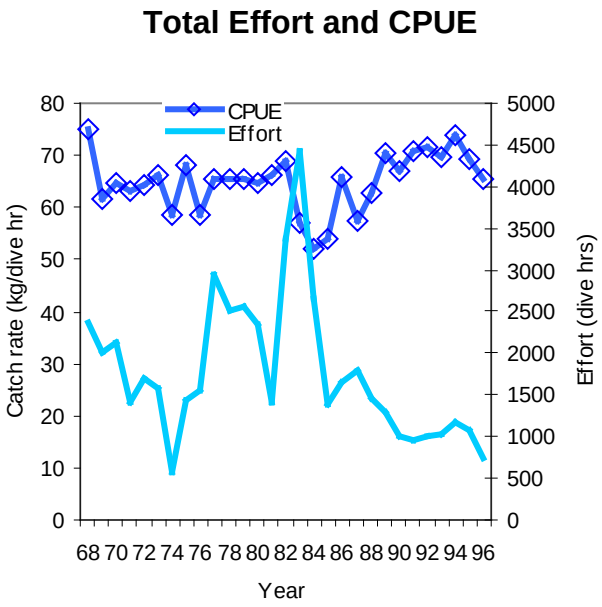


YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
68	6225	24564	30789	569	54.1
69	74382	64269	138651	1655	83.8
70	39186	14274	53460	928	57.6
71	90456	40968	131424	1713	76.7
72	37617	17097	54714	933	58.7
73	63099	55767	118866	1829	65.0
74	54189	21615	75804	1218	62.2
75	5973	12459	18432	297	62.2
76	24714	14886	39600	578	68.5
77	25569	26883	52452	990	53.0
78	20223	10419	30642	501	61.2
79	48300	16086	64386	995	64.7
80	52617	17373	69990	1093	64.0
81	95229	31335	126564	1896	66.8
82	90891	31311	122202	1675	73.0
83	62028	26073	88101	1406	62.7
84	68119	20391	88510	1398	63.3
85	31621	8772	40393	741	54.5
86	50377	10225	60602	954	63.6
87	56413	15075	71488	1026	69.7
88	33189	4356	37545	496	75.7
89	43941	5466	49407	675	73.2
90	26127	2451	28578	386	74.0
91	58863	3531	62394	780	80.0
92	12010	3582	15592	228	68.5
93	41040	5349	46389	590	78.7
94	20217	2163	22380	314	71.3
95	31158	1503	32661	428	76.3
96	21935	3162	25097	385	65.2

Figure 3.6: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hours) and catch per unit effort (kg per diver hour) at Coffin Peninsula (Subzone 6) from 1968 to 1996

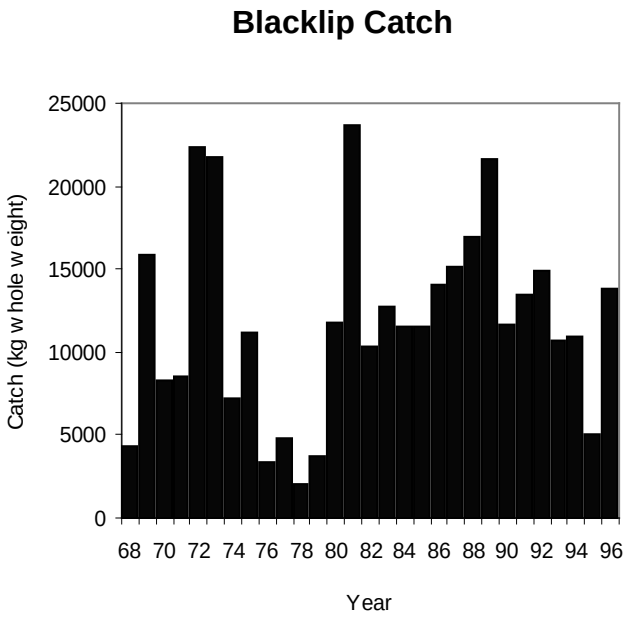


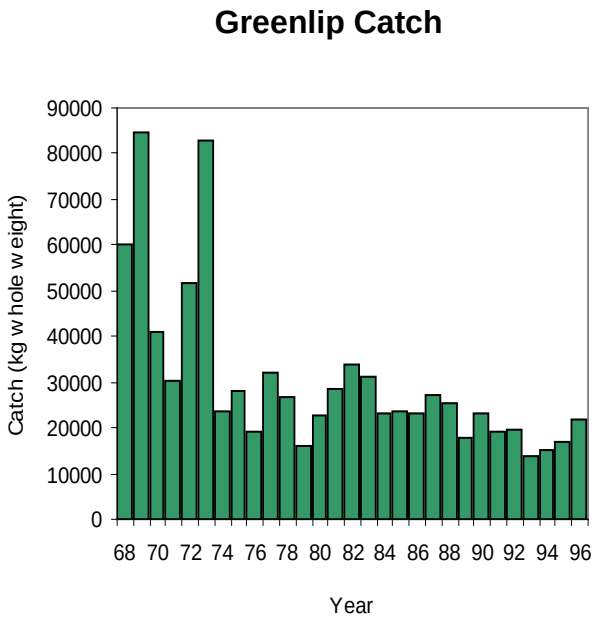


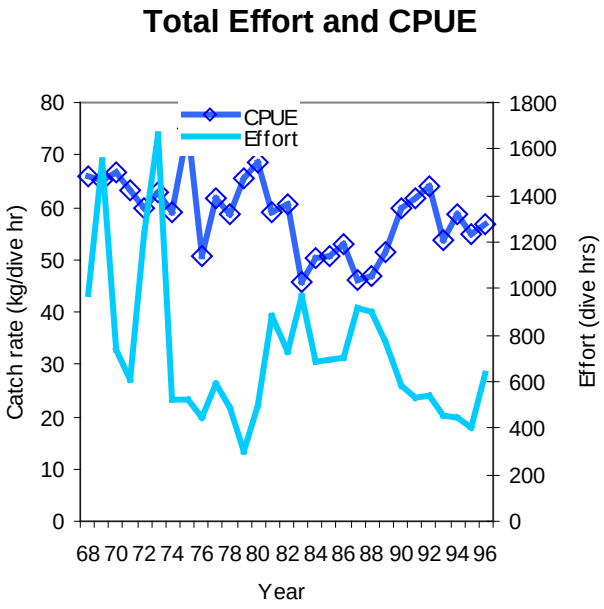


YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
68	4905	172236	177141	2358	75.1
69	9795	114807	124602	2016	61.8
70	23313	114951	138264	2140	64.6
71	16536	71964	88500	1405	63.0
72	18264	91506	109770	1709	64.2
73	19053	84894	103947	1569	66.3
74	6888	26706	33594	575	58.4
75	17103	80154	97257	1427	68.2
76	16698	75144	91842	1565	58.7
77	17337	175440	192777	2954	65.3
78	13395	151572	164967	2519	65.5
79	23256	143946	167202	2550	65.6
80	42300	108927	151227	2340	64.6
81	36612	57489	94101	1417	66.4
82	66120	165822	231942	3364	68.9
83	75949	176028	251977	4416	57.1
84	47106	91015	138121	2646	52.2
85	36204	38808	75012	1389	54.0
86	40879	68400	109279	1662	65.8
87	59647	43878	103525	1803	57.4
88	42917	48171	91088	1452	62.7
89	43906	46247	90153	1281	70.4
90	45180	22095	67275	1006	66.9
91	45827	22290	68117	960	71.0
92	47857	24140	71997	1009	71.4
93	46293	25731	72024	1034	69.7
94	56730	29661	86391	1172	73.7
95	52185	22104	74289	1075	69.1
96	29541	19059	48600	743	65.4

Figure 3.7: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Sleaford (Subzone 7) from 1968 to 1996.

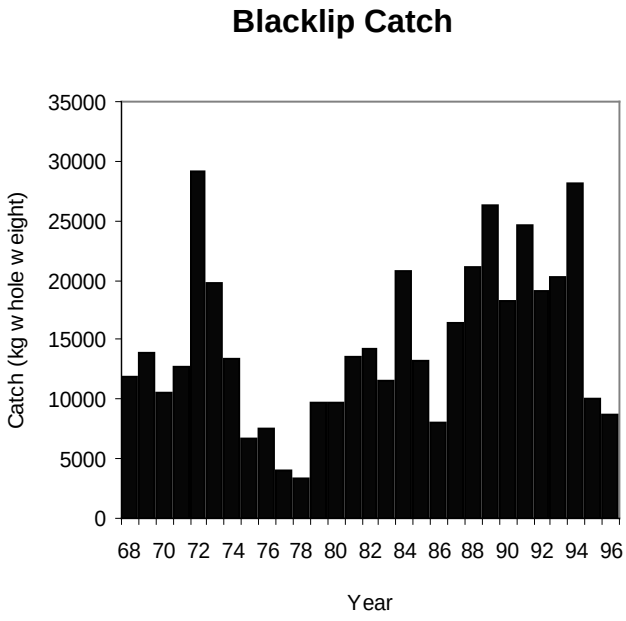


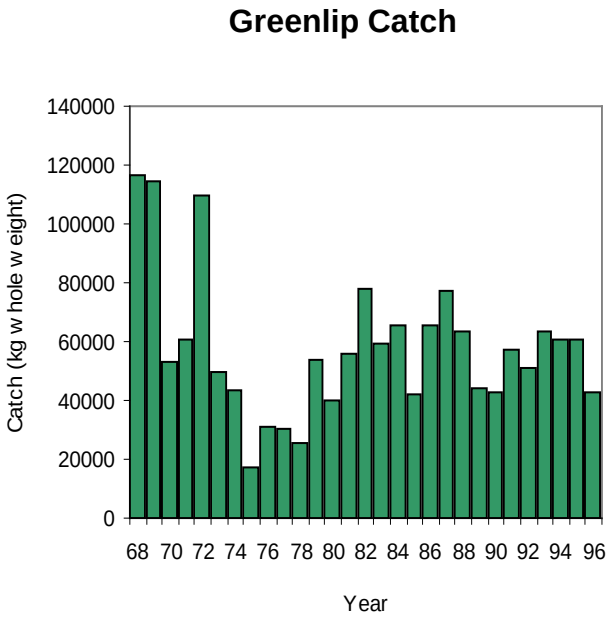


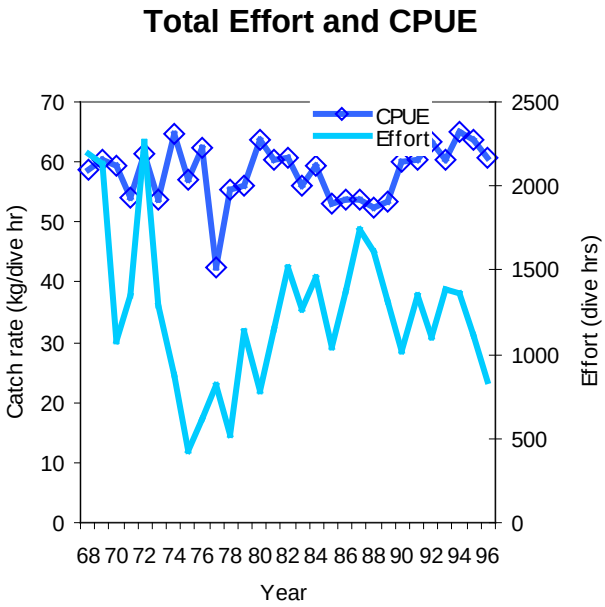


YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
68	4338	60111	64449	977	66.0
69	15864	84768	100632	1548	65.0
70	8268	40914	49182	737	66.7
71	8484	30264	38748	612	63.3
72	22320	51639	73959	1236	59.8
73	21705	82677	104382	1661	62.8
74	7185	23790	30975	523	59.2
75	11124	28068	39192	522	75.2
76	3348	19098	22446	444	50.6
77	4782	31947	36729	594	61.8
78	1998	26622	28620	487	58.8
79	3678	16161	19839	303	65.5
80	11802	22530	34332	500	68.7
81	23637	28452	52089	881	59.1
82	10389	33672	44061	727	60.6
83	12798	31218	44016	966	45.6
84	11488	23058	34546	687	50.3
85	11592	23799	35391	697	50.8
86	14106	23067	37173	703	52.9
87	15134	27036	42170	914	46.1
88	16992	25446	42438	904	46.9
89	21584	17981	39565	770	51.4
90	11697	23172	34869	582	59.9
91	13484	19276	32760	531	61.7
92	14871	19506	34377	538	63.9
93	10679	13746	24425	454	53.8
94	10980	15000	25980	444	58.5
95	5076	17094	22170	405	54.7
96	13831	21981	35812	633	56.6

Figure 3.8:Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Thistle Island (Subzone 8) from 1968 to 1996

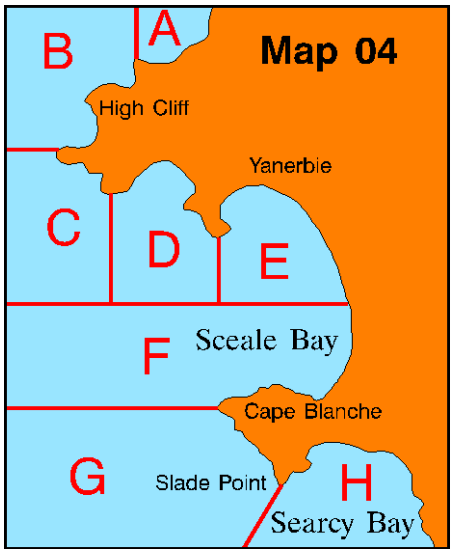


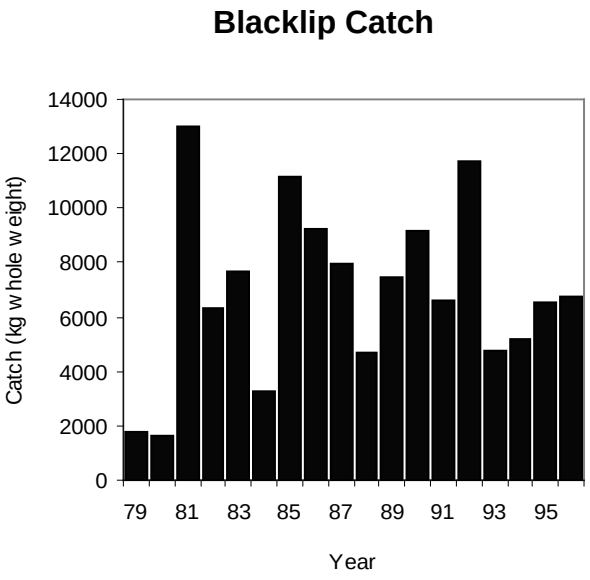


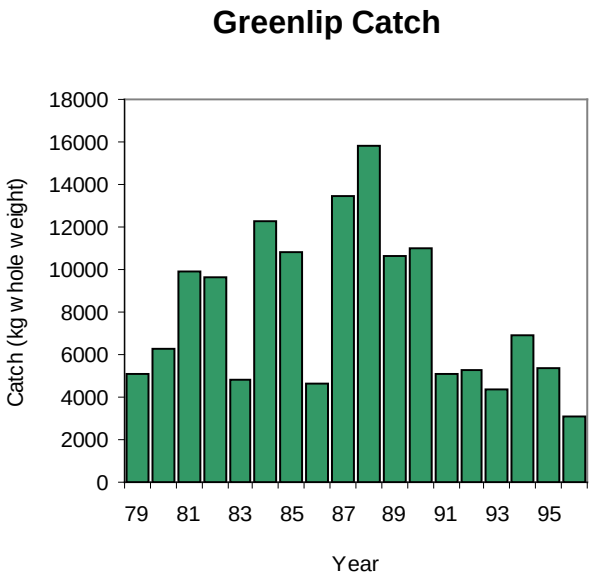


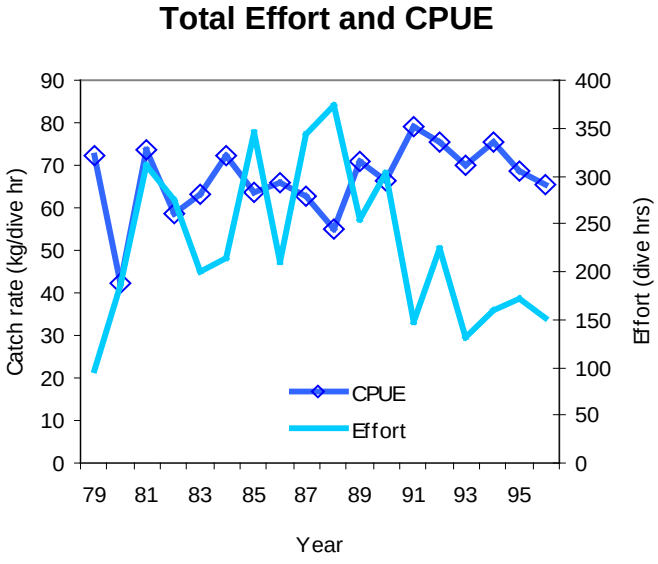
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
68	11859	116514	128373	2188	58.7
69	13941	114795	128736	2135	60.3
70	10518	53079	63597	1073	59.3
71	12702	60399	73101	1354	54.0
72	29091	109650	138741	2267	61.2
73	19710	49314	69024	1287	53.6
74	13392	43725	57117	881	64.8
75	6777	17508	24285	426	57.0
76	7557	31077	38634	620	62.3
77	4029	30414	34443	812	42.4
78	3327	25695	29022	524	55.4
79	9741	53676	63417	1133	56.0
80	9786	40221	50007	786	63.6
81	13482	56136	69618	1150	60.5
82	14208	78042	92250	1520	60.7
83	11574	59418	70992	1266	56.1
84	20685	65832	86517	1453	59.5
85	13243	41754	54997	1039	52.9
86	8079	65826	73905	1373	53.8
87	16390	77049	93439	1740	53.7
88	21169	63397	84566	1611	52.5
89	26239	44211	70450	1316	53.5
90	18183	42855	61038	1017	60.0
91	24585	57058	81643	1351	60.5
92	19028	50925	69953	1103	63.4
93	20238	63678	83916	1389	60.4
94	28194	60431	88625	1360	65.2
95	10077	60792	70869	1110	63.8
96	8665	42501	51166	842	60.8

Figure 3.9: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Cape Blanche (Mapcode 4F, 4G, 4H) from 1979 to 1996.



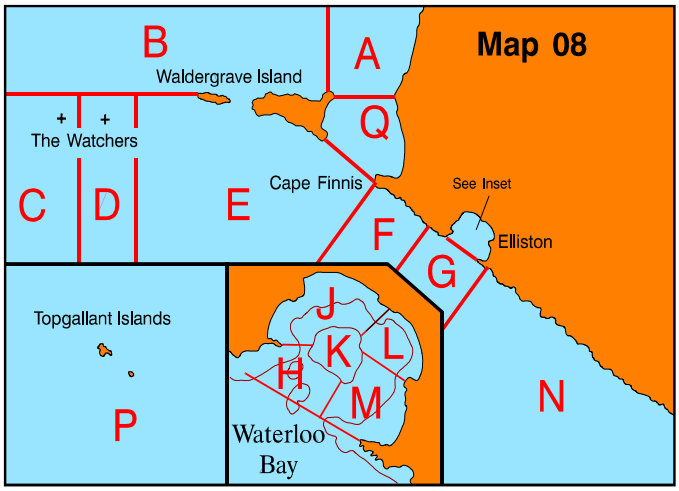


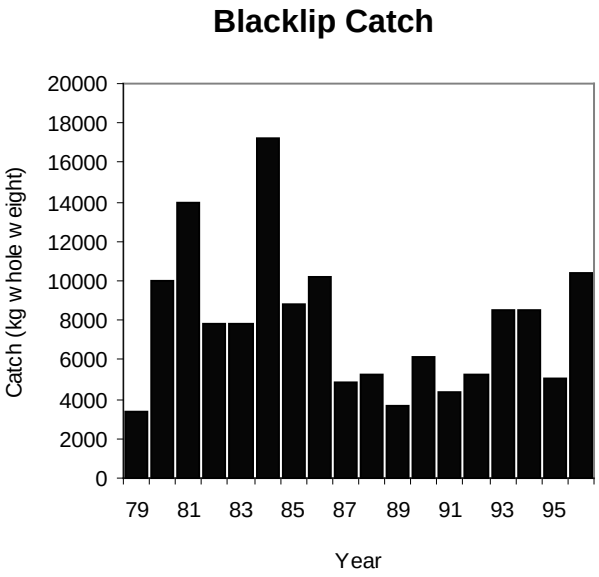


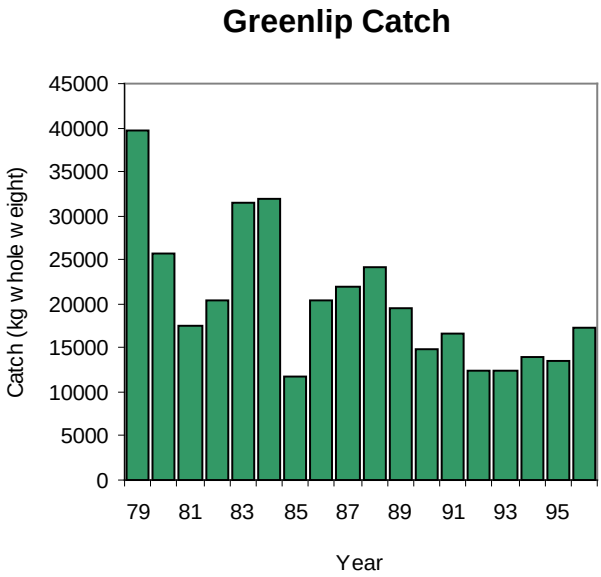


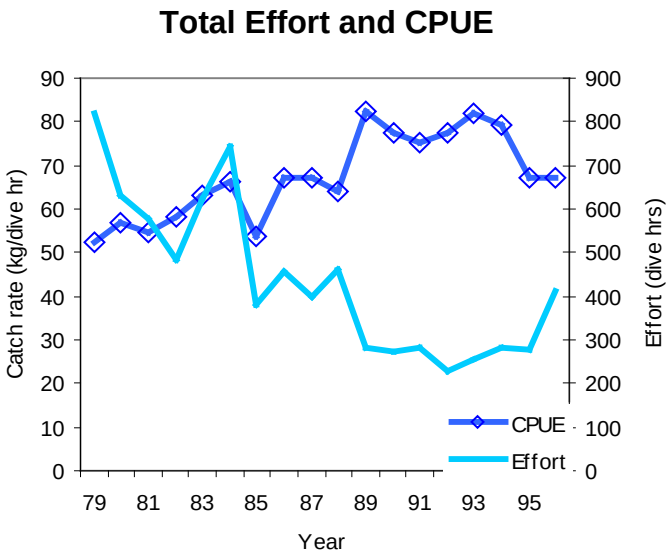
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	1788	5133	6921	96	72.1
80	1641	6237	7878	186	42.4
81	13014	9948	22962	312	73.6
82	6354	9672	16026	274	58.5
83	7704	4839	12543	199	63.0
84	3240	12264	15504	215	72.1
85	11145	10797	21942	346	63.4
86	9246	4641	13887	211	65.8
87	7955	13488	21443	343	62.5
88	4684	15860	20544	373	55.1
89	7486	10645	18131	255	71.1
90	9193	10998	20191	304	66.4
91	6627	5094	11721	148	79.2
92	11749	5244	16993	225	75.5
93	4738	4374	9112	131	69.8
94	5155	6873	12028	159	75.6
95	6534	5319	11853	173	68.7
96	6777	3078	9855	151	65.3

Figure 3.10: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Waldegrave Area (Mapcode 8A, 8B, 8E, 8Q) from 1979 to 1996.



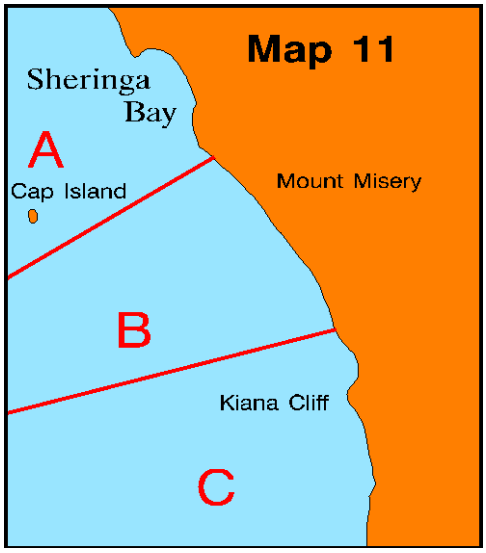


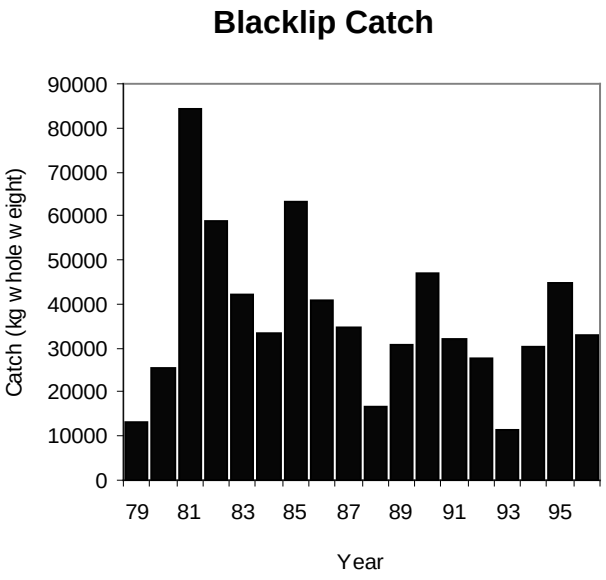


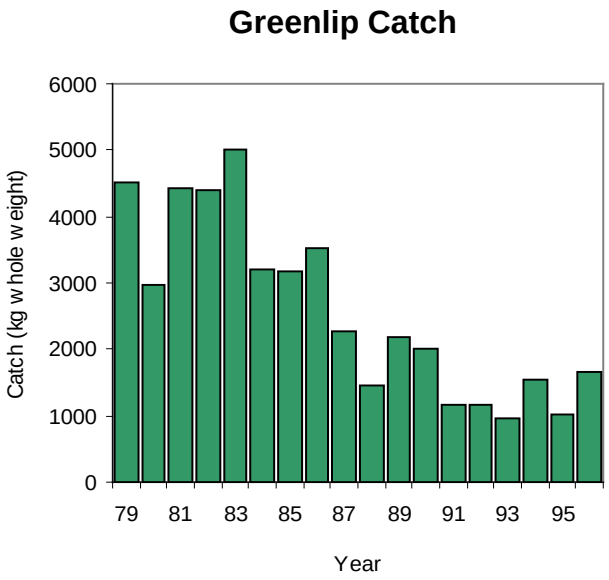


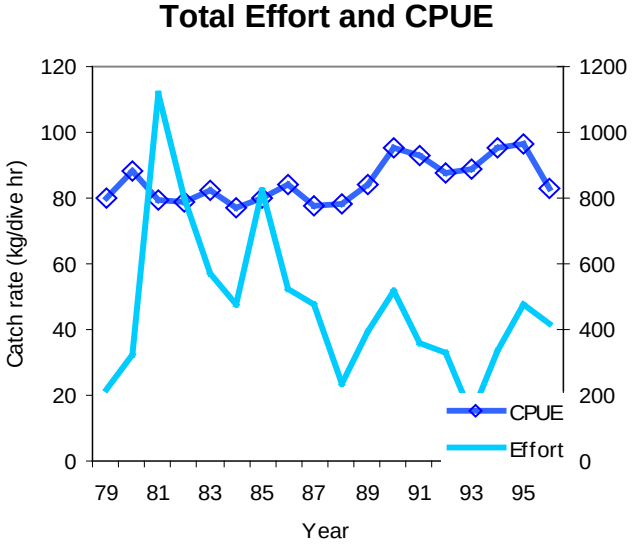
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	3321	39585	42906	818	52.5
80	10026	25698	35724	630	56.7
81	13956	17607	31563	576	54.8
82	7791	20406	28197	485	58.1
83	7782	31452	39234	622	63.1
84	17199	32007	49206	744	66.2
85	8805	11643	20448	381	53.7
86	10185	20469	30654	457	67.1
87	4848	21881	26729	399	67.0
88	5289	24111	29400	459	64.1
89	3643	19437	23080	281	82.3
90	6138	14871	21009	271	77.5
91	4388	16736	21124	281	75.3
92	5222	12513	17735	229	77.4
93	8494	12491	20985	257	81.8
94	8529	13932	22461	283	79.4
95	5007	13488	18495	276	67.0
96	10416	17190	27606	410	67.3

Figure 3.11: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Sheringa Bay (Mapcode 11A) from 1979 to 1996.



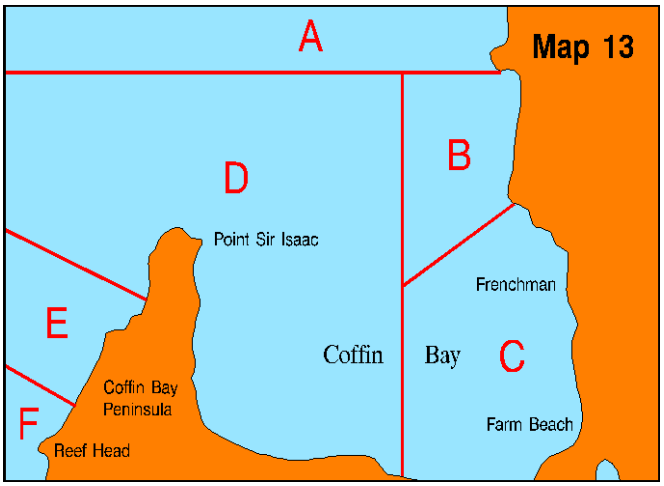


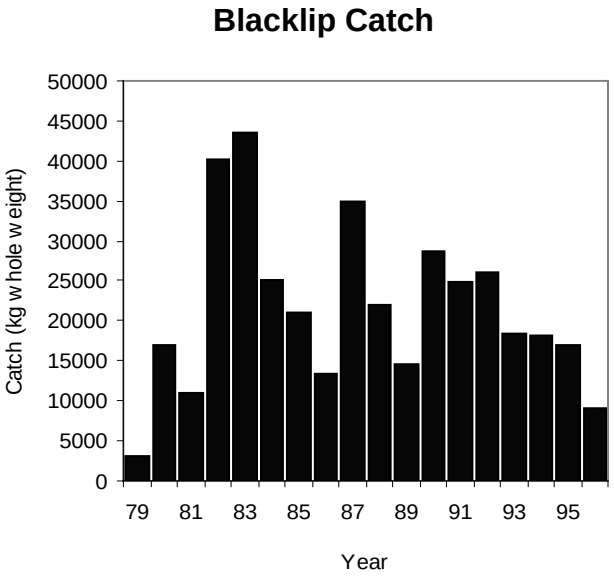


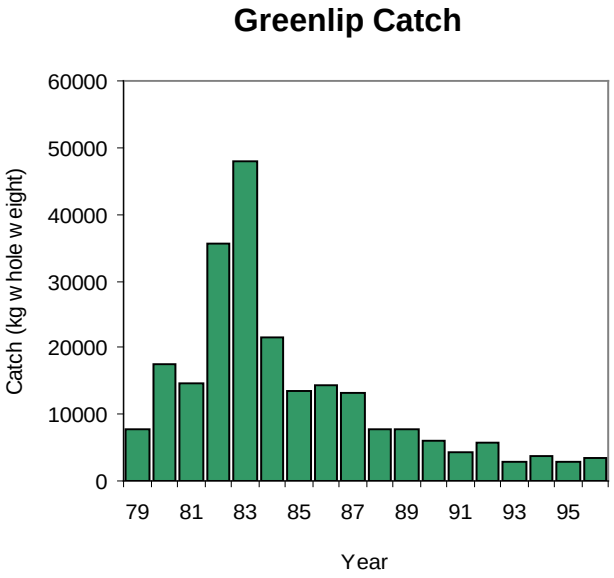


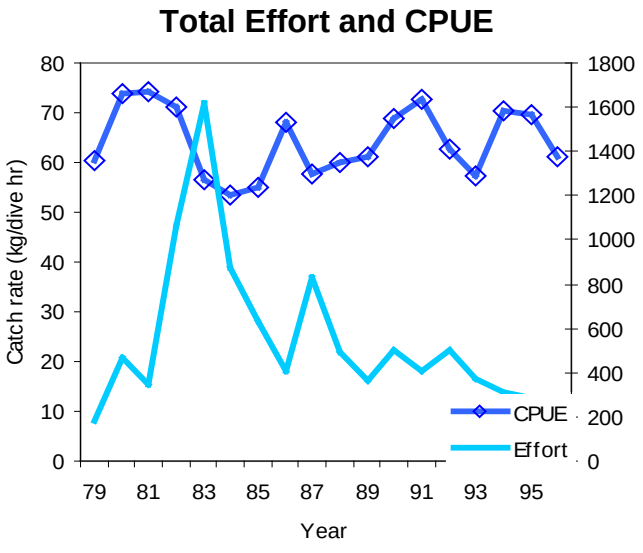
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	13005	4509	17514	219	80.0
80	25533	2961	28494	324	87.9
81	84438	4437	88875	1120	79.4
82	58968	4401	63369	802	79.0
83	42240	5022	47262	573	82.5
84	33310	3201	36511	475	76.9
85	63048	3186	66234	826	80.2
86	40620	3528	44148	526	83.9
87	34871	2260	37131	477	77.8
88	16757	1463	18220	233	78.2
89	30951	2175	33126	395	83.9
90	47178	2010	49188	516	95.3
91	32127	1165	33292	358	93.0
92	27656	1151	28807	329	87.6
93	11400	954	12354	139	88.9
94	30339	1548	31887	335	95.2
95	44970	1011	45981	478	96.2
96	33078	1665	34743	420	82.8

Figure 3.12: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Sir Isaac - Reef Head (Mapcode 13D, 13E, 13F) from 1979 to 1996.



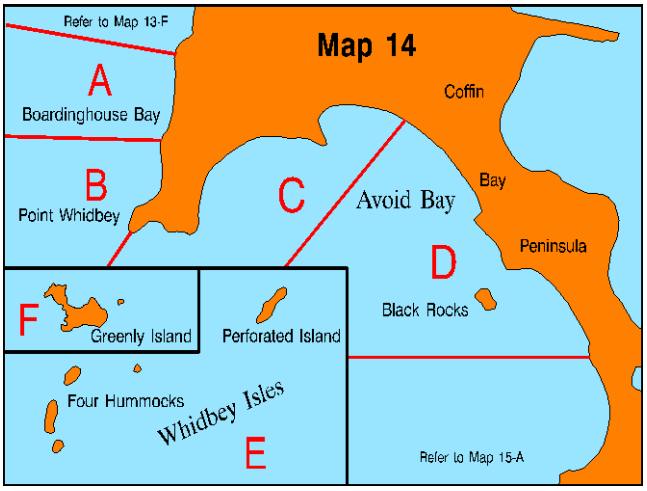


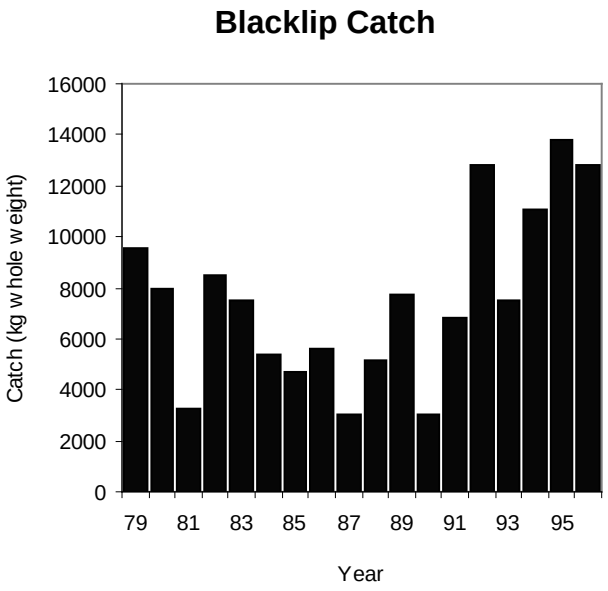


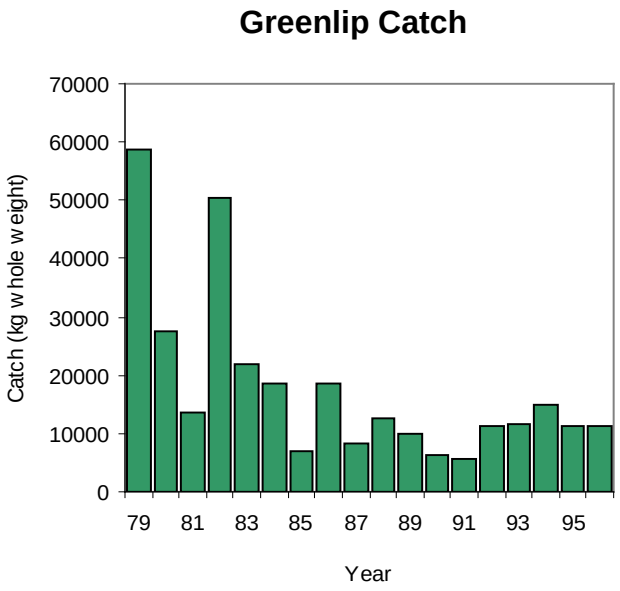


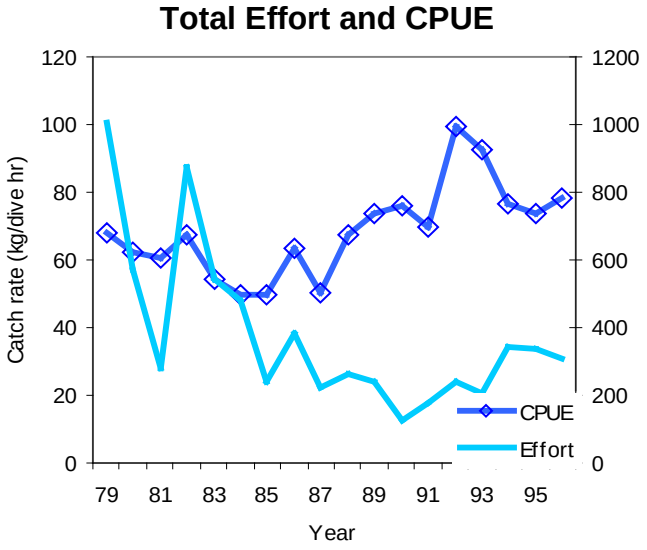
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	3216	7611	10827	179	60.5
80	16998	17397	34395	466	73.8
81	10959	14706	25665	345	74.4
82	40110	35574	75684	1061	71.3
83	43447	47841	91288	1619	56.4
84	25097	21610	46707	876	53.3
85	21096	13629	34725	631	55.0
86	13392	14241	27633	405	68.2
87	34898	13158	48056	834	57.6
88	21890	7755	29645	495	59.9
89	14677	7769	22446	367	61.2
90	28740	6081	34821	506	68.8
91	24930	4293	29223	403	72.5
92	26103	5616	31719	506	62.7
93	18321	2889	21210	371	57.2
94	18297	3660	21957	312	70.4
95	16905	2844	19749	284	69.7
96	9039	3408	12447	204	61.0

Figure 3.13: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Misery Bay - Black Rocks (Mapcode 14C, 14D) from 1979 to 1996



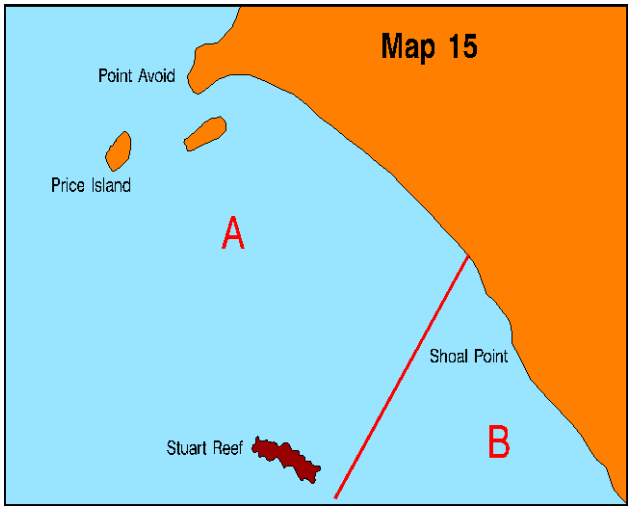


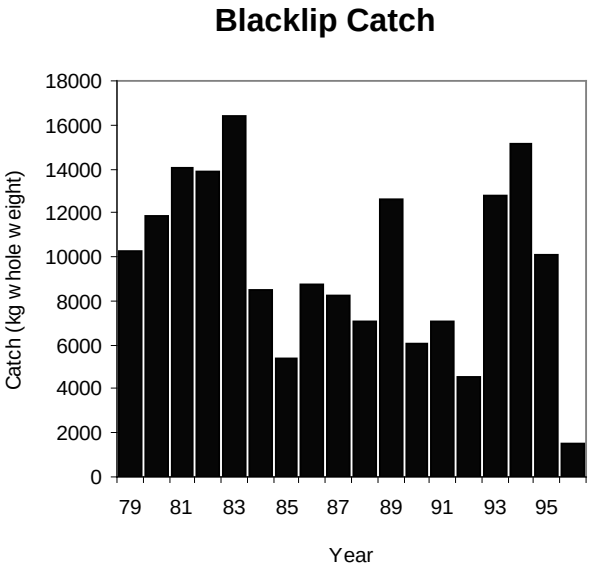


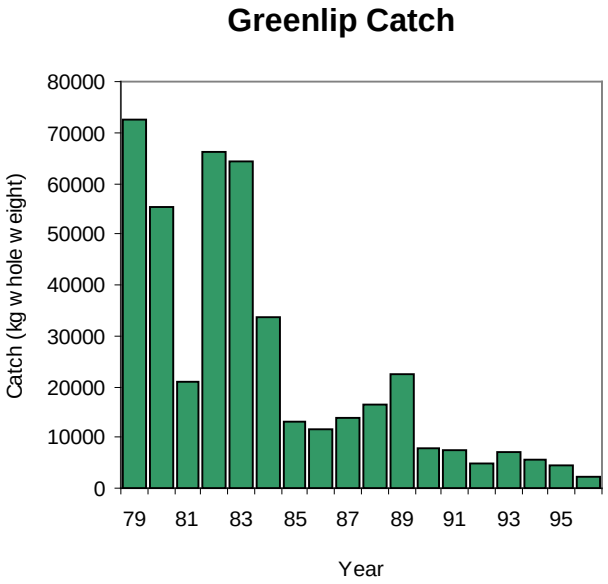


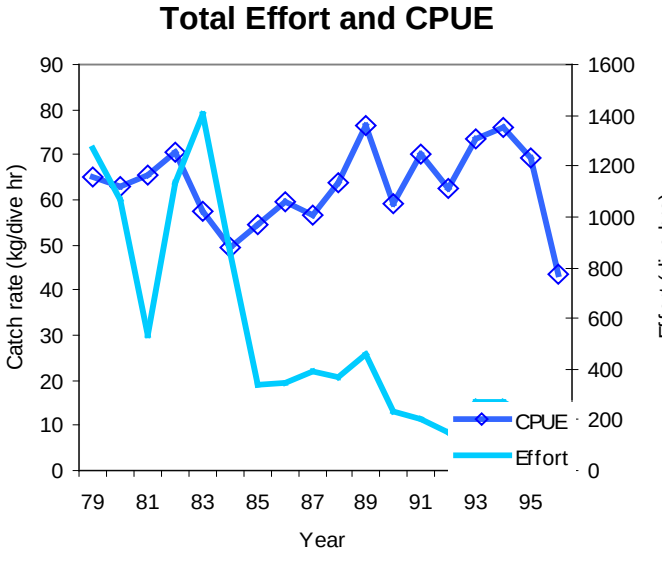
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	9591	58563	68154	1005	67.8
80	7950	27651	35601	571	62.3
81	3273	13713	16986	280	60.7
82	8460	50472	58932	872	67.6
83	7542	21966	29508	544	54.2
84	5361	18543	23904	480	49.8
85	4698	7101	11799	238	49.6
86	5640	18645	24285	384	63.2
87	3065	8223	11288	224	50.4
88	5127	12729	17856	265	67.4
89	7771	10053	17824	242	73.8
90	3015	6366	9381	123	76.3
91	6816	5739	12555	180	69.8
92	12793	11261	24054	243	99.2
93	7485	11697	19182	207	92.7
94	11094	15087	26181	341	76.8
95	13794	11238	25032	340	73.6
96	12852	11124	23976	307	78.1

Figure 3.14: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Pt Avoid (Mapcode 15A) from 1979 to 1996



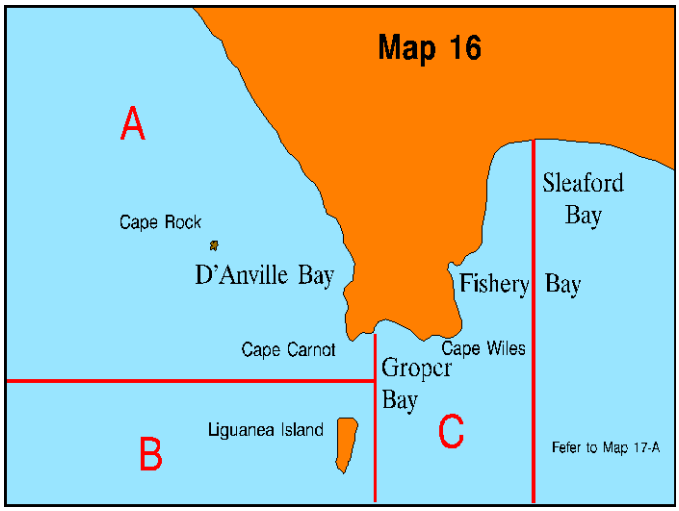


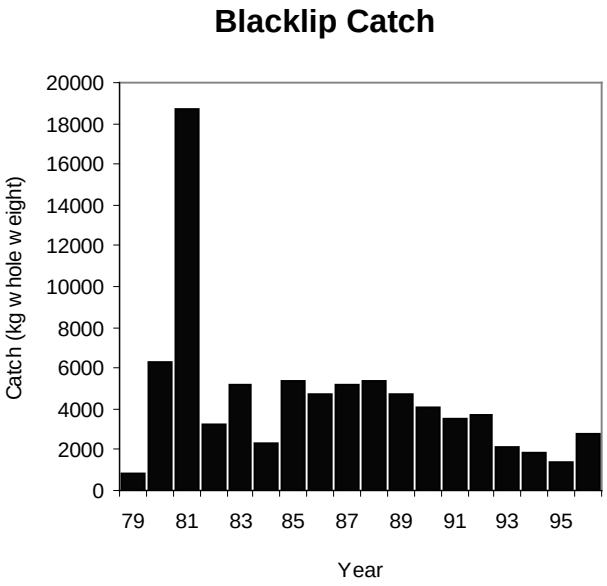


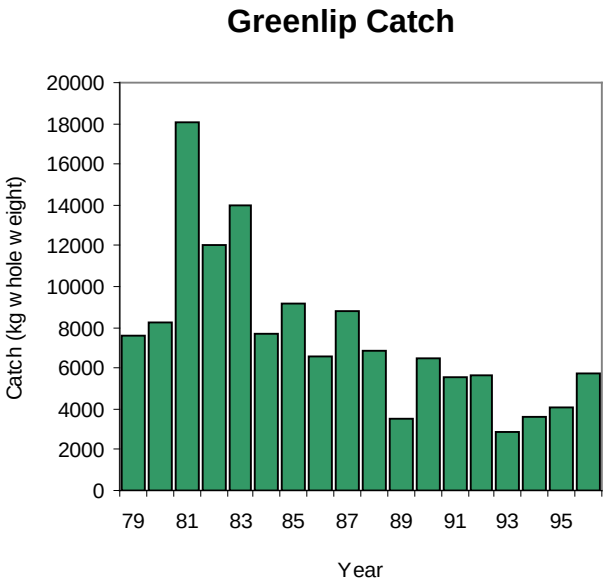


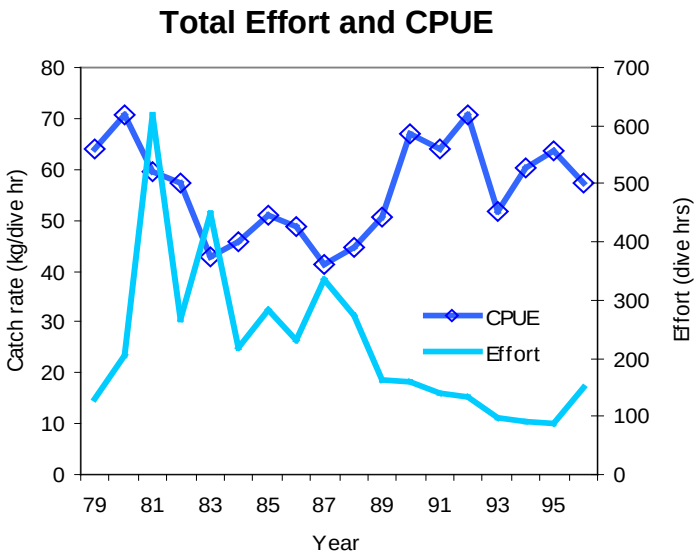
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	10236	72642	82878	1271	65.2
80	11883	55275	67158	1066	63.0
81	14031	20874	34905	532	65.6
82	13872	66180	80052	1134	70.6
83	16374	64155	80529	1404	57.4
84	8466	33625	42091	854	49.3
85	5415	13038	18453	338	54.6
86	8734	11718	20452	343	59.6
87	8274	13689	21963	388	56.6
88	7038	16302	23340	367	63.6
89	12642	22456	35098	458	76.6
90	6030	7929	13959	236	59.1
91	7041	7377	14418	206	70.0
92	4578	4932	9510	153	62.4
93	12759	7035	19794	270	73.3
94	15144	5697	20841	274	76.1
95	10074	4521	14595	211	69.3
96	1476	2253	3729	86	43.4

Figure 3.15: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Fishery Bay (Mapcode 16C) from 1979 to 1996.



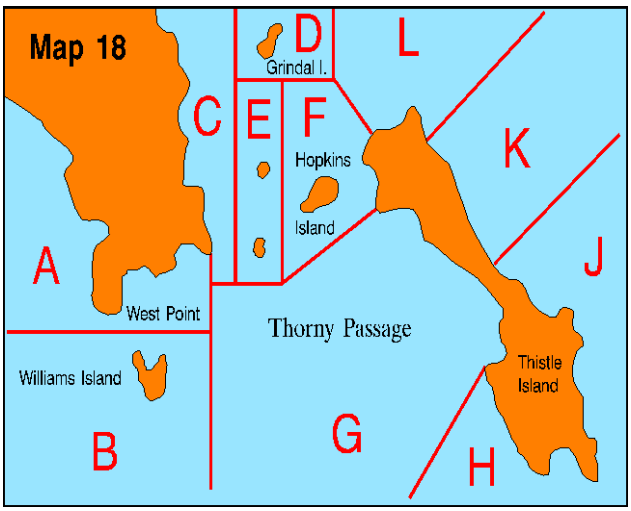


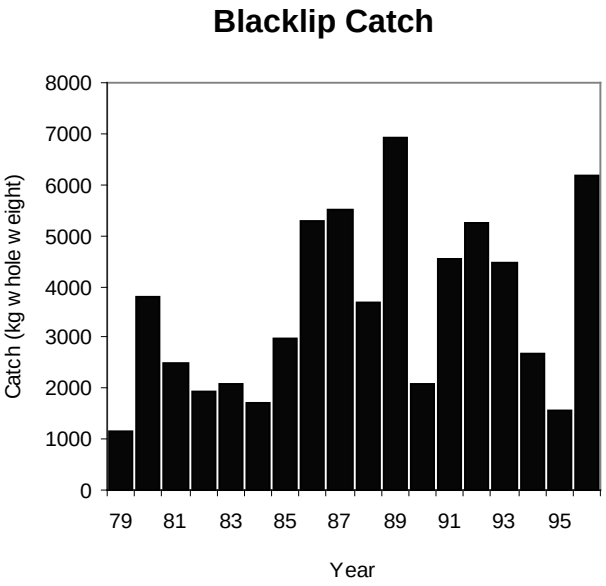


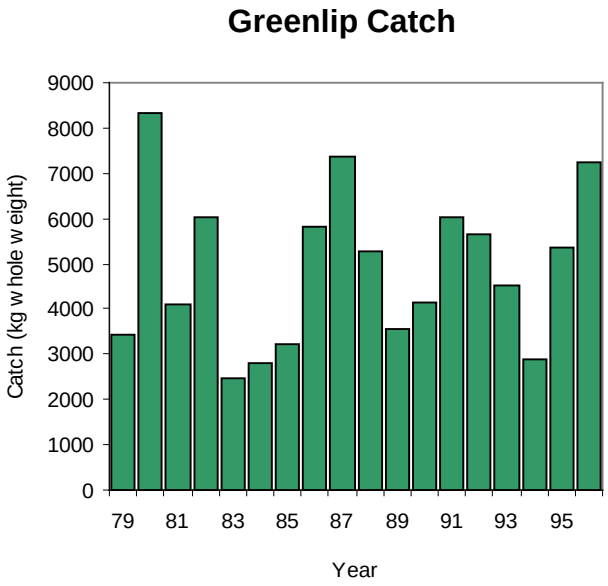


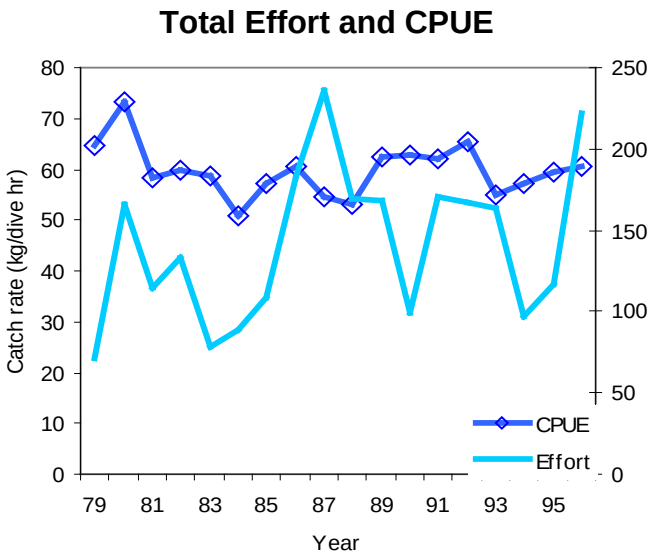
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	840	7557	8397	131	64.1
80	6252	8211	14463	205	70.6
81	18684	18087	36771	619	59.4
82	3264	11997	15261	266	57.4
83	5223	14016	19239	448	42.9
84	2298	7659	9957	217	45.9
85	5325	9150	14475	284	51.0
86	4734	6549	11283	232	48.7
87	5156	8772	13928	336	41.5
88	5391	6834	12225	273	44.8
89	4701	3528	8229	163	50.5
90	4119	6501	10620	159	66.8
91	3489	5545	9034	141	64.1
92	3750	5604	9354	132	70.9
93	2130	2877	5007	97	51.6
94	1821	3603	5424	90	60.3
95	1416	4113	5529	87	63.6
96	2811	5772	8583	150	57.2

Figure 3.16: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at West Point (Mapcode 18A, 18B) from 1979 to 1996.



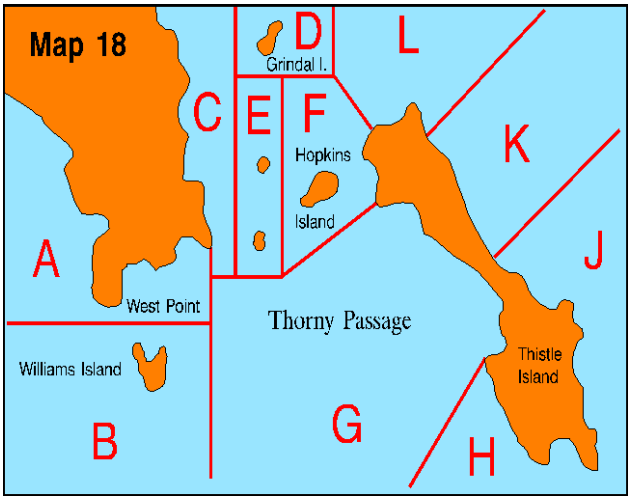


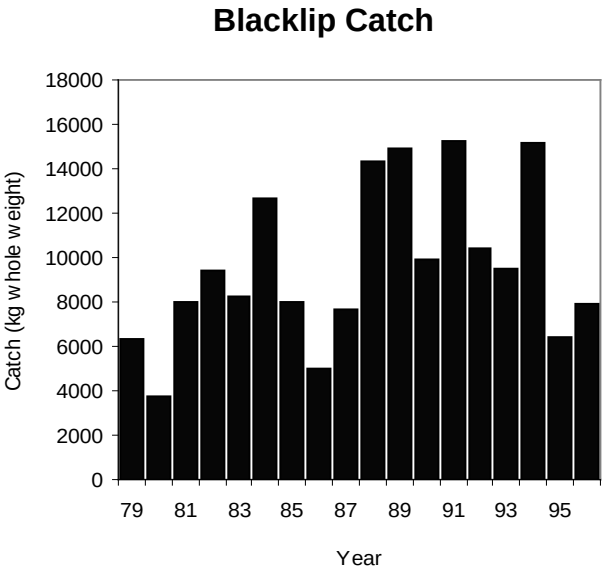


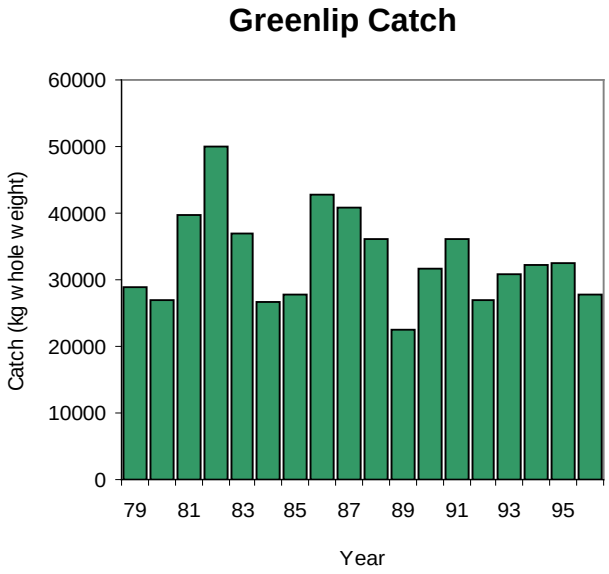


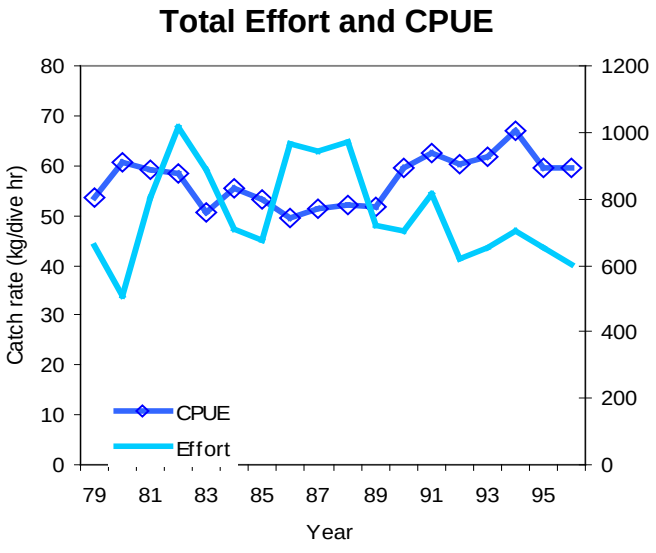
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	1137	3444	4581	71	64.5
80	3795	8340	12135	166.0	73.1
81	2511	4122	6633	114	58.2
82	1950	6009	7959	133	59.8
83	2097	2475	4572	78	58.6
84	1707	2820	4527	89	50.9
85	2991	3228	6219	109	57.1
86	5289	5823	11112	183	60.7
87	5499	7386	12885	236	54.6
88	3690	5292	8982	169	53.1
89	6912	3559	10471	168	62.3
90	2067	4140	6207	99	62.7
91	4538	6042	10580	171	61.9
92	5256	5664	10920	167	65.4
93	4457	4515	8972	163	55.0
94	2691	2871	5562	97	57.3
95	1566	5378	6944	117	59.4
96	6159	7254	13413	222	60.4

Figure 3.17: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Southern Thorny Passage (Mapcode 18C, 18D, 18E, 18F) from 1979 to 1996





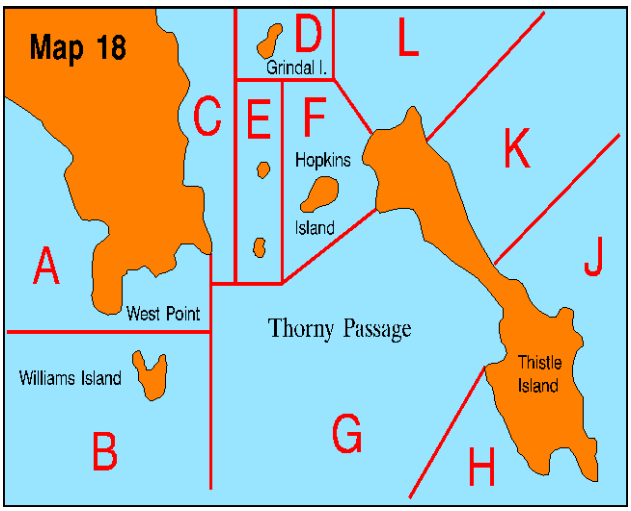


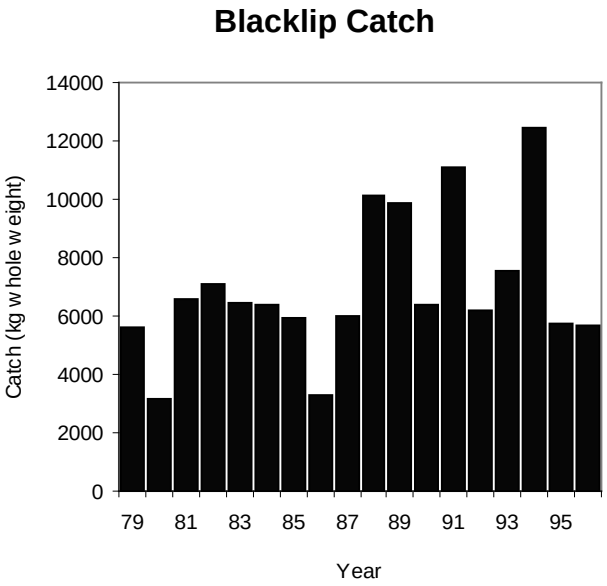


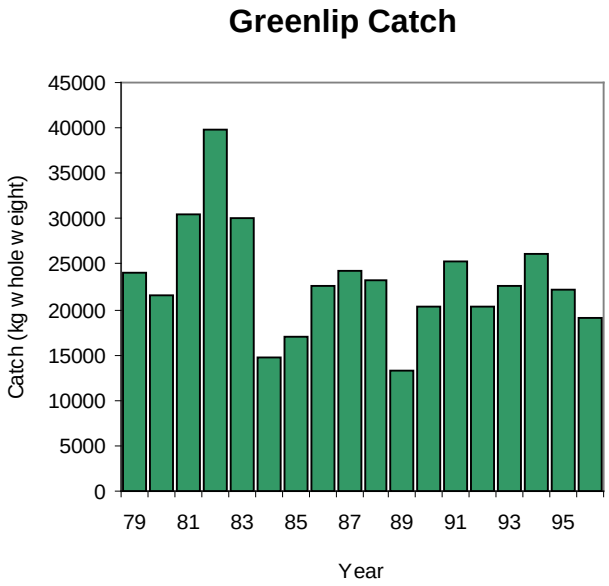
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	6342	28977	35319	660	53.5
80	3738	26985	30723	508	60.5
81	8019	39585	47604	805	59.1
82	9384	49983	59367	1017	58.4
83	8223	36807	45030	890	50.6
84	12657	26613	39270	708	55.5
85	8012	27891	35903	675	53.2
86	4986	42684	47670	965	49.4
87	7630	40857	48487	942	51.5
88	14338	36172	50510	973	51.9
89	14889	22468	37357	720	51.9
90	9924	31773	41697	702	59.4
91	15243	35982	51225	818	62.7
92	10377	27024	37401	620	60.4
93	9522	30738	40260	653	61.7
94	15159	32106	47265	706	66.9
95	6378	32628	39006	655	59.6
96	7932	27845	35777	602	59.4

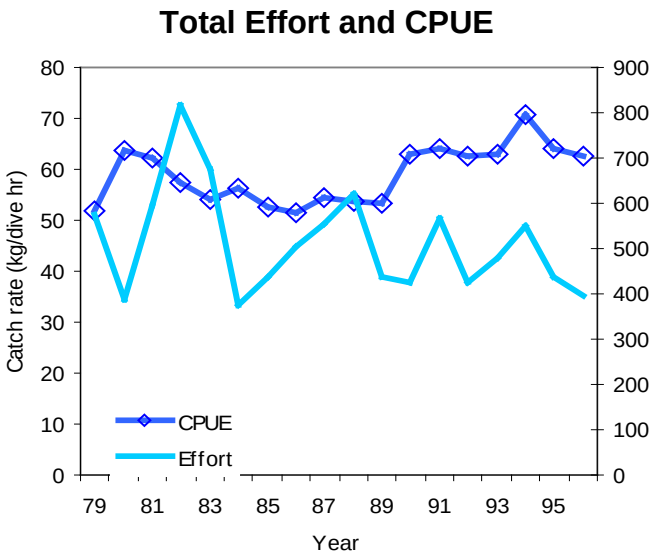
Effort (dive hrs)

Figure 3.18: Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at The Gap (Mapcode 18F) from 1979 to 1996





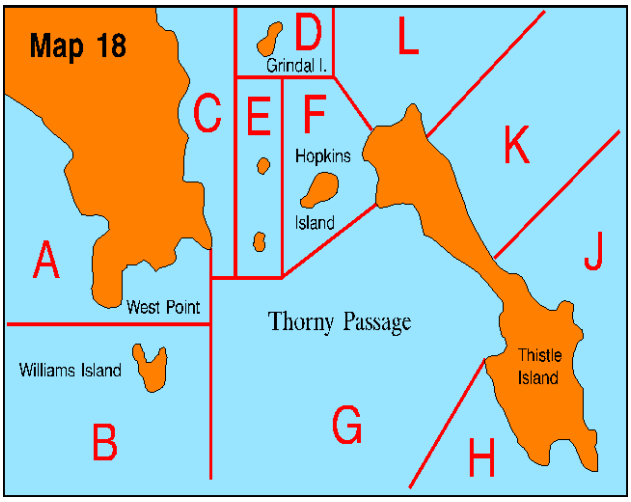


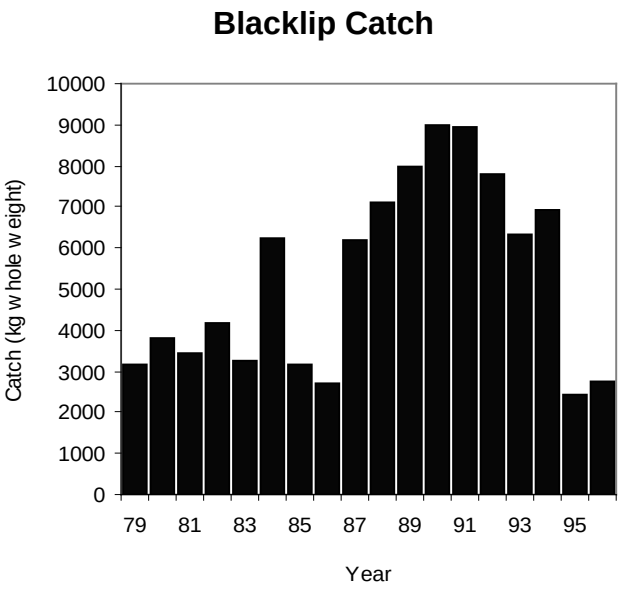


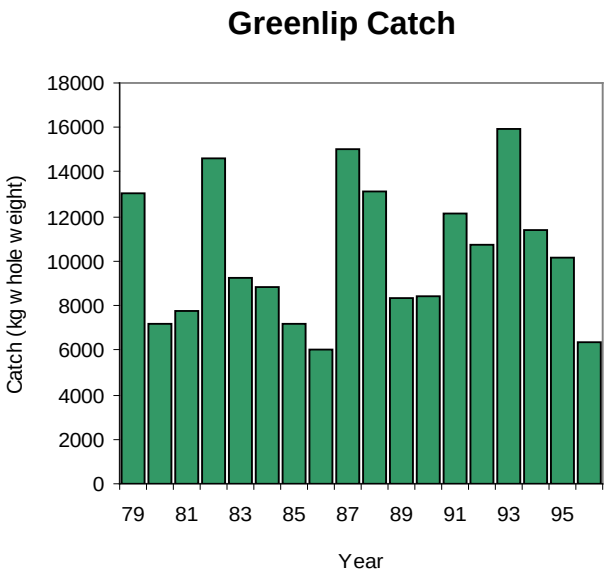
YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	5589	24144	29733	573	51.9
80	3150	21612	24762	389	63.7
81	6573	30534	37107	596	62.3
82	7086	39777	46863	818	57.3
83	6438	30102	36540	677	54.0
84	6417	14760	21177	375	56.5
85	5942	17013	22955	436	52.6
86	3276	22665	25941	504	51.5
87	6007	24195	30202	555	54.4
88	10128	23277	33405	622	53.7
89	9843	13350	23193	436	53.2
90	6402	20370	26772	426	62.8
91	11085	25272	36357	567	64.2
92	6210	20316	26526	424	62.6
93	7536	22659	30195	480	62.9
94	12480	26190	38670	548	70.6
95	5721	22284	28005	437	64.2
96	5649	19113	24762	396	62.5

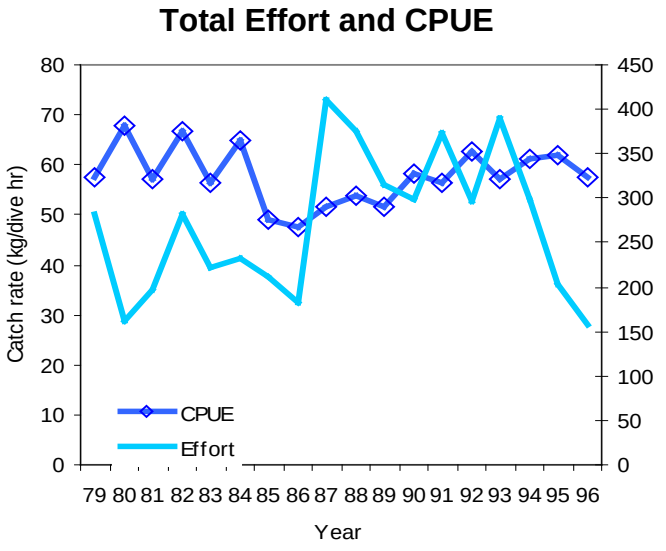
Effort (dive hrs)

Figure 3.19:Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Thistle Island (Mapcode 18G, 18H, 18J, 18K, 18L) from 1979 to 1996









Effort (dive hrs)

YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79	3186	13083	16269	283	57.5
80	3798	7209	11007	162	67.9
81	3432	7746	11178	196	57.0
82	4179	14592	18771	282	66.6
83	3237	9228	12465	221	56.4
84	6225	8862	15087	233	64.8
85	3153	7155	10308	211	48.9
86	2685	6045	8730	183	47.7
87	6215	14997	21212	410	51.7
88	7125	13123	20248	375	54.0
89	7971	8346	16317	316	51.6
90	8982	8436	17418	299	58.3
91	8955	12151	21106	374	56.4
92	7817	10749	18566	297	62.5
93	6312	15939	22251	389	57.2
94	6909	11415	18324	299	61.3
95	2436	10134	12570	203	61.9
96	2749	6352	9101	158	57.6

3.4 CENTRAL ZONE

3.4.1 Introduction

The Central Zone extends from the major portion of Spencer Gulf eastwards to include Investigator Strait, Gulf St Vincent and the south coast of Fleurieu Peninsula as far east as the Murray Mouth.

The Central Zone fishery exploits both blacklip and greenlip abalone of which greenlip is by far the most important. The Central Zone greenlip fishery established more slowly than that of the Western Zone with catches increasing from 100 tonnes in 1968 to 250 tonnes in 1989 immediately prior to the introduction of a quota management system which since has capped greenlip abalone catches at around 140 tonnes per annum. The fishery for greenlip abalone is carried out principally in the Spencer Gulf region of Tiparra with catches from this region accounting for about 110 tonnes of the Central Zone total of 140 tonnes.

Blacklip abalone make up a smaller component of the Central Zone catch with the quota being set around 40 tonnes since 1990. Prior to that, catches were erratic peaking early in the history of the fishery with a catch of 120 tonnes in 1970 and then declining to 3 to 30 tonnes throughout the mid 1970's and 1980's. Catches increased again from 1984 to peak at 55 tonnes immediately prior to the introduction of quotas in 1990.

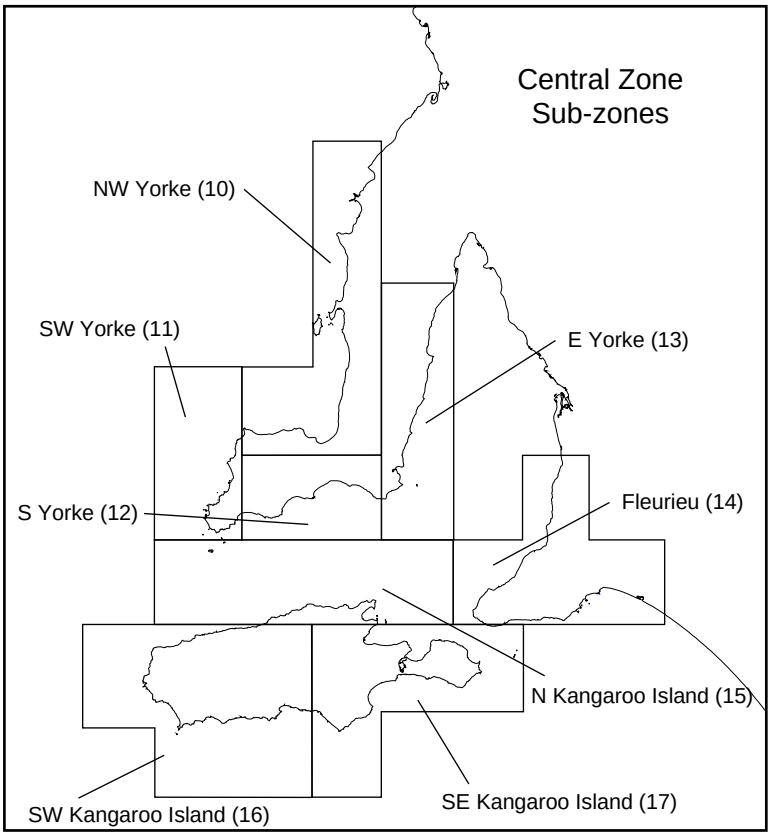


Figure 3.20: Map showing eight sub-zones within the Central Zone of the South Australian abalone which made up the statistical reporting areas for the fishery dependent catch and effort data between 1968 and 1978.

3.4.2 Summary of patterns of catches and catch rate for the Central Zone

Before 1979 catch and effort data were obtained from fishers on a 1º grid each divided into 9 square sub-blocks. These catches and catch rates of abalone in the Central Zone from 1968 were examined from each of the eight subzones shown in figure 3.20. Catches and catch rates from 1979 and onwards have been recorded at a much finer spatial scale comprising 44 mapcodes. These have been aggregated into 23 fishing or metapopulation areas.

3.4.2.1 NW Yorke (Subzone 10), Map Codes 21A-H, 22A, 24A)

Very little blacklip occurs in the region but greenlip production is very high and the mainstay of the Central Zone fishery. See Shepherd and Hearn (1983) for growth rates at Tiparra, and Shepherd et al. (1982) for natural mortality estimates.

3.4.2.2 SW Yorke (Subzone 11), Map Codes 23A-D)

This section of Yorke Peninsula has low blacklip production and a small greenlip catch that has possibly now stabilised after progressive removal of virgin stocks.

3.4.2.3 S Yorke (Subzone 12), Map Code 24F)

See Moorowie-Marion Reef below.

3.4.2.4 E Yorke (Subzone 13), Map Codes 24B-E)

These beds were apparently discovered progressively from about 1972 prior to their collapse after Perkinsus became widespread (see Stansbury above). Alternatively, some early divers claimed that they searched the area thoroughly in the period 1968-70 and discovered no beds. If this is true then it must be supposed that the beds were populated rapidly from a larval source probably from Marion Reef (given the net current flow northwards) from about 1966.

3.4.2.5 Fleurieu (Subzone 14), Map Codes 25A, 25B-D)

Substantial greenlip populations occurred at Tunkalilla, West Is., (see Shepherd and Baker 1998 for historical catches) and east to Middleton. All except those at Cape Jervis collapsed in the first few years, and those at Cape Jervis collapsed by 1990.

3.4.2.6 N Kangaroo (Subzone 15), Map Codes 32A,B)

See North East Kangaroo Island below.

3.4.2.7 SW Kangaroo (Subzone 16), Map Codes 26A,B, 27,28)

Serious exploitation commenced about 1970 and the catch has stabilised at 5-10 tonnes yr^{-1} for each species since then.

3.4.2.8 SE Kangaroo (Subzone 17), Map Codes 29-31, 32C)

Overall catches have been stable, except for some decline in the greenlip catch since about 1988 noted above.

3.4.2.9 Tiparra Reef – Nth Bottom (Mapcode = 21A)

Numerous patches of outcropping but low relief rock among seagrass support large but sporadic catches of greenlip.

3.4.2.10 Tiparra Reef – Outer Main Reef (Mapcode 21B)

This and the two succeeding mapcode areas support the bulk of the catch where growth rates are highest. Catch fluctuations suggest a six-year periodicity in recruitment as noted for many reefs in the eastern great Australian Bight.

3.4.2.11 Tiparra Reef – Outside Bottom (Mapcode 21C)

The lower depth limit of seagrass at 12 m sets the lower depth of abalone, although reef and rubbly bottom continue into deeper water. Rocky bottom relief is about 1 m.

3.4.2.12 Tiparra Reef – Main Reef (Mapcode = 21D)

Most greenlip is found on the southern edge of the reef which drops about 2 m onto sand and seagrass, and very little on the reef surface. This reef edge follows the southern boundary of the map code 21D past Coal Reef, (so named because of the coal dumped on the bottom from a wreck) to the junction with the Outside Bottom.

3.4.2.13 Tiparra Reef – Middle Bottom (Mapcode 21E)

This area is characterised by many flat-topped, mushroom-shaped bombies, presumably formed during a lower sea-level. Greenlip abalone live at the base and blacklip under the overhangs of the bombies. The area was little exploited before 1993.

3.4.2.14 Tiparra Reef – Sth Bottom (Mapcode 21F)

This extensive area of low-relief, almost continuous reef of several square km at a depth of 6-8 m has a large, unexploited population of stunted greenlip. Fecundity and growth of greenlip are described by Shepherd (1987).

3.4.2.15 Tiparra Reef – Inside Bottom (Mapcode 21G)

Reef of low relief at a depth of 5-6 m is scattered here among extensive *Posidonia* and *Amphibolis* beds.

3.4.2.16 Tiparra Reef – Total (Mapcode 21A – 21G)

The reef is complex comprising an estimated 6 km^2 of sandstone substratum emergent from sandy bottom colonised by *Posidonia sinuosa* and *Amphibolis* spp over a total area of about 200 km^2 from 5-12 m depth. Blacklip habitat is in the few areas of high relief, whereas that of greenlip is on rock of low relief among extensive seagrass beds on which the abalone are dependent for drift epiphytic algae for food (Shepherd 1973). Growth rates, fecundity and natural mortality are summarised in Shepherd and Baker (1998) from various sources.

Tiparra Reef was probably the first reef system in South Australia to be exploited from 1965. Catches from 1967-8 are given by Shepherd and Baker 1998 with an EPR analysis. The mean annual catch of greenlip for 1971-8 was 45.1 tonnes and for blacklip 0.6 tonnes.

3.4.2.17 Cape Elizabeth (Mapcode = 21H)

Limestone reef of low to moderate relief extends offshore, and there are extensive smaller patches of reef of low relief to the north of the Cape. The mean annual catch for 1971-8 was 7.4 tonnes greenlip. The catch of greenlip fluctuates and is due in part at least to the periodic discovery of patches of reef by divers.

3.4.2.18 Cowell Grounds (Mapcode = 21J)

Nothing is known of the substratum. The reef was first exploited by divers in 1989 and has been little visited since.

3.4.2.19 Hardwicke Bay (Mapcode = 22A, 24A)

The substratum is limestone reef of low relief with an extensive (many square km) but unknown reef area. The mean annual catch from 1971-8 was 2.7 tonnes greenlip. The extent of the exploitable population was progressively discovered from 1979 to about 1987. The decline in the greenlip catch since 1987 may simply reflect the gradual removal of virgin populations.

3.4.2.20 SW Yorke Peninsula (Mapcode = 23A, 23B, 23C, 23D)

The substratum is calcrete overlying basement gneiss. Blacklip habitat is inshore reefs and greenlip habitat on rocky bottom in seagrass. Blacklip catches are low, and greenlip catches stable after removal of accumulated stocks before quota introduction in 1989.

3.4.2.21 Moorowie – Marion Reef (Mapcode = 24E, 24F)

The substratum is mainly tertiary limestone forming extensive reef of low relief outcropping north of Marion Reef and south of Troubridge Is. over about 10 ha at 5-8 m depth and in Foul and Sturt Bays. The decline of greenlip populations in 1985 correlated with a strong increase in the incidence of Perkinsus infection of abalone (see Goggin and Lester 1995).

3.4.2.22 Stansbury (Mapcode = 22B, 24B, 24C, 24D)

The substratum is extensive limestone of low relief in seagrass beds from 5-10 m depth from Coobowie Bay and Stansbury. The main beds were off Oyster Pt, Stansbury over an area of 20 ha. and in Coobowie Bay south of Giles Pt at depths to 9 m over 25 ha. Greenlip populations collapsed at the same time as those further south when Perkinsus infection became widespread.

3.4.2.23 Cape Jervis – Encounter Bay (Mapcode = 25A, 25B, 25C, 25D)

The substratum of Backstairs Passage is Cambrian greywackes and schists, tilted at a sharp angle. Reefs project from shore underwater to a depth of about 12 m in Fishery Bay providing habitat for greenlip over an estimated 25 ha on the coast of Fleurieu Peninsula from Cape Jervis to Blowhole Creek with scattered populations extending to Deep Creek. Blacklip habitat is mainly inshore on high relief reefs. Mean annual catches for 1971-8 were 6.4 tonnes for blacklip and 6.2 tonnes for greenlip. Since then blacklip catches have been low and sporadic. Greenlip catches have collapsed by 90%. Greenlip and some blacklip also occurred on the gneissic reefs eastward to Encounter Bay, but fishing ceased after about 1970 as populations were depleted and never recovered.

3.4.2.24 West Bay – Cape du Couedic (Mapcode = 26A, 26B, 26)

The substratum is gneissic and abalone habitat largely limited to inshore reef of high relief. The coast is difficult to access and divers launch at Southwest River. The mean annual catch for 1971-8 was 3.8 tonnes blacklip and 1.0 tonnes greenlip. Current annual catches of blacklip are 8-10 tonnes and of greenlip 1-2 tonnes.

3.4.2.25 Hanson Bay (Mapcode = 27A, 27B, 27)

The substratum is gneissic overlain in places by extensive calcrete reefs of low relief. Blacklip habitat is inshore on reef of high relief while greenlip occur at the base of cliffs mostly in Weirs Cove near Cape de Couedic and between Cape Bouguer and Stunsail Boom River. The mean annual catch for 1971-8 was 2.0 tonnes blacklip and 1.1 tonnes greenlip. Catches of both species are low but stable.

3.4.2.26 Vivonne Bay (Mapcode = 28A, 28B, 29A, 28)

The substratum is as described for Hanson Bay. The mean annual catch for 1971-8 was 2.8 tonnes blacklip and 1.8 tonnes greenlip. The catches of blacklip are apparently stable after the large catches of 1985-8 but those of greenlip have scarcely changed since 1989. The greenlip catch is mostly in Seal Bay near Nobby Is. and east to Black Pt.

3.4.2.27 Cape Gantheaume (Mapcode = 29B, 29C, 29D)

The substratum is as described for Hanson Bay. Greenlip occur close to the cliffs at the weedline and blacklip on reef of high relief near Reynolds Pt and east to Charlies Gulch. The mean annual catch for 1971-8 was 1.5 tonnes blacklip and 4.5 tonnes greenlip. The greenlip catch has declined by 80% in the last decade.

3.4.2.28 D'Estrees Bay (Mapcode = 30A, 30B, 30C, 30)

Catches of both species peaked in the late 1980's at 8 tonnes for blacklip and 11 tonne for greenlip. Since quota introduction catches for both species have fluctuated between 1-4 tonnes.

3.4.2.29 Cape Willoughby – Cape St Alban (Mapcode 31A, 31B, 31C, 31)

The substratum is variously Encounter Bay gneisses, sandstone, greywackes and schists, providing inshore reef of high relief for blacklip and offshore reef of low relief for greenlip. Most greenlip catches are from reefs off Cape St Albans. The mean annual catch for 1971-8 was 2.6 tonnes blacklip and 3.7 tonnes greenlip. The greenlip catch has declined by 85% in the last decade.

3.4.2.30 Nth East KI (Mapcode = 32A, 32B, 32C, 32)

The substratum is sandstone and mudstone. The mean annual catch for 1971-8 was 0.2 tonnes blacklip and 2.0 tonnes greenlip which came from populations around Pt Marsden and in the north western part of the Bay of Shoals. Since then catches have been sporadic without major trends.

3.5 SOUTHERN ZONE

3.5.1 Introduction

The Southern Zone extends from the Murray mouth eastwards along the South Australian south east coast to the South Australian - Victorian border.

The fishery for Southern Zone is based principally around blacklip abalone. The greenlip abalone catch since introduction of quotas in 1988 has been between 2 and 6 tonnes and prior to that catches of greenlip abalone only exceeded 6 tonnes in 1969 and 1973.

The substratum of the Zone is mainly calcrete limestone in a beach-dune system extending off shore to 100 m depth. Greenlip habitat is mainly in embayments and blacklip on calcrete reef of moderate to high relief to depths of 5-10 (rarely 15) m.

Exploitation of blacklip abalone began in the 1960's with catches increasing from 28 tonnes in 1968 to 140 tonnes in 1973. Since that time catches have fluctuated between 84 tonnes in 1983 and 186 tonnes in 1993. Although quotas for this fishery were established in 1988, the catches have continued to fluctuate in recent years as a result of adaptive management practices enabling fishdown of previously unexploited stunted stocks in some localised areas.

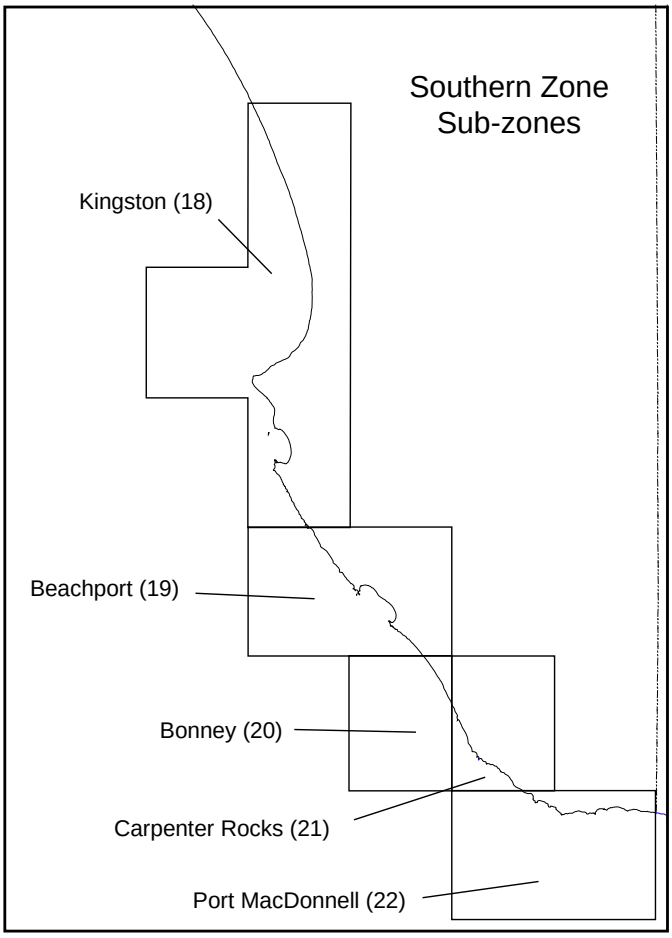


Figure 3.21: Map showing five sub-zones within the Southern Zone of the South Australian abalone which made up the statistical reporting areas for the fishery dependent catch and effort data between 1968 and 1978.

3.5.2 Summary of patterns of catches and catch rate for the Southern Zone

Before 1979 catch and effort data were obtained from fishers on a 1º grid each divided into 9 square sub-blocks. Catches and catch rates of abalone in the Southern Zone from 1968 were examined from each of the subzones shown in figure 3.21. Catches and catch rates from 1979 and onwards have been recorded at a much finer spatial scale comprising 42 individual mapcodes. These have been aggregated into 21 fishing or metapopulation areas.

3.5.2.1 Kingston (Subzone 18), (Map Codes 33-35A,B)

Major exploitation commenced in about 1972. The catches in this subzone are relatively low, but stable.

3.5.2.2 Beachport (Subzone 19), (Map Codes 35C-E, 36)

Blacklip catches have steadily increased, assisted by fishdowns, to the present and show no sign of declining. High catches of greenlip were taken from 1968, but after removal of virgin stocks, have declined to a low, but likely stable, level.

3.5.2.3 Bonney (Subzone 20), (Map Codes 37A-G,38)

Fishing began in about 1972 and high exploitation levels of blacklip have continued unabated. The long-term decline in the blacklip catch in the last two decades is a matter of increasing concern.

3.5.2.4 Carpenters Rock (Subzone 21), (Map Codes 37H,J, 38J, 39A-E)

The subzone is considered stable in terms of the blacklip and greenlip fishery.

3.5.2.5 Port Macdonnell (Subzone 22), (Map Codes 39F,G, 40)

Exploitation of blacklip stocks has gradually increased over three decades of fishing, aided by more recent fishdowns.

3.5.2.6 Cape Jaffa (Mapcode = 33A, 33B, 33C)

Sparse greenlip populations occur around Margaret Brock Reef and south east of the reef at a depth of 5-12 m toward Cape Thomas. The mean annual catch of greenlip was 0.6 tonnes for 1971-8. Catches have been low and sporadic since.

3.5.2.7 Robe (Mapcode = 34A, 34B, 34C, 34D)

The mean annual catch for 1971-8 was 10.6 tonnes blacklip and 1.0 tonnes greenlip. Catches of both species have declined steeply for both species in the last 15 years. However, in the last decade the area has been seldom visited so the status of the stocks is not known.

3.5.2.8 Nora Creina (Mapcode = 35A, 35B, 35C, 35D, 35E)

The mean annual catch for 1971-8 was 13.8 tonnes blacklip and 0.5 tonnes greenlip, but may have included harvesting of virgin stock. Catches of both species since then show no long-term trends.

3.5.2.9 Beachport (Mapcode = 36A)

The mean annual catch for 1971-8 was 9.0 tonnes blacklip only. Since then blacklip catches have been stable at about 2 tonnes.

3.5.2.10 Ringwood (Mapcode = 36B)

The mean annual catch for 1971-8 was 5.2 tonnes blacklip and 0.4 tonnes greenlip. The main blacklip catches come from Ringwood Reef and greenlip from extensive reefs of inshore Rivoli Bay at depths of 3-10 m. Since then catches of blacklip have increased and those of greenlip have shown little change.

3.5.2.11 South End (Mapcode = 36C, 37A)

The mean annual catch for 1971-8 was 26 tonnes blacklip and 0.2 tonnes greenlip. Since then catches of blacklip have remained steady at about 8 t and the greenlip catch has been low and sporadic.

3.5.2.12 "Number 2" – Total (Mapcode = 37B – 37H, 38B – 38H, 38)

The mean annual catch for 1971-8 was 27.3 t blacklip only. Since then the catch of blacklip has declined to about 20 tonnes. This small reef remains one of the major blacklip-producing reefs in this zone.

3.5.2.13 Carpenters Rocks (Mapcode = 37J, 39A, 39B, 39C)

The mean annual catch for 1971-8 was 14.9 tonnes blacklip only. Catches since then have remained at about the same level. There are also very small catches of greenlip.

3.5.2.14 Gerloff's (Mapcode = 39D, figure 3.22)

The mean annual catch for 1971-8 was 15.2 tonnes blacklip and 0.6 tonnes greenlip. Catches of blacklip have increased in recent years due to fishdowns (1992/93 and 1995/96) of a part of the area at a lower size limit of 115 mm.

3.5.2.15 Blackfellows (Mapcode = 39E)

Mean annual catches before 1979 were only 0.1 tonne blacklip and 30 kg greenlip. Blacklip catches are now 4-5 t blacklip and up to 0.5 tonnes greenlip.

3.5.2.16 Nene Valley – Cape Douglas (Mapcode = 39F)

Within this area are extensive stocks of stunted blacklip. Fishdowns have substantially increased the catch in recent years.

3.5.2.17 Cape Douglas (Mapcode = 39G)

The mean annual catch for 1971-8 was 14.0 tonnes blacklip only. Since then the catch of blacklip has declined by 67% from catches of about 20 tonnes in 1979-81, and there are low greenlip catches.

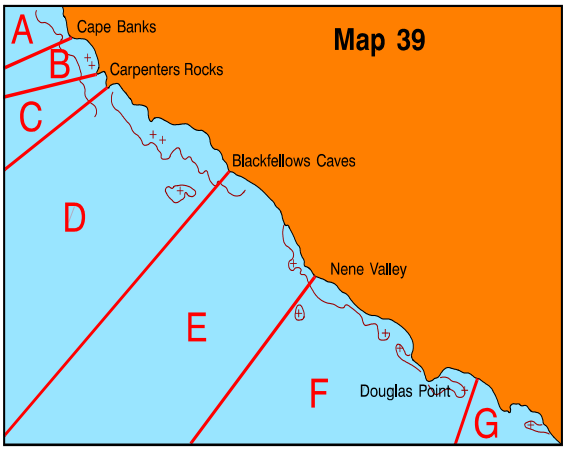
3.5.2.18 Port Macdonnell (Mapcode = 40A, 40B)

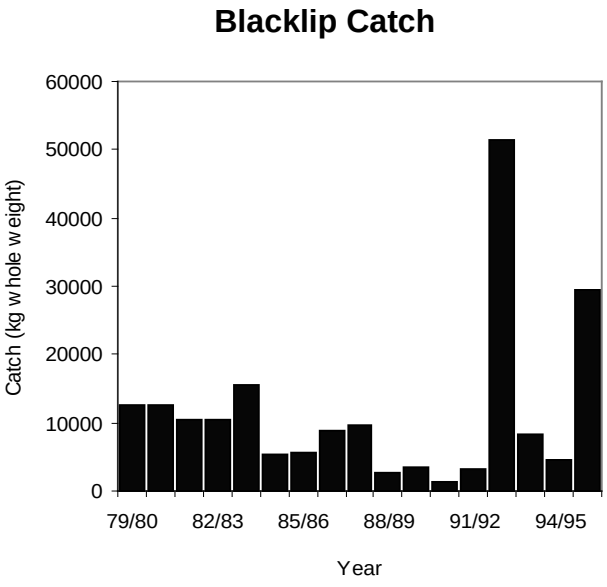
The mean annual catch for 1971-8 was 5.4 tonnes blacklip and 160 kg greenlip. Blacklip catches have increased substantially due to the discovery of deeper blacklip stocks in Map Code 40A and the exploitation of stunted stocks during fishdowns in Area 40B.

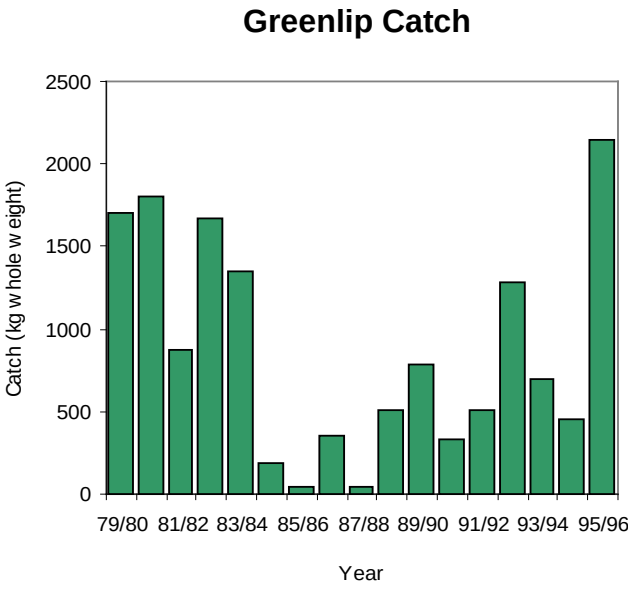
3.5.2.19 East of Port Macdonnell (Mapcode = 40C, 40D)

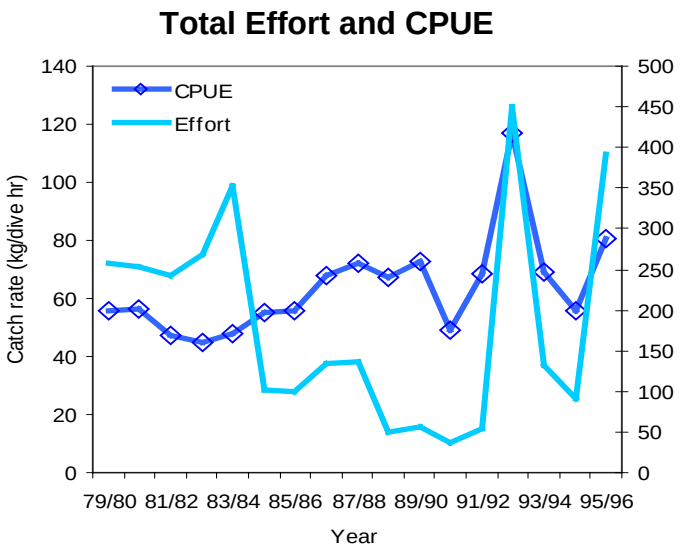
The mean annual catch for 1971-8 was 0.2 tonnes blacklip and 16 kg greenlip. The substantial increase in the catch since then is due to exploitation of stunted stocks during fishdowns in Area 40C.

Figure 3.22:Total catch (kg whole weight) of blacklip and greenlip abalone, total effort (diver hrs) and catch per unit effort (kg per diver hr) at Gerloff's (Mapcode 39D) from 1979/80 to 1995/1996









YEAR	Blacklip	Greenlip	Total Catch	Effort	CPUE
79/80	12655	1708	14363	257	55.9
80/81	12559	1800	14359	254	56.5
81/82	10503	870	11373	242	47.0
82/83	10385	1673	12058	269	44.8
83/84	15577	1352	16929	352	48.1
84/85	5417	187	5604	101.5	55.2
85/86	5531	40	5571	100	55.7
86/87	8775	349	9124	134	68.1
87/88	9751	42	9793	136	72.0
88/89	2794	512	3306	49	67.5
89/90	3354	782	4136	57	72.6
90/91	1434	331	1765	36	49.0
91/92	3247	513	3760	55	68.4
92/93	51365	1279	52644	451	116.7
93/94	8435	699	9134	132	69.2
94/95	4581	456	5037	90	56.0
95/96	29371	2143	31514	391	80.6

4 SECTION FOUR.

Analyses of catch data from the South Australian abalone fishery

Objective

Produce detailed analysis of trends and spatial and temporal interactions in the fishery from the catch and effort data of the South Australian abalone fishery. This will include an analysis of catch size structure and fishing patterns.

This analysis is presented in this section and provides a comprehensive assessment of temporal changes in the fishery through detailed regression analysis and an illustrated and textual analysis of temporal changes in the fishery. An analysis of temporal change in size structure of the catch is also presented.

4.1 INTRODUCTION

In analysing the historical catch data for blacklip and greenlip abalone in the Western and Central Zones, three characteristics of the catch data are assessed:

- spatial trends in abalone catches since 1980
- Regression analysis of temporal change in abalone catches since the introduction of quota management
- size composition of the catches

High densities of stunted blacklip abalone populations exist within the Southern Zone. "Fishdowns" of these stocks is a feature of the management of the fishery. Hence temporal and size composition changes in the exploitation of the abalone within this zone are marked by these events. Greenlip abalone are essentially a minor component of the catch. Thus for the Southern Zone only the changes in spatial trends in catches are analysed and discussed.

Only a very broad qualitative approach is taken to the analysis of spatial trends in the fishery. Maps of the fishery for each year since 1980 have been produced by overlaying a different colour for each of six categories of catch levels: <1, 1-5, 5-10, 10-20, 20-30, >30 tonnes per annum in each of the 195 individual mapcodes. This provides within and between year patterns of spatial variability in catches.

Regression analyses of temporal change in abalone catches were undertaken to provide a robust assessment of the catch trends in individual metapopulations since the introduction of quota management in the Western and Central Zones. The methodology used was standard regression with the significance of trends tested by analysis of variance. The graphs showing trends and statistical analyses are shown within the western Zone. Where there had been a change in quota over the period of analysis, two analyses were undertaken; one on the standard raw data and a second on the data corrected for the quota adjustment. The correction applied was done by increasing the actual catch by the percentage reduction in the overall quota for the zone. The correction factors applied to blacklip catches in the Western Zone are:

- 1988 - 1989; 1.058824
- 1995 - 1996; 1.120

The correction factor applied to greenlip catches in the Western Zone from 1989 to present is; 1.294118.

Since 1978 divers from the Western and Central Zones have provided on a voluntary basis the size gradings of their catches, which were provided to them by the processors of the catches, in their monthly return forms. On average 50-60% of the divers have provided this information. The gradings are in three categories: 1-2 meats per pound, 2-3 per pound, and 3-5 per pound. (The pound is 0.454 kg and was retained by processors after metric conversion in 1968).

Catch (size) gradings may assist in interpreting changes in populations structure at a local scale. A high proportion of catch graded infers a higher probability that the size structure of the graded catch reflects the size structure of the fished population. Size gradings are not easy to interpret. A reduction in the proportion of the largest sizes in the catch over time may indicate increasing fishing mortality i.e. a reduction in the proportion of larger, and presumably older, individuals in the catch. Conversely an increase in that size grading should indicate declining fishing mortality. However, the non-independence of the grading proportions means that other and opposite explanations are possible. Thus increasing size gradings may indicate declining recruitment i.e. a lack of smaller individuals available for harvest as found by Tarr (in press) in South Africa. Secondly, a change in the gradings may indicate selection by divers for particular sizes favoured by the processors. Thus, during the 1980s divers claimed that a reduction in average size of blacklip was due to processor preference and higher prices being offered for smaller blacklip.

The failure of size gradings to change over time is also ambiguous. On the one hand, it may indicate stability in the fishery, but, and this is especially true for greenlip, it may remain constant despite the collapse of a population. Constancy of size-frequency distributions was observed in collapsing populations of greenlip at Cape Jervis and Avoid Bay. This occurred because the populations declined in spatial extent faster than in density, while subject to a more or less constant fishing mortality. With respect to blacklip, it is not clear to what extent spatial contraction occurs as the population declines, so that it is difficult to predict how overfishing will affect, if at all, the size gradings.

Overall, the most promising use of gradings may be to detect a decline in the proportion of the smallest size grades, because this may indicate a decline in recruitment. Graphs are presented for each metapopulation area in the Western and Central Zones plotting the data for each size grading since 1979.

In conclusion long-term changes in the proportion of the largest and smallest size gradings are likely to be the most useful as evidence of changes in the dynamics of fished abalone populations. However, both are ambiguous and need to be considered in concert with all other data, especially fishery-independent data, if underlying trends are to be elucidated. Lastly we add the caveat that interpretation of changes in size gradings is not symmetrical i.e. if a proportional decline in a grading signifies one conclusion, the reverse trend does not necessarily imply the opposite.

4.2 WESTERN ZONE

4.2.1 Assessment of spatial trends in Greenlip abalone catches since 1980.

Figures 4.1 to 4.19 provide an overview of the broad patterns of catch distribution. The Western Zone catch of greenlip abalone is about 230 tonnes. Whilst greenlip are caught throughout the zone, the most important areas are Thorny Passage (map 18), Ward Island (9A-B), The Hotspot (9C-D), Pearson Island (9E-F), Baird Bay (5E), Sheringa (11A) and the

Avoid Point/Avoid Bay area (14C,D, 15A) which collectively account for over 150 – 180 tonnes of the entire catch at present.

One of the features of the Western Zone is the consistent catches taken from the small area of the Gap (18F) in Thorny Passage which has produced over 20 tonnes per annum for 16 of the last 20 years to 1998. Similarly the areas of Pearson Island, The Hotspot and Ward Island have been very important consistent producers of greenlip with catches in recent years regularly over 60 tonnes and mostly over 40 tonnes for most of the last 20 years.

While these areas have maintained their importance others have declined. The Whidbey Isles produced large catches exceeding 20 tonnes in the mid 1980's and have been fished little since 1989. Golden and Price Islands south of Avoid Point produced over 50 tonnes per annum for four of the five years between 1979 and 1983 while catches there have declined from just 8 tonnes in 1990 to about 1 tonne in 1998. Similarly the Coffin Bay Peninsula produced 30 to 90 tonnes in the late 1970s to early 1980s but has only produced 20 tonnes or less since about 1989. It has to be pointed out that quota has been introduced in the Western Zone since 1985 and this has capped catches in many areas, however some of the areas have suffered declines in productivity subsequent to heavy exploitation.

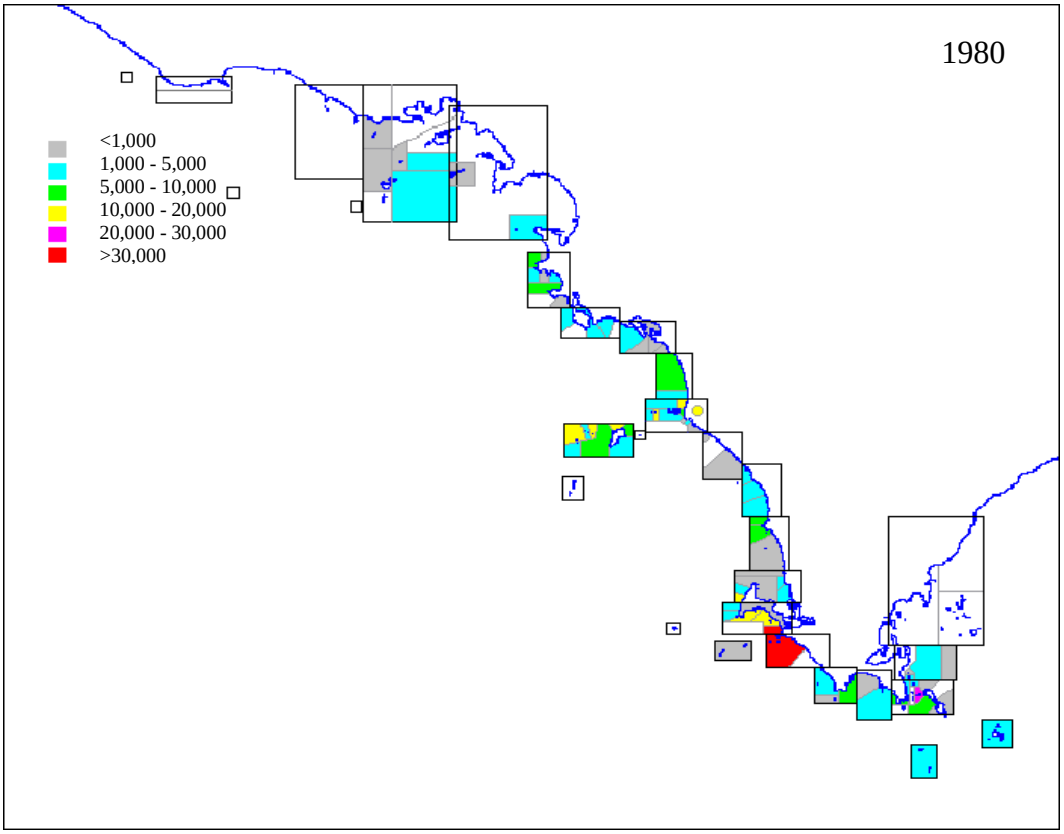


Figure 4.1: The distribution of total greenlip ablone catch (kg) by mapcode in the Western Zone - 1980

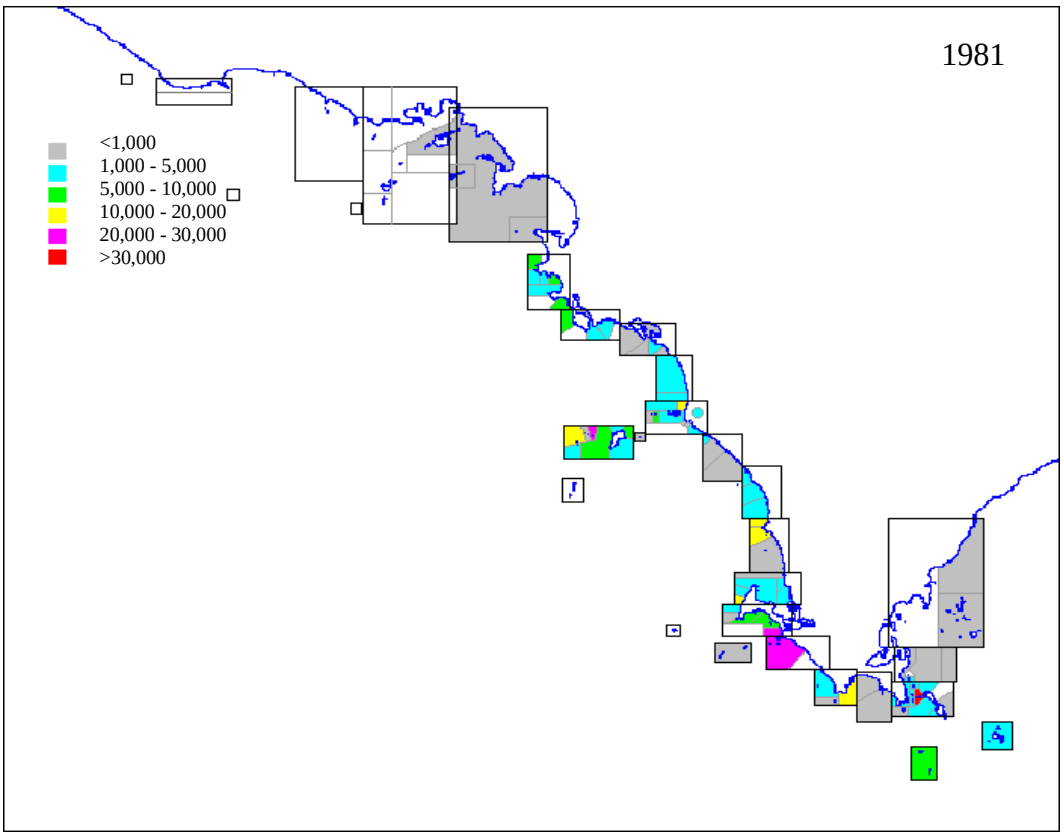


Figure 4.2: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1981

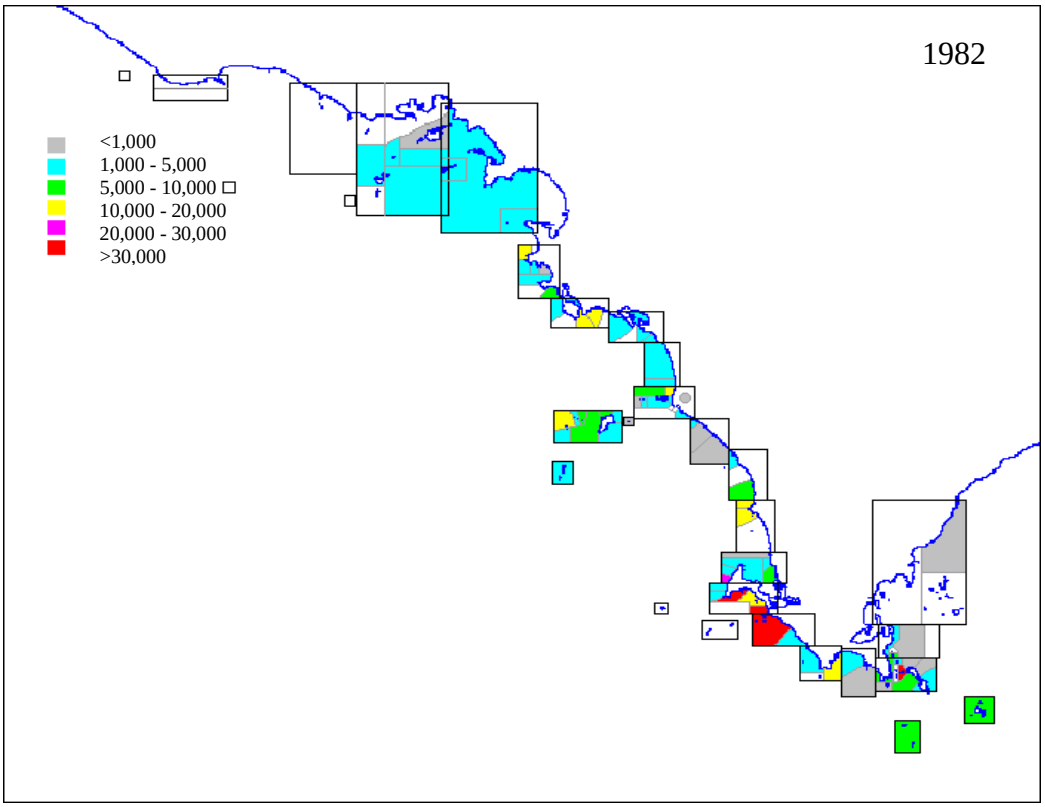


Figure 4.3: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1982

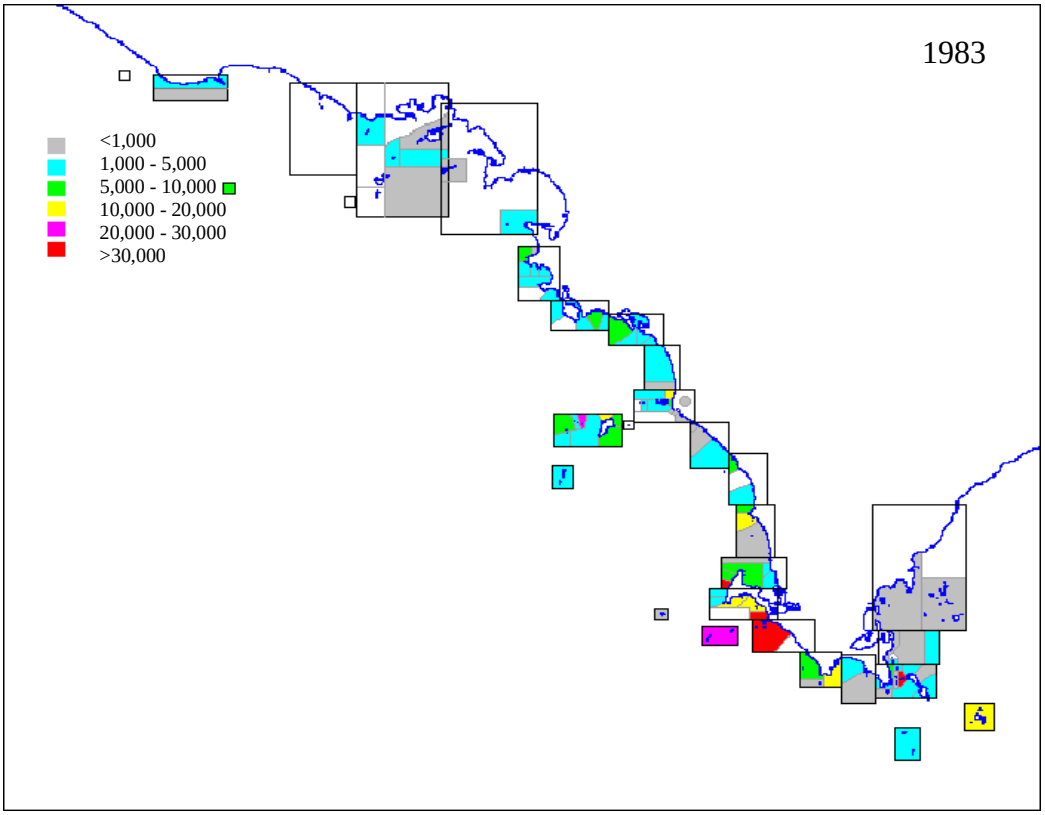


Figure 4.4: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1983

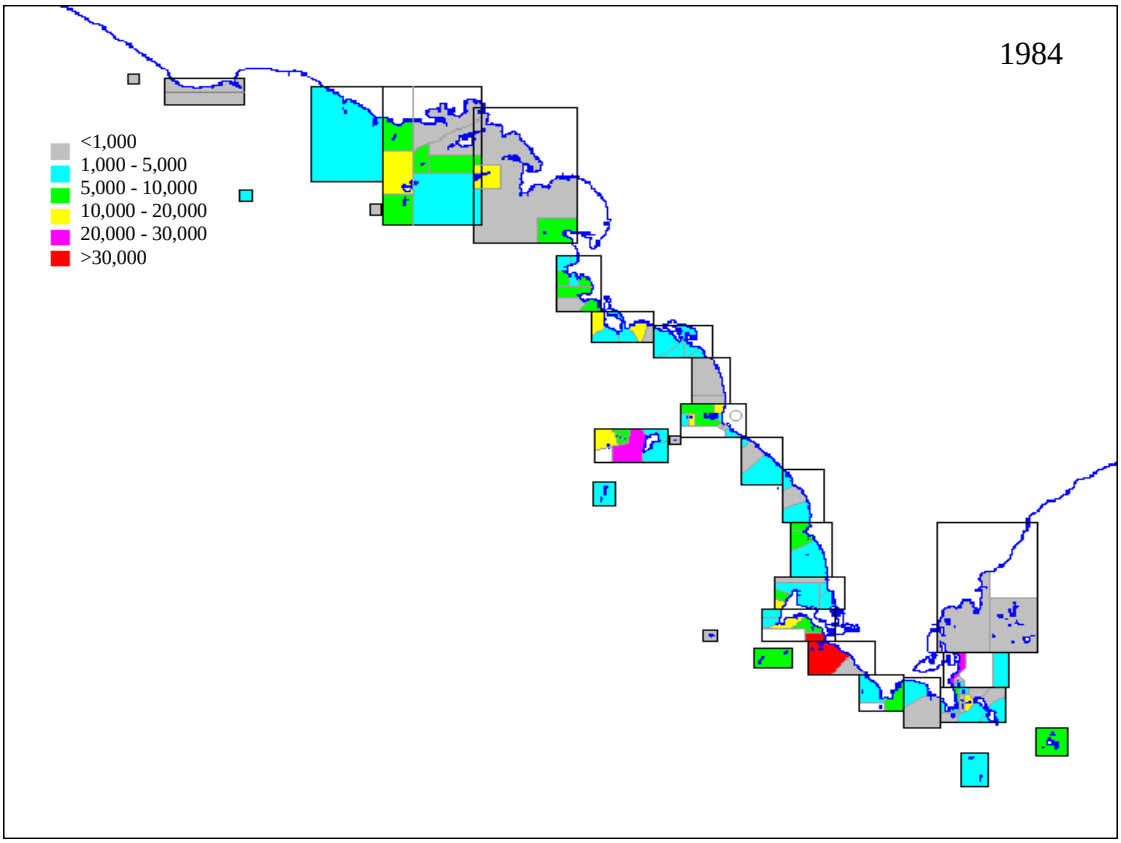


Figure 4.5: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1984

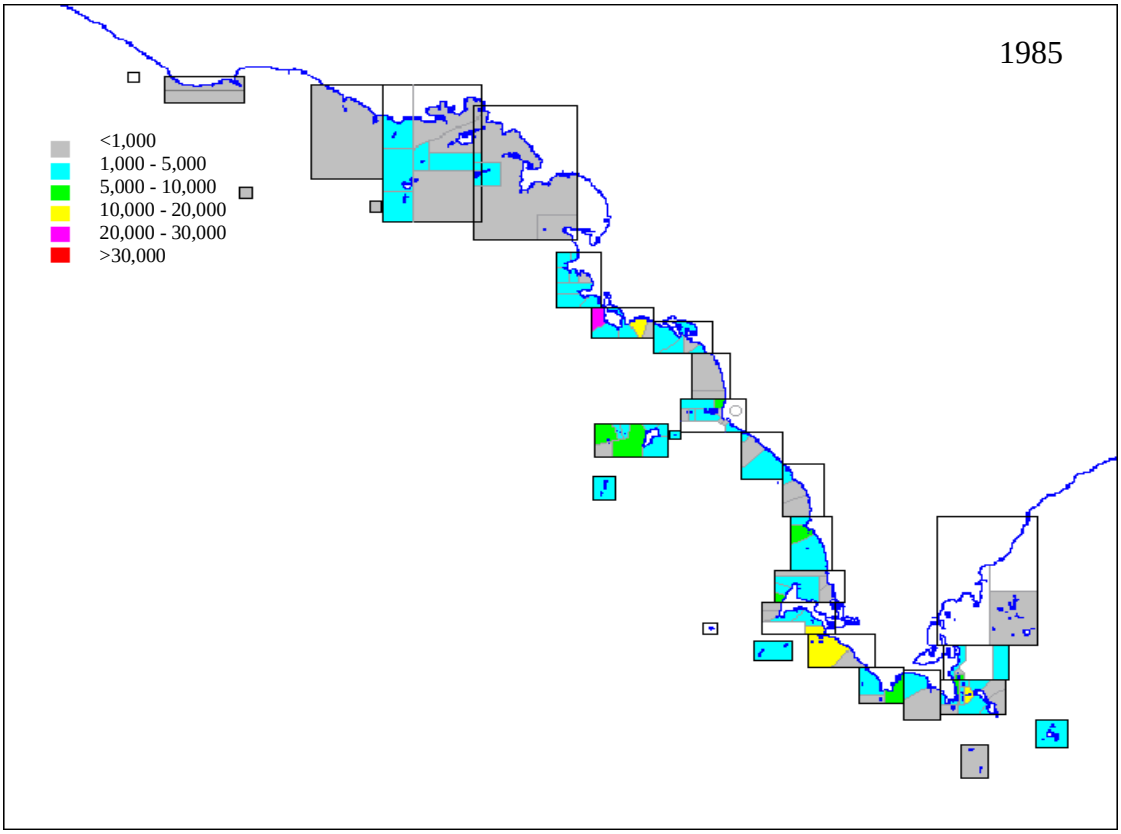


Figure 4.6:The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1985

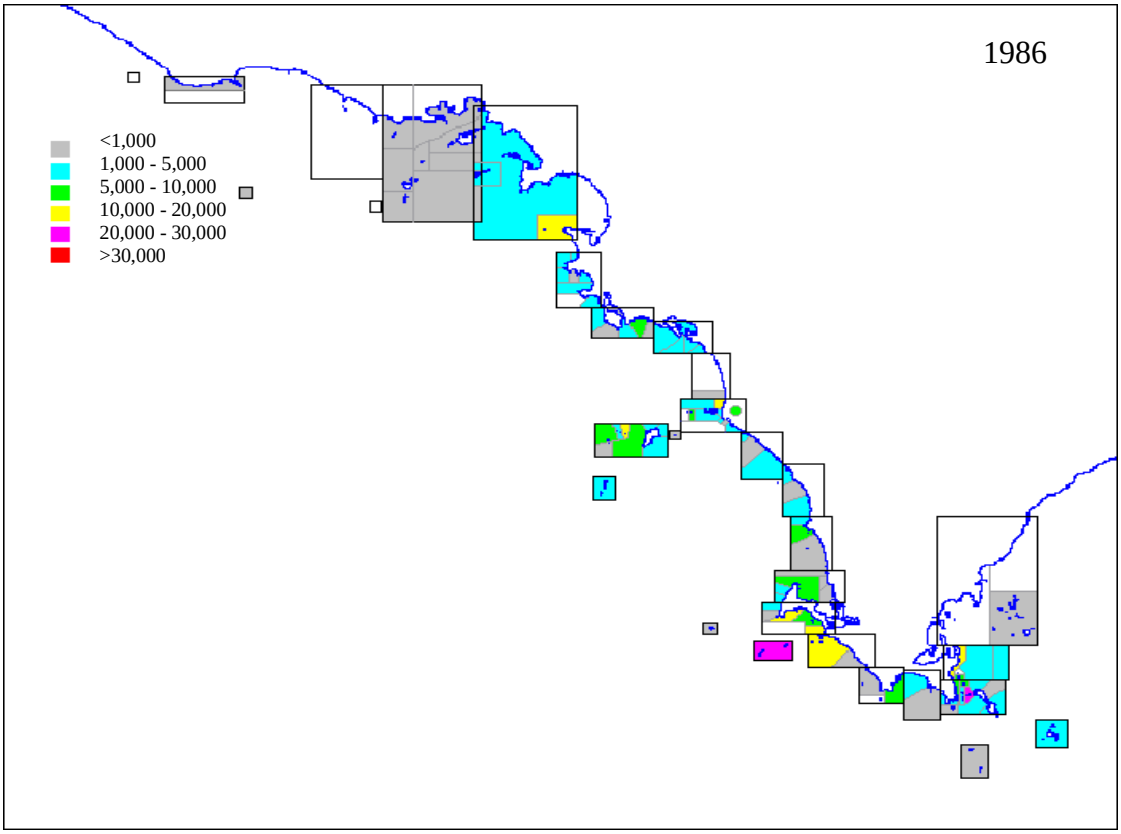


Figure 4.7: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1986

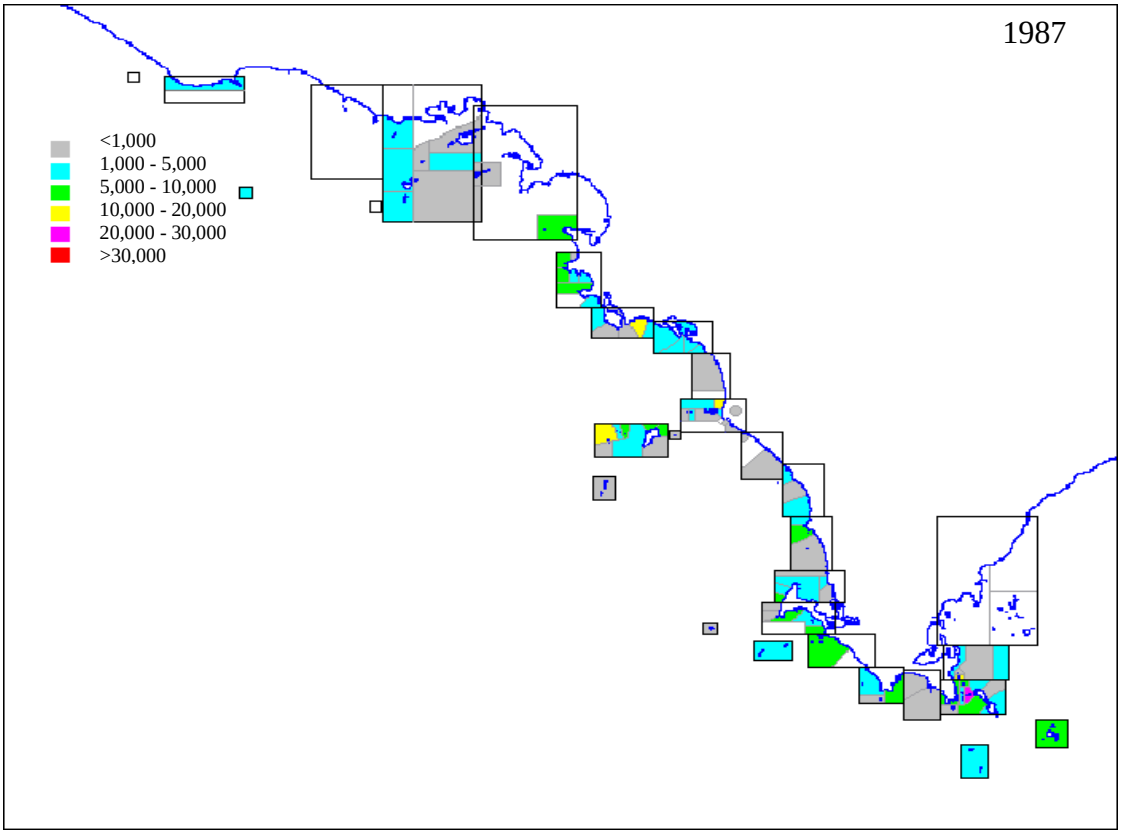


Figure 4.8: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1987

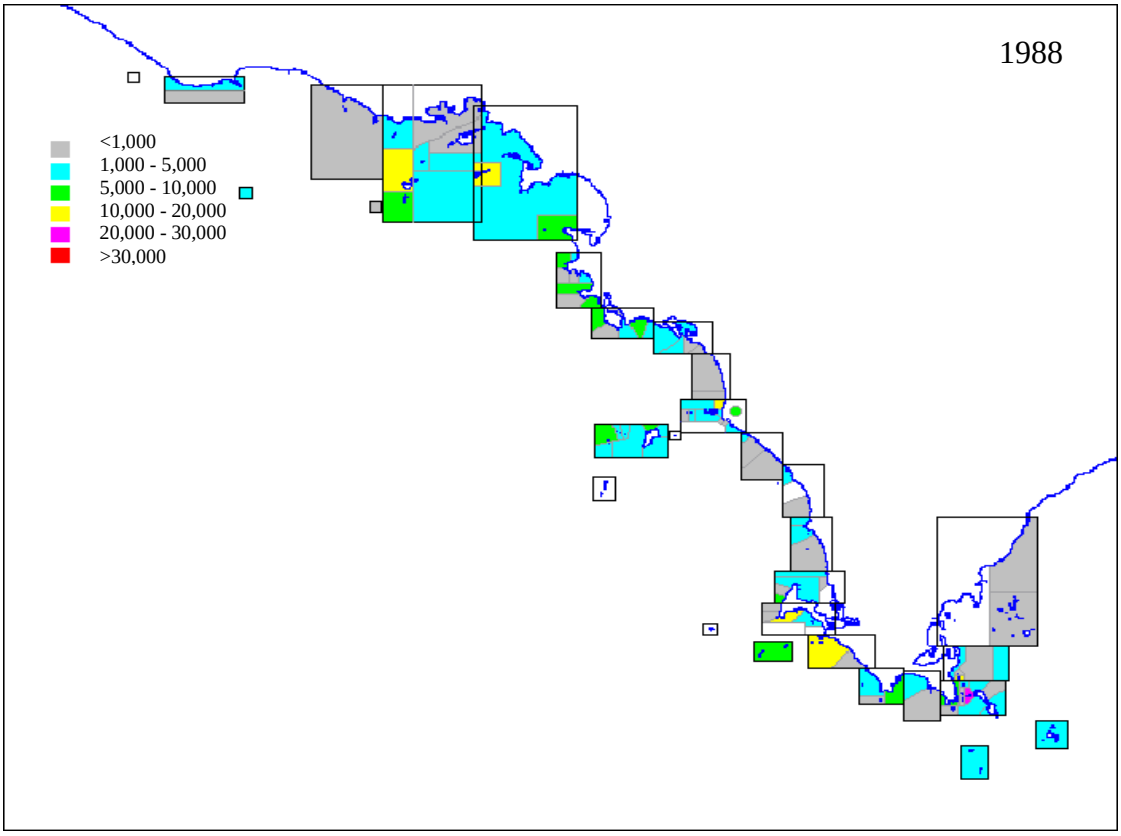


Figure 4.9: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1988

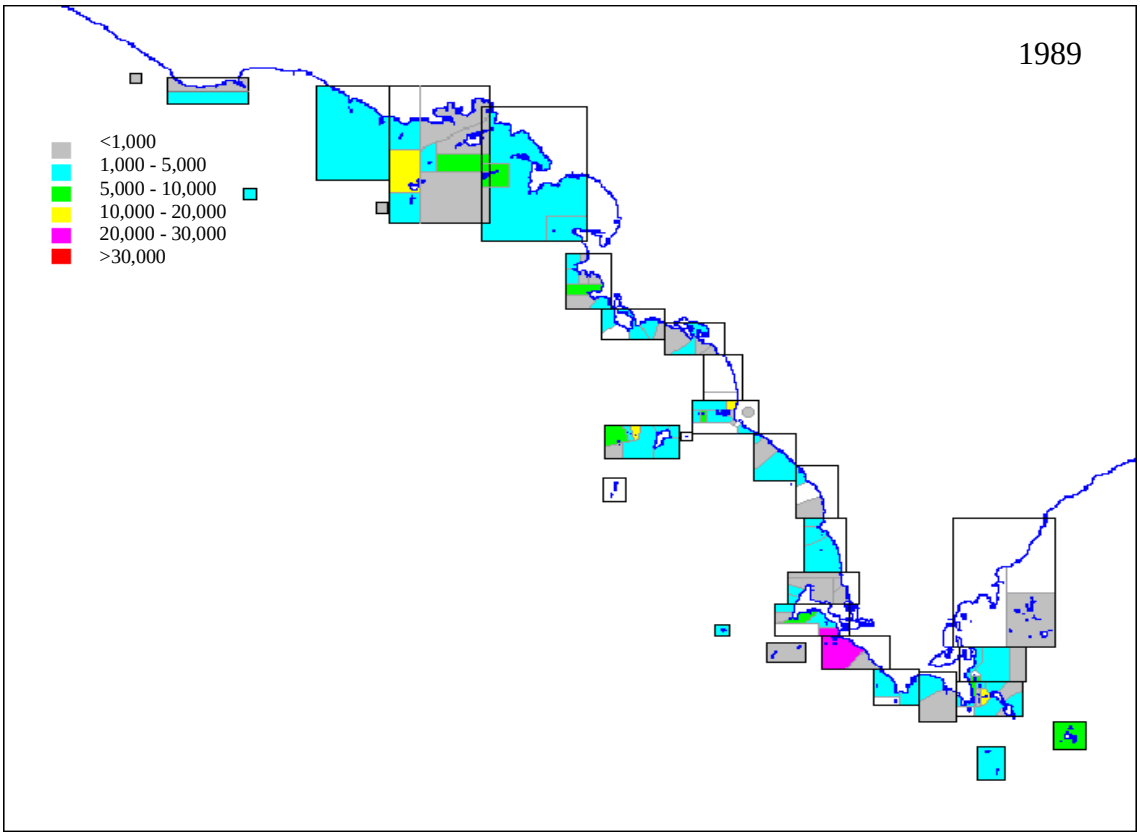


Figure 4.10: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1989

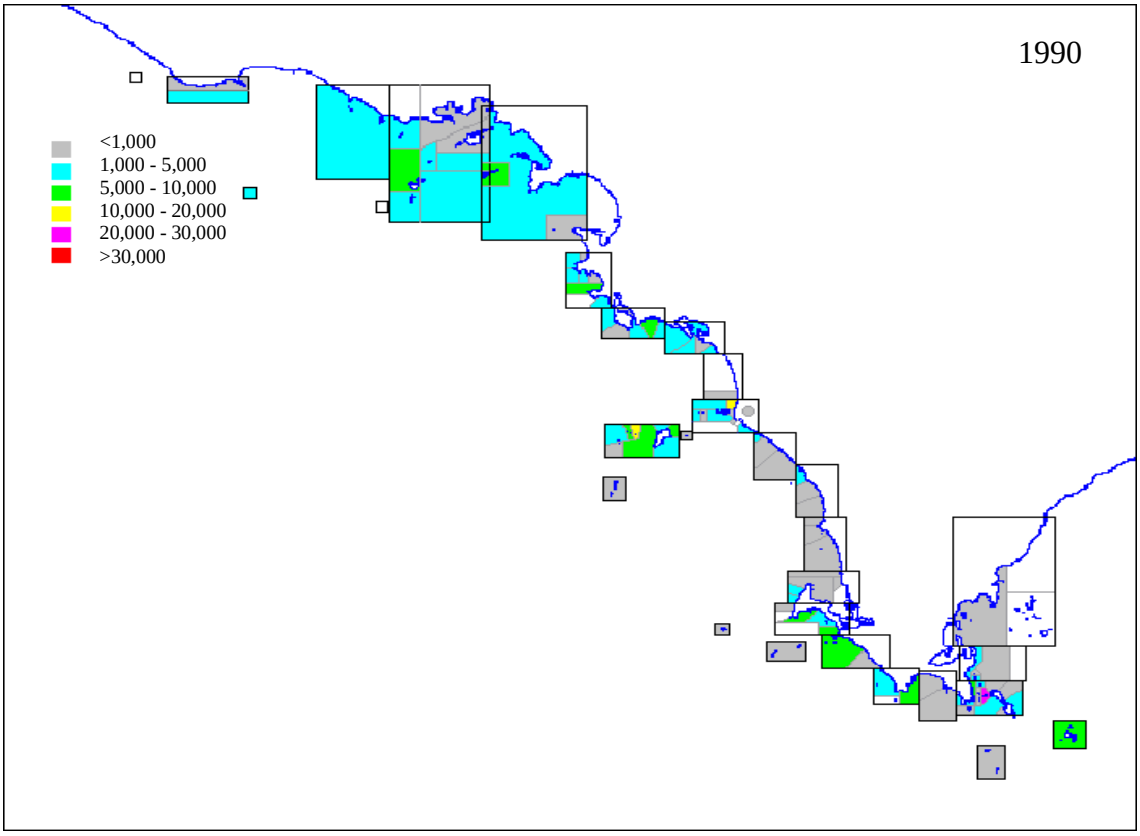


Figure 4.11: THe distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1990

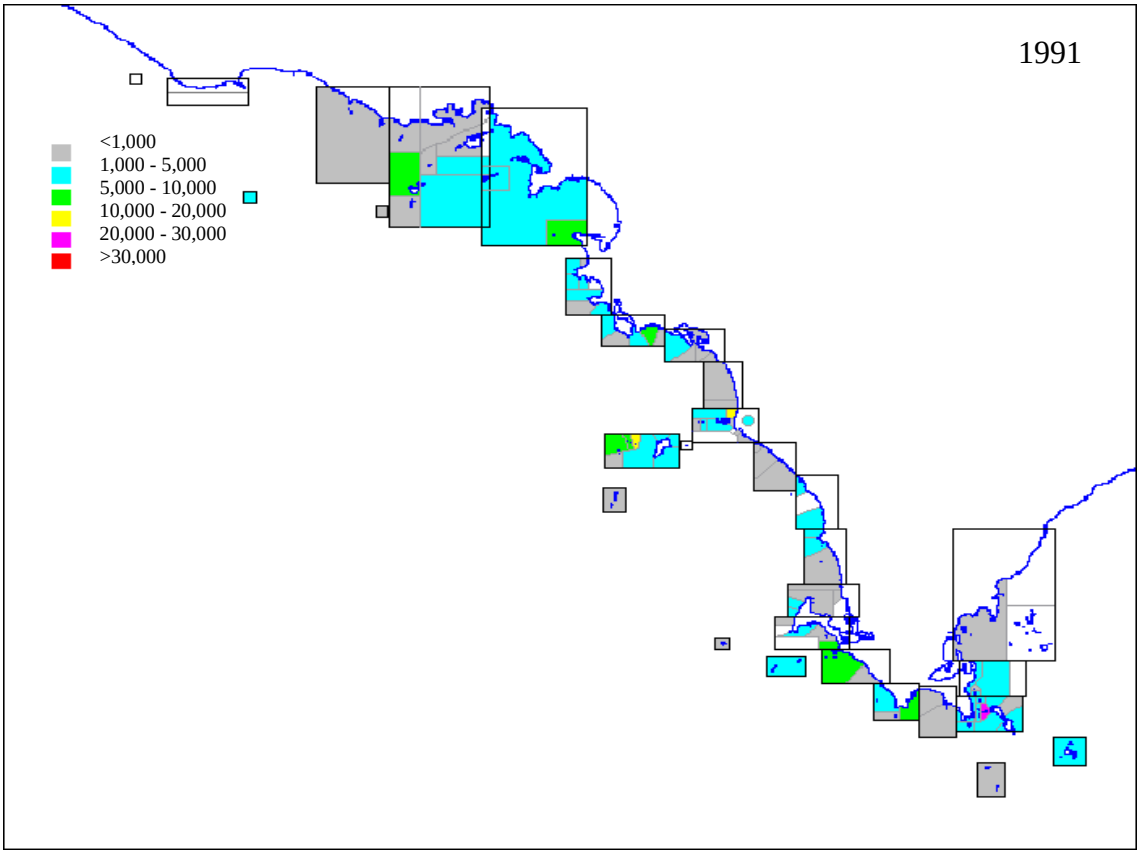


Figure 4.12: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1991

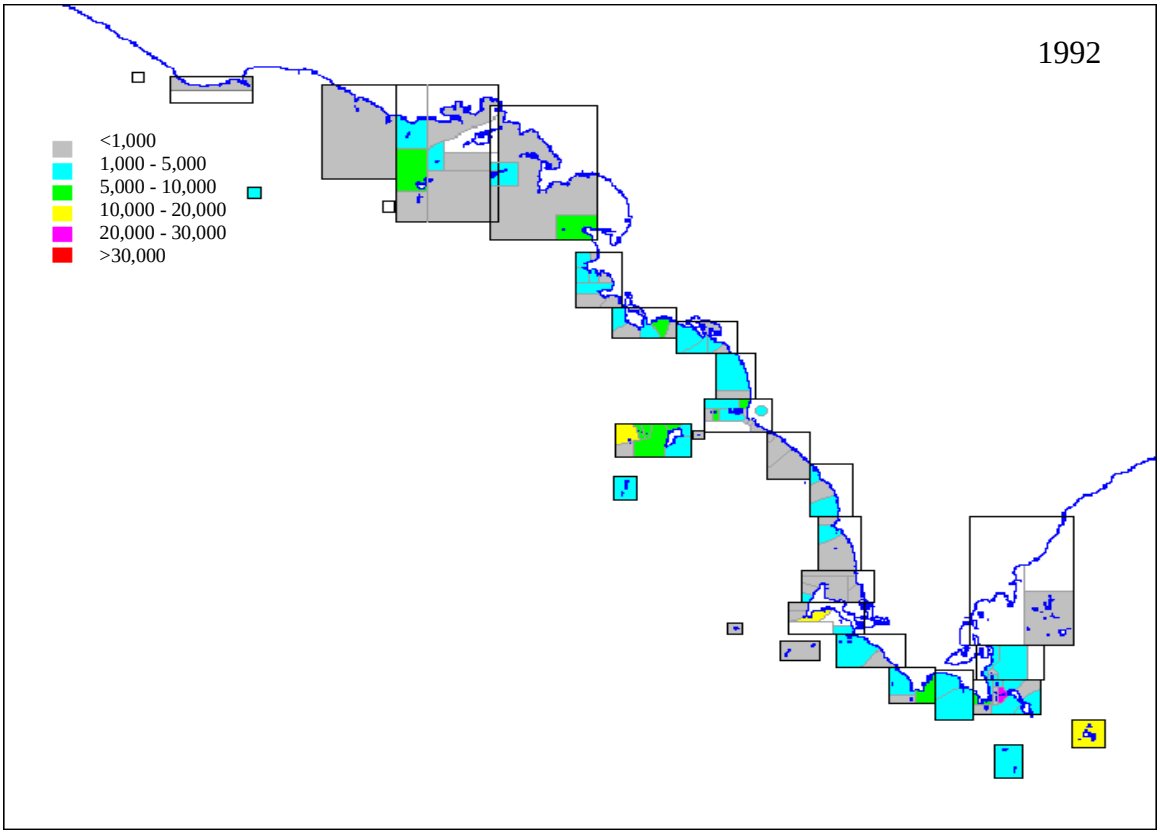


Figure 4.13: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1992

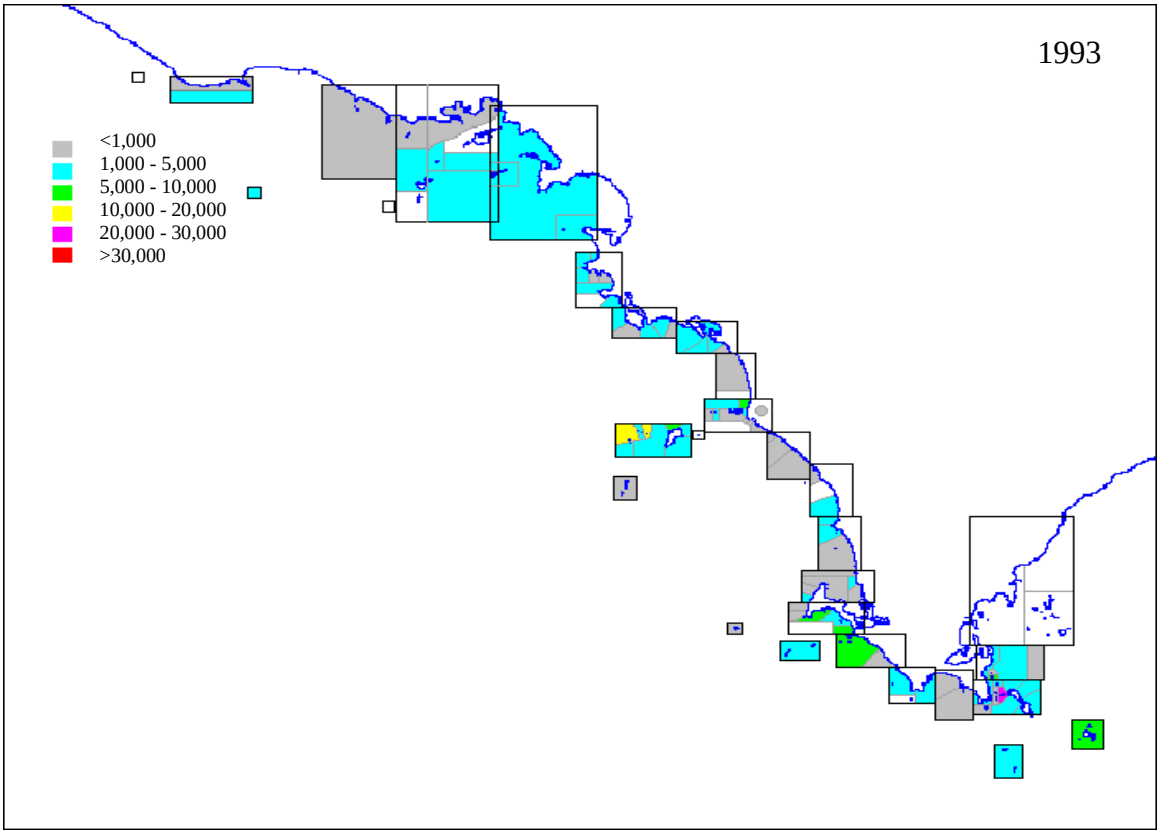


Figure 4.14: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1993

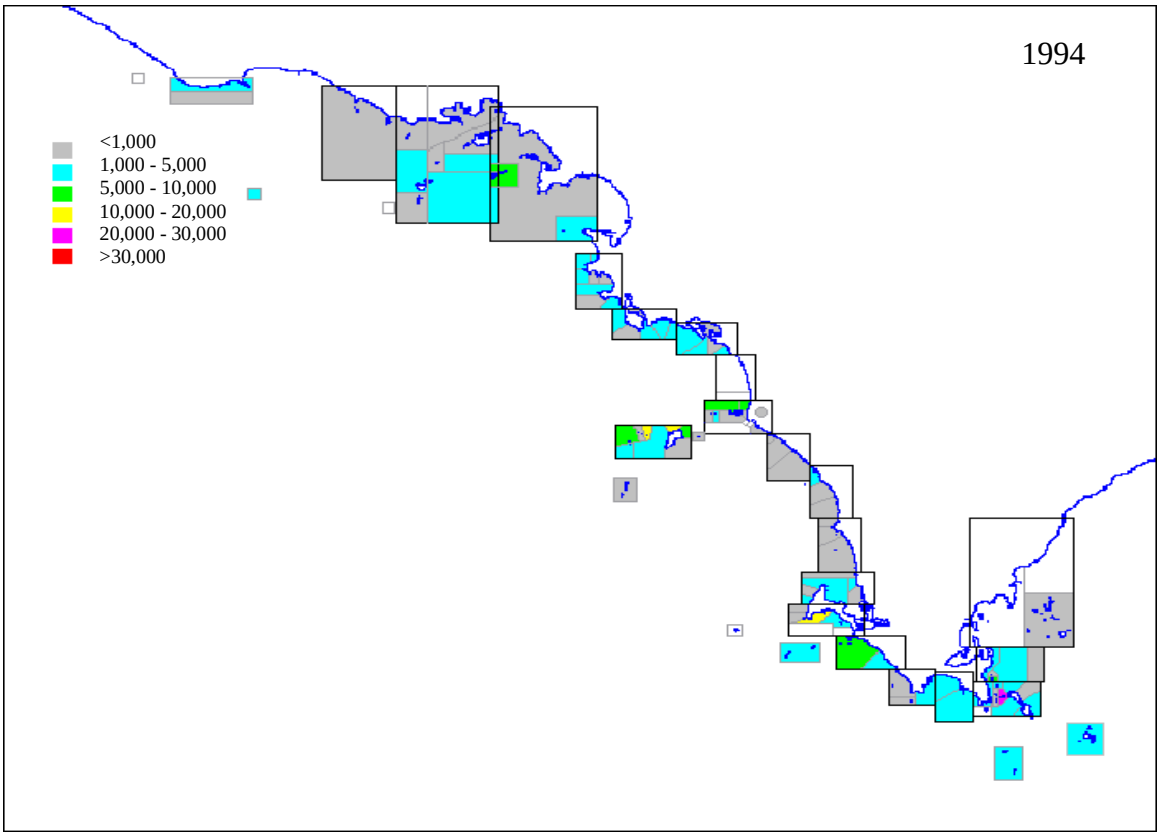


Figure 4.15: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1994

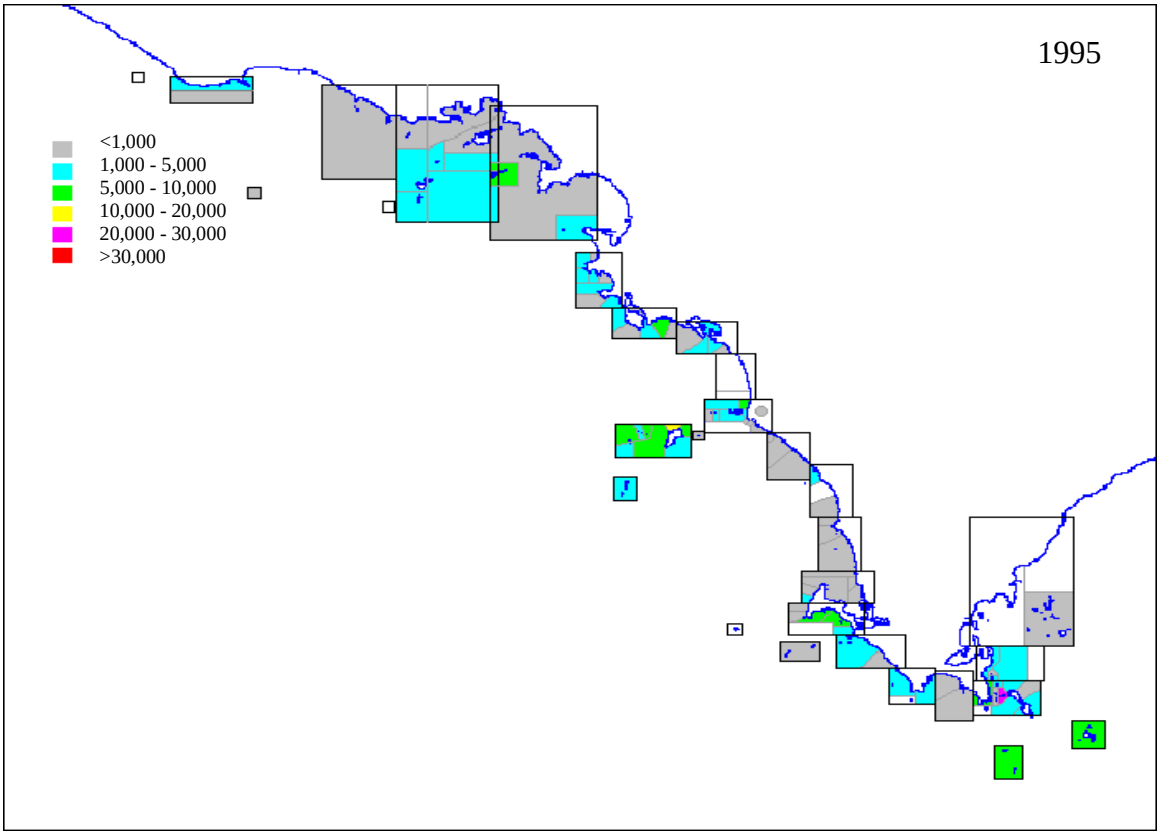


Figure 4.16: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1995

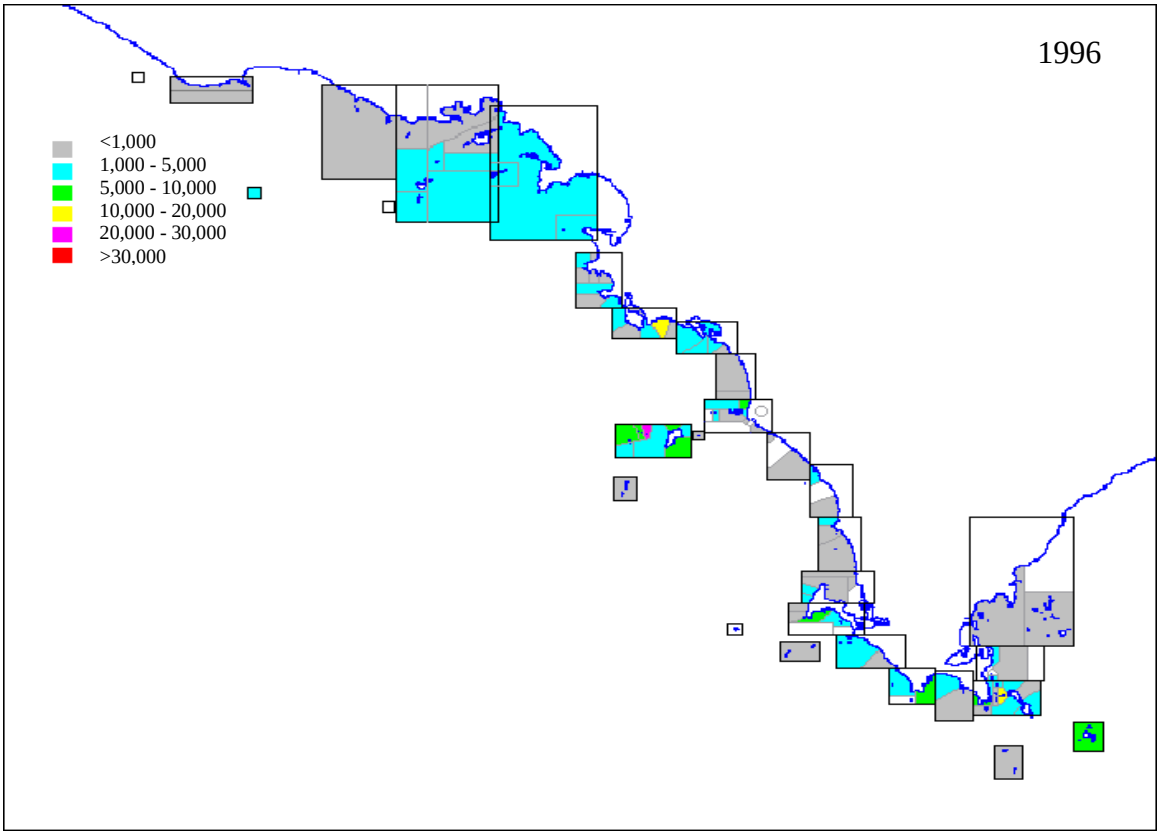


Figure 4.17: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1996

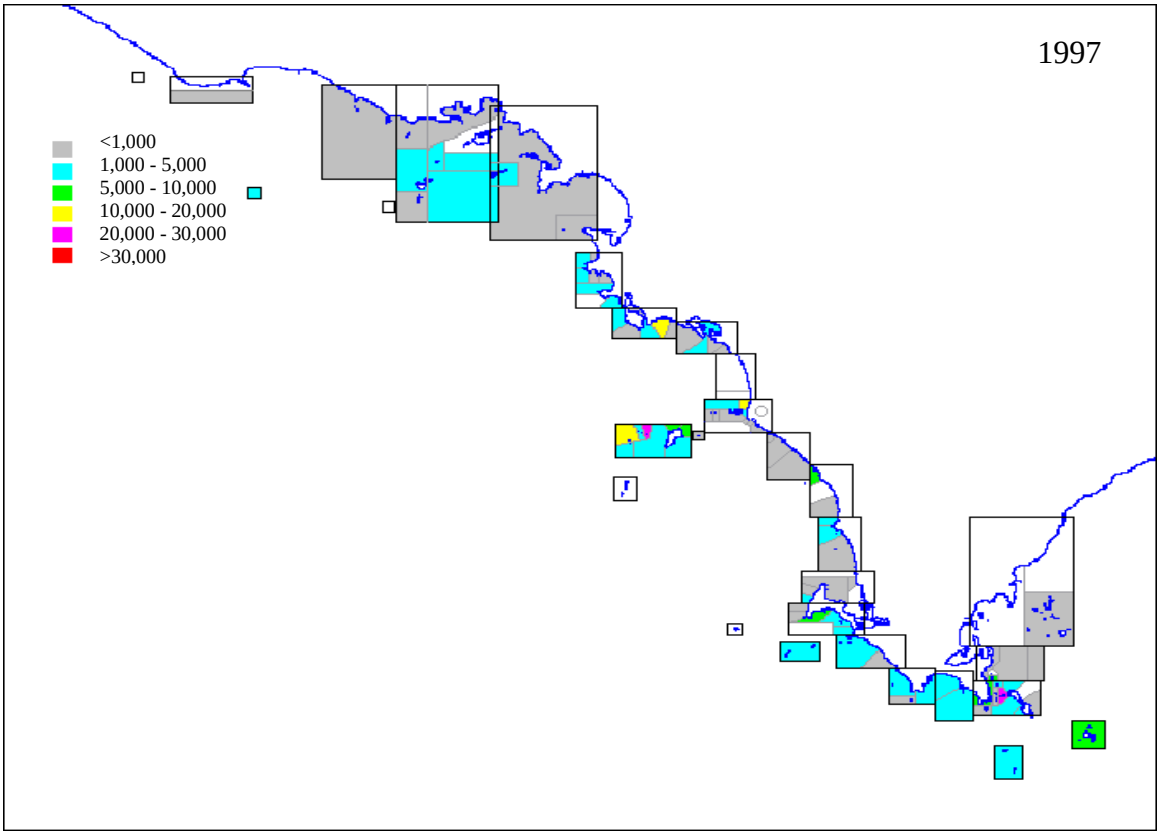


Figure 4.18: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1997

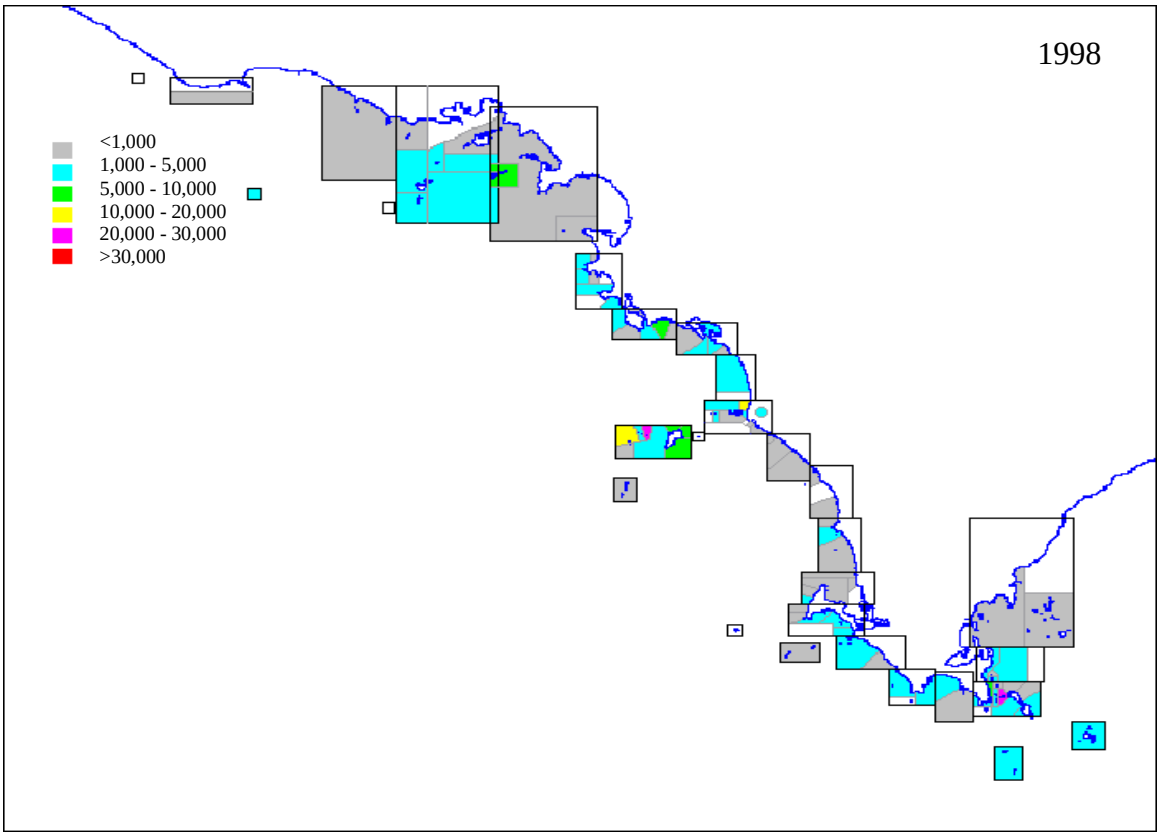


Figure 4.19: The distribution of total greenlip abalone catch (kg) by mapcode in the Western Zone - 1998

4.2.2 Assessment of spatial trends in Blacklip abalone catches since 1980.

Figures 4.20 to 4.38 provide an overview of the broad patterns of catch distribution. The Western Zone catch of blacklip abalone is about 300 tonnes. Blacklip are caught throughout the zone but the most important areas are Ward Island (9A-B), Sheringa (11A), High Cliff (4A-C), Pt Labatt (5A) and Venus Bay (6A-D) which collectively account for over one-third of the entire catch at present.

Some the above areas (Sheringa, High Cliff) have consistently produced large amounts of blacklip abalone since the early 1980's. Others such as Ward Island have been exploited in more recent times. For example from 1980-1984 catches of blacklip were 5 tonnes or less while from 1984-1998 catches were 15 to 23 tonnes. Clearly there has been a spatial shift from areas such as Pt Drummond (12 A) where catches from 1980-1984 were 30 – 47 tonnes and have fallen to 7 to 16 tonnes from 1994-1998. Other areas where catches have fallen over the same period are Reef Head (13F).

The only particularly strong or persistent change in the blacklip fishery of the period of analysis is the shift to increased catches in the Ward Island and Hotspot areas in the late 1990's.

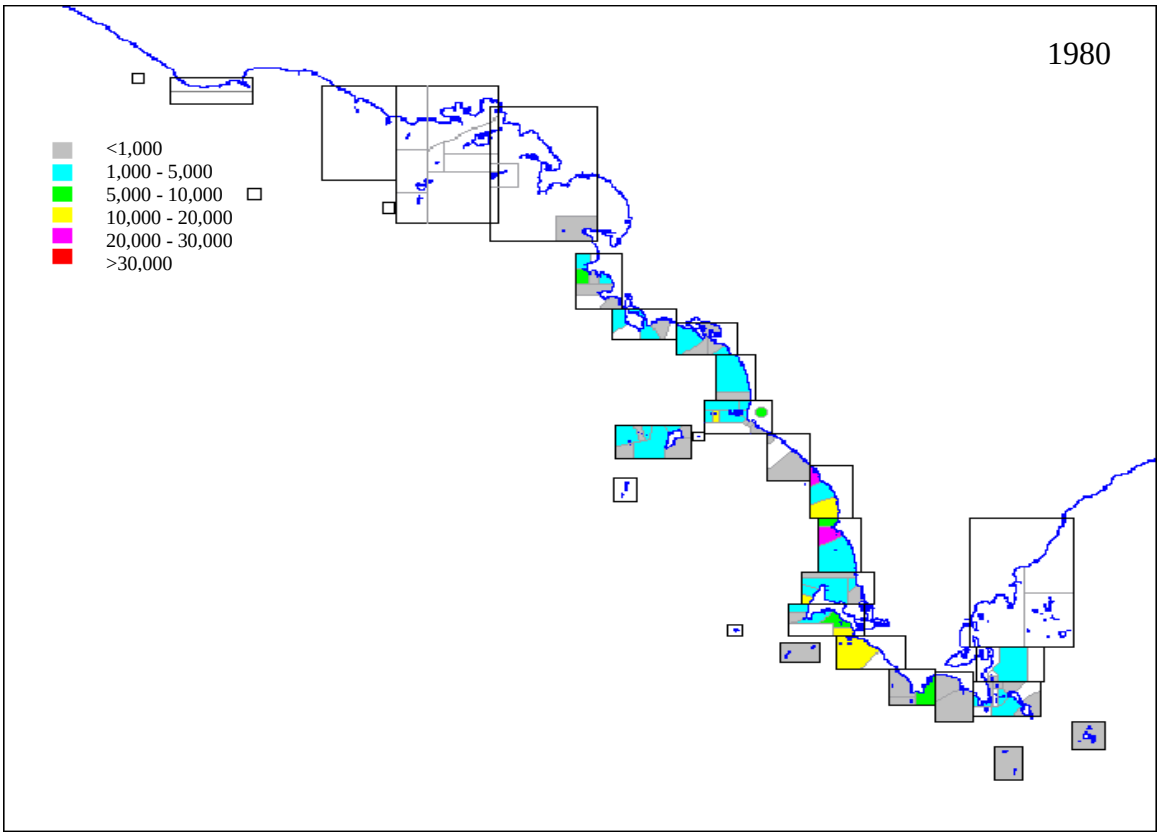


Figure 4.20: The distribution of total blacklip abalone catch (kg) in the Western Zone - 1980

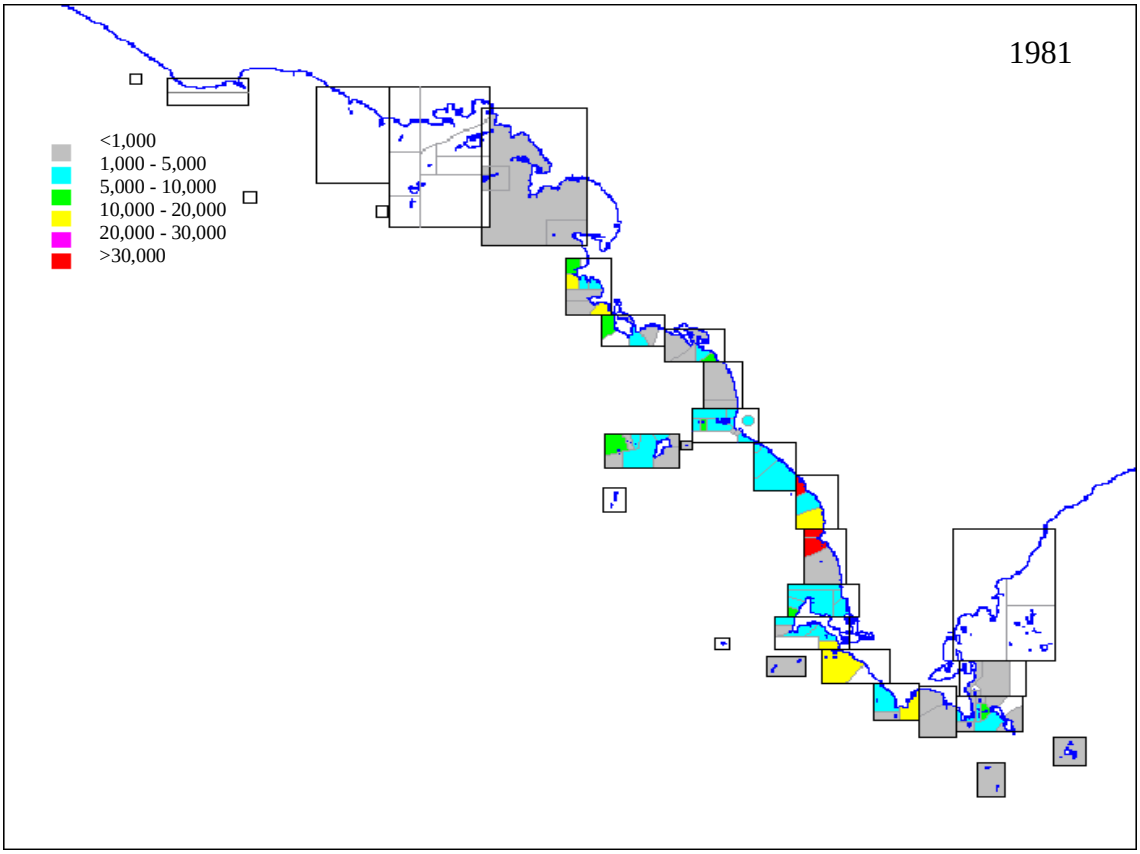


Figure 4.21: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1981

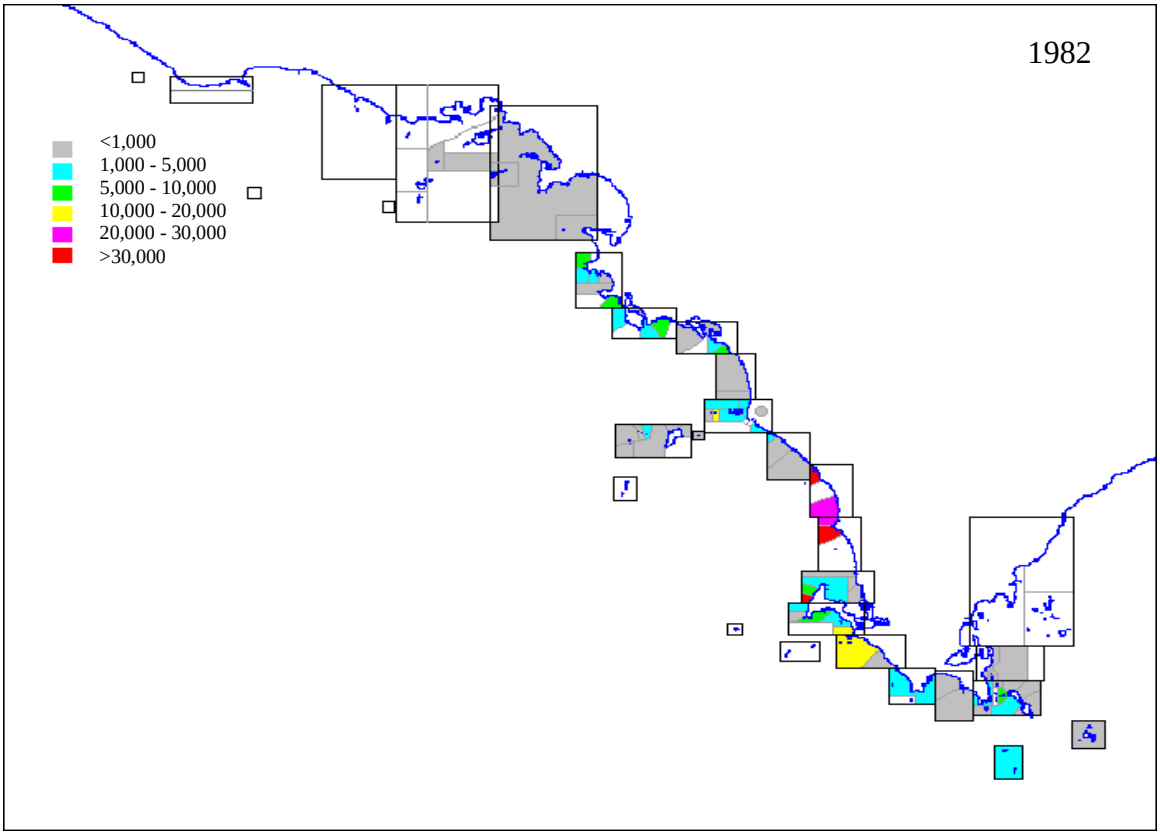


Figure 4.22: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1982

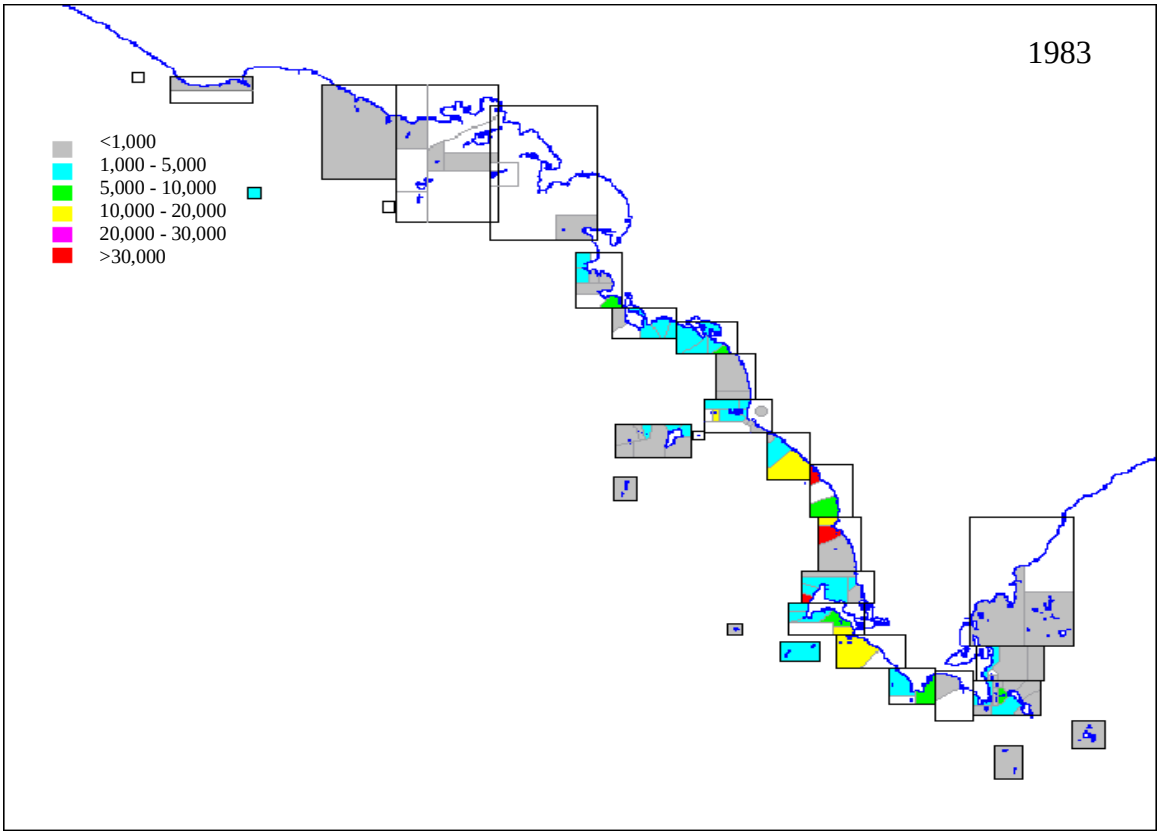


Figure 4.23:The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1983

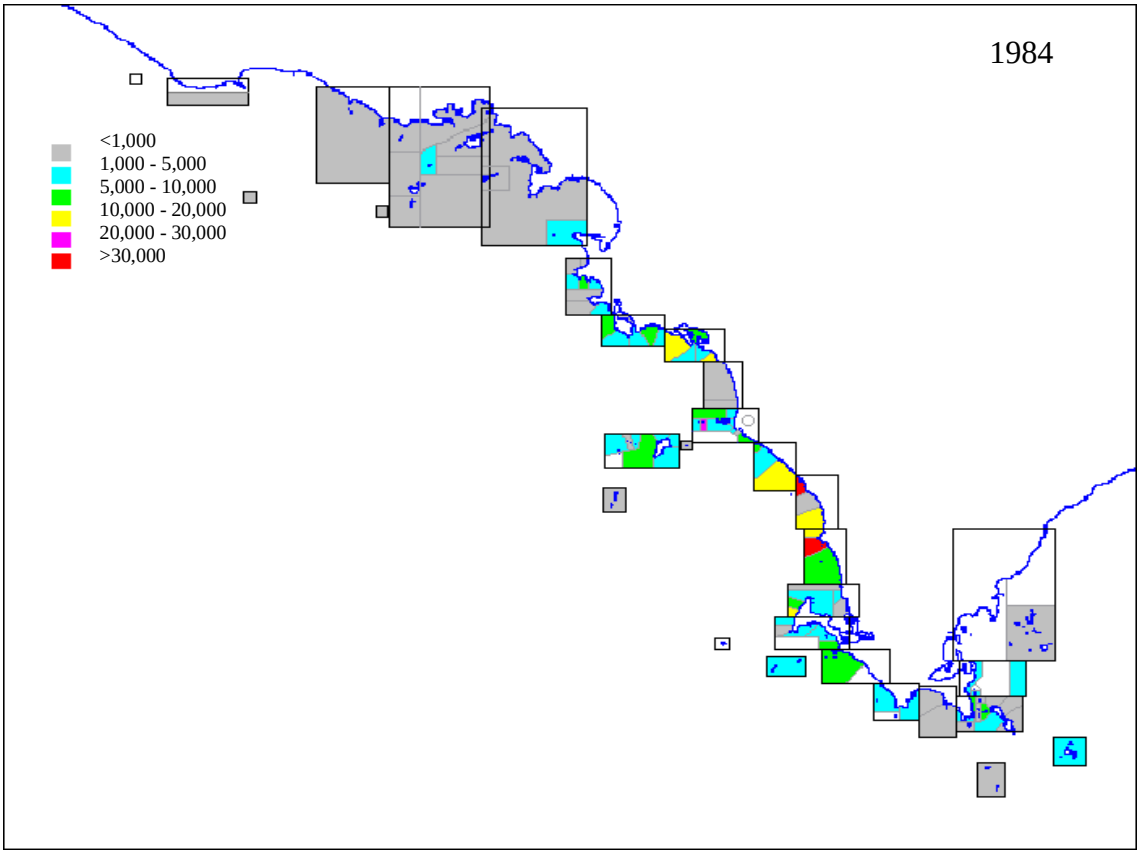


Figure 4.24: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1984

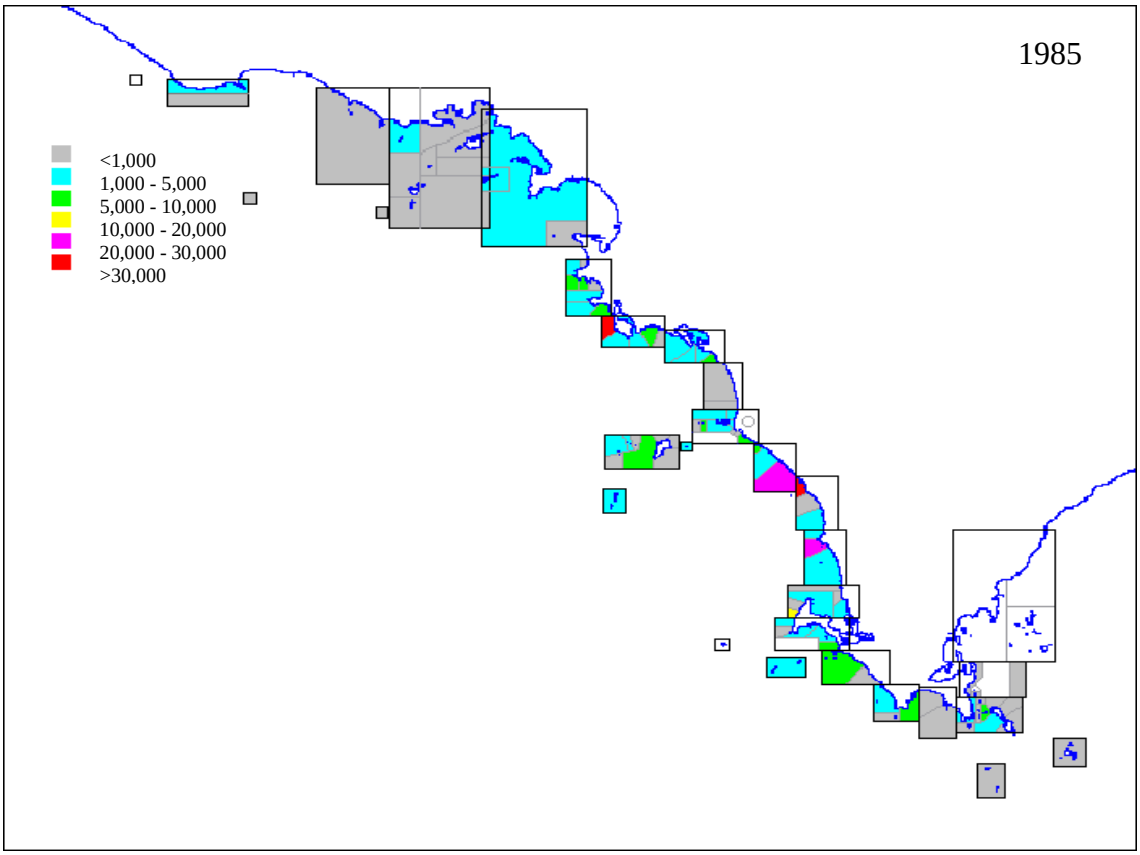


Figure 4.25: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1985

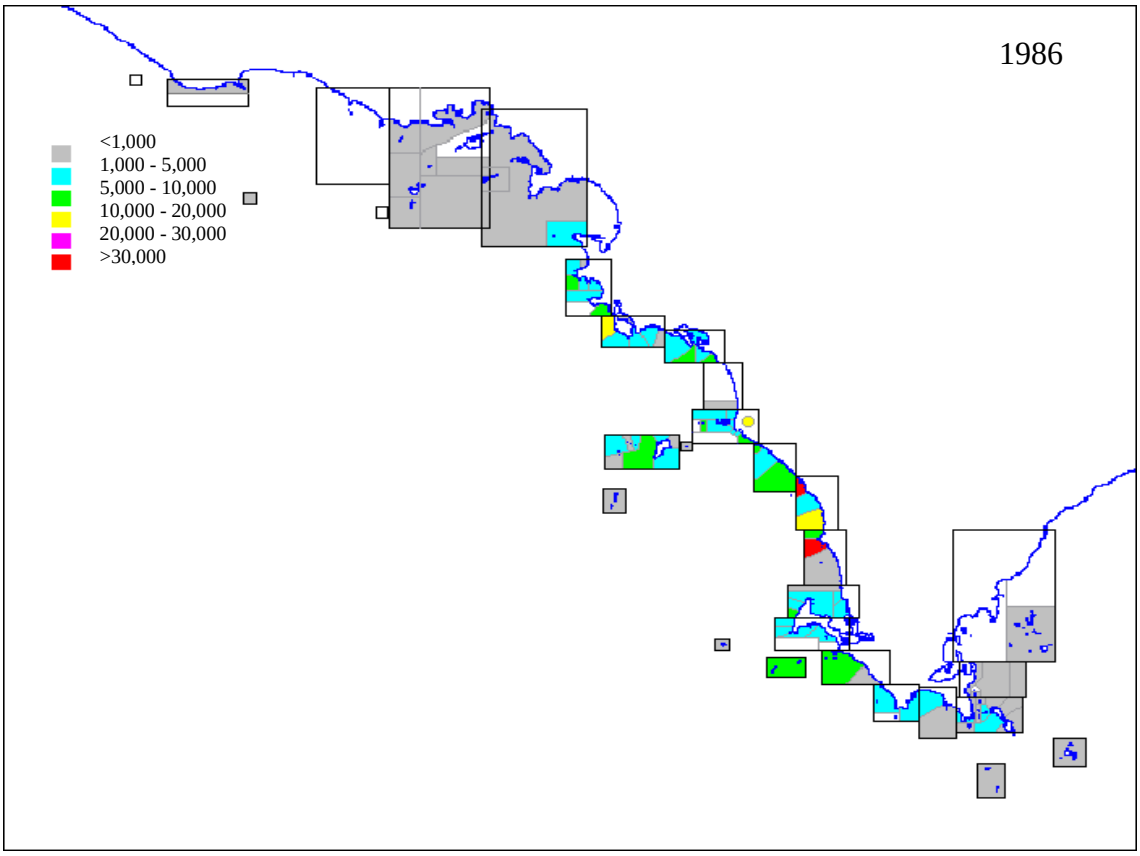


Figure 4.26: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1986

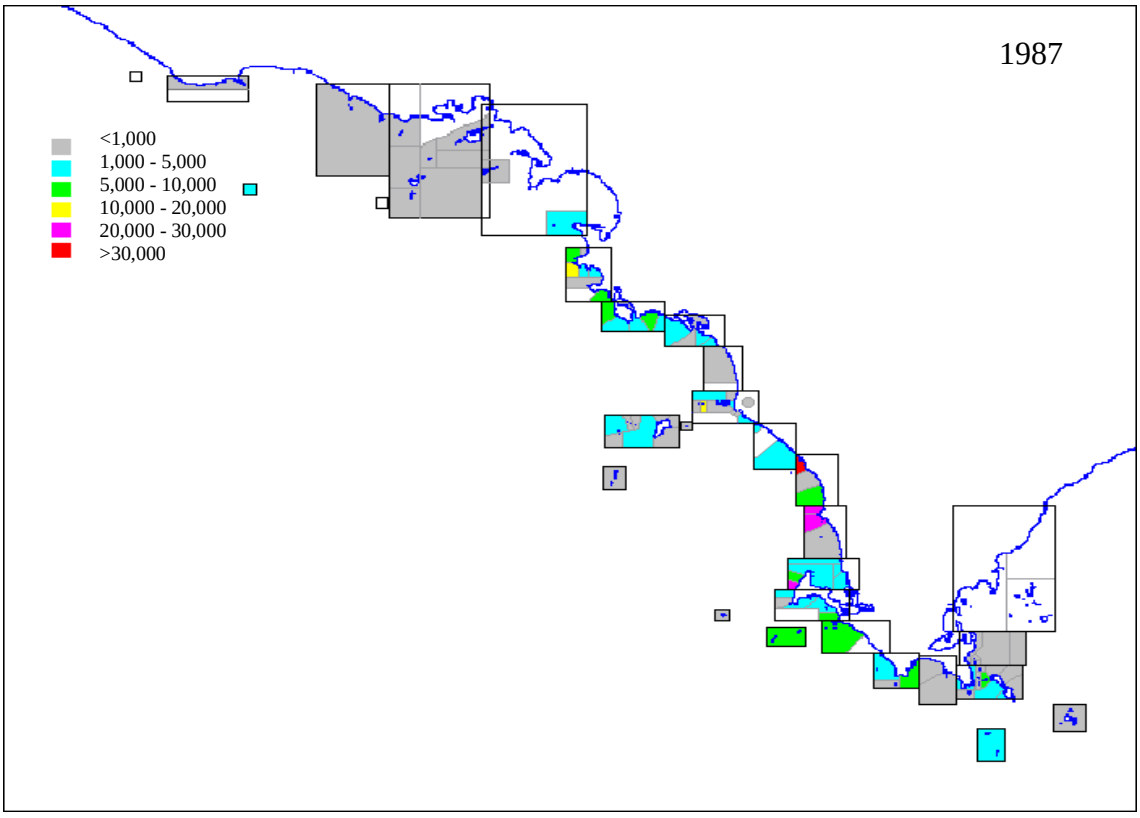


Figure 4.27: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1987

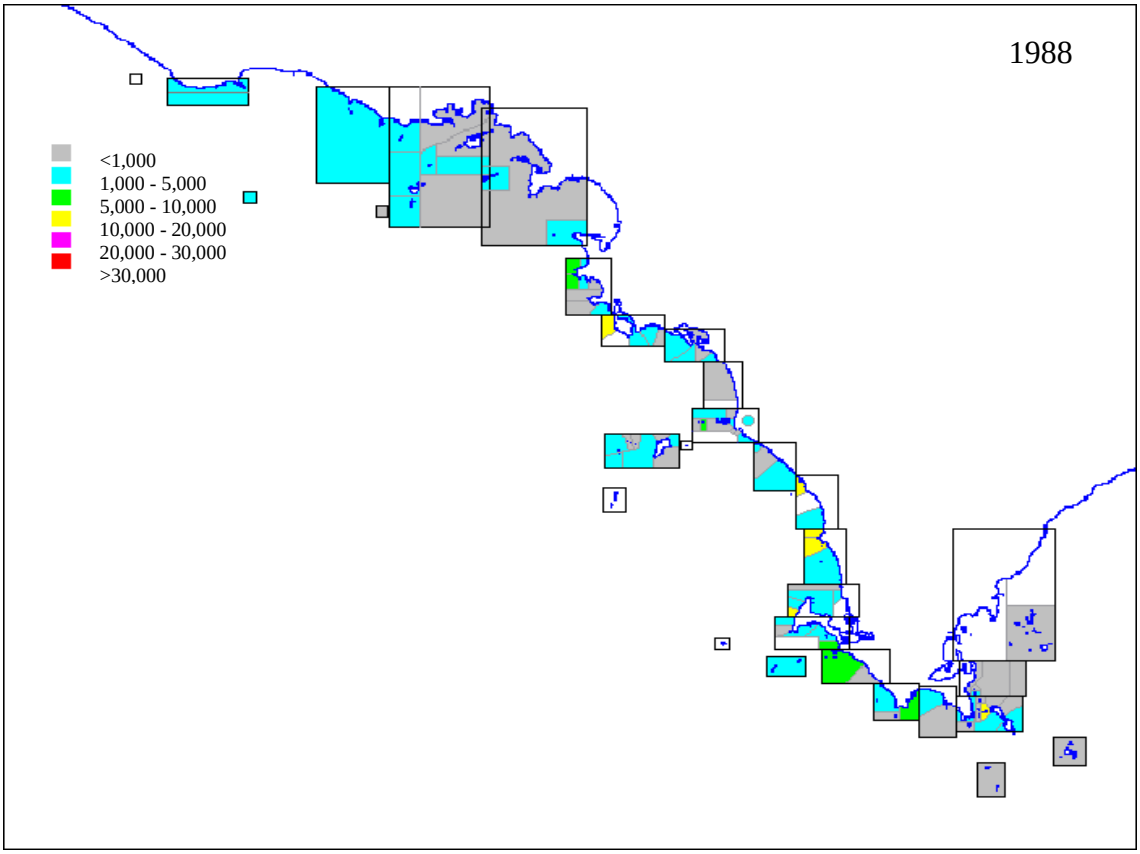


Figure 4.28: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1988

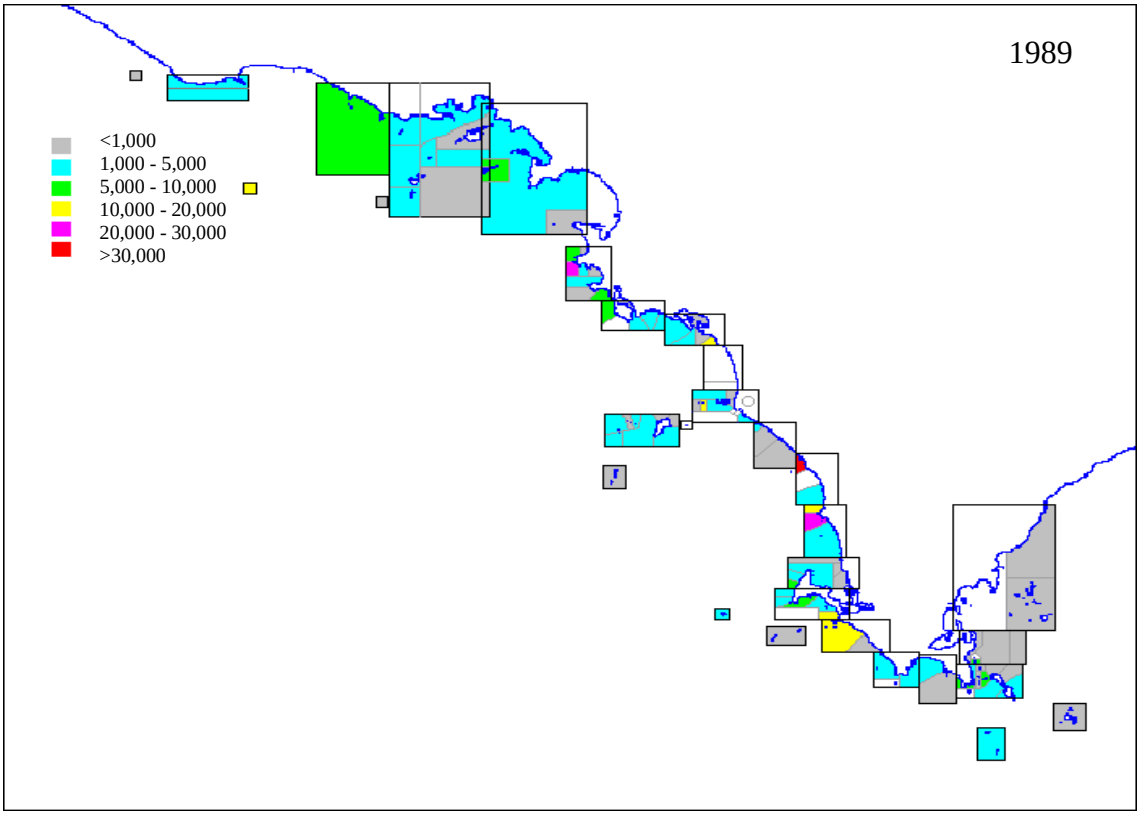


Figure 4.29: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1989

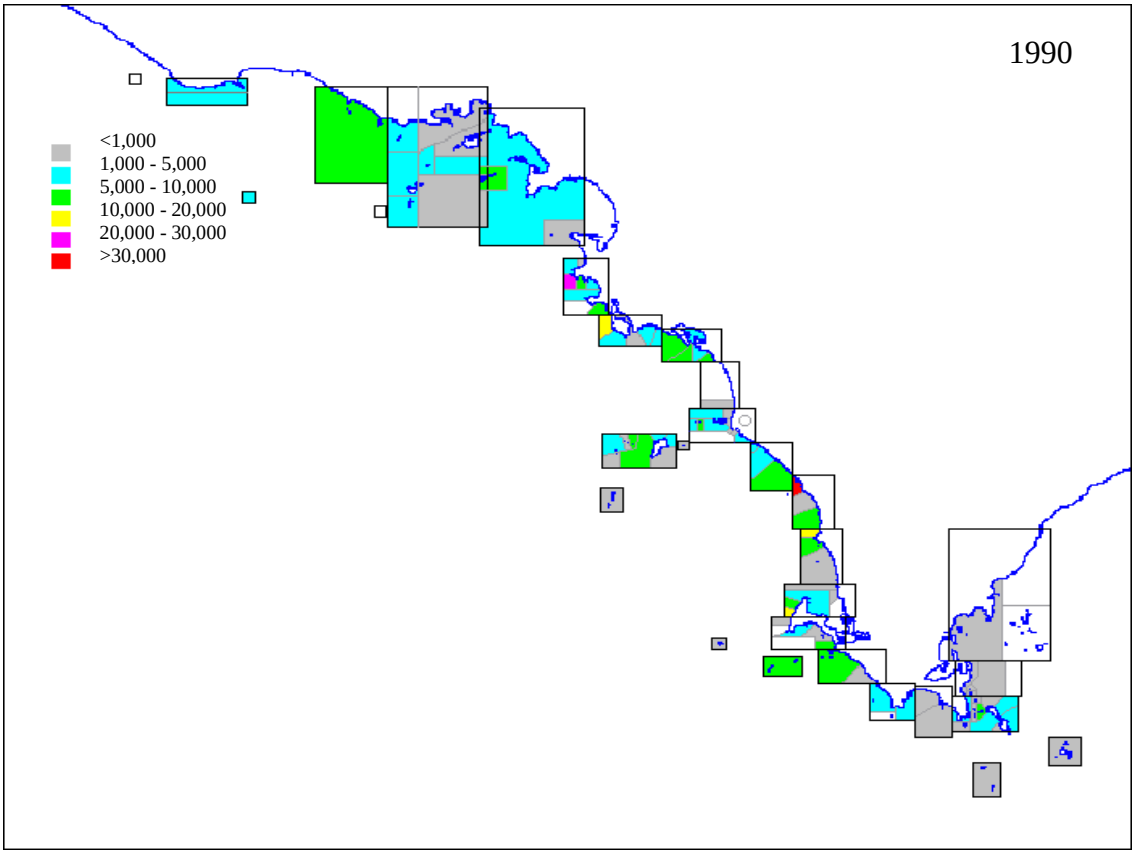


Figure 4.30: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1990

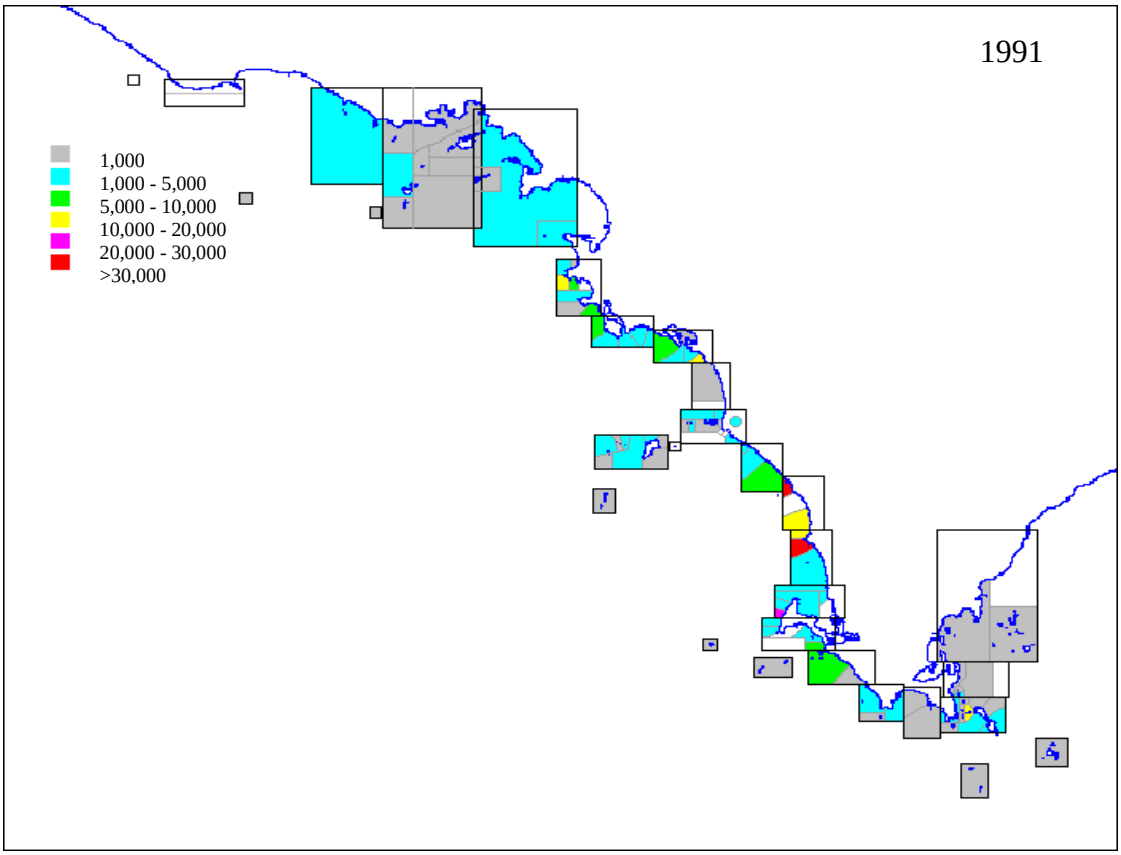


Figure 4.31: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1991

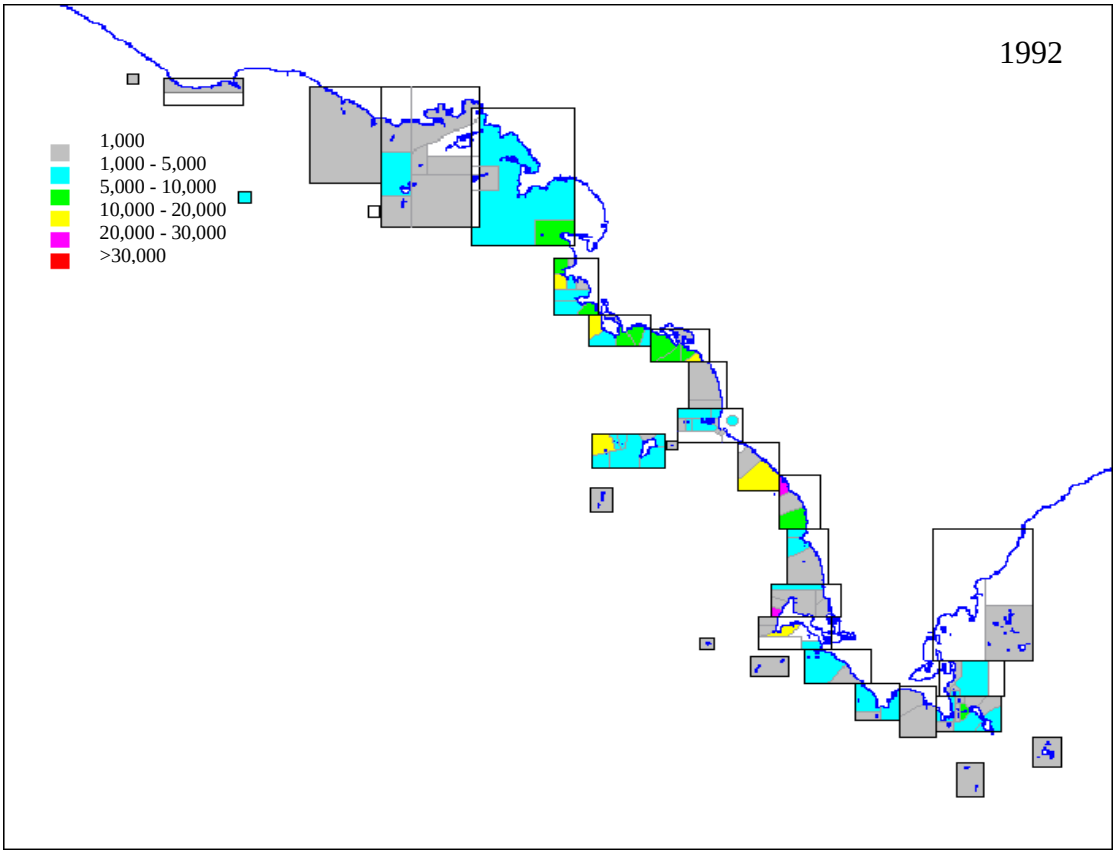


Figure 4.32: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1992

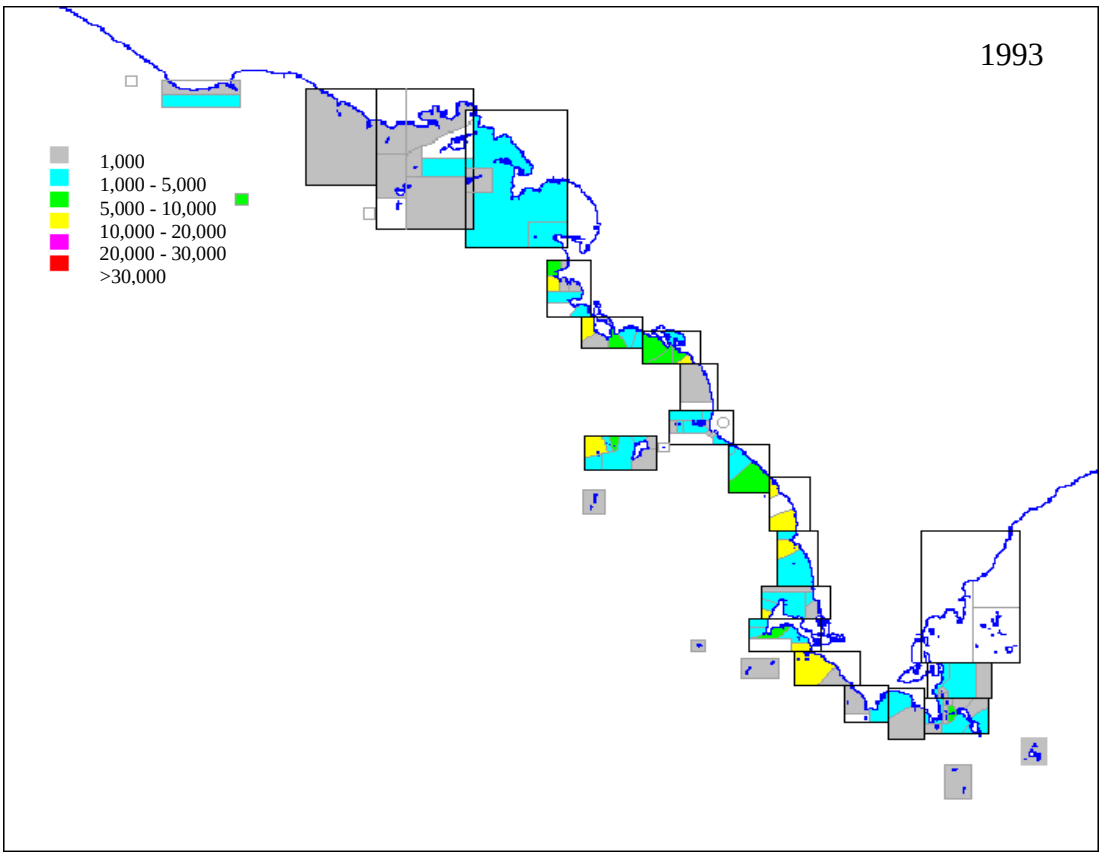


Figure 4.33: The distribution of blacklip abalone catch (kg) by mapcode in the Western Zone - 1993

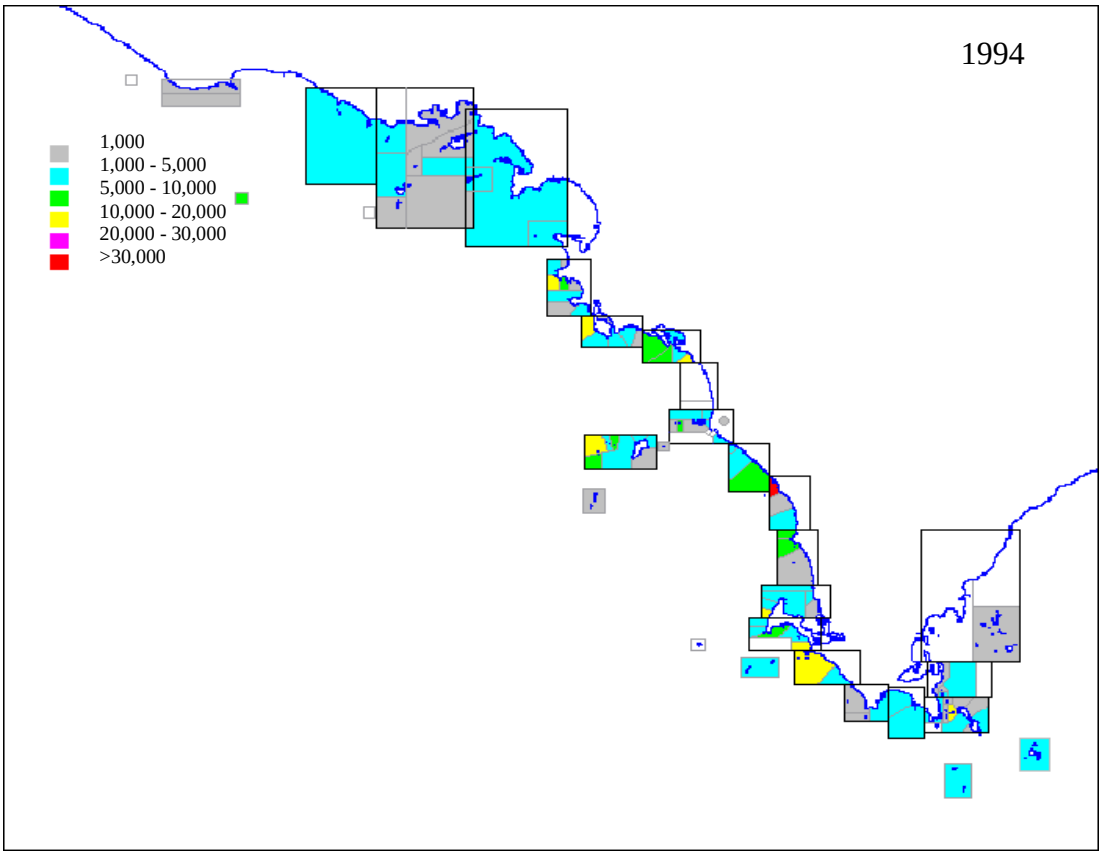


Figure 4.34: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1994

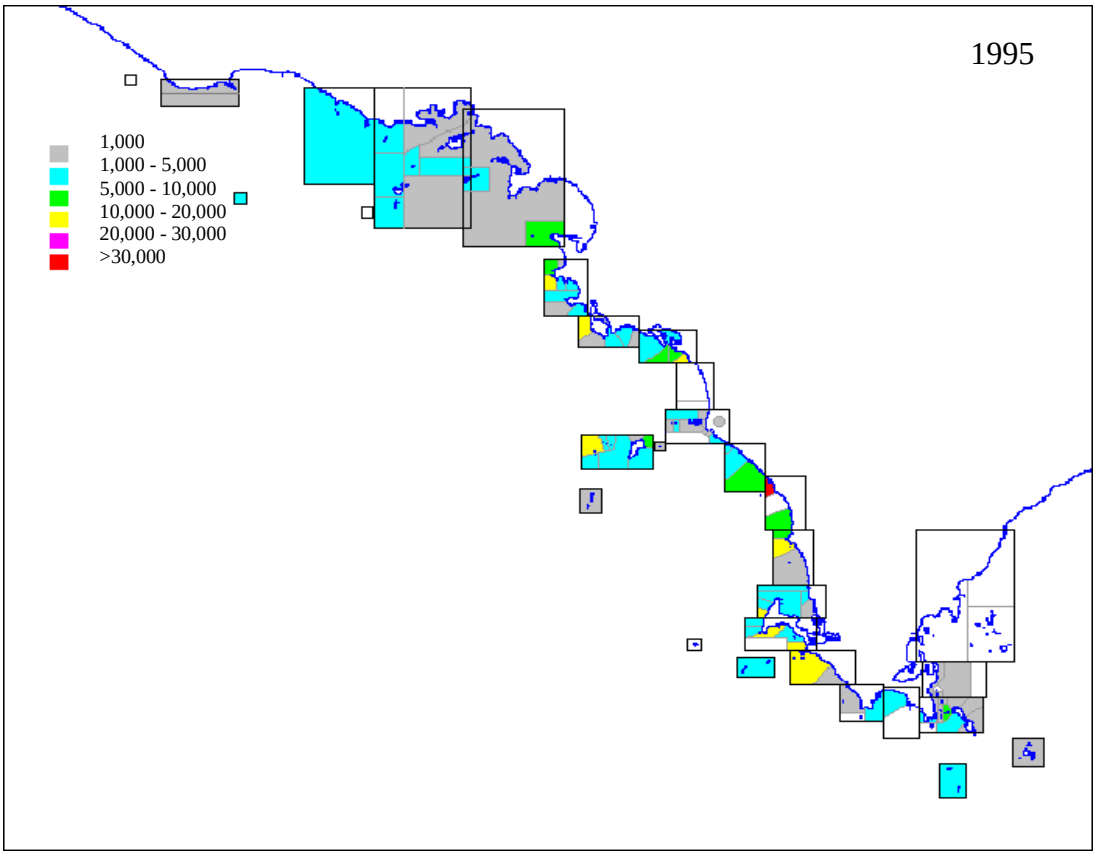


Figure 4.35: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1995

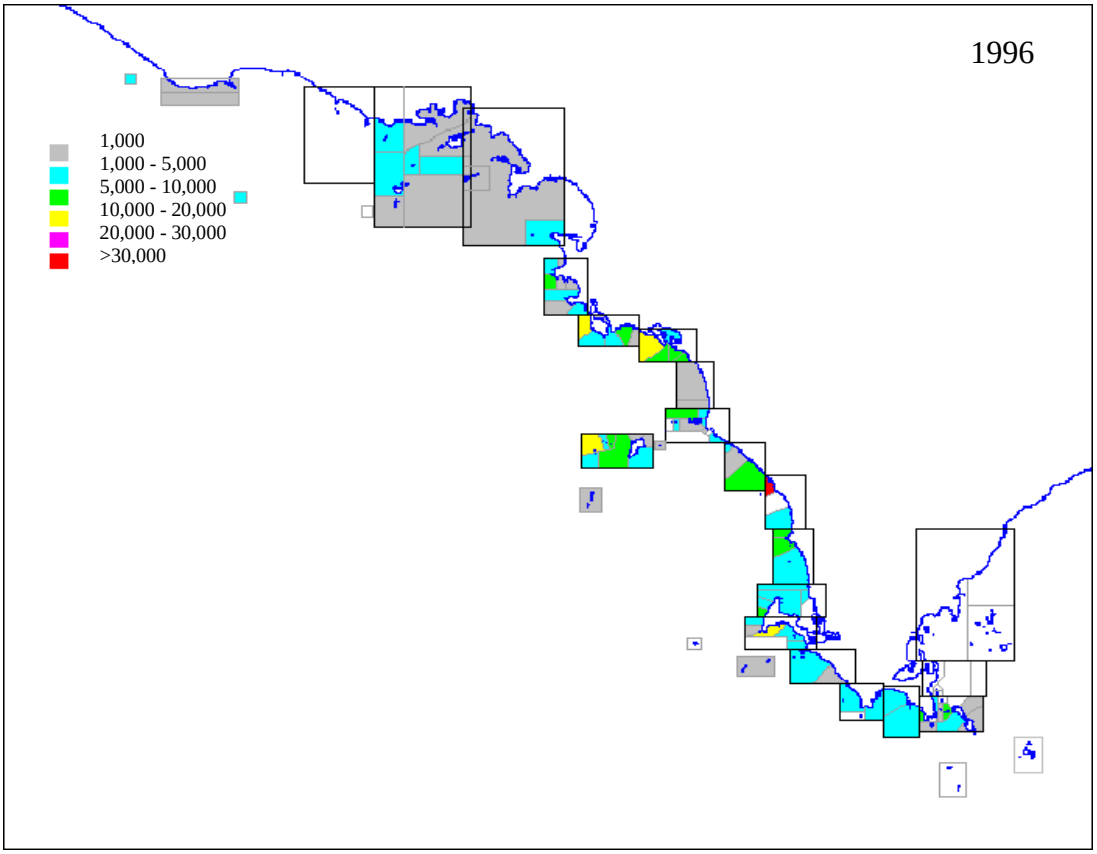


Figure 4.36: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1996

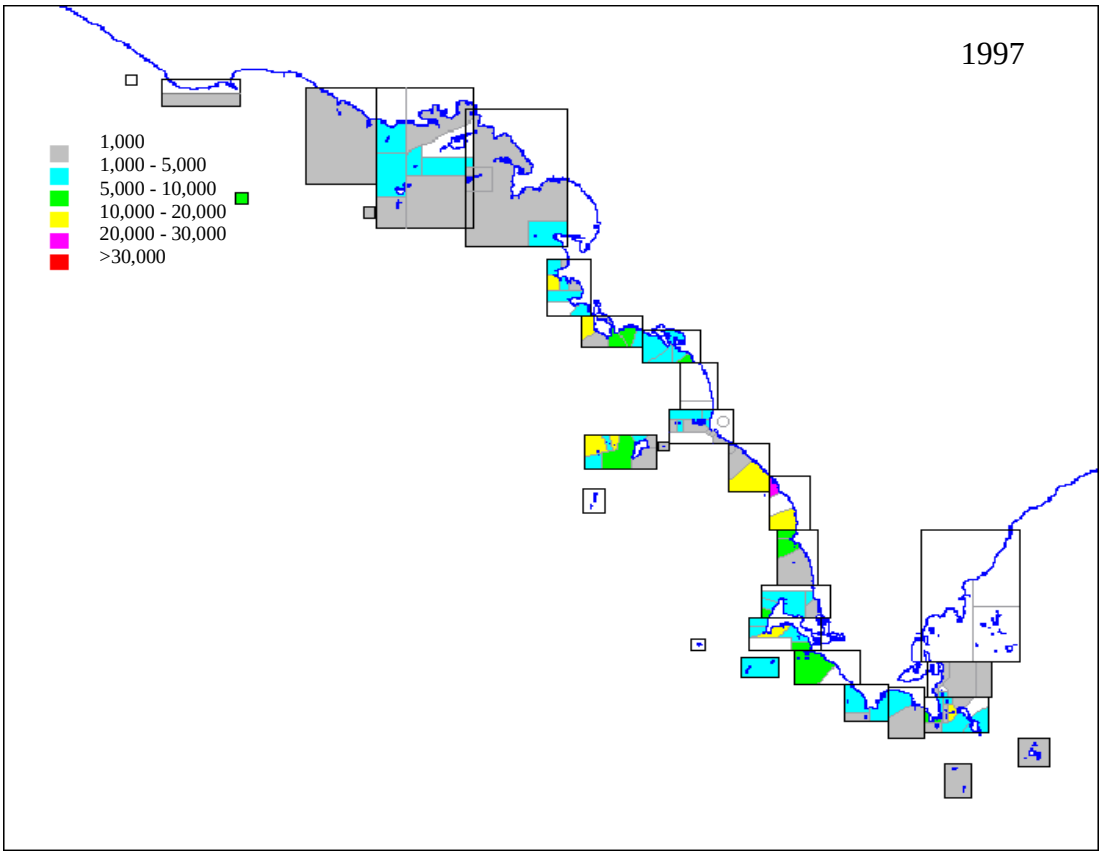


Figure 4.37: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1997

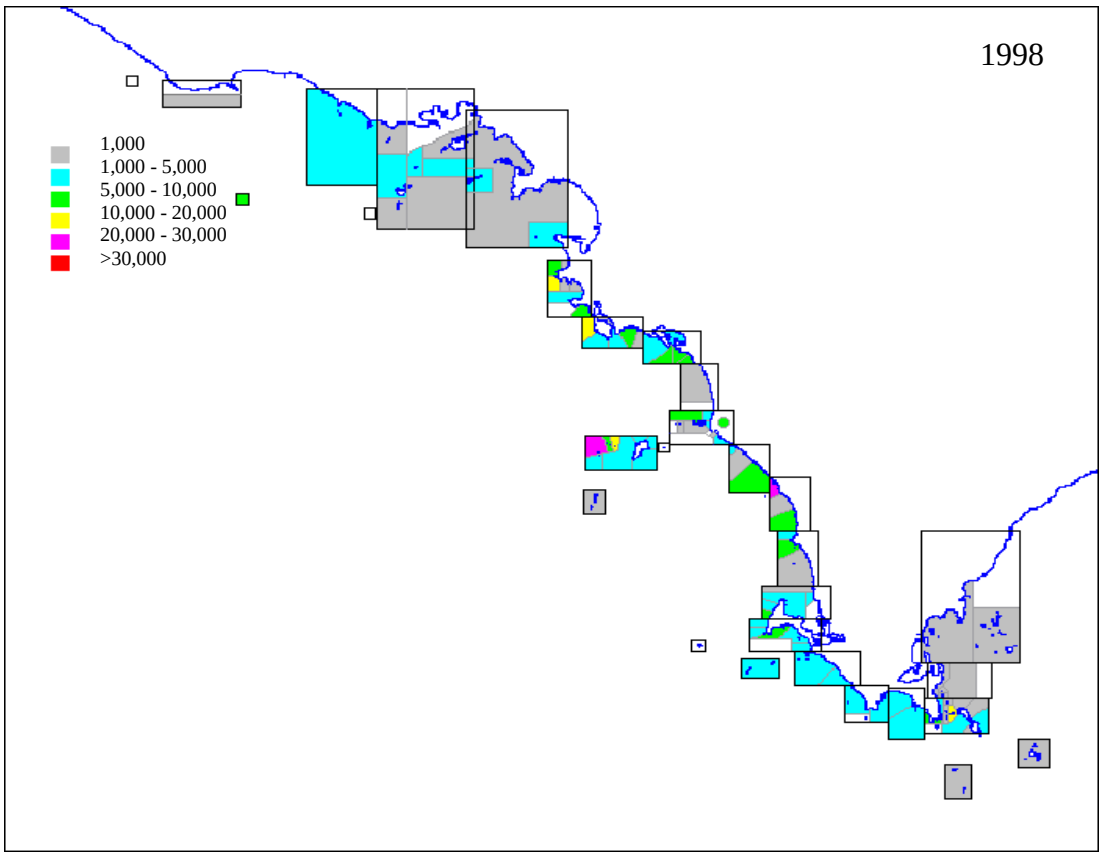


Figure 4.38: The distribution of total blacklip abalone catch (kg) by mapcode in the Western Zone - 1998

4.2.3 **Temporal changes in Greenlip abalone catches, 1985 - 1998** (Table 4.1, figures 4.39 to 4.55).

Analyses for 17 greenlip abalone metapopulation areas with total catches averaging 194 tonnes over each of 14 years showed significant decreases in catches in 6 or 35 % of metapopulations and significant increases in 3 (18 %) since the introduction of quotas.

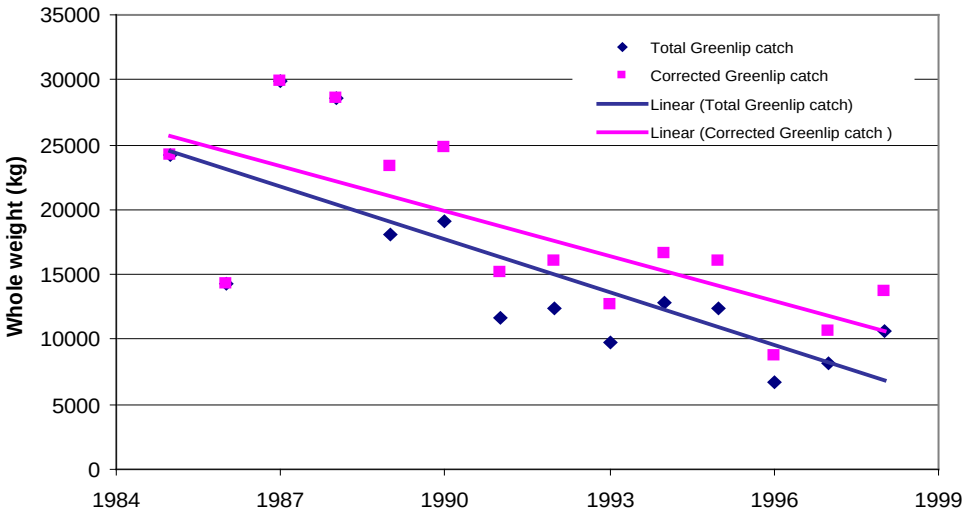
Areas with significant increases in catches were Ward Island (366 kg per year), the Hotspot (1188 kg per year) and Flinders Island (804 kg per year). These increases represent 3.6 %, 7.4 % and 4.4 % increases respectively of the mean catches in these areas.

Areas with significant declines in catches were Sceale Bay (1359 kg per year), the Watchers (399 kg per year), Pearson Island (135 kg per year), Drummond (517 kg per year), Coffin Peninsula (1094 kg per year) and Avoid Bay (1351 kg per year). These declines represent 8.7 %, 11.6 %, 14.6 %, 13.5 %, 12.3 % and 7.2% decreases respectively of the mean catches in these areas.

Greenlip - Western Zone										
Slope is average change in annual catch in kg over 13 years										
Probability is chance that there has been no significant change (up or down) in catch over 13 years										
A probability of less than 0.05 means that there is 95% certainty that there is a significant trend either up or down in the catch										
			NON-CORRECTED DATA				CORRECTED DATA			
REGION	**SLOPE**	**MEAN CATCH**	**PERCENT OF MEAN**	**PROBABILITY**		**SLOPE**	**MEAN CATCH**	**PERCENT OF MEAN**	**PROBABILITY**	**SIGNIFICANT CHANGE**
SCEALE BAY	-1359	15629	-8.70	0.0012		-1150	18188	-6.32	0.0039	decrease
POINT LABATT	-1118	17610	-6.35	0.0672		-724	20626	-3.51	0.2112	
VENUS BAY	-108	7521	-1.44	0.4139		84	9013	0.93	0.5824	
WALDEGRAVE AREA	-247	16700	-1.48	0.3467		160	19972	0.80	0.5385	
THE WATCHERS	-399	3427	-11.64	0.0063		-403	3503	-11.50	0.0079	decrease
WARD ISLAND	366	10283	3.56	0.0742		721	12473	5.78	0.005	increase
THE HOTSPOT	1188	16023	7.41	0.0106		1765	20032	8.81	0.0046	increase
FLINDERS ISLAND	804	18338	4.38	0.0096		1441	22429	6.42	0.0006	increase
PEARSON ISLAND	-135	927	-14.56	0.0041		-127	1067	-11.90	0.0079	decrease
DRUMMOND	-517	3818	-13.54	0.0061		-467	4300	-10.86	0.0108	decrease
COFFIN PENINSULA	-1094	8883	-12.32	<0.0001		-1002	10170	-9.85	<0.0004	decrease
AVOID BAY	-1352	18768	-7.20	0.0029		-1105	22157	-4.99	0.0391	decrease
FISHERY BAY	-418	7037	-5.94	0.0062		-285	8294	-3.44	0.0727	
NEPTUNE ISLANDS	154	2577	5.98	0.2239		247	3159	7.82	0.1217	
NORTHERN THORNY PASSAGE	-783	14983	-5.23	0.0216		-483	17604	-2.74	0.1212	
SOUTHERN THORNY PASSAGE	-91	26382	-0.34	0.8039		634	31667	2.00	0.1125	
WEDGE ISLAND	158	5258	3.00	0.2768		304	6476	4.69	0.1205	
TOTALS	-4951	194164	-2.55			-390	231130	-0.17		

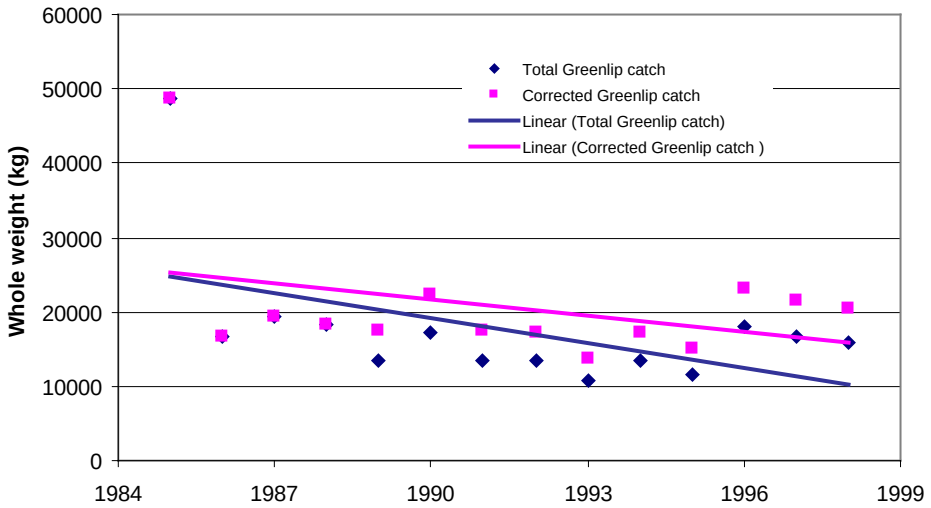
Table 4.1: Summary table showing significane and direction of change in greenlip abalone catches between 1985 and 1998 in the Western Zone.

Figure 4.39: Regression analysis of temporal changes in greenlip abalone catches at Sceale Bay (Mapcode 4A-4H) from 1985 - 1998.



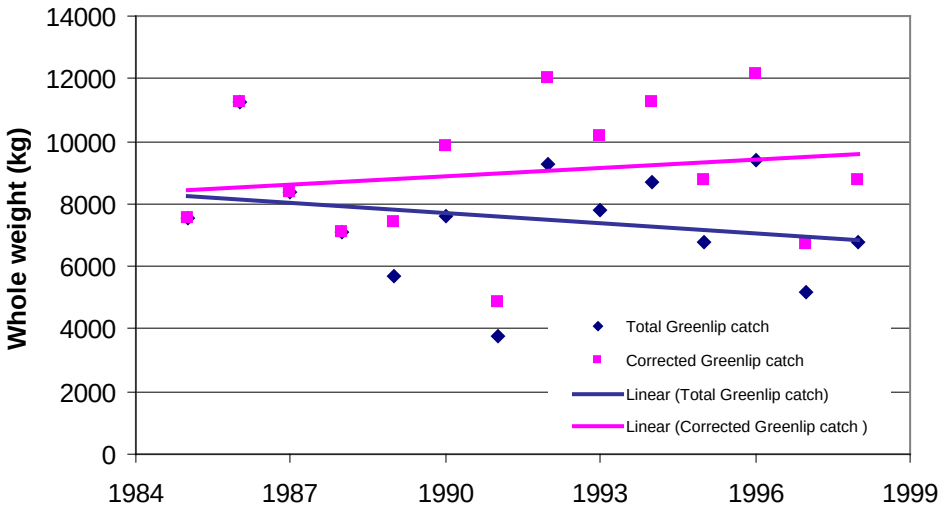
The slope of the regression for Sceale Bay of total greenlip abalone catch (whole weight kg) versus time (year) is significant (slope = -1358.9, r^2 = 0.596; p = 0.001). There has been a decrease in the total greenlip catches in the region during the period analysed. The slope of the regression for Sceale Bay of corrected greenlip abalone catch (whole weight kg) versus time (year) is significant (slope = -1150.4; r^2 = 0.513; p = 0.003). There has been a decrease in the corrected greenlip catches in the region by 1359 kg per year during the period analysed.

Figure 4.40 : Regression analysis of temporal changes in greenlip abalone catches at Point Labatt (Mapcode 5A - 5F) from 1985 - 1998.



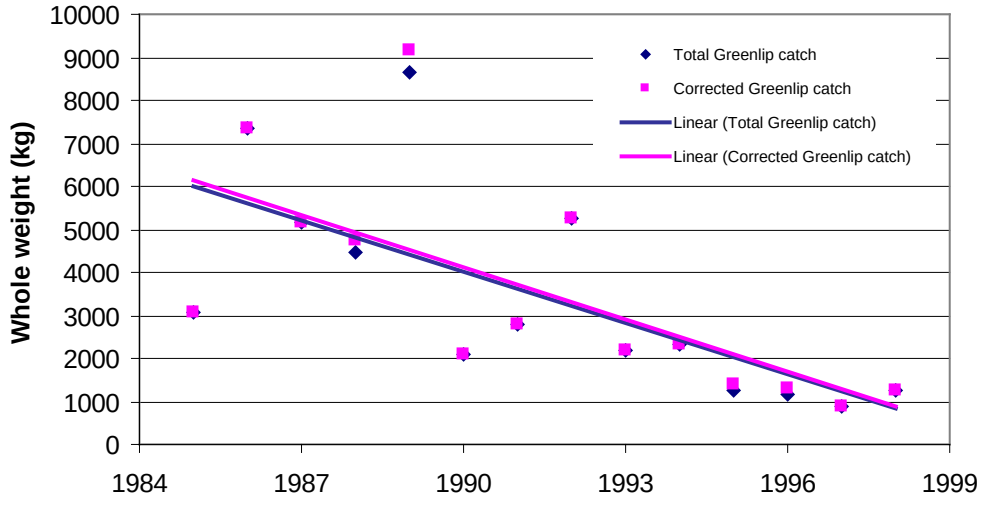
The slope of the regression for Point Labatt of total greenlip abalone catch (whole weight kg) versus time (year) is not significant (slope = -1117.8; r^2 = 0.252; p = 0.067). The slope of the regression for Point Labatt of corrected greenlip abalone catch (whole weight kg) versus time (year) is not significant (slope = -723.8; r^2 = 0.126; p = 0.211)

Figure 4.41: Regression analysis of temporal changes in greenlip abalone catches at Venus Bay (Mapcode 6) from 1985 - 1998.



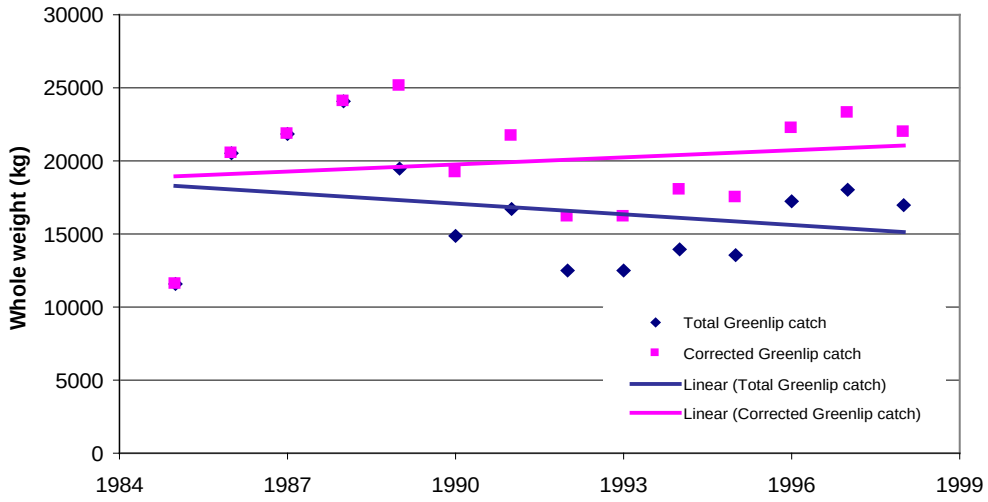
The slope of the regression for Venus Bay of total greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = -108.0; r^2 = 0.056; p = 0.413). The slope of the regression from Venus Bay of corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 84.4; r^2 = 0.025; p = 0.582).

Figure 4.42: Regression analysis of temporal changes in greenlip abalone catches at "The Watchers" (Mapcode 8C, 8D) from 1985 - 1998.



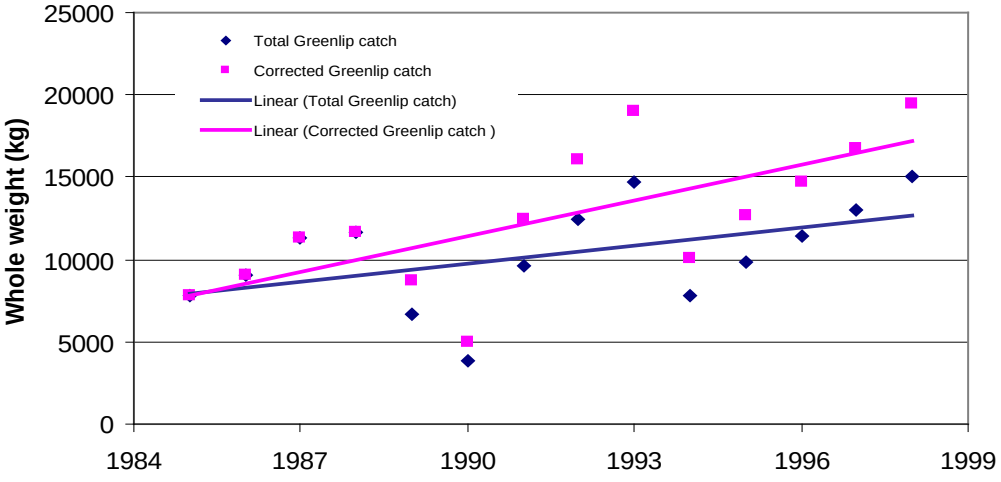
The slope of the regression for The Watchers of total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -398.9; r^2 = 0.475; p = 0.006). There has been a decrease in the total greenlip abalone catches in the region during the period analysed. The slope of the regression from The Watchers of corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -403.4; r^2 = 0.456; p = 0.007). There has been a decrease in the corrected abalone catches in the region by 399 kg per year during the period analysed.

Figure 4.43: Regression analysis of temporal changes in greenlip abalone catches at the Waldegrave Area (Mapcode 8A, 8B, 8E, 8Q) from 1985 - 1998.



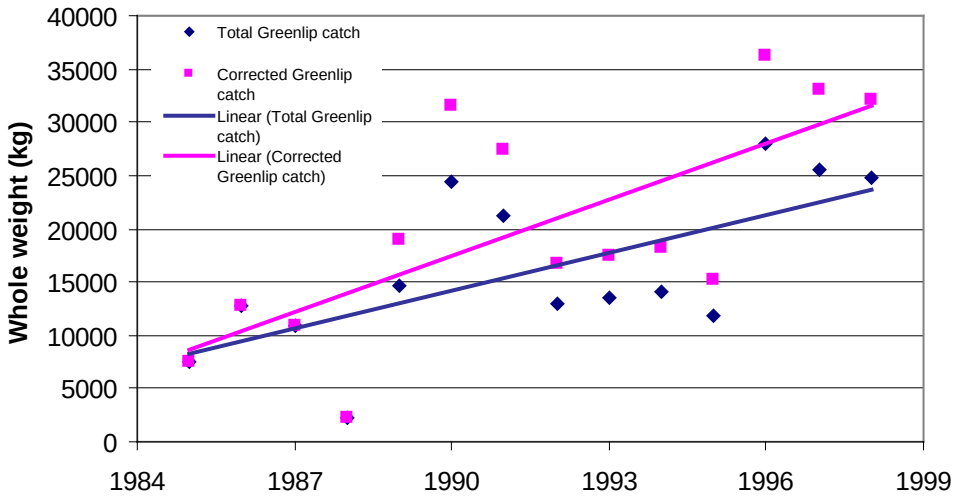
The slope of the regression for the Waldegrave Area of total greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = -247.1; r^2 = 0.074; p = 0.346). The slope of the regression for the Waldegrave Area of corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 159.9; r^2 = 0.032; p = 0.538).

Figure 4.44: Regression analysis of temporal changes in greenlip abalone catches at Ward Island (Mapcode 9A, 9B) from 1985 - 1998



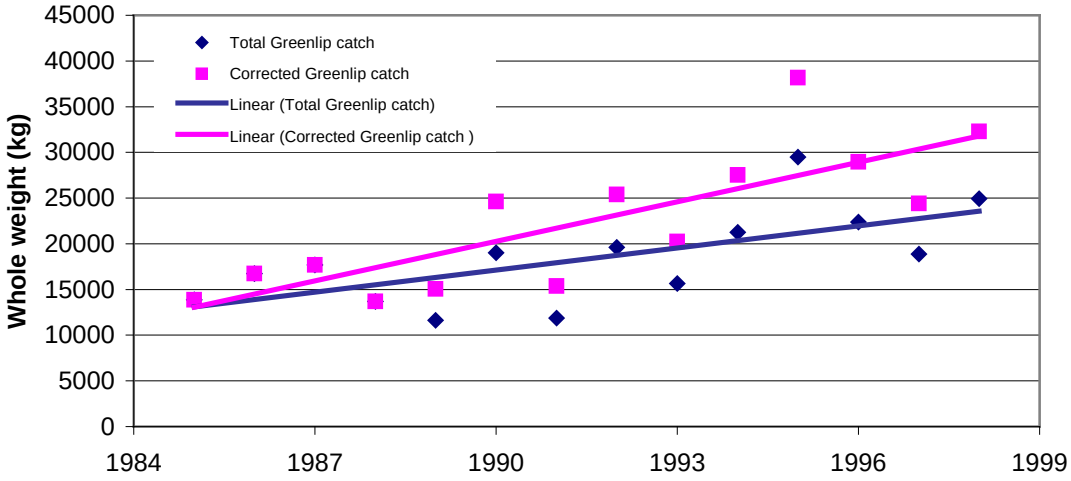
The slope of the regression for Ward Island of the total greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 366; r^2 = 0.241; p = 0.074). The slope of the regression for Ward Island of corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = 721.3; r^2 = 0.494; p = 0.005). The greenlip catches have increased in the region by 366 kg per year during the period analysed.

Figure 4.45: Regression analysis of temporal changes in greenlip abalone catches at The Hotspot (Mapcode 9C, 9D) from 1985 - 1998.



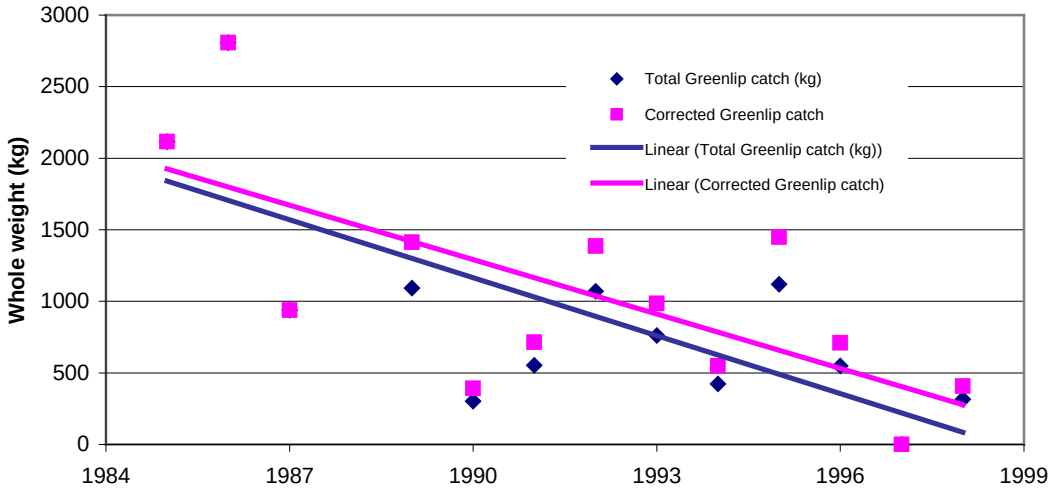
The slope of the regression for The Hotspot region of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = 1188.4; r^2 = 0.431; p = 0.010). The greenlip catches have increased in the region during the period analysed. The slope of the regression for The Hotspot region of corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = 1765.4; r^2 = 0.500; p = 0.004). The greenlip catches have increased in the region by 1188 kg per year during the period analysed.

Figure 4.46: Regression analysis of temporal changes in greenlip abalone catches at Flinders Island (Mapcode 9E - G) from 1985 - 1998



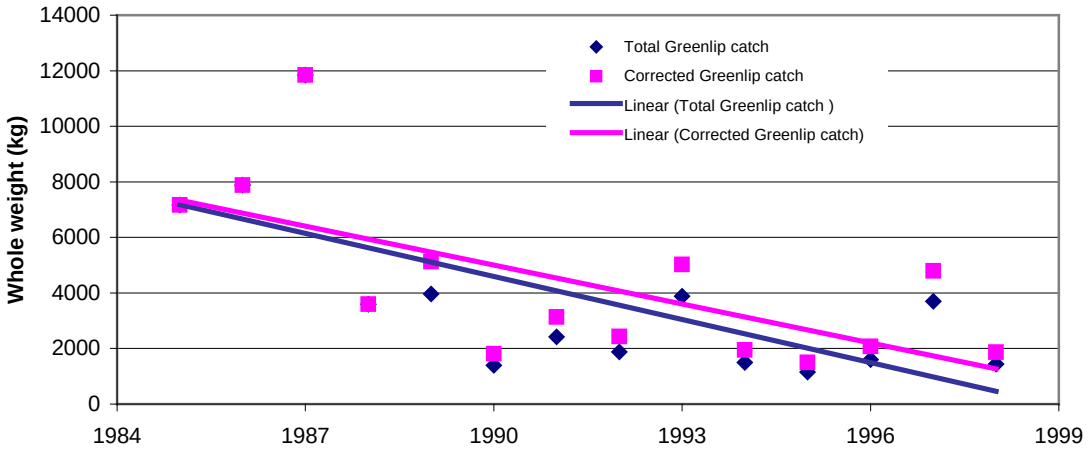
The slope of the regression for Flinders Island region of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = 804.0; r^2 = 0.440; p = 0.009). The greenlip catches have increased in the region during the period analysed. The slope of the regression for Flinders Island region of corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = 1441.0; r^2 = 0.634; p = 0.0006). The greenlip catches have increased in the region by 804 kg per year during the period analysed.

Figure 4.47: Regression analysis of temporal changes in greenlip abalone catches at Pearson Island (Mapcode 10C) from 1985 - 1998.



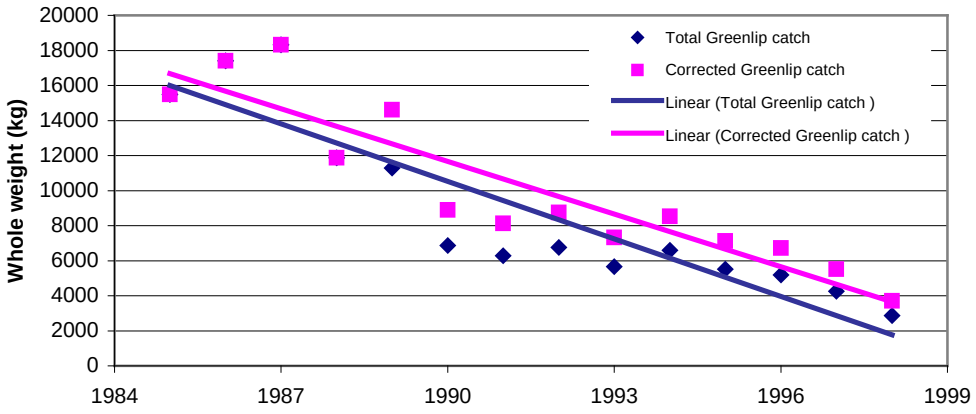
The slope of the regression for Pearson Island region of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -135.0; r^2 = 0.541; p = 0.004). The greenlip catches have decreased in the region during the period analysed. The slope of the regression for Pearson Island region of corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -126.7; r^2 = 0.487; p = 0.007). The greenlip catches have decreased in the region by 135 kg per year during the period analysed.

Figure 4.48: Regression analysis of temporal changes in greenlip abalone catches at Drummond area (Mapcode 12A, 12B) from 1985 - 1998.



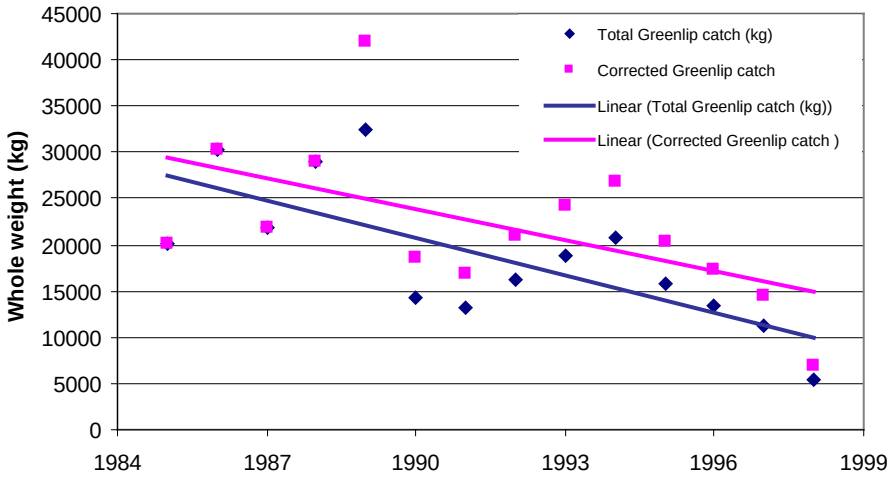
The slope of the regression for Drummond area of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -516.7; r^2 = 0.478; p = 0.006). The greenlip abalone catches have decreased in the area during the period analysed. The slope of the regression for Drummond area of corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -467.2; r^2 = 0.430; p = 0.010). The corrected greenlip abalone catches have decreased in the area by 517 kg per year during the period analysed.

Figure 4.49: Regression analysis of temporal changes in greenlip abalone catches in the Coffin Bay Peninsula region (Mapcode 13A-E, 14A, 14B) from 1985 - 1998



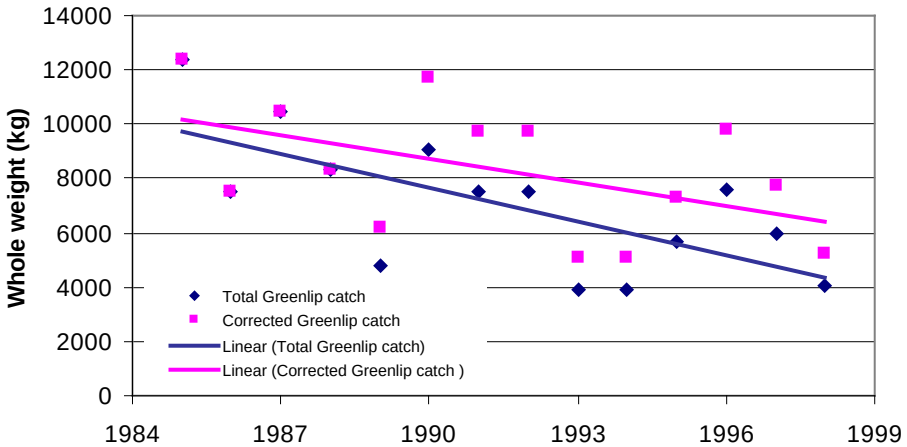
The slope of the regression for Coffin Bay Peninsula region of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -1094.4; r^2 = 0.817; p < 0.0001). The greenlip abalone catches have decreased in the area during the period analysed. The slope of the regression for Coffin Bay Peninsula of the corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -1002.1; r^2 = 0.837; p < 0.0001). The corrected greenlip abalone catches have decreased in the region by 1094 kg per year during the period analysed.

Figure 4.50: Regression analysis of temporal changes in greenlip abalone catches in the Avoid Bay region (Mapcodes 15A, 14C, 14D) from 1985 - 1998



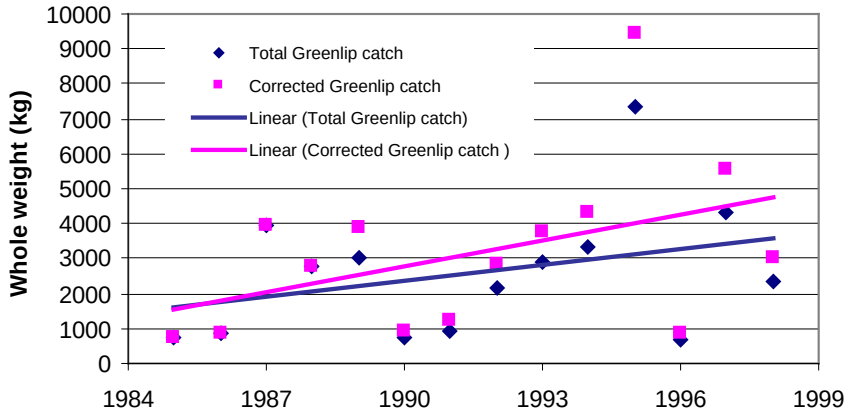
The slope of the regression for Avoid Bay region of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -1351.6; r^2 = 0.534; p = 0.002). The greenlip abalone catches have decreased in the area during the period analysed. The slope of the regression for Avoid Bay region of the corrected greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -1105.2; r^2 = 0.308; p = 0.0039). The corrected greenlip abalone catches have decreased in the region by 1352 kg per year during the period analysed.

Figure 4.51: Regression analysis of temporal changes in greenlip abalone catches in the Fishery bay region (Mapcode 16A-C) from 1985 - 1998.



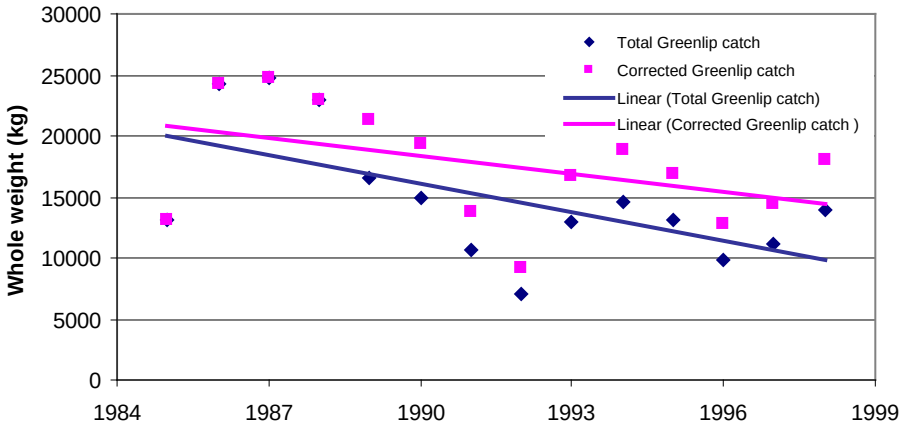
The slope of the regression for Fishery Bay region of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -418.0; r^2 = 0.476; p = 0.006). The greenlip abalone catches have decreased in the area during the period analysed. The slope of the regression for Fishery Bay region of the corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = -285.0; r^2 = 0.243; p = 0.072).

Figure 4.52: Regression analysis of temporal changes in greenlip abalone catches in the Neptune Islands region (Mapcode 17C) from 1985 - 1998.



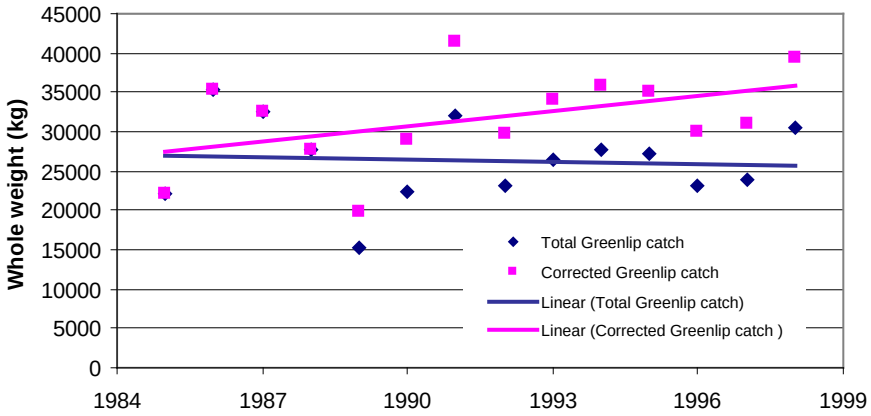
The slope of the regression for the Neptune Islands region of the total greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 153.5; r^2 = 0.120; p = 0.223). The slope of the regression for the Neptune Islands region of the corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 246.7; r^2 = 0.187; p = 0.121).

Figure 4.53: Regression analysis of temporal changes in greenlip abalone catches in the northern Thorny Passage (Mapcodes 18C, 19A-C) from 1985 - 1998



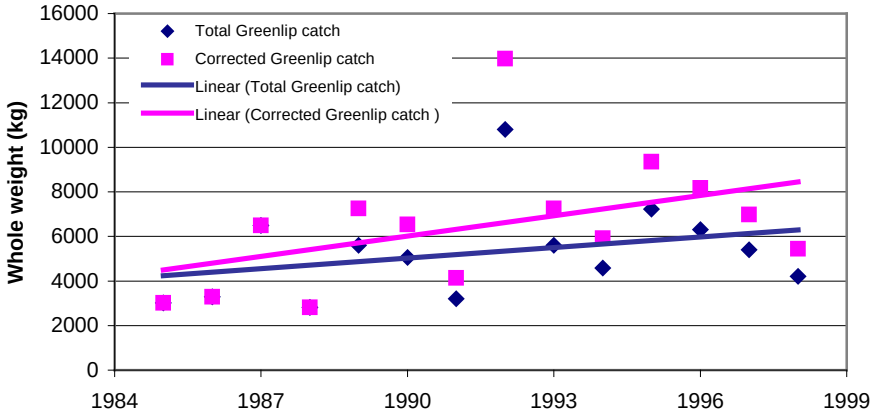
The slope of the regression for the northern Thorny Passage of the total greenlip abalone catches (whole weight kg) versus time (year) is significant (slope = -783.0; r^2 = 0.366; p = 0.021). The total greenlip abalone catch has decreased in this area during the period analysed. The slope of the regression for the northern Thorny Passage of the corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = -482.5; r^2 = 0.188; p = 0.121).

Figure 4.54: Regression analysis of temporal changes in greenlip abalone catches in the southern Thorny Passage region (Mapcodes 18D, E, F) from 1985 - 1998.



The slope of the regression for the southern Thorny Passage region of the total greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = -91.4; r^2 = 0.005; p = 0.803). The slope of the regression for the southern Thorny Passage region of the corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 634.3; r^2 = 0.196; p = 0.112).

Figure 4.55: Regression analysis of temporal changes in greenlip abalone catches in the Wedge Island region (Mapcode 19F) from 1985 - 1998



The slope of the regression for the Wedge Island region of the total greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 158.0; r^2 = 0.097; p = 0.276). The slope of the regression for the Wedge Island region of the corrected greenlip abalone catches (whole weight kg) versus time (year) is not significant (slope = 303.7; r^2 = 0.188; p = 0.120).

4.2.4 Temporal changes in Blacklip abalone catches, 1985 - 1998 (Table 4.2, figures 4.56 - 4.70).

Analyses for 15 blacklip abalone metapopulation areas with total catches averaging 250 tonnes over each of 14 years showed significant decreases in catches in 3 or 20 % of metapopulations and significant increases in 4 (26 %) metapopulations since the introduction of quotas.

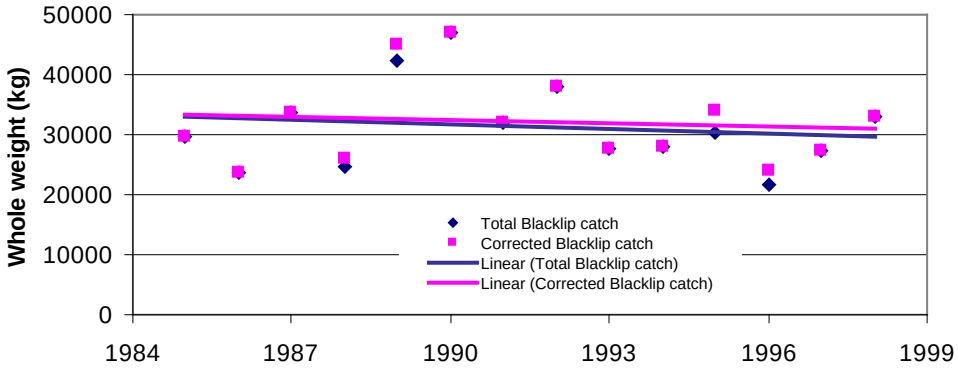
Areas with significant increases in catches were Ward Island (1695 kg per year), Venus Bay (1269 kg per year), the Hotspot (1240 kg per year) and Southern Thorny Passage (480 kg per year). These increases represent 14.7%, 5.0 %, 18.6 % and 5.2 % increases respectively of the mean catches in these areas.

Areas with significant declines in catches were the Watchers (695 kg per year), Drummond (2152 kg per year) and Fishery Bay (339 kg per year). These increases represent 10.7 %, 8.5 % and 6.7 % increases respectively of the mean catches in these areas.

Blacklip - Western Zone										
Slope is average change in annual catch in kg over 13 years										
Probability is chance that there has been no significant change (up or down) in catch over 13 years										
A probability of less than 0.05 means that there is 95% certainty that there is a significant trend either up or down in the catch										
			NON-CORRECTED DATA					CORRECTED DATA		
REGION	**SLOPE**	**MEAN CATCH**	**PERCENT OF MEAN**	**PROBABILITY**		**SLOPE**	**MEAN CATCH**	**PERCENT OF MEAN**	**PROBABILITY**	**SIGNIFICANT CHANGE**
SCEALE BAY	-239	31381	-0.76	0.6361		-181	32108	-0.56	0.7197	
POINT LABATT	-483	27300	-1.77	0.54		-397	27945	-1.42	0.616	
VENUS BAY	1269	25363	5.00	0.0329		1385	26051	5.32	0.0251	increase
WALDEGRAVE AREA	193	7170	2.69	0.2491		220	7340	3.00	0.1987	
THE WATCHERS	-695	6485	-10.72	0.0021		-704	6606	-10.66	0.0024	decrease
WARD ISLAND	1695	11512	14.72	<0.0001		1757	11847	14.83	<0.0001	increase
THE HOTSPOT	1240	6680	18.56	0.0002		1270	6813	18.64	0.0001	increase
FLINDERS ISLAND	264	8798	3.00	0.2419		302	9029	3.34	0.1918	
SHERINGA	-1157	40607	-2.85	0.1676		-1012	41607	-2.43	0.2441	
DRUMMOND	-2152	25287	-8.51	0.0102		-2125	25898	-8.21	0.0126	decrease
COFFIN PENINSULA	-813	25071	-3.24	0.0895		-766	25625	-2.99	0.1066	
AVOID BAY	587	16157	3.63	0.1206		641	16621	3.86	0.1091	
FISHERY BAY	-339	5028	-6.74	0.0033		-336	5138	-6.54	0.0046	decrease
NORTHERN THORNY PASSAGE	-101	4088	-2.47	0.5791		-108	4185	-2.58	0.5734	
SOUTHERN THORNY PASSAGE	480	9196	5.22	0.0554		488	9384	5.20	0.0463	increase
TOTALS	-251	250123	-0.10			434	256197	0.17		

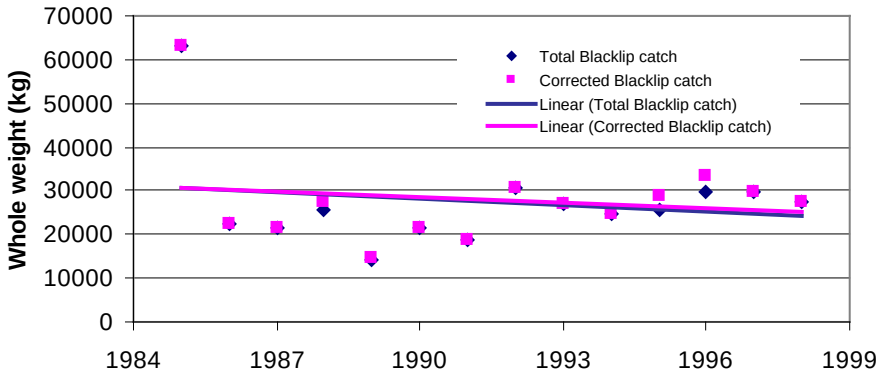
Table 4.2. Summary tables showing significance and direction of change in blacklip abalone catches between 1985 and 1998 in the Western Zone.

Figure 4.56: Regression analysis of temporal changes in blacklip abalone catches in the Sceale Bay region (Mapcode 4A-H) from 1985 - 1998.



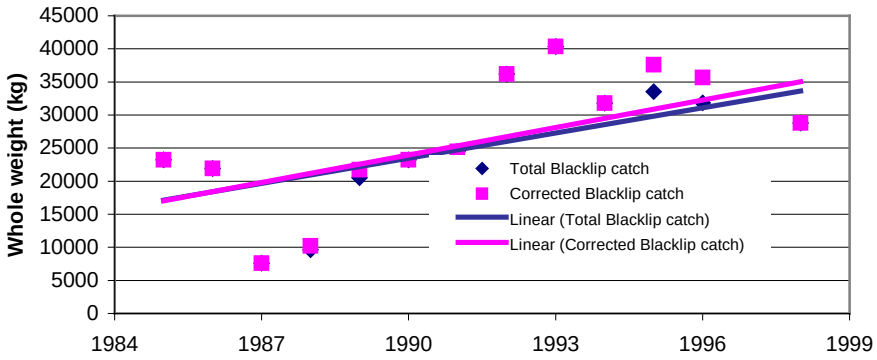
The slope of the regression for the Sceale Bay region of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -238.8; r^2 = 0.019; p = 0.636). The slope of the regression for the Sceale Bay region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -181.2; r^2 = 0.011; p = 0.719).

Figure 4.57: Regression analysis of temporal changes in blacklip abalone catches in the Point Labatt region (Mapcode 5A-F) from 1985 - 1998.



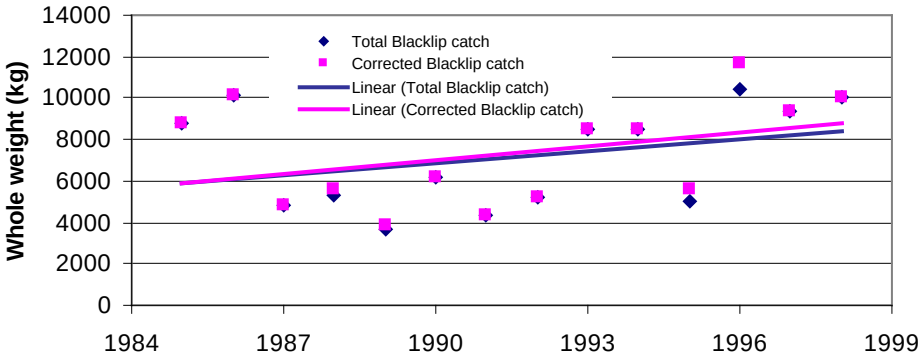
The slope of the regression for the Point Labatt region of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -482.8; r^2 = 0.032; p = 0.540). The slope of the regression for the Point Labatt region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -396.5; r^2 = 0.021; p = 0.616).

Figure 4.58: Regression analysis of the temporal changes in blacklip abalone catches in the Venus Bay region (Mapcode 6A-E) from 1985 - 1998.



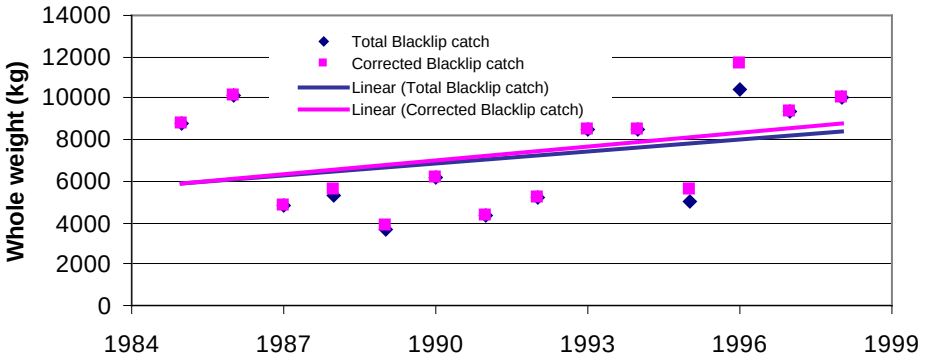
The slope of the regression for the Venus Bay region of the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 1269.3; r^2 = 0.325; p = 0.032). There has been an increase in blacklip abalone catches in the area during the period analysed. The slope of the regression for the Venus Bay region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 1384.9; r^2 = 0.352; p = 0.025). There has been an increase in the corrected blacklip abalone catches in the area by 1269 kg per year during the period analysed.

Figure 4.59: Regression analysis of blacklip abalone catches in the Waldegrave Area (Mapcodes 8A, 8B, 8E and 8Q) from 1985 - 1998.



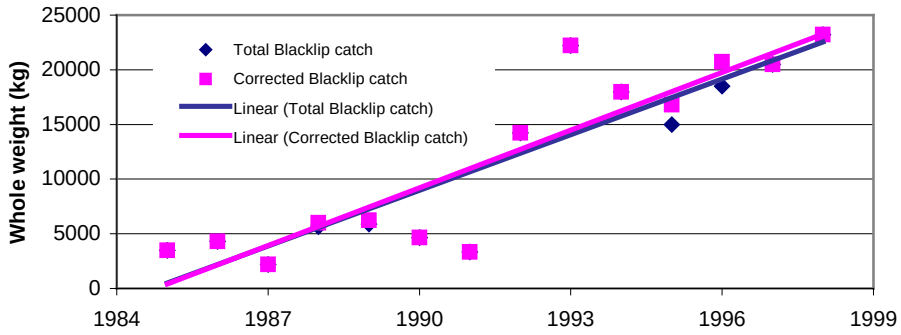
The slope of the regression for the Waldegrave Area for the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = 192.9; r^2 = 0.108; p = 0.249). The slope of the regression for the Waldegrave Area for the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = 219.7; r^2 = 0.133; p = 0.198).

Figure 4.60: Regression analysis of blacklip abalone catches in the Watchers region (Mapcode 8C, 8D) from 1985 - 1998.



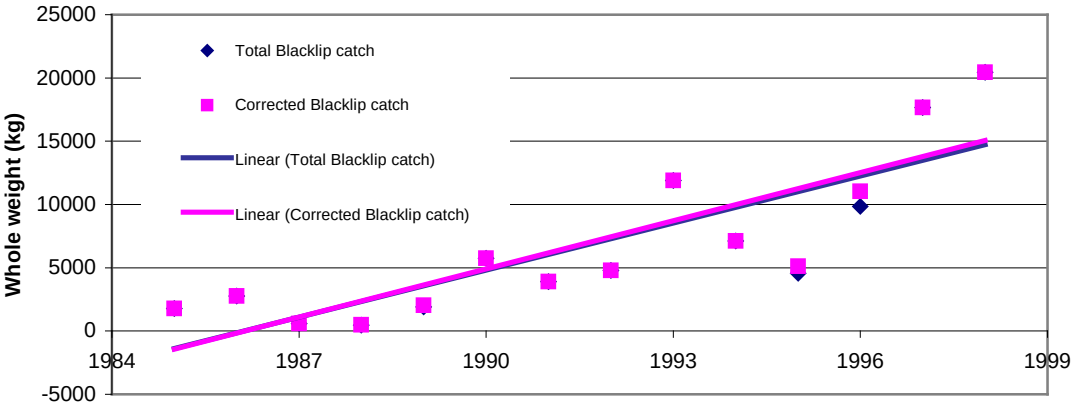
The slope of the regression of The Watchers region for the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -695.2; $r^2 = 0.559$; $p = 0.002$). The total blacklip abalone catches have decreased in this region during the period analysed. The slope of the regression of The Watchers region for the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -703.7; $r^2 = 0.547$; $p = 0.002$). The corrected blacklip abalone catches have decreased in this region by 695 kg per year during the period analysed.

Figure 4.61: Regression analysis of blacklip abalone catches in the Ward Island region (Mapcode 9A, 9B) from 1985 - 1998.



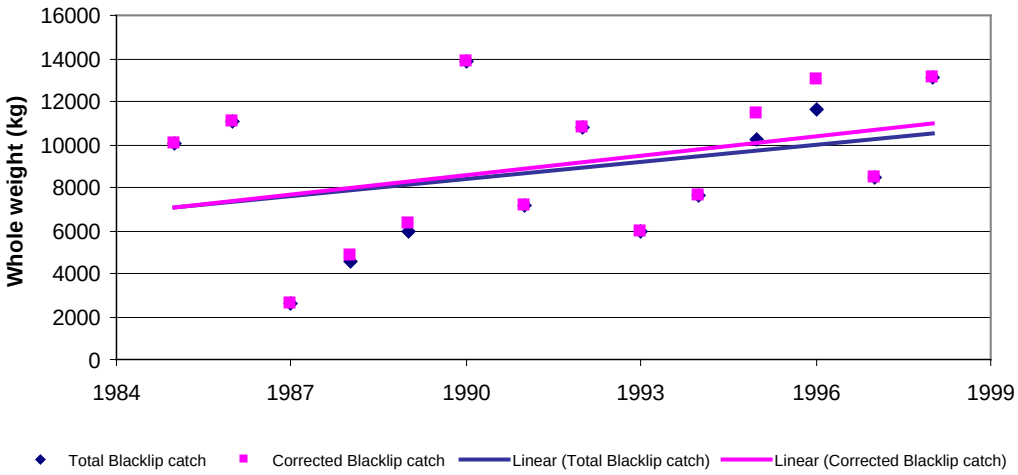
The slope of the regression of the Ward Island region for the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -1694.7; $r^2 = 0.791$; $p < 0.0001$). The total blacklip abalone catches have increased in this region during the period analysed. The slope of the regression of the Ward Island region for the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 1757.4; $r^2 = 0.809$; $p < 0.0001$). The corrected blacklip abalone catches have increased in this region by 1695 kg per year during the period analysed.

Figure 4.62: Regression analysis of temporal changes in blacklip abalone catches in The Hotspot region (Mapcodes 9C, 9D) from 1985 - 1998.



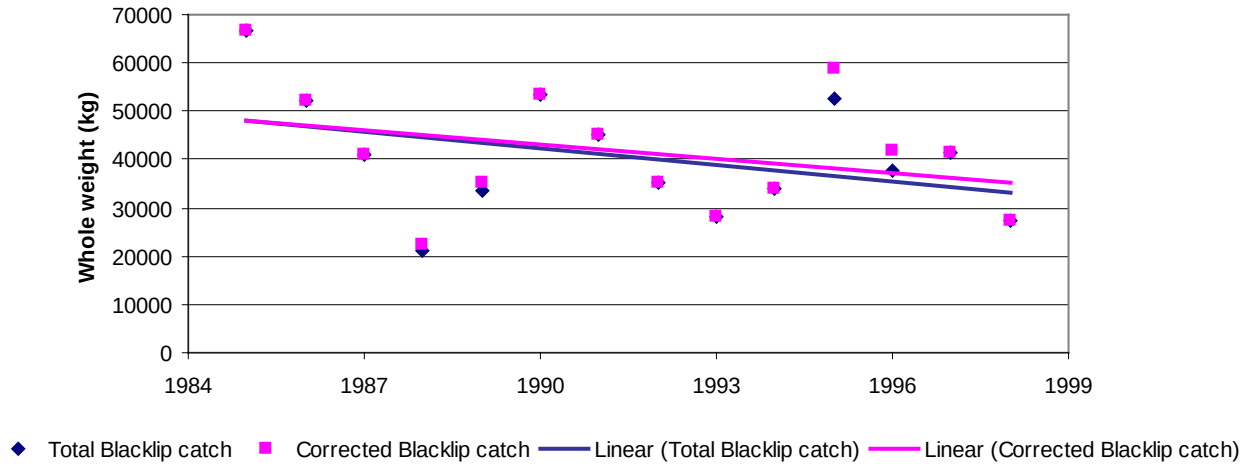
The slope of the regression of the Hotspot region for the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 1240.1; r^2 = 0.695; p = 0.0002). The total catches of blacklip abalone have increased in the region during the period analysed. The slope of the regression of the Hotspot region for the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 1270.3; r^2 = 0.722; p = 0.0001). The corrected blacklip abalone catches have increased in the region by 1240 kg per year during the period analysed.

Figure 4.63: Regression analysis of temporal changes in blacklip abalone catches in the Flinders Island region (Mapcode 9E - H) from 1985 - 1998.



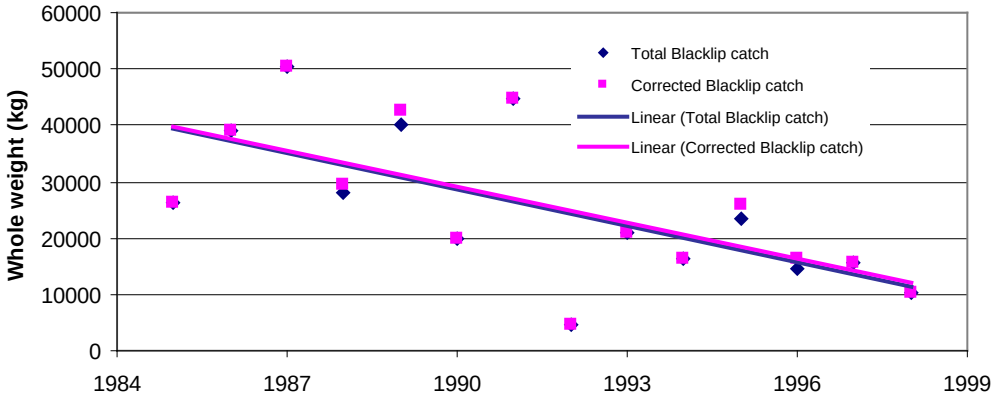
The slope of the regression for the Flinders Island region of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = 263.9; r^2 = 0.112; p = 0.241). The slope of the regression for the Flinders Island region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = 302.3; r^2 = 0.137; p = 0.191).

Figure 4.64: Regression analysis of temporal changes in blacklip abalone catches in the Sheringa area (Mapcode 11A - C) from 1985 - 1998.



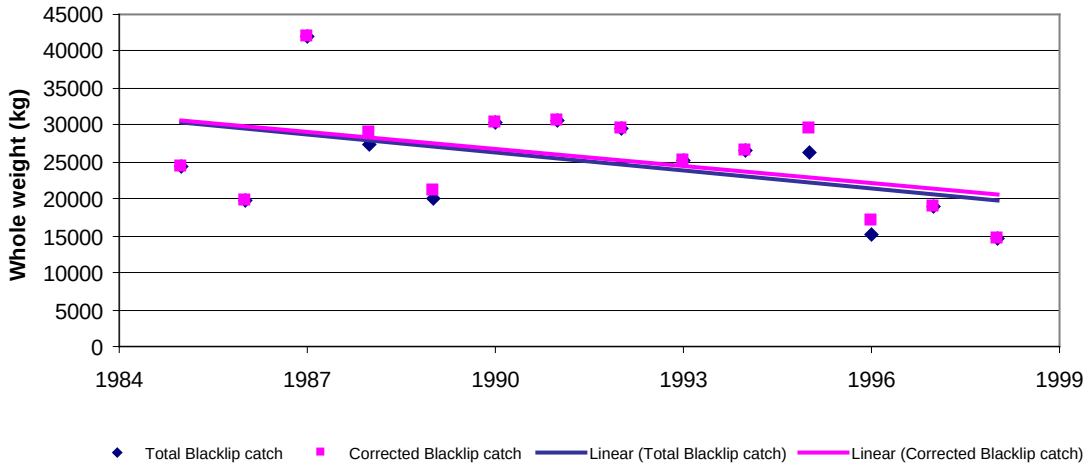
The slope of the regression for the Sheringa area of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -1157.4; r^2 = 0.152; p = 0.167). The slope of the regression for the Sheringa area of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -1012.1; r^2 = 0.111; p = 0.244).

Figure 4.65: Regression analysis of temporal changes in blacklip abalone catches in the Drummond area (Mapcode 12A, 12B) from 1985 - 1998.



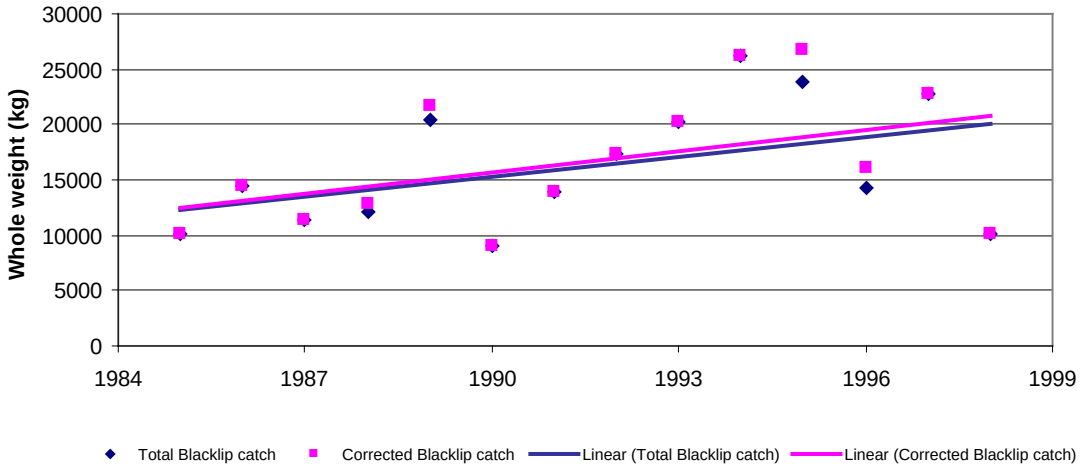
The slope of the regression for the Drummond area of the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -2151.5; r^2 = 0.435; p = 0.010). The total blacklip abalone catches decreased in the area during the period analysed. The slope of the regression for the Drummond area of the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -2125.1; r^2 = 0.416; p = 0.012). The corrected blacklip abalone catches decreased in the area by 2152 kg per year during the period analysed.

Figure 4.66: Regression analysis of temporal changes in blacklip abalone catches in the Coffin Bay region (Mapcodes 13A - F, 14A, 14B) from 1985 - 1998.



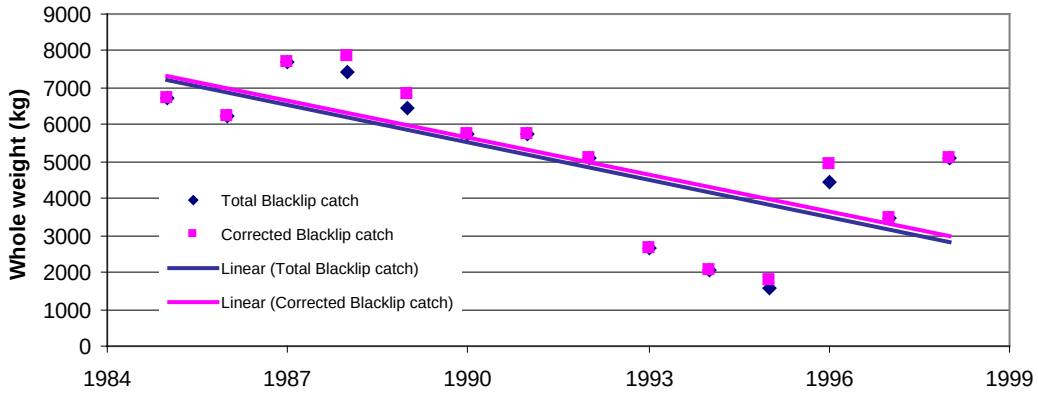
The slope of the regression of the Cofin Bay Peninsula region of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -812.9; $r^2 = 0.221$; p = 0.089). The slope of the regression of the Coffin Bay Peninsula region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -765.8; $r^2 = 0.202$; p = 0.106).

Figure 4.67: Regression analysis of the temporal changes in blacklip abalone catches in the Avoid Bay region (Mapcode 15A, 14C, 14D) from 1985 - 1998.



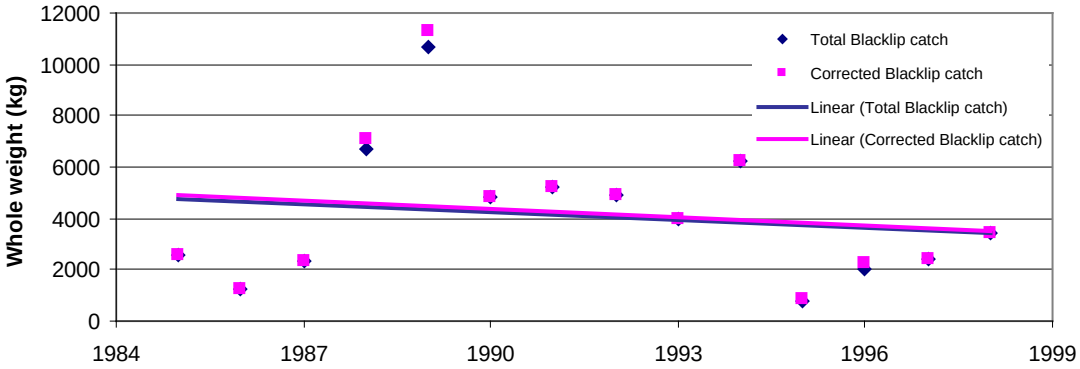
The slope of the regression of the Avoid Bay region of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = 586.7; $r^2 = 0.188$; p = 0.120). The slope of the regression of the Avoid Bay region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = 640.6; $r^2 = 0.199$; p = 0.109).

Figure 4.68: Regression analysis of the temporal changes in blacklip abalone catches in the Fishery Bay region (Mapcode 16A-C) from 1985 - 1998.



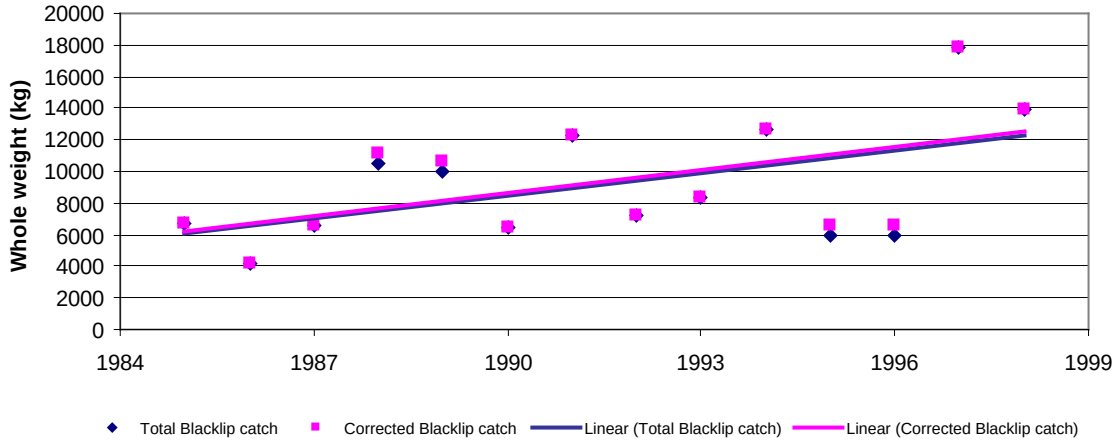
The slope of the regression of the Fishery Bay region of the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -338.2; r^2 = 0.526; p = 0.003). The total blacklip abalone catches in this region have decreased over the period analysed. The slope of the regression of the Fishery Bay region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = -335.6; r^2 = 0.501; p = 0.004). The corrected blacklip abalone catches in this region have decreased by 339 kg per year over the period analysed.

Figure 4.69: Regression analysis of the temporal changes in blacklip abalone catches in the northern Thorny Passage region (Mapcodes 18C, 19A-C) from 1985 - 1998.



The slope of the regression of the northern Thorny Passage region of the total blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -101.3; r^2 = 0.026; p = 0.579). The slope of the regression of the northern Thorny Passage region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is not significant (slope = -108.0; r^2 = 0.027; p = 0.573).

Figure 4.70: Regression analysis of the temporal changes in blacklip abalone catches in the southern Thorny Passage region (Mapcodes 18D - F) from 1985 - 1998.



The slope of the regression of the southern Thorny Passage region of the total blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 479.5; r^2 = 0.272; p = 0.055). The total blacklip abalone catches in the region have increased over the period analysed. The slope of the regression of the southern Thorny Passage region of the corrected blacklip abalone catches (whole weight kg) versus time (year) is significant (slope = 488.4; r^2 = 0.291; p = 0.046). The corrected blacklip abalone catches in this region have increased over the period analysed.

4.2.5 Analysis of size composition of greenlip abalone catches in the Western Zone

Composition of greenlip abalone catches in the Western Zone, as determined by catch gradings, may assist in interpreting the population at a local scale. However caution is required in interpetting the results because there are factors other than size structure of the population that can influence the size of abalone taken, for example, market demand for smaller animals can bring about a shift in exploitation from large to smaller fish.

In examining greenlip gradings from the Western Zone (figure 4.71 - 4.87) it can be seen that at Ward Island (figure 4.76) this smallest size grading has declined concomitantly with the decline in abundance of recruits (see Shepherd et al. 1999); conversely a similar decline in the 3-5 size grading occurred at Hotspot (figure 4.77) and Flinders Island (figure 4.78) where either the survey data showed no decline in recruitment or catches have not declined. At other sites of declining catches and presumably declining abundance, this size grading has declined but sometimes with a lag of up to 5 years after the major decline in the catch (e.g. Highcliff, Waldegrave, Drummond, Frenchmans, Misery Bay to Black Rocks, Pt Avoid, Northern Thorny Passage). For other populations with a declining catch the decline in this size grade is ambiguous or only shows a late decline e.g. Watchers, D'Anville Bay, and Fishery Bay.

At many sites both the largest (1-2) and the smallest (3-5) gradings have shown respective long-term increases and decreases; such sites were Flinders Island (figure 4.78), Drummond Point (figure 4.80), Frenchmans region (figure 4.81), Avoid Bay (figure 4.82), D'Anville Bay-Fishery Bay region (figure 4.83), and northern Thorny Passage (figure 4.85). All of these except Flinders Island have shown long-term declines in the catch (and also effort) and are from other evidence believed to be overfished. An increase in the largest size grading is suggestive of reducing fishing mortality and the declining proportion of the smallest size grading is suggestive of declining recruitment. Both changes occurred in the long-term study of the Avoid Bay population, which collapsed. Hence in these cases it seems likely that the catch tracks a declining population; as productivity declines fishing mortality may also decline, but not enough to enable the population to recover. The result is the long-term decline or collapse of the population.

Figure 4.71: Catch per grading by year for greenlip abalone from the High Cliff, Sceale Bay (Yanerbie) and Cape Blanche region from 1985 to 1998. 100% of the toal greenlip catch in each year was graded.

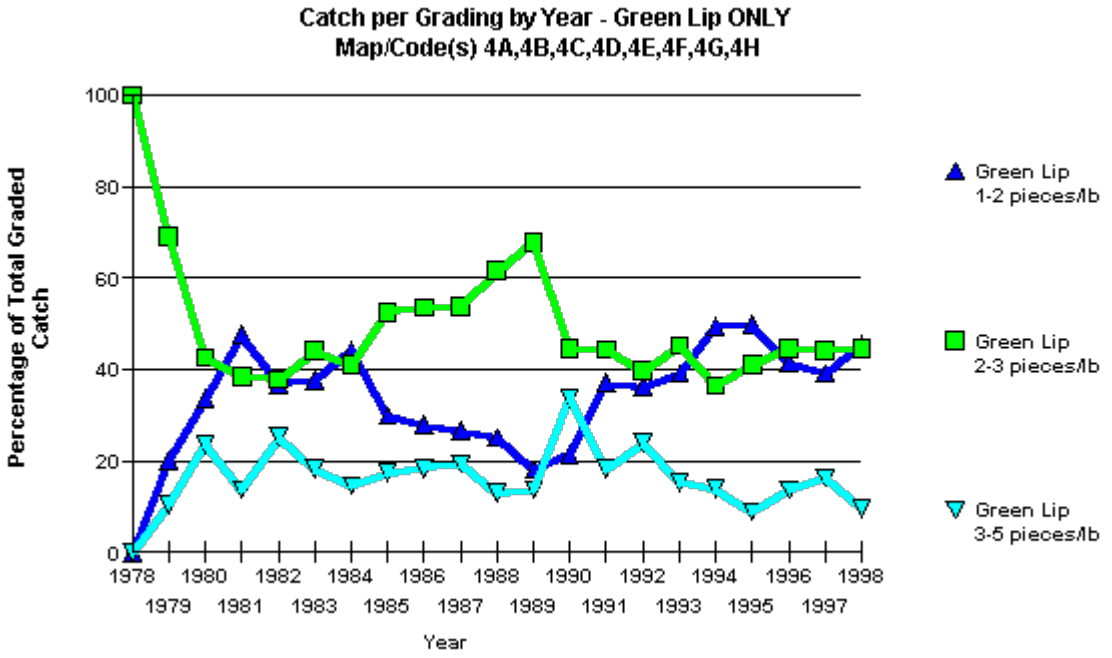


Figure 4.72: Catch per grading by year for greenlip abalone from the Point Labatt, Radstock-Baird Bay region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

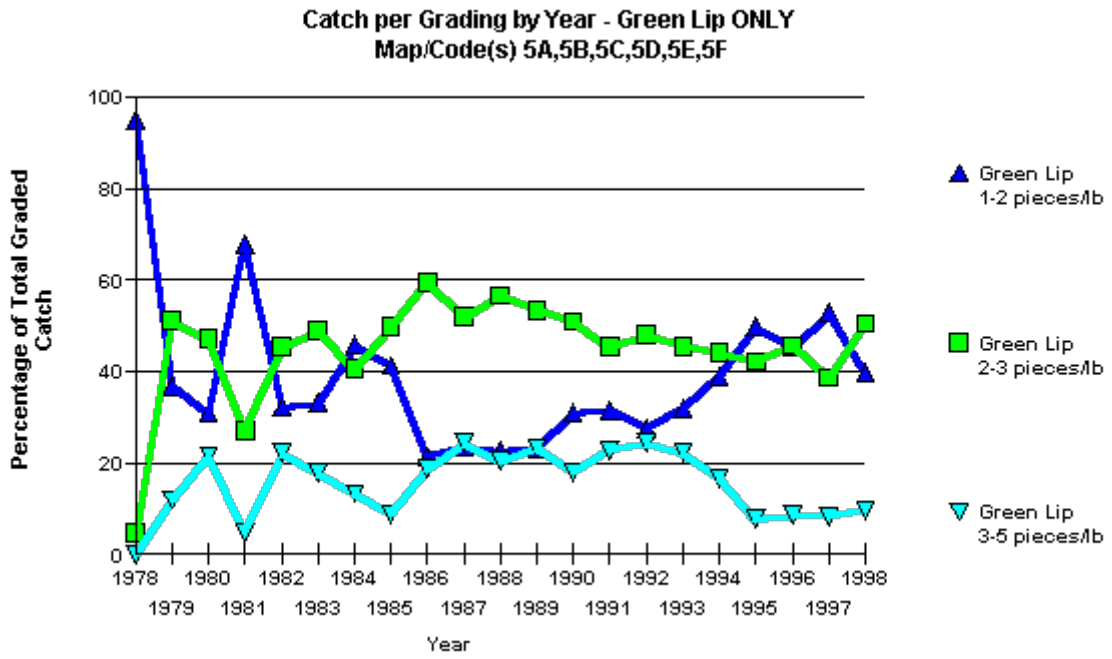


Figure 4.73: Catch per grading by year for greenlip abalone from the Venus Bay region from 1978 to 1998. 100% of the total greenlip catch in each year was graded

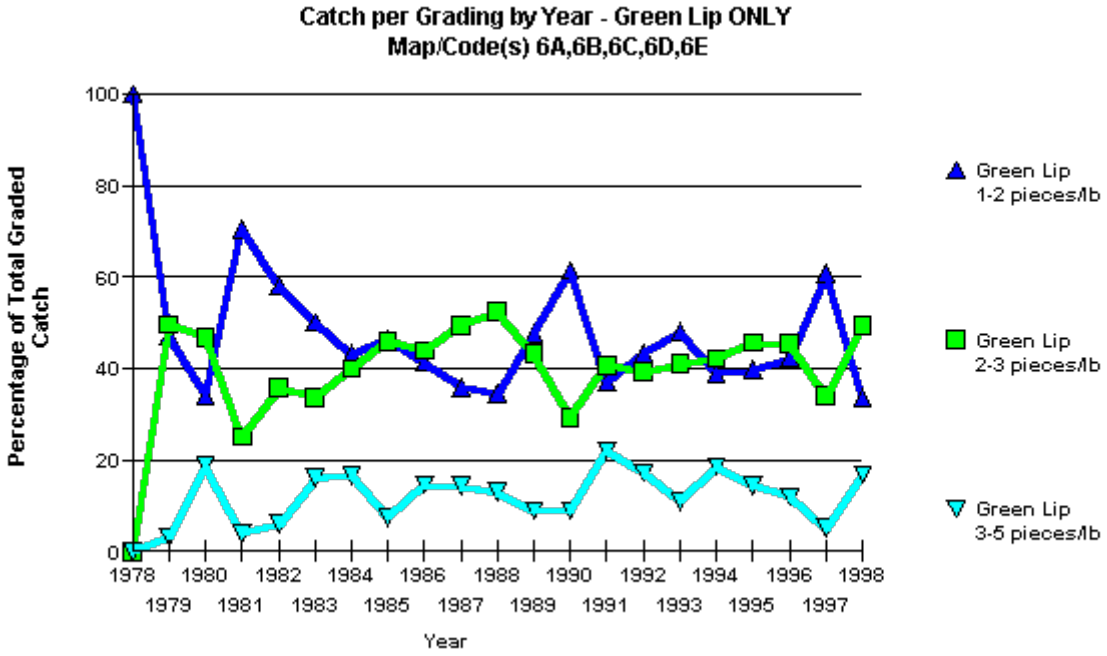


Figure 4.74: catch per grading by year for greenlip abalone from the Waldegrave area region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

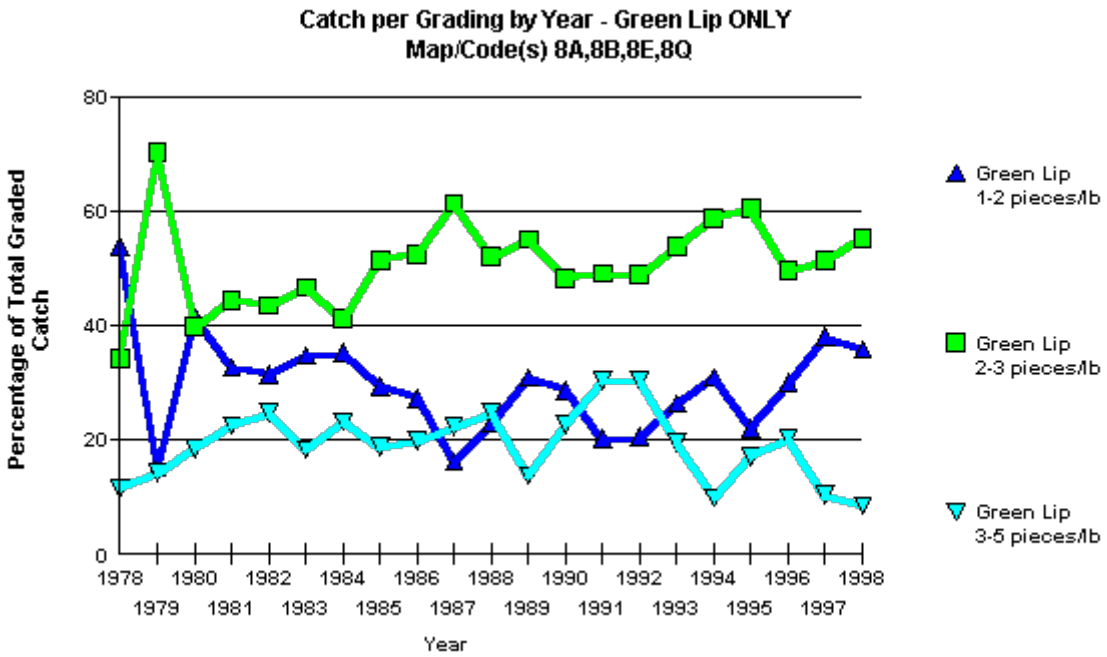


Figure 4.75: Catch per grading by year for greenlip abalone from the "The Watchers" region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

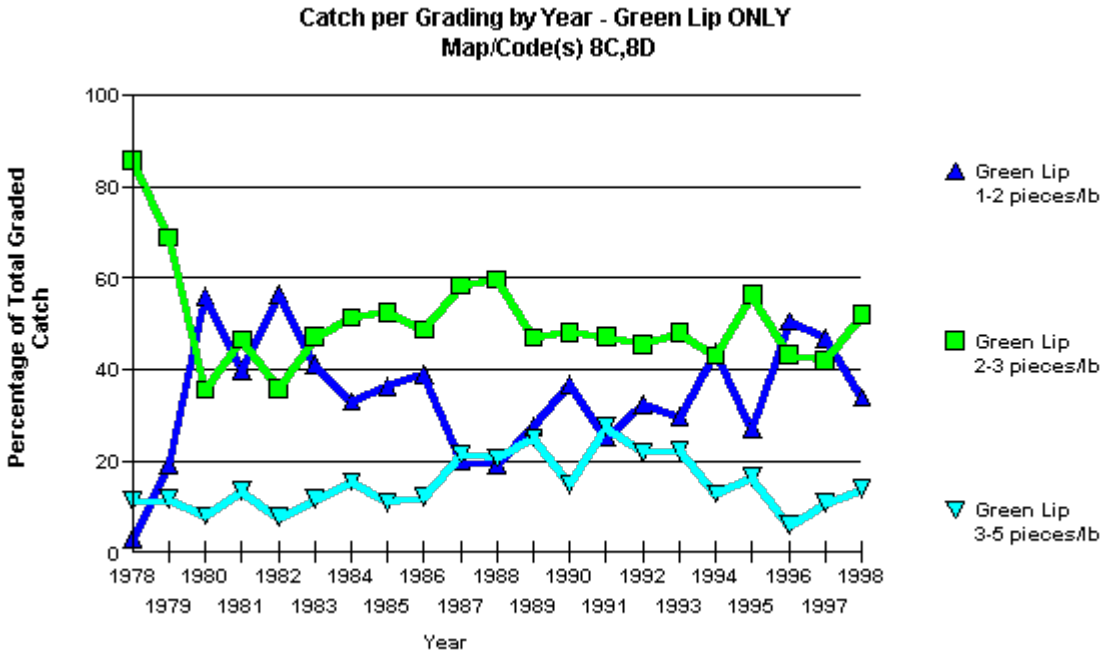


Figure 4.76: Catch per grading by year for greenlip abalone from the Ward Islands region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

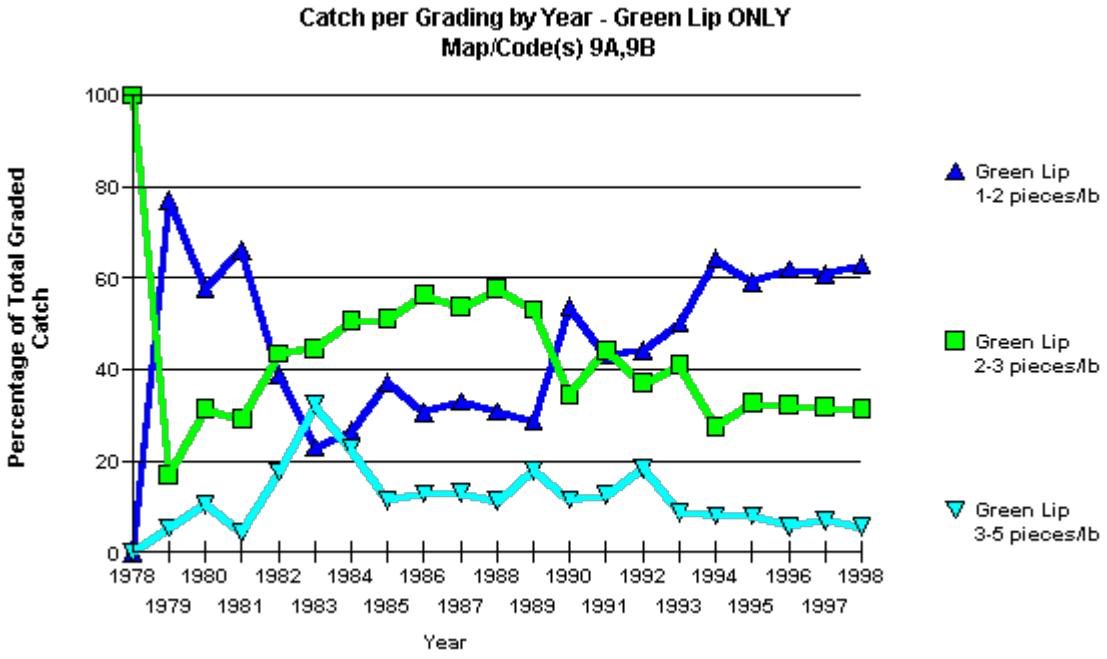


Figure 4.77: Catch per grading by year for greenlip abalone from "The Hotspot" region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

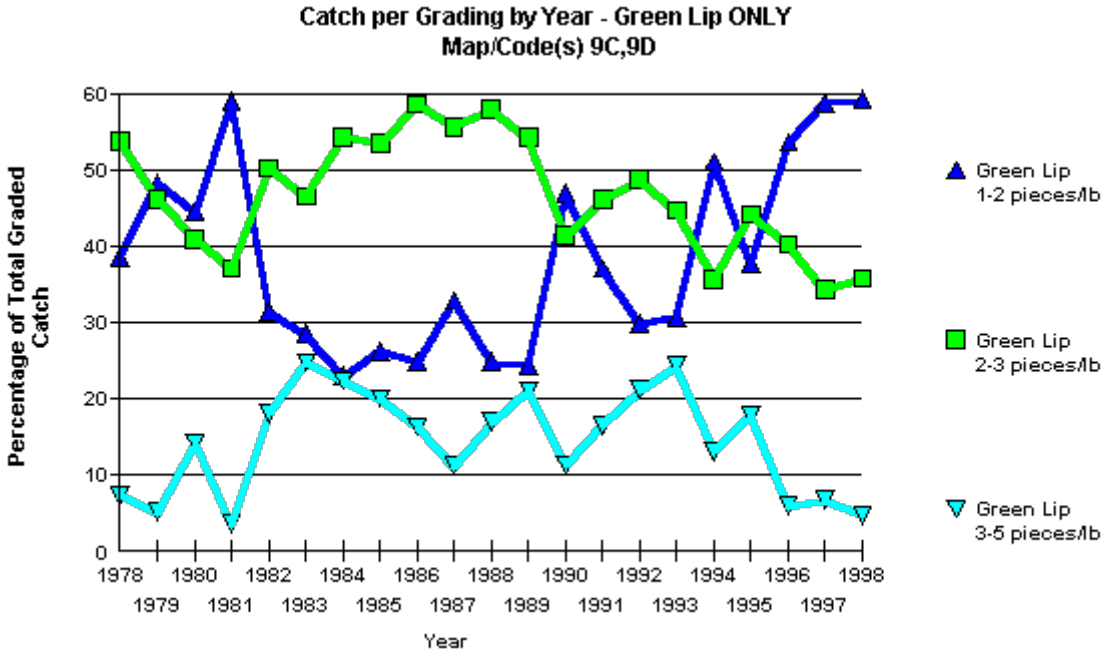


Figure 4.78: Catch per grading by year for greenlip abalone from Flinders island (SE side and Gem Reef) and Topgallant Islands region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

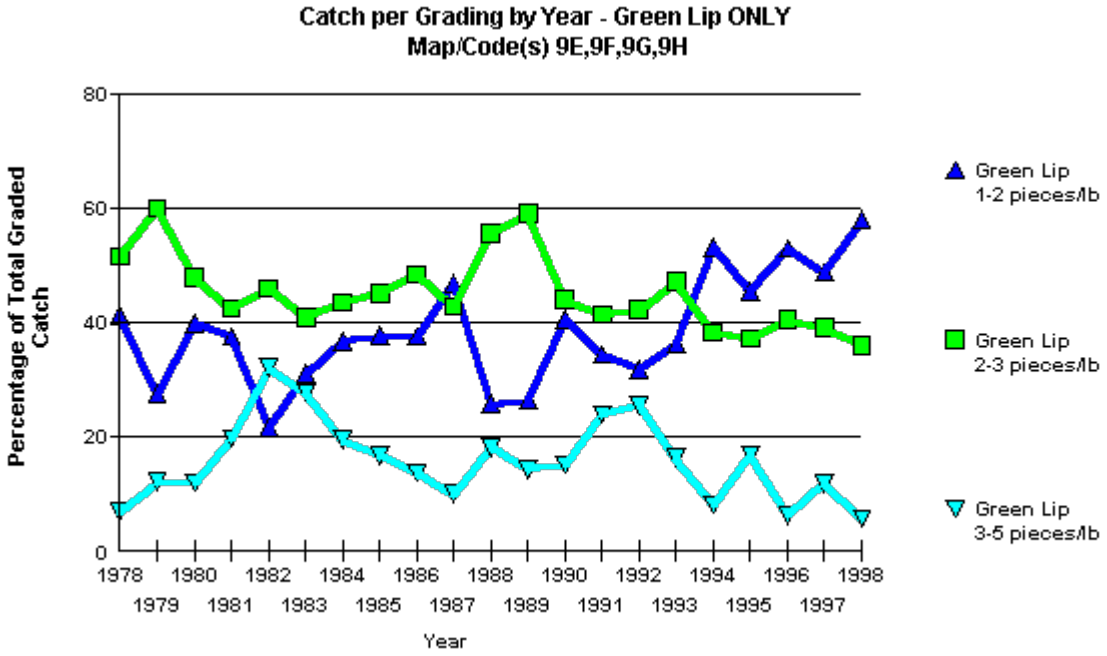


Figure 4.79: Catch per grading by year for greenlip abalone from the Pearson Island region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

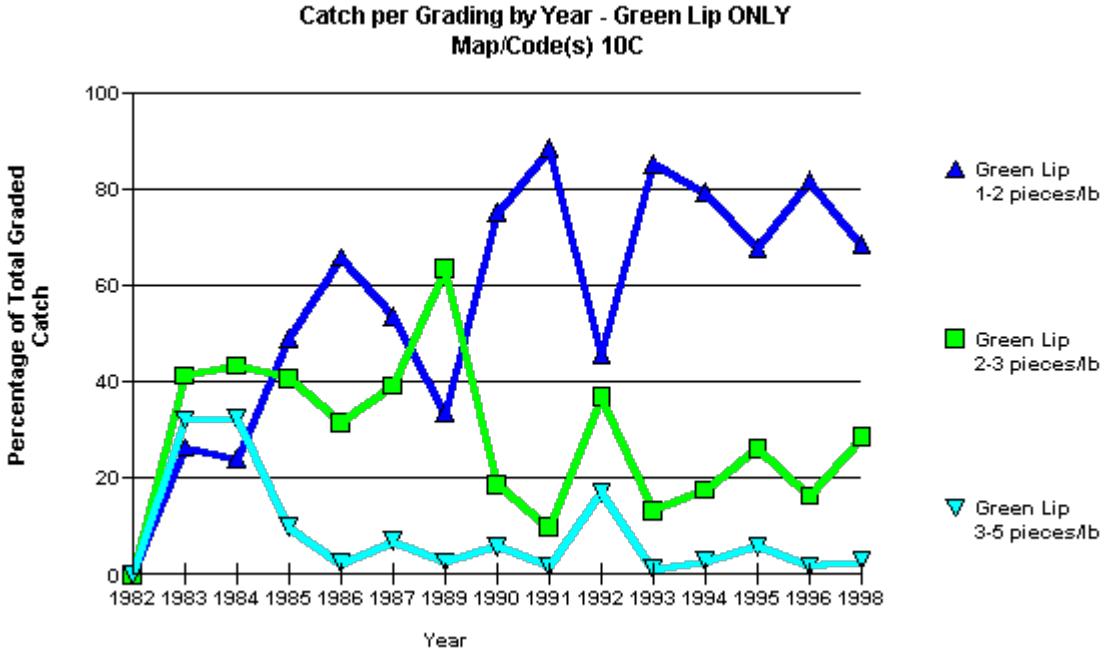


Figure 4.80: Catch per grading by year for greenlip abalone from Hall Bay and Drummond Point region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

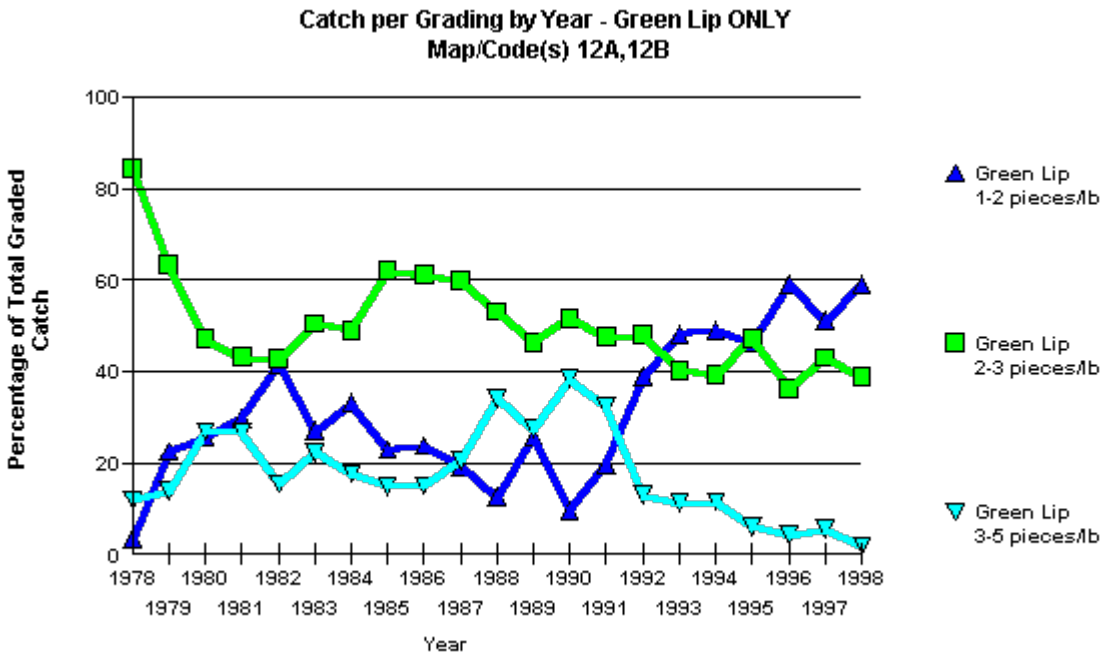


Figure 4.81: Catch per grading by year for greenlip abalone from the Frenchmans, Sir Isaac (Reef Head) and Boardinghouse Bay (Pt. Whidbey) region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

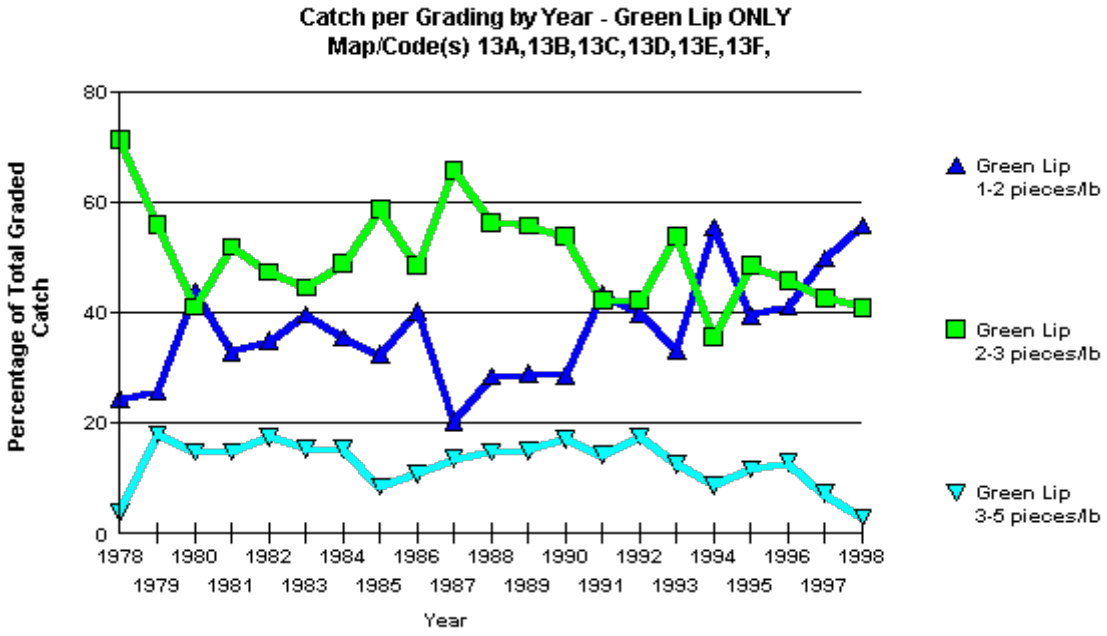


Figure 4.82: Catch per grading by year for greenlip abalone from the Misery Bay (Black Rocks) and Point Avoid region from 1978 to 1998. 100% of the toal greenlip catch in each year was graded.

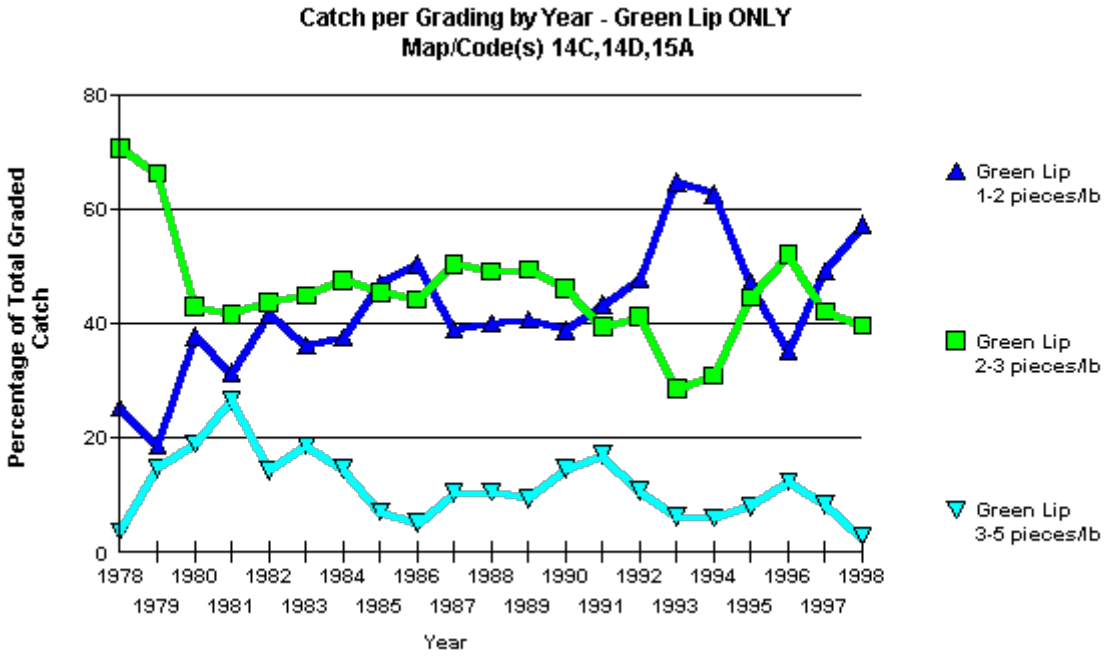


Figure 4.83: Catch per grading by year for greenlip abalone from the D'Anville Bay, Liguanea Island and Fishery Bay region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

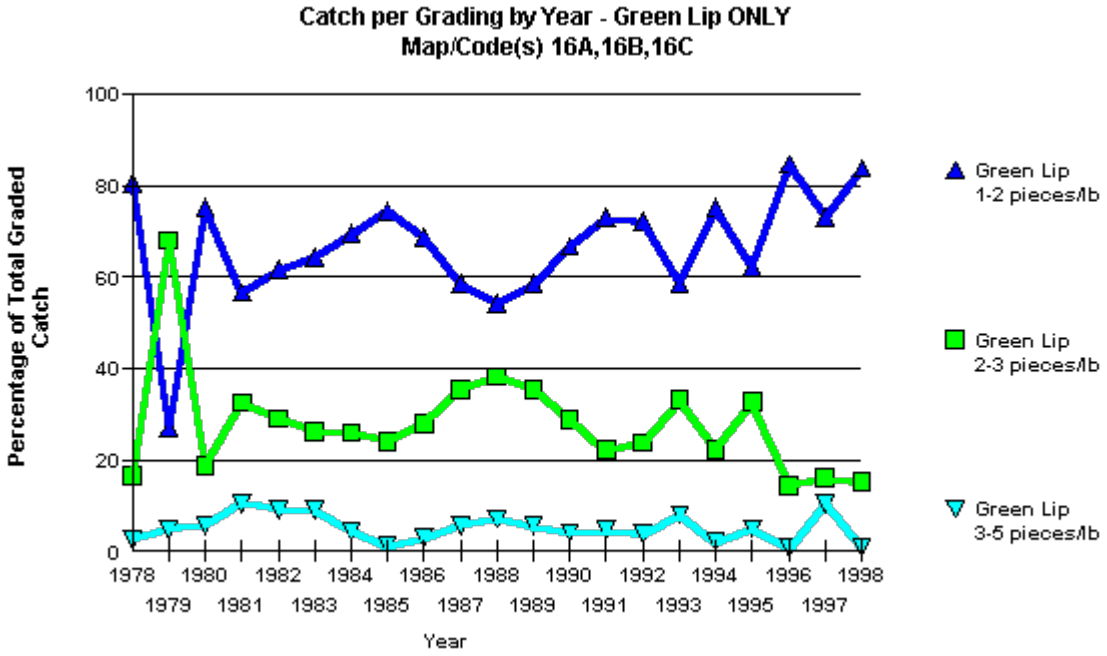


Figure 4.84: Catch per grading by year for greenlip abalone from the Neptune Islands region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

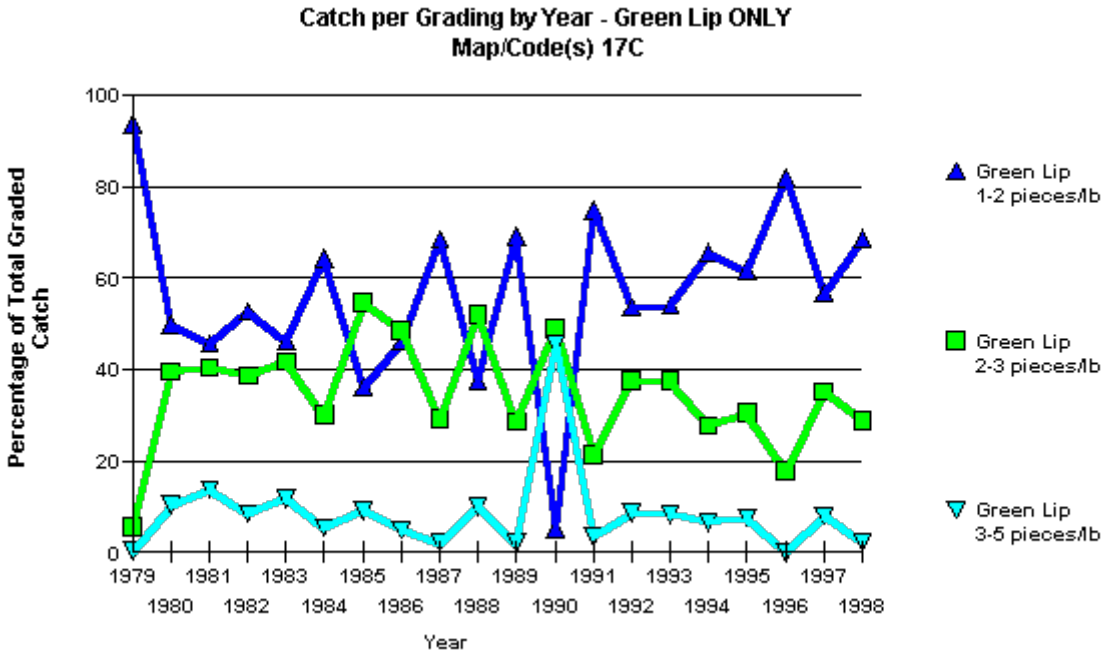


Figure 4.85: Catch per grading for greenlip abalone from the northern Thorny Passage region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

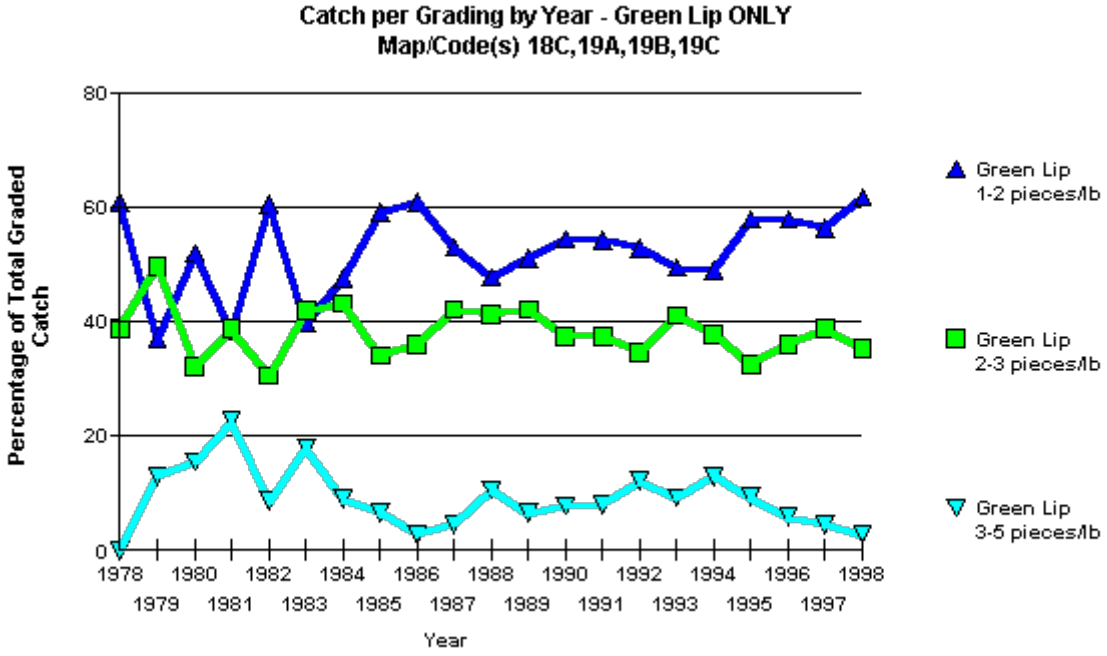


Figure 4.86: Catch per grading by year for greenlip abalone from the southern Thorny Passage region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.

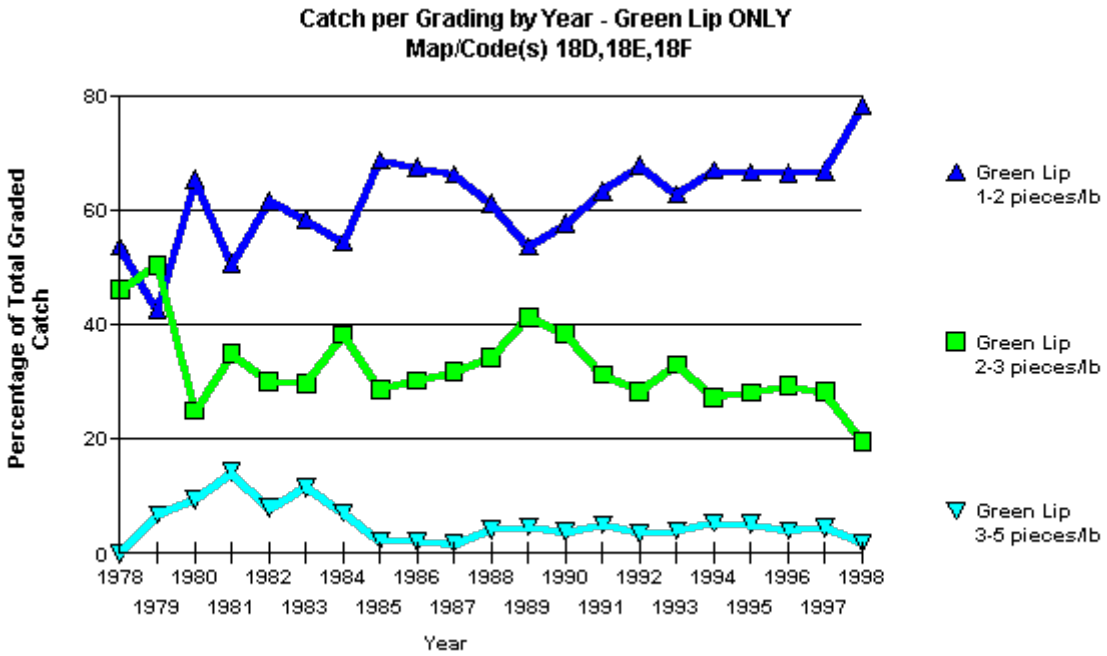
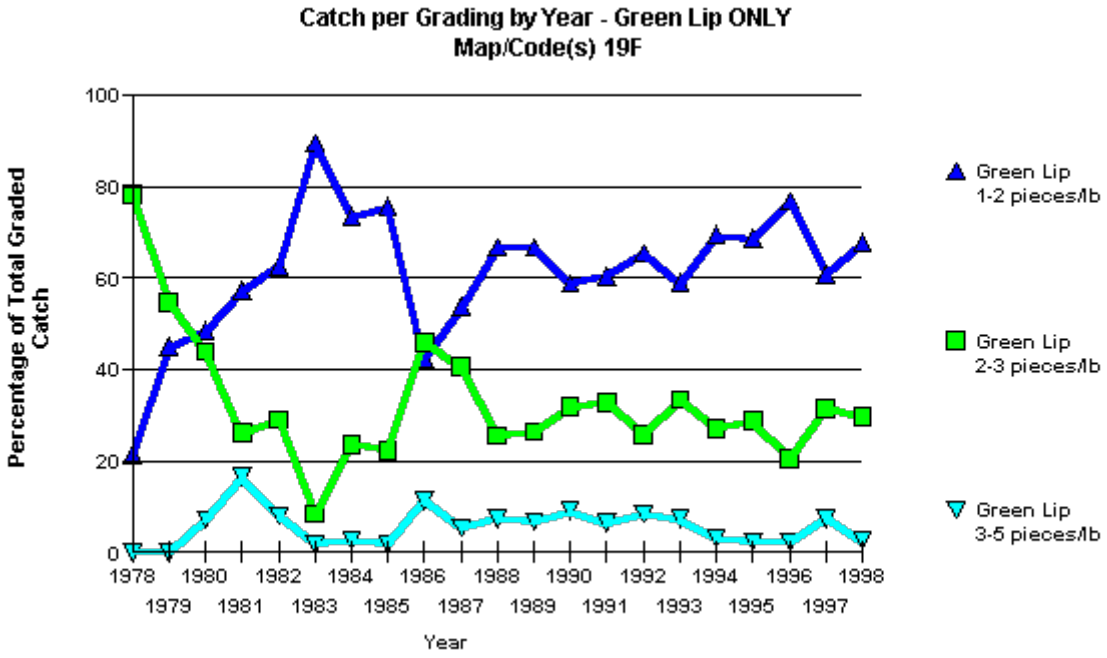


Figure 4.87: Catch per grading by year for greenlip abalone from the Wedge Island region from 1978 to 1998. 100% of the total greenlip catch in each year was graded.



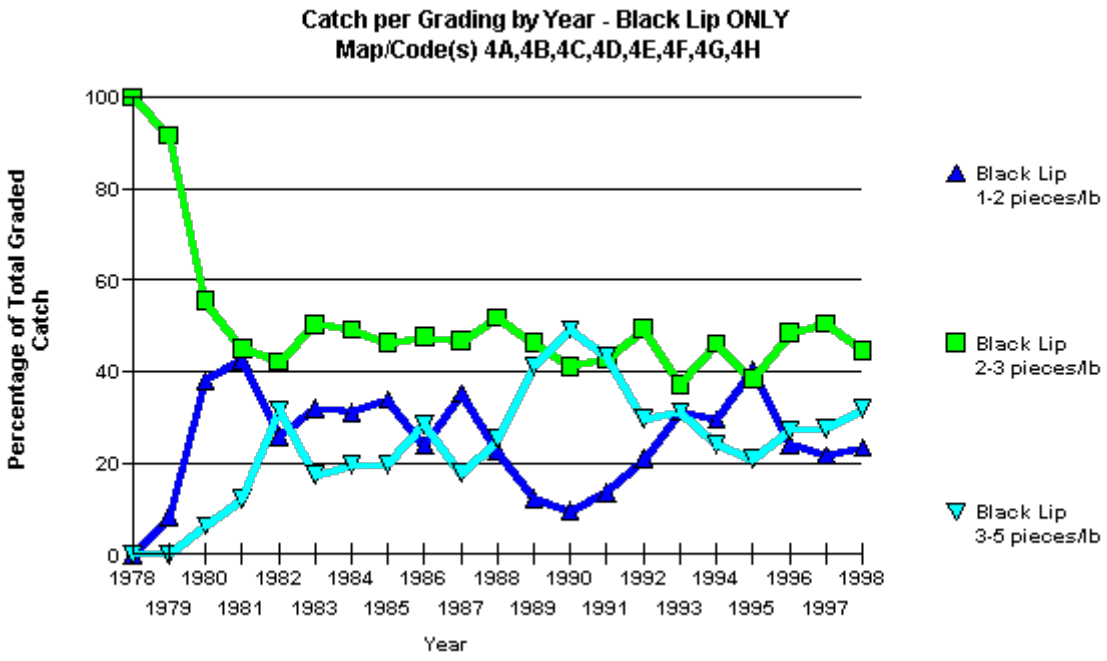
4.2.6 Size composition of blacklip abalone catches in the western Zone

Composition of blacklip abalone catches may assist in interpretting changes in the population structure at a local scale. However as mentioned previously (Section 4.2.5), caution is required in interpretting the results.

The percentage of blackip abalone catches graded is less than the greenlip abalone. The percentages of total catch graded in each year for each site along with the size composition according to the catch gradings are reported (figure 4.88 - 4.102).

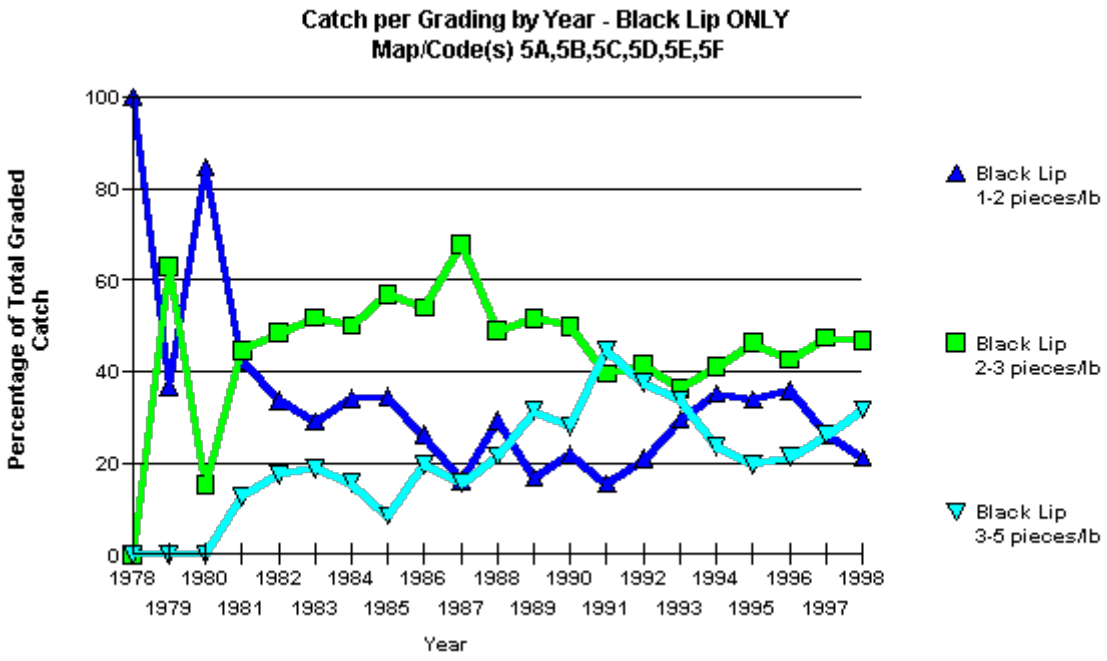
In blacklip populations some long-term trends are evident in the largest (1-2 per lb) and smallest (3-5 per lb) gradings in a few populations. There are long-term trends of an increasing proportion of 3-5s at Pt Labatt, Radstock-Baird Bay region (figure 4.89), Venus Bay (figure 4.90) and Ward I. (figure 4.93) in apparently stable populations. This is consistent with a pattern of increasing recruitment, but other explanations (diver behaviour) are also possible. At a few sites e.g. Venus Bay and Waldegrave area (figure 4.91), the largest grades (1-2) have declined, and at Sheringa Bay (figure 4.96)oth the largest grade has declined and the smallest (3-5) has increased. If stunting occurs as a long-term response to fishing, as has been reported for greenlip in Waterloo Bay (Shepherd, unpublished data), then we would predict a decline in the largest and an increase in the smallest size gradings. The data for Sheringa Bay and to a lesser extent Venus Bay and Waldegrave Area are consistent with this hypothesis.

Figure 4.88: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the High Cliff, Sceale Bay (Yanerbie) and Cape Blanche region.



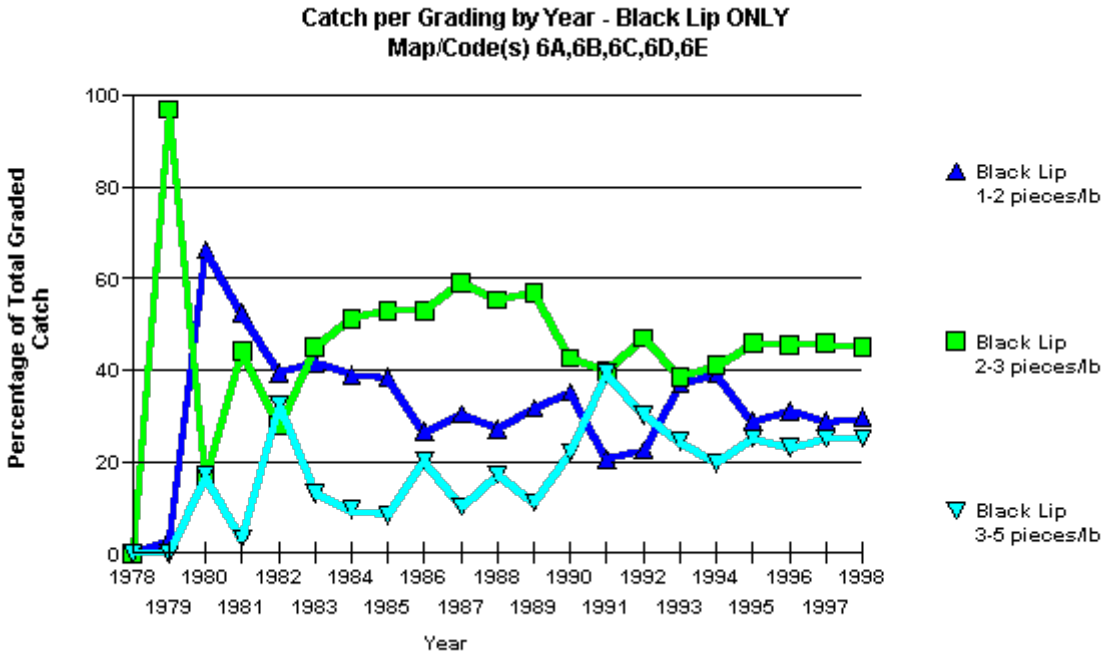
Year	Percentage of total catch graded
1978	100
1979	60.83
1980	44.43
1981	53.16
1982	97.87
1983	100.00
1984	92.37
1985	89.89
1986	80.86
1987	54.31
1988	43.25
1989	26.08
1990	45.91
1991	30.75
1992	47.62
1993	29.50
1994	39.94
1995	48.44
1996	51.96
1997	47.08
1998	36.54

Figure 4.89: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Point Labatt and Radstock - Baird Bay region.



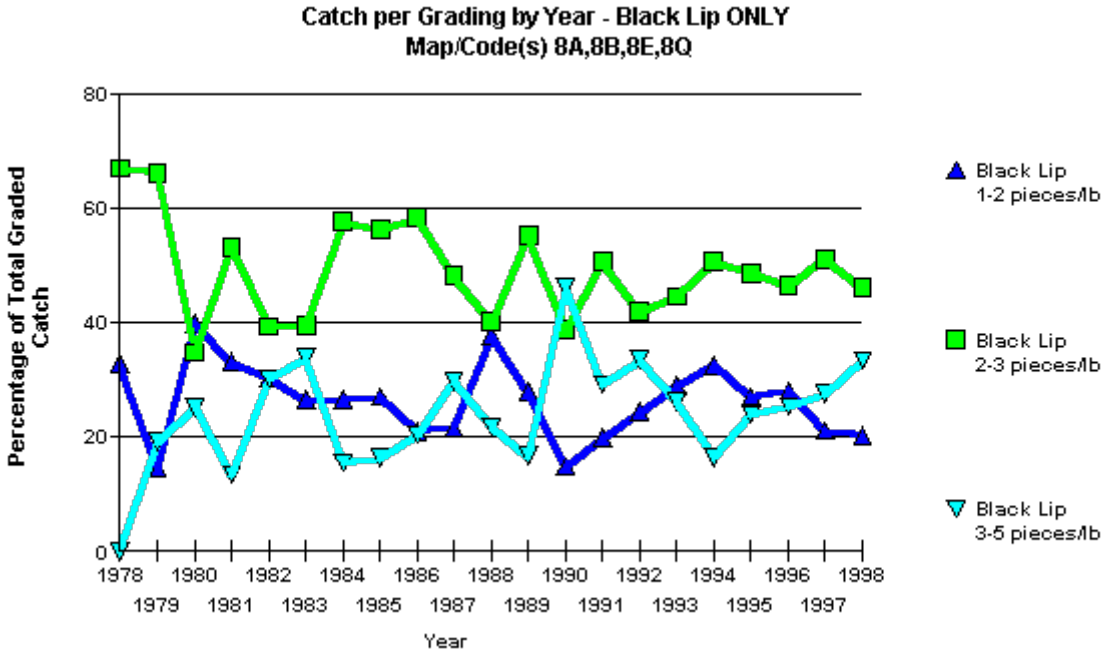
Year	Percentage of total catch graded
1978	100
1979	47.53
1980	5.77
1981	65.51
1982	90.51
1983	100.00
1984	82.49
1985	97.63
1986	95.92
1987	70.91
1988	56.95
1989	71.59
1990	64.09
1991	87.36
1992	77.70
1993	71.87
1994	64.07
1995	55.39
1996	51.09
1997	54.35
1998	66.20

Figure 4.90: Catch per grading by year for blacklip abalone and the perentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Venus Bay region.



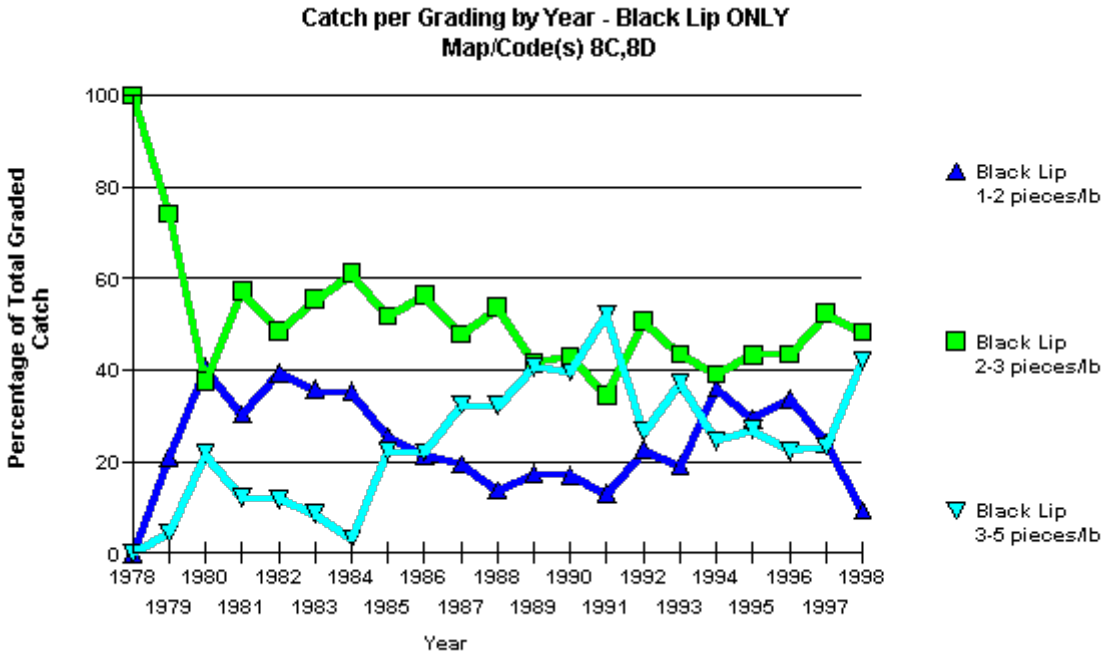
Year	Percentage of total catch graded
1978	0.00
1979	63.65
1980	14.47
1981	68.67
1982	90.27
1983	100.00
1984	75.80
1985	90.36
1986	99.66
1987	90.90
1988	56.86
1989	39.97
1990	86.08
1991	70.54
1992	76.60
1993	79.81
1994	89.21
1995	85.89
1996	85.75
1997	89.40
1998	93.25

Figure 4.91: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Waldegrave Area region.



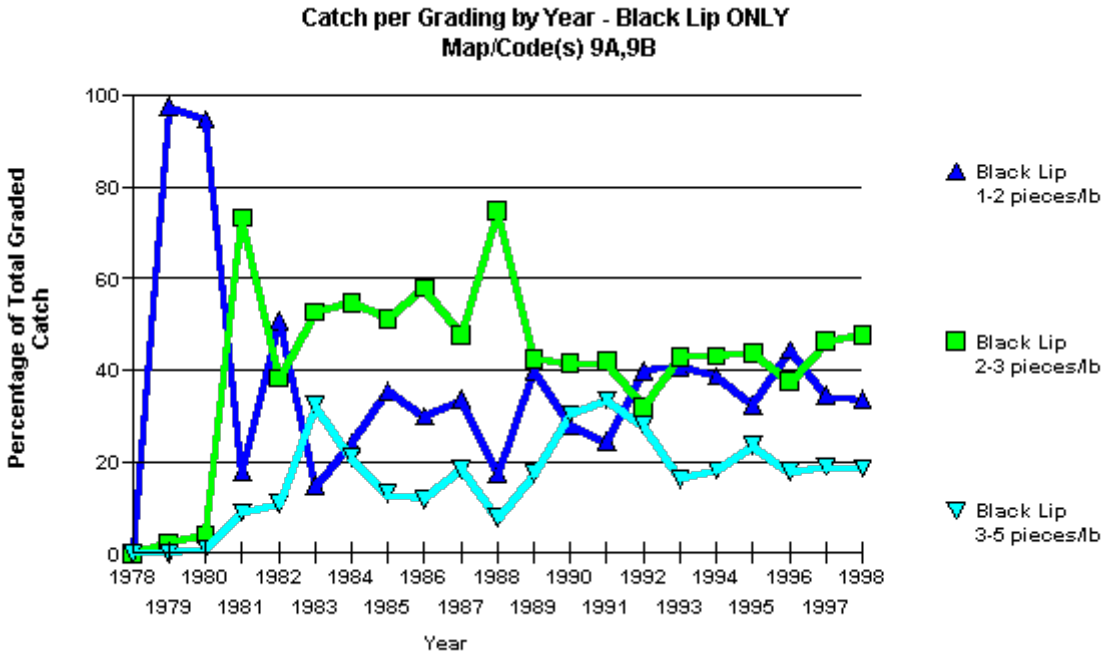
Year	Percentage of total catch graded
1978	82.53
1979	34.78
1980	40.57
1981	74.14
1982	96.77
1983	96.92
1984	100.00
1985	99.15
1986	100.00
1987	100.00
1988	96.14
1989	70.57
1990	86.95
1991	64.24
1992	84.83
1993	81.46
1994	70.10
1995	98.44
1996	71.72
1997	67.88
1998	79.47

Figure 4.92: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for "The Watchers" region.



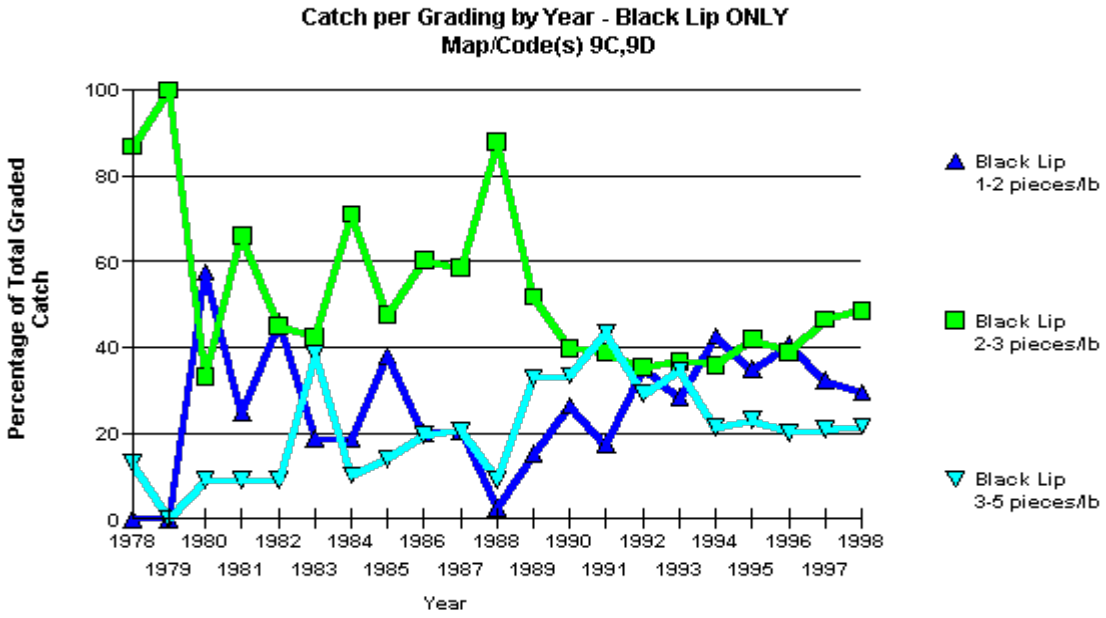
Year	Percentage of total catch graded
1978	100
1979	50.06
1980	45.87
1981	43.01
1982	98.18
1983	85.01
1984	76.25
1985	89.67
1986	94.96
1987	80.58
1988	85.29
1989	92.20
1990	100.00
1991	97.21
1992	99.07
1993	96.13
1994	85.61
1995	100.00
1996	100.00
1997	100.00
1998	100.00

Figure 4.93: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Ward Islands region



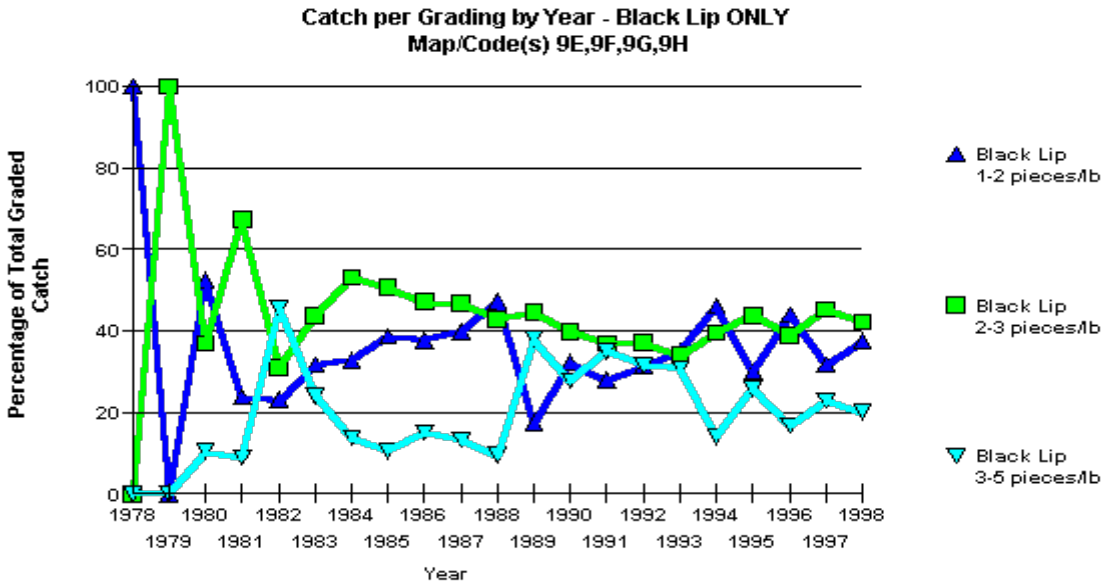
Year	Percentage of total catch graded
1978	0.00
1979	20.20
1980	17.68
1981	58.52
1982	100.00
1983	100.00
1984	100.00
1985	100.00
1986	100.00
1987	76.36
1988	40.75
1989	73.52
1990	77.26
1991	73.59
1992	92.47
1993	83.87
1994	96.05
1995	92.06
1996	91.72
1997	96.17
1998	94.38

Figure 4.94: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for "The Hotspot" region.



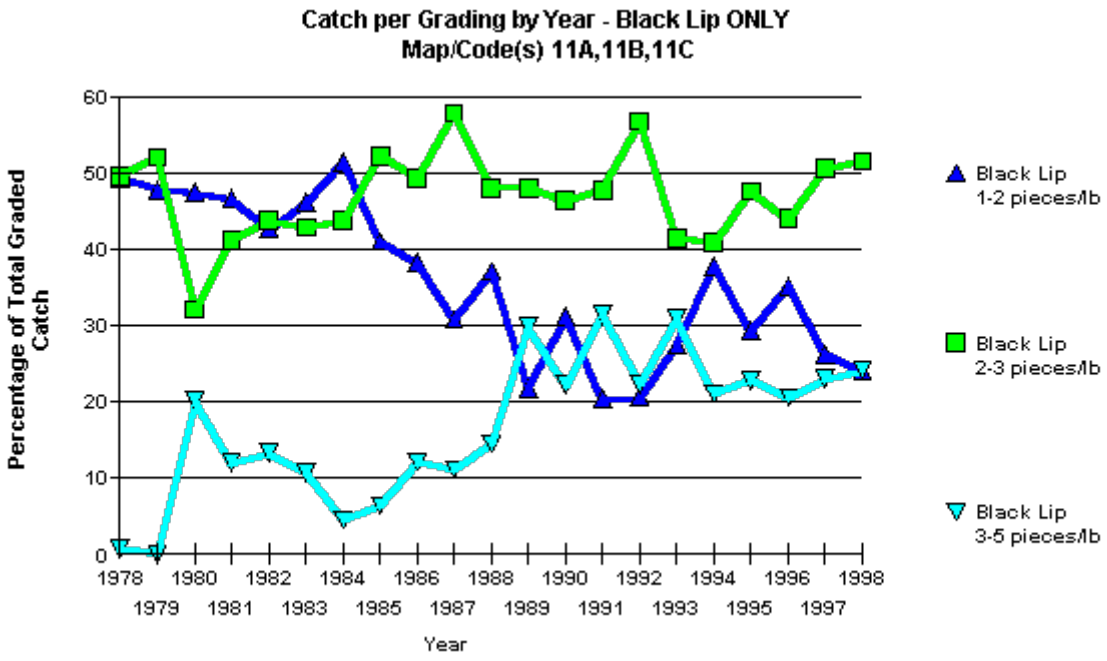
Year	Percentage of total catch graded
1978	100
1979	86.36
1980	4.86
1981	63.50
1982	100.00
1983	100.00
1984	99.91
1985	100.00
1986	100.00
1987	86.22
1988	49.34
1989	59.56
1990	90.41
1991	99.38
1992	91.00
1993	72.86
1994	97.72
1995	99.93
1996	95.13
1997	97.23
1998	97.51

Figure 4.95: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Flinders Island (SE side and Gem Reef) and Topgallant Islands region.



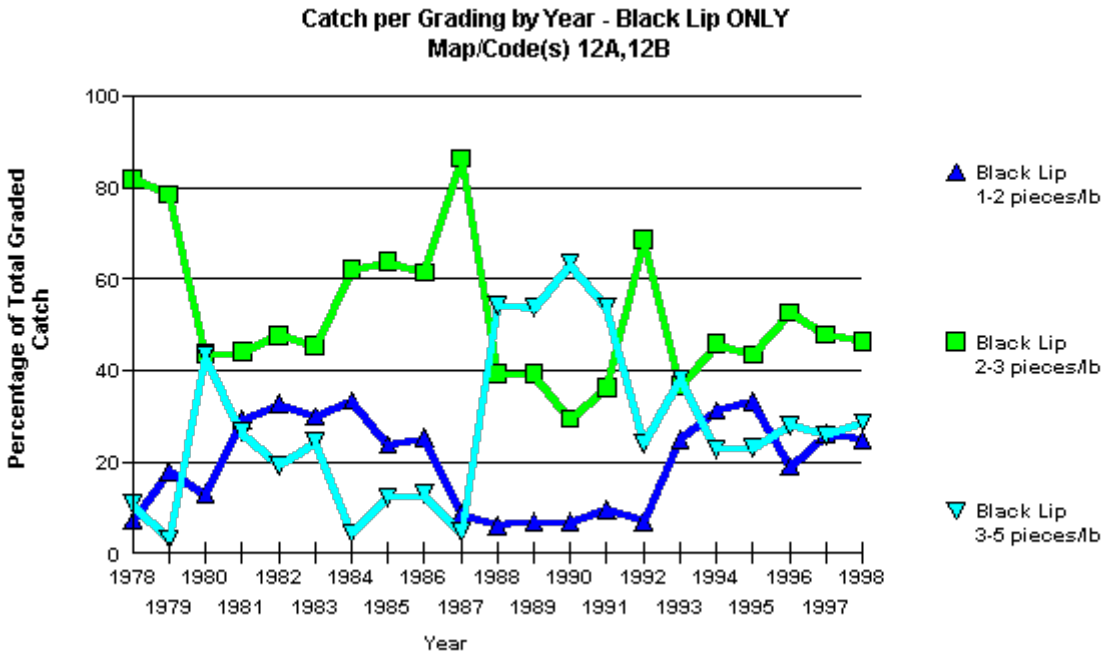
Year	Percentage of total catch graded
1978	100
1979	29.70
1980	34.80
1981	28.78
1982	100.00
1983	82.05
1984	90.79
1985	100.00
1986	97.76
1987	84.50
1988	92.13
1989	63.21
1990	72.31
1991	74.60
1992	57.55
1993	70.72
1994	63.82
1995	49.04
1996	94.75
1997	94.34
1998	79.15

Figure 4.96: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Sheringa Bay and Mt Misery (Kiana Cliffs).



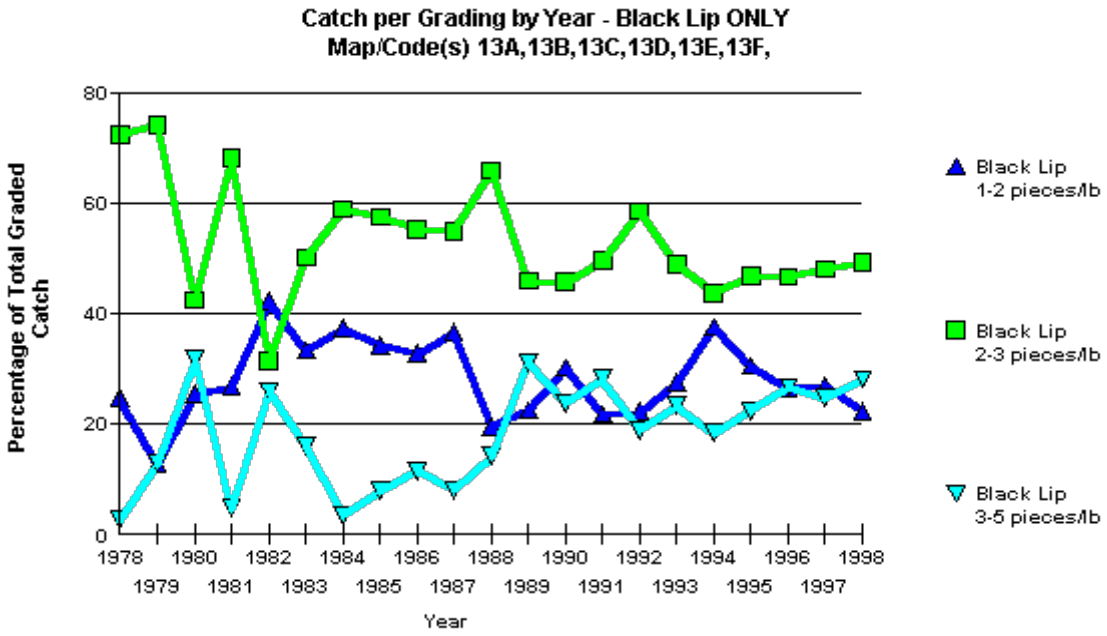
Year	Percentage of total catch graded
1978	100
1979	48.10
1980	42.51
1981	42.05
1982	55.64
1983	75.20
1984	82.41
1985	84.24
1986	91.03
1987	63.13
1988	77.04
1989	54.62
1990	74.24
1991	82.04
1992	86.61
1993	87.09
1994	81.04
1995	82.40
1996	96.25
1997	88.84
1998	80.14

Figure 4.97: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Hall Bay and Drummond Point region



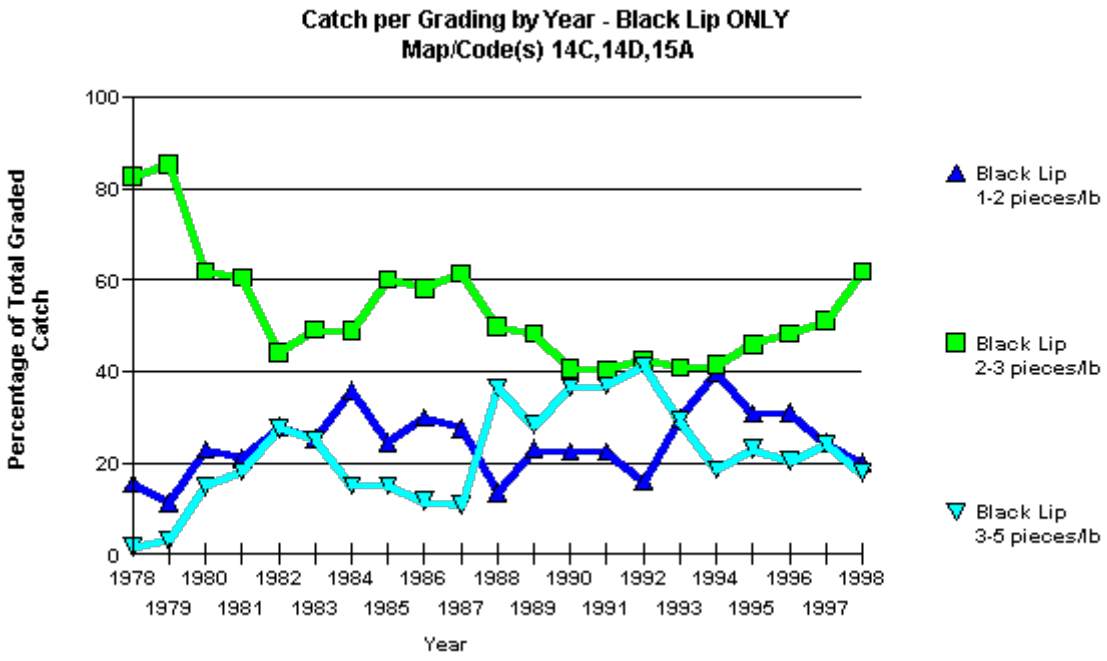
Year	Percentage of total catch graded
1978	100
1979	67.93
1980	37.41
1981	57.58
1982	58.84
1983	71.52
1984	72.43
1985	70.74
1986	79.38
1987	41.98
1988	74.90
1989	85.10
1990	95.30
1991	89.43
1992	95.56
1993	86.62
1994	88.09
1995	96.02
1996	85.48
1997	93.96
1998	92.55

Figure 4.98: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Frenchmans, Sir Isaac (Reef Head) and Boardinghouse Bay (Pt Whidbey) region



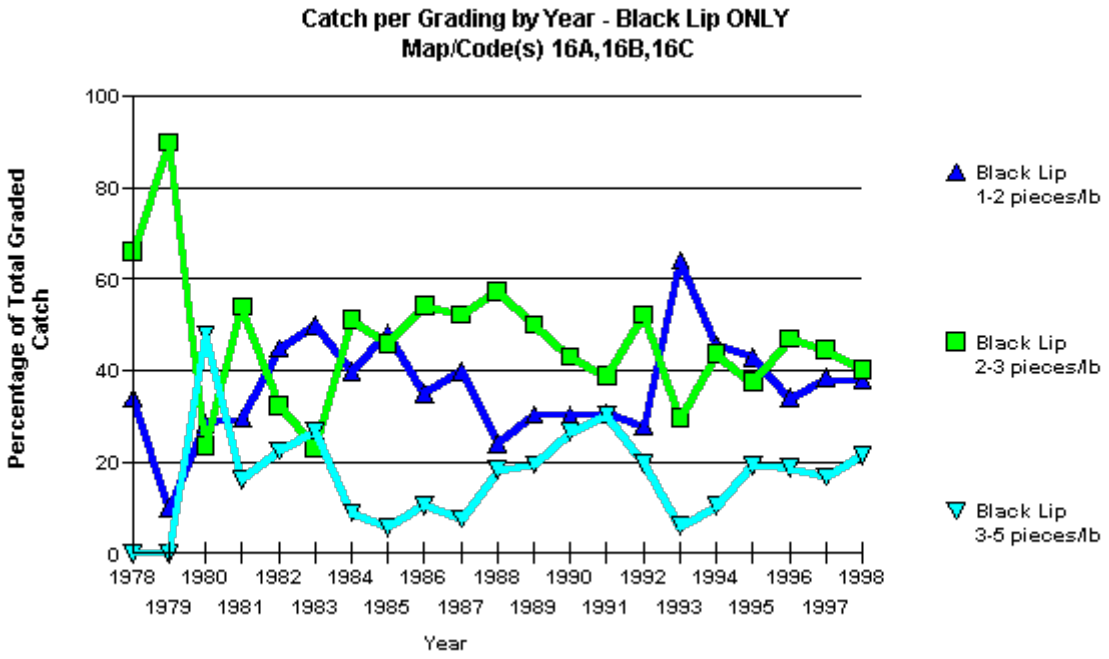
Year	Percentage of total catch graded
1978	90.88
1979	48.72
1980	11.17
1981	49.84
1982	77.13
1983	74.22
1984	80.00
1985	88.41
1986	86.59
1987	64.95
1988	65.19
1989	65.54
1990	65.81
1991	56.19
1992	70.20
1993	51.61
1994	84.36
1995	87.86
1996	85.62
1997	88.72
1998	89.48

Figure 4.99: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the Misery Bay (Black Rocks) and Pt Avoid region



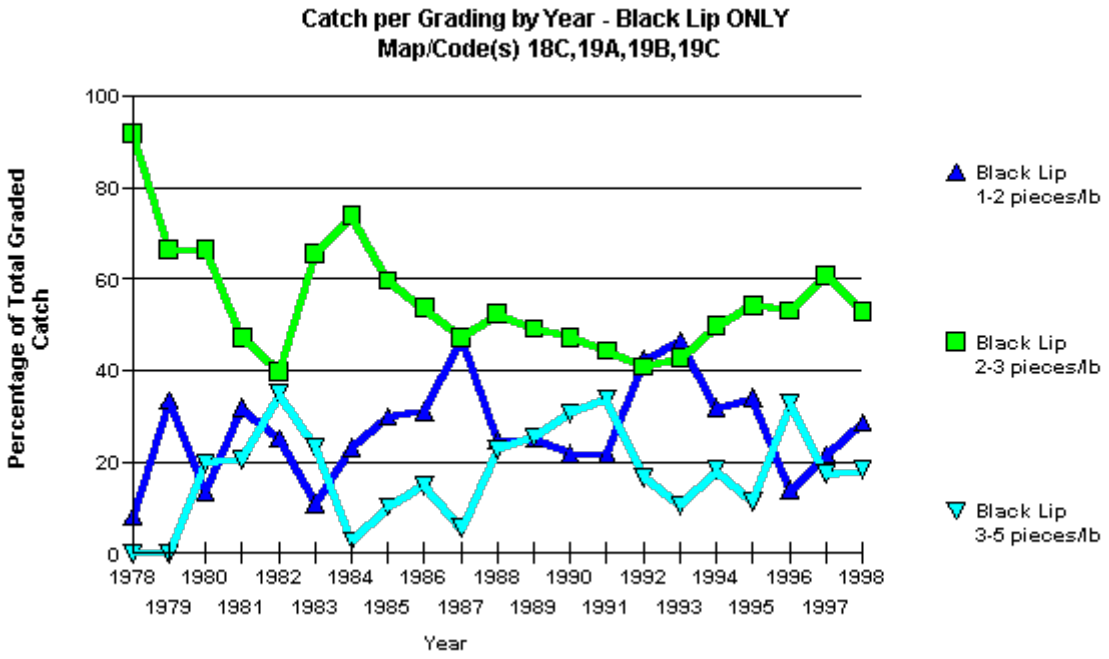
Year	Percentage of total catch graded
1978	89.50
1979	52.59
1980	20.00
1981	48.04
1982	63.55
1983	87.87
1984	92.45
1985	89.20
1986	89.27
1987	86.31
1988	67.55
1989	89.34
1990	57.01
1991	82.64
1992	65.81
1993	78.93
1994	91.28
1995	85.33
1996	99.83
1997	92.49
1998	93.86

Figure 4.100: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the D'Anville Bay, Liguanea Island and Fishery Bay region



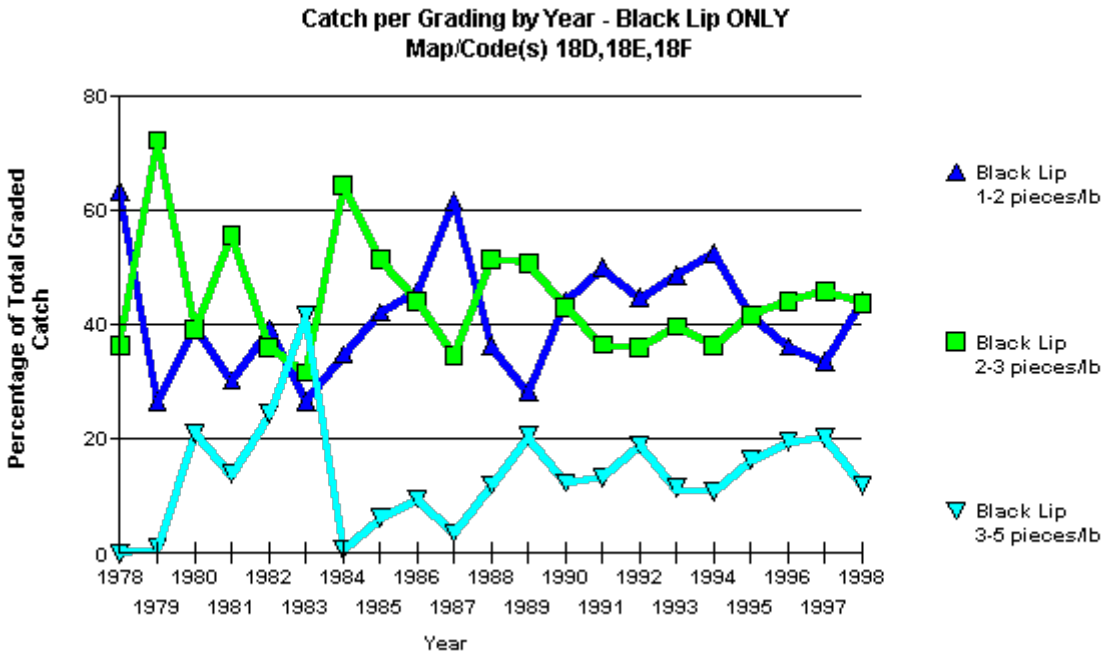
Year	Percentage of total catch graded
1978	100
1979	56.59
1980	10.23
1981	82.91
1982	75.74
1983	71.12
1984	90.61
1985	70.27
1986	65.40
1987	72.38
1988	80.25
1989	49.12
1990	29.22
1991	62.49
1992	58.05
1993	76.98
1994	70.48
1995	100.00
1996	62.68
1997	97.14
1998	70.56

Figure 4.101:Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the northern Thorny Passage region.



Year	Percentage of total catch graded
1978	80.43
1979	49.16
1980	27.16
1981	48.70
1982	21.24
1983	52.71
1984	74.33
1985	92.08
1986	87.82
1987	63.67
1988	44.94
1989	35.10
1990	53.18
1991	47.01
1992	51.78
1993	39.85
1994	49.47
1995	96.09
1996	29.73
1997	57.12
1998	70.78

Figure 4.102: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1978 to 1998 for the southern Thorny Passage region.



Year	Percentage of total catch graded
1978	100
1979	76.50
1980	28.30
1981	42.90
1982	69.01
1983	80.81
1984	96.39
1985	97.00
1986	81.31
1987	94.01
1988	69.71
1989	18.59
1990	44.35
1991	56.40
1992	59.68
1993	68.58
1994	41.95
1995	84.00
1996	56.24
1997	61.62
1998	71.55

4.3 CENTRAL ZONE

In following the spatial trends in catches in the Central Zone, a striking feature is the spatial split of the catch of the two species and the critical importance of the Tiparra Reef area (Map 21) to the Central Zone fishery and the disappearance of the stocks from the Cape Jervis and the Stansbury/Edithburgh area on Yorke Peninsula.

4.3.1 Assessment of Spatial trends in greenlip abalone catches since 1980

Figures 4.105 to 4.123 provide an overview of the broad patterns of greenlip abalone catch distribution between 1980 and 1998.

The total greenlip abalone catch for the Central Zone is currently about 140 tonnes of which 100 to 120 tonnes comes from the Tiparra Reef area (map 21). Good catches also currently come from the Point Turtin area (24A). Over the last five years these two areas have contributed 84 to 89 % of the total greenlip catch for the Central Zone.

Historically the picture was much different in the Central Zone greenlip fishery and this can be gleaned from the maps (figures 4.105 - 4.123) and graphs (figure 4.103 and 4.104). Up to 1984 significant greenlip catches came from the eastern side of Yorke Peninsula in the Edithburgh area (24B-F). From 1978 to 1984 over 230 tonnes were caught from this area with catches of 13 to 47 tonnes per annum until a collapse to practically zero in 1985. The cause for this collapse was believed to be the parasite *Perkinsus*.

The other significant feature within the Central Zone is that greenlip catches around Cape Jervis on the Fleurieu Peninsula (map 25) were from 5 to 12 tonnes in most years up until 1989. The collapse in this stock is believed to be due to overfishing. In the early 1980's total greenlip catches were around 120 tonnes per annum with a more balanced spread of catches spatially. Because of the importance of the two areas above prior to their collapse, Tiparra and Point Turtin together contributed less than half the total greenlip catch as opposed to almost 90 % today. The change in the spatial distribution of the catch between the early 1980's and the current time is evident in figures 4.103 and 4.104 (greenlip catches in 1983 and 1998).

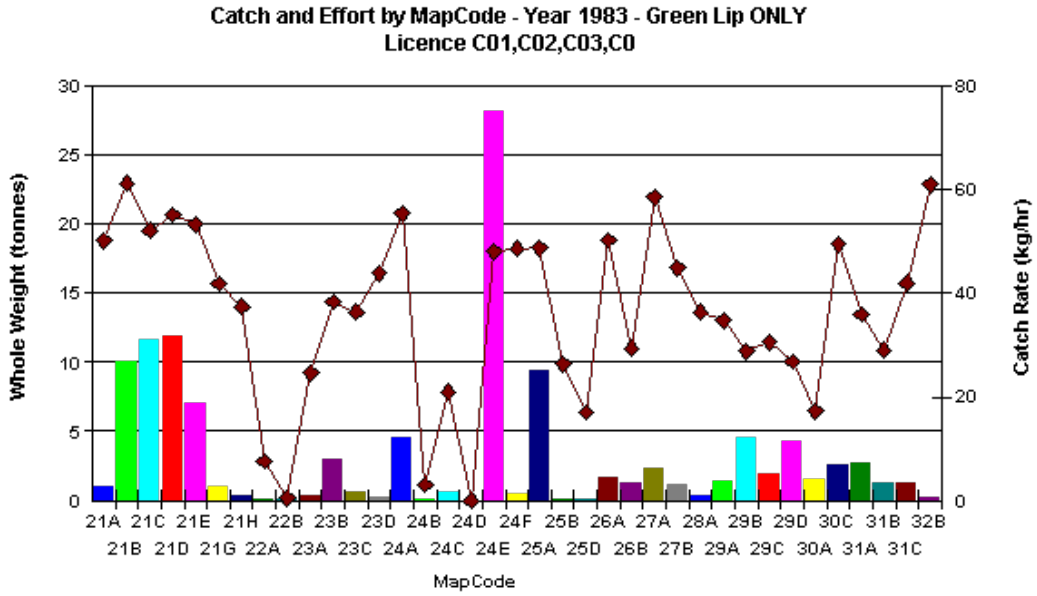


Figure 4.103: The 1983 greenlip abalone catch and effort by mapcode within the Central Zone fishery.

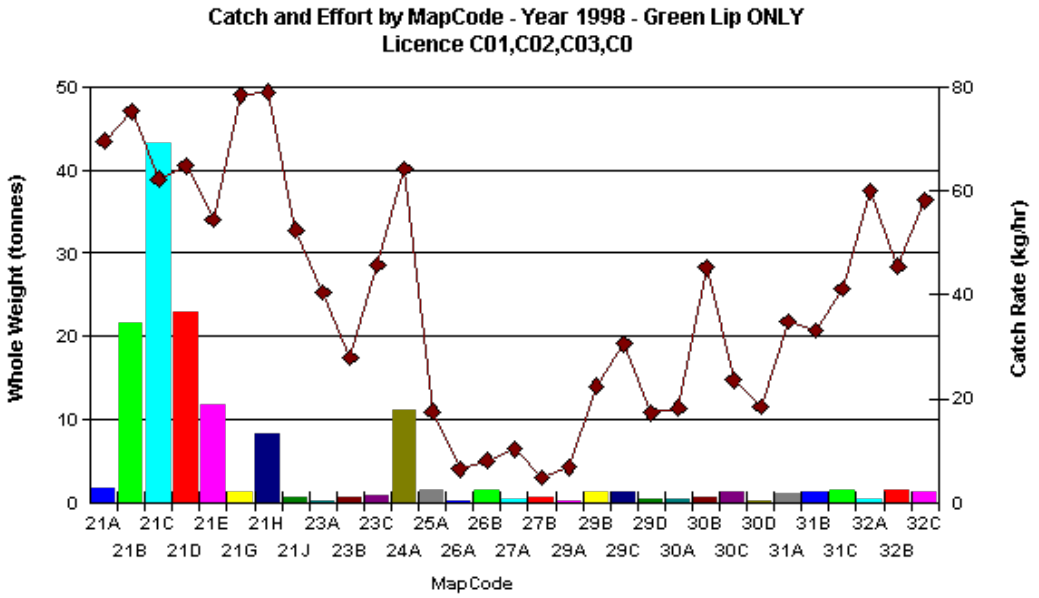


Figure 4.104: The 1998 greenlip abalone catch and effort by mapcode within the Central Zone fishery.

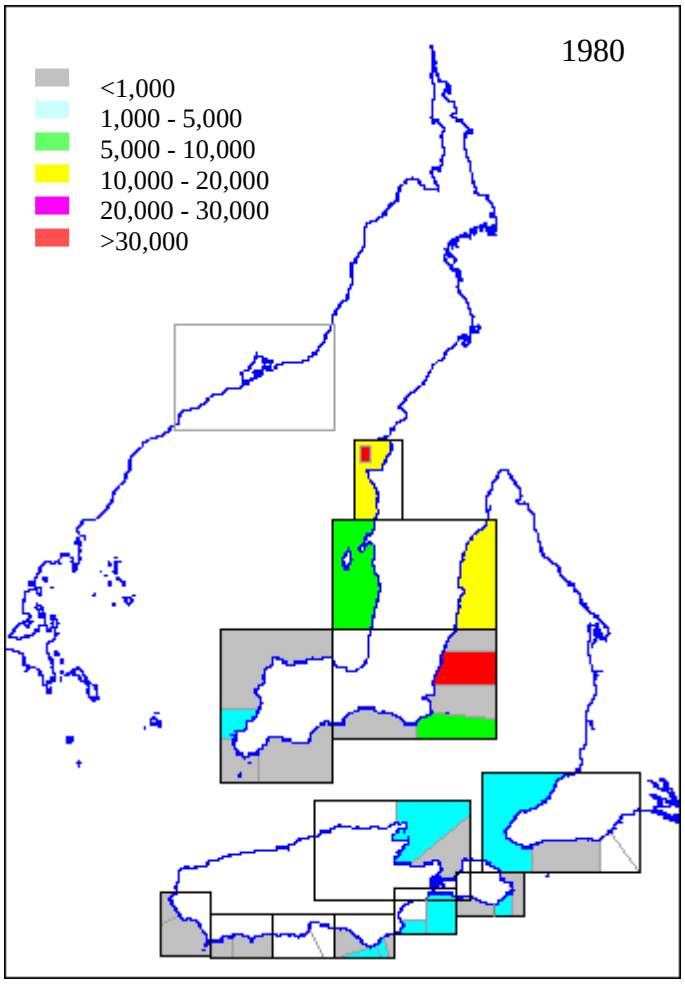


Figure 4.105: The distribution of the total greenlip abalone catch (kg) by mapcode in the Central Zone - 1980.

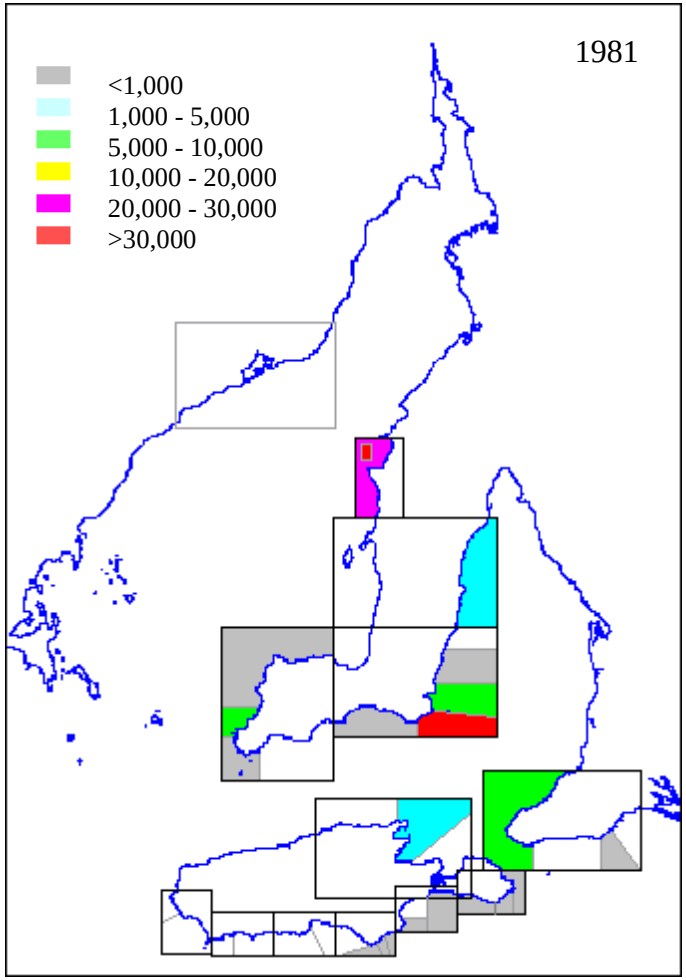


Figure 4.106: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1981

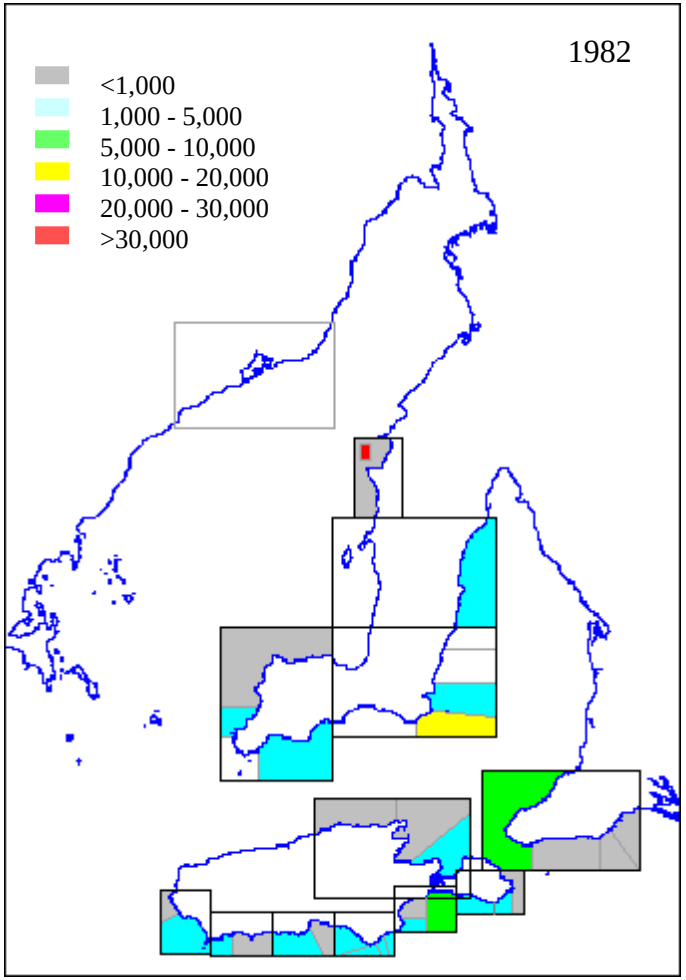


Figure 4.107: The distribution of total greenlip abalone catch (kg) by mapcode in the central Zone - 1982**.**

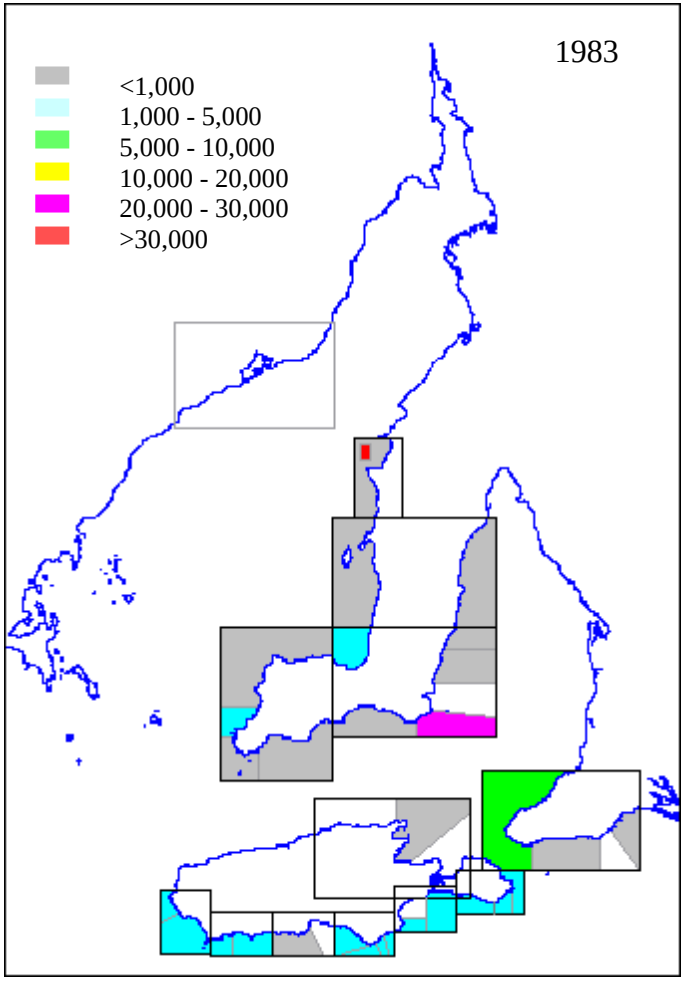


Figure 4.108: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1983.

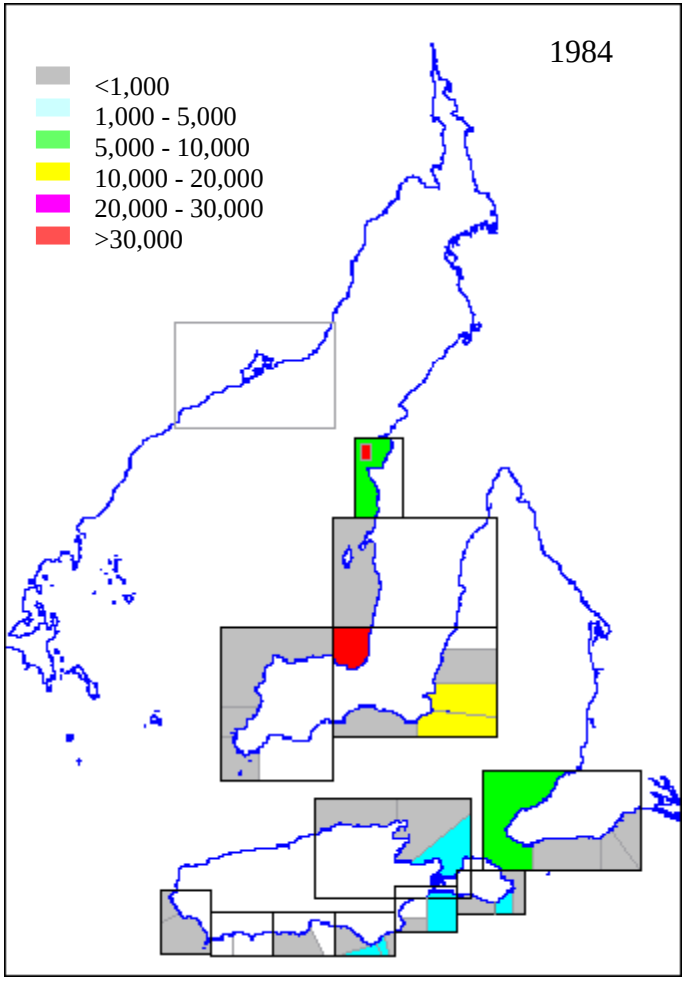


Figure 4.109: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1984.

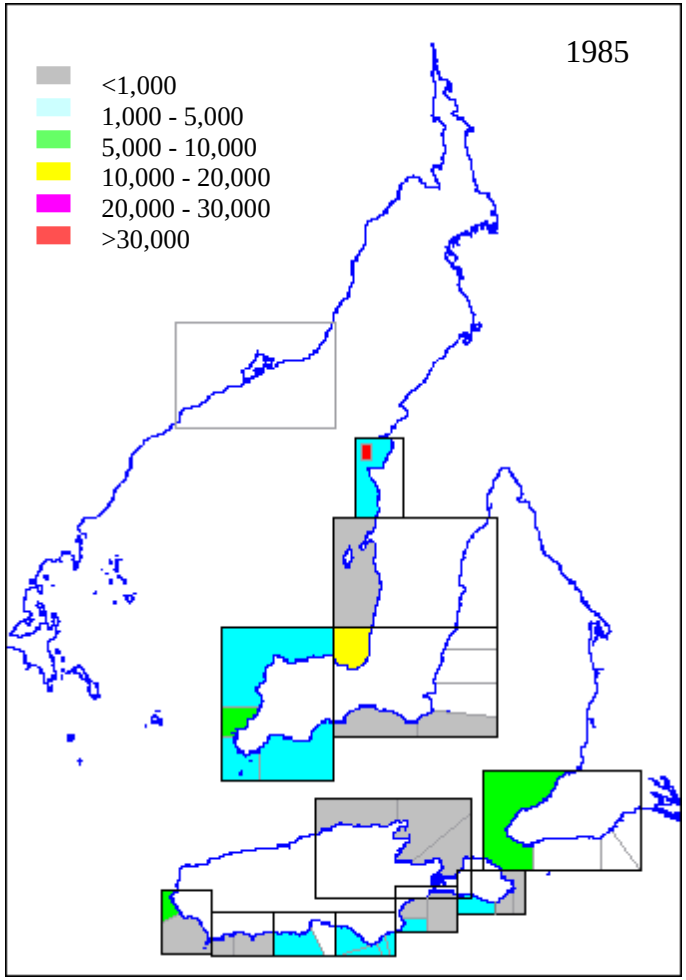


Figure 4.110: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1985.

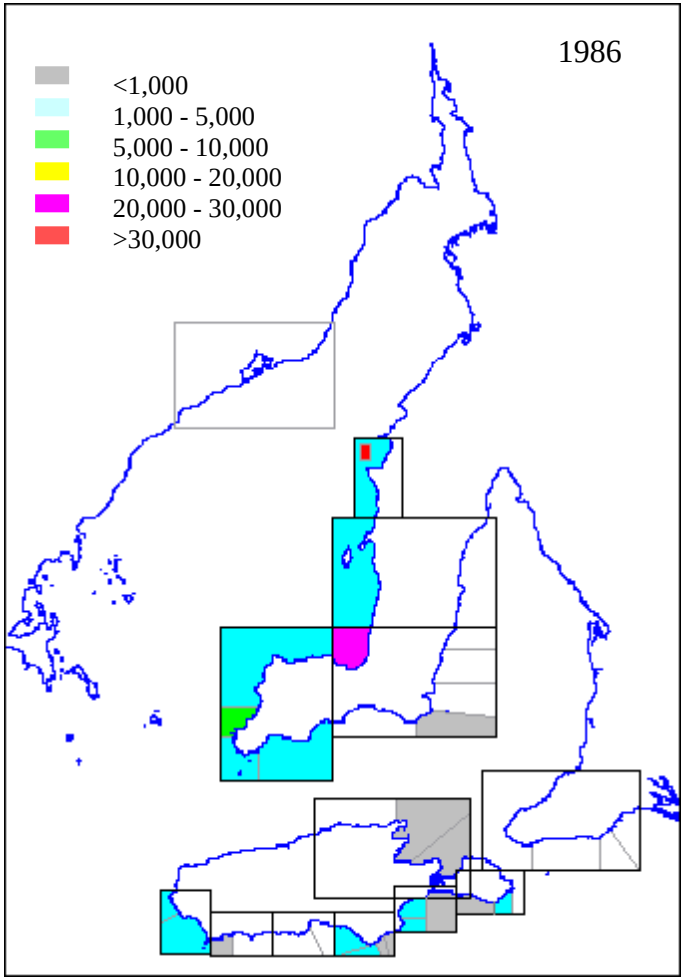


Figure 4.111: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1986.

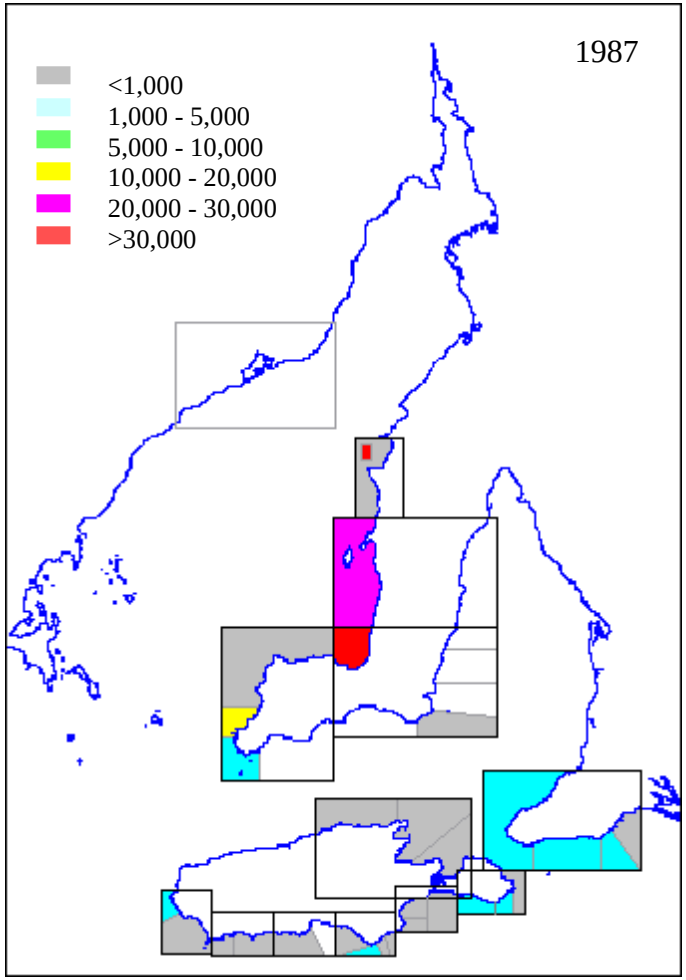


Figure 4.112: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1987

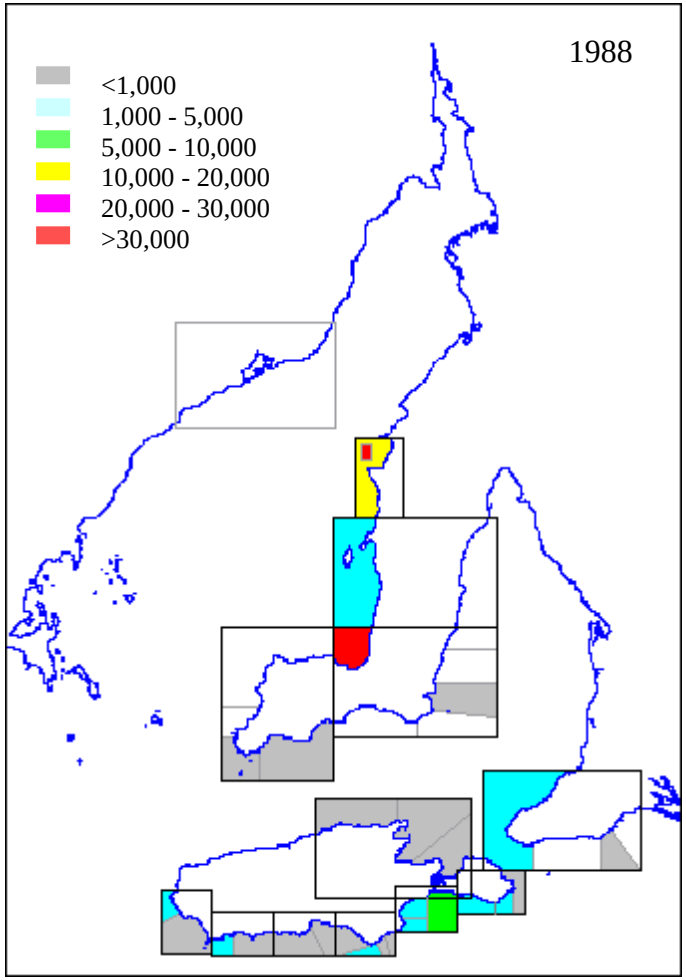


Figure 4.113: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1988

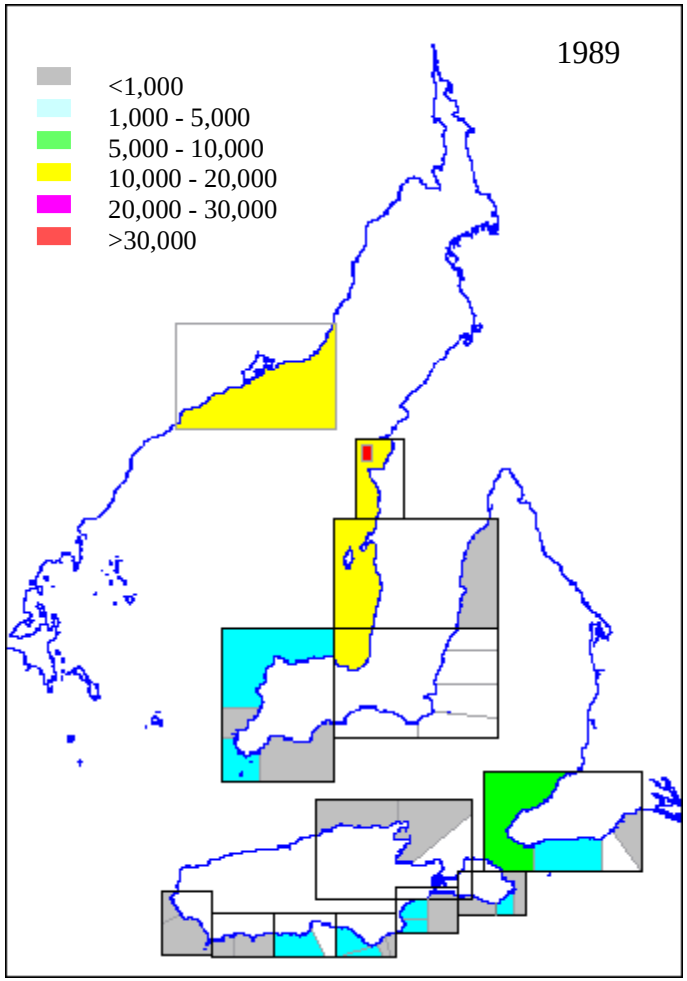


Figure 4.114: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1989

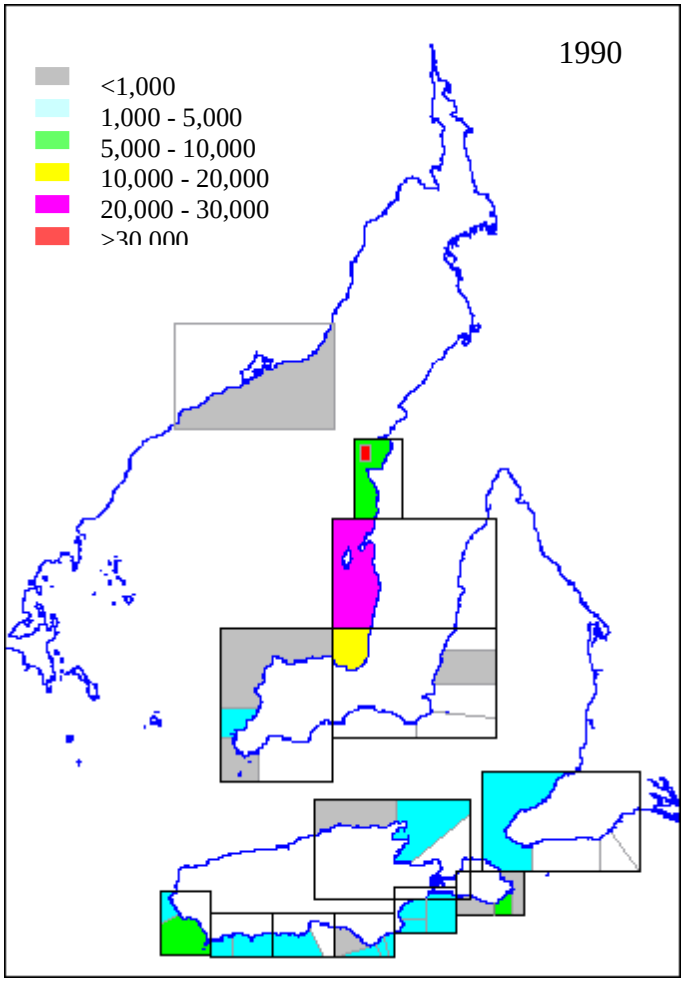


Figure 4.115: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1990.

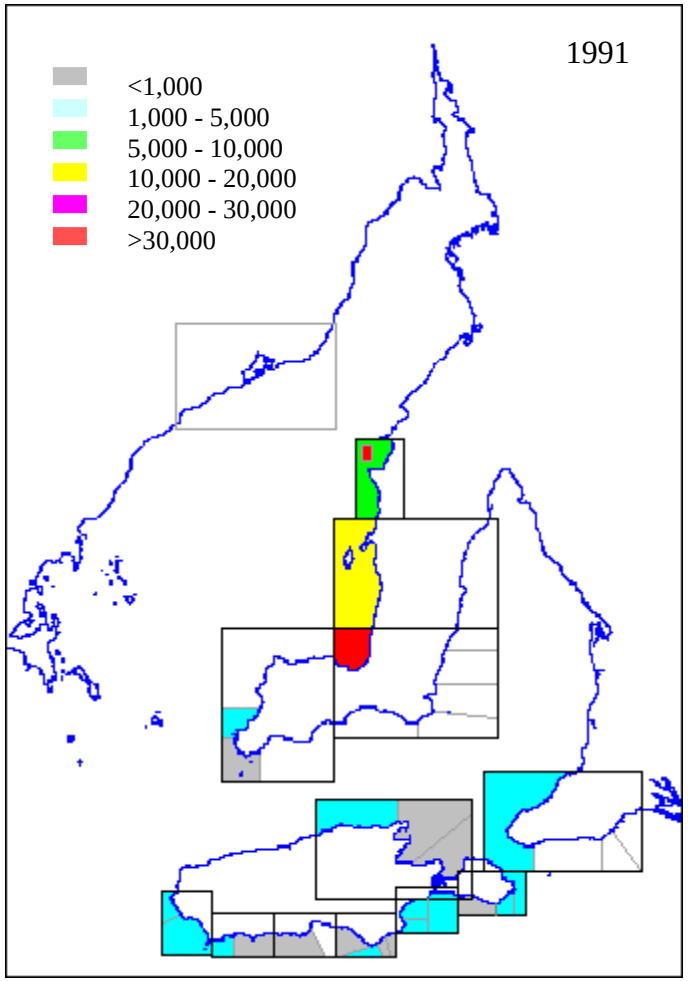


Figure 4.116: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1991.

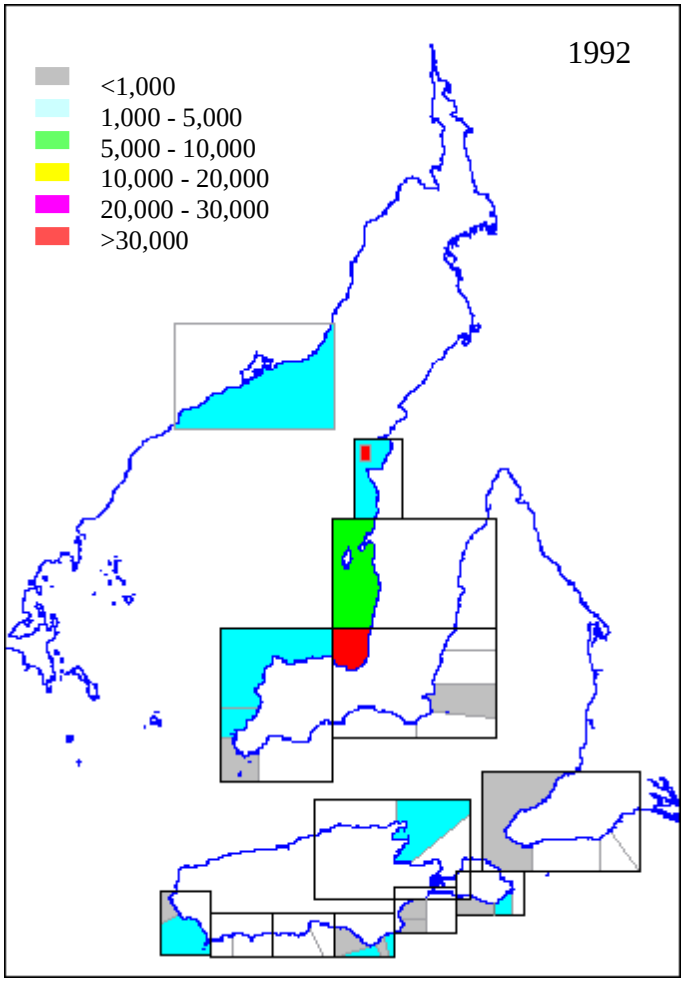


Figure 4.117:The distribution of the total greenlip abalone catch (kg) by mapcode in the Central Zone - 1992.

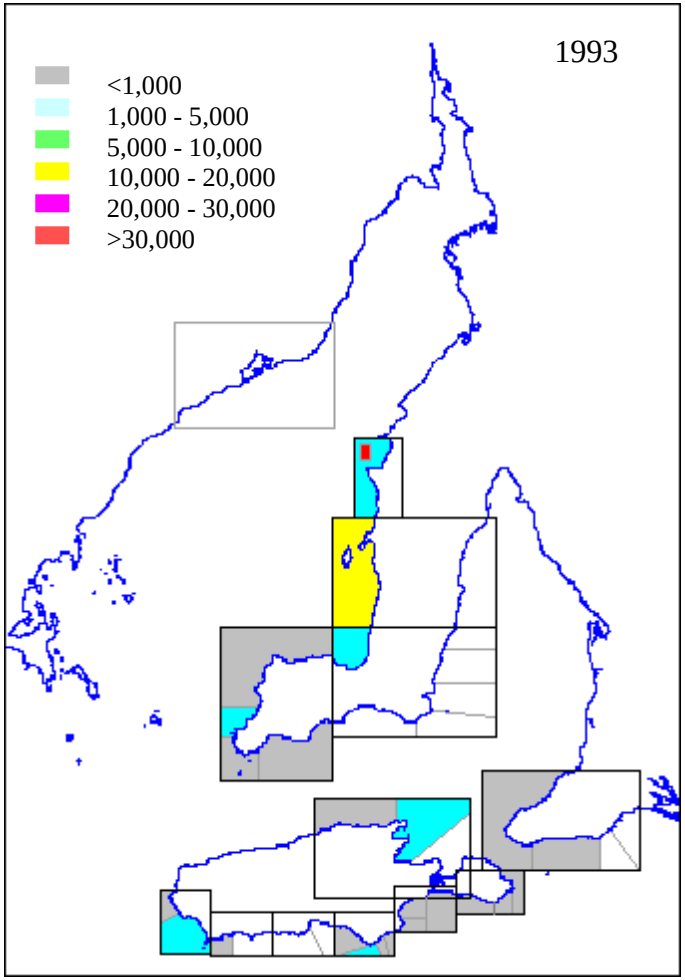


Figure 4.118: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1993

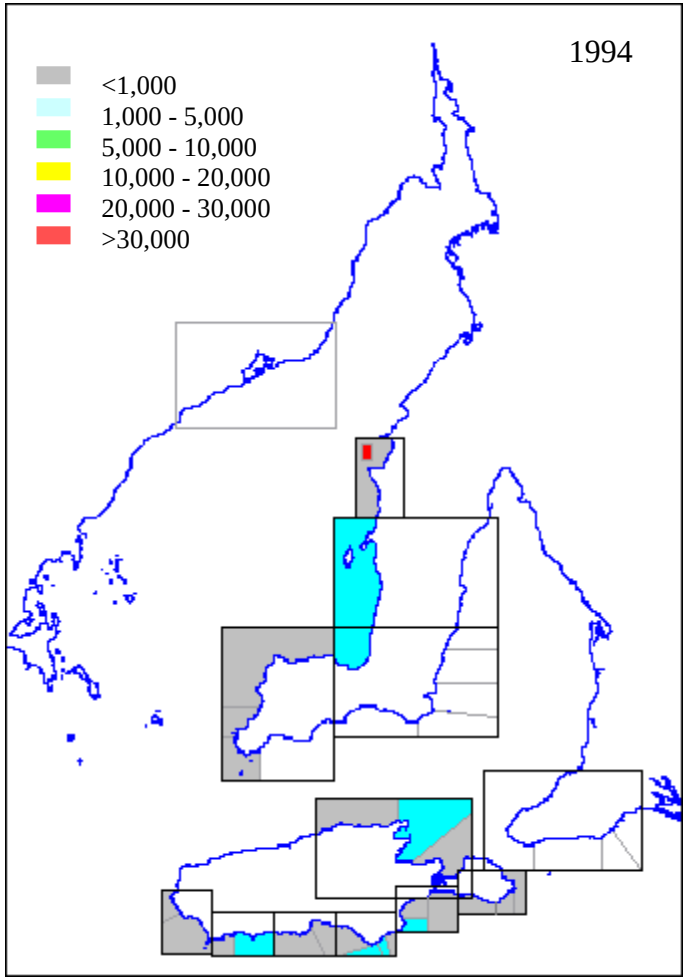


Figure 4.119: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1994.

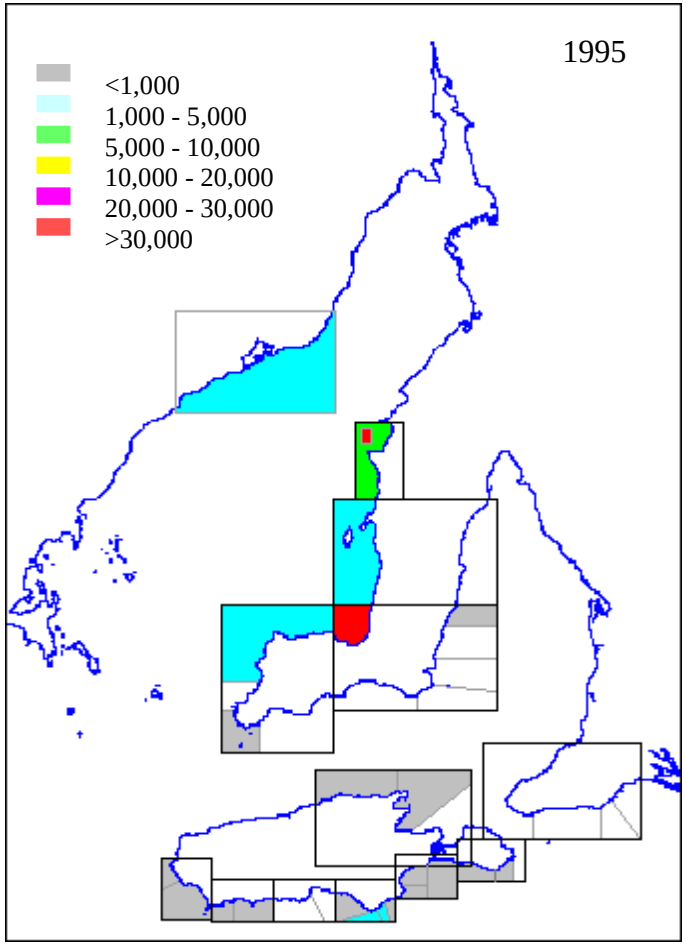


Figure 4.120: The distribution of total greenlip abalone catch (kg) by mapcode in the central Zone - 1995

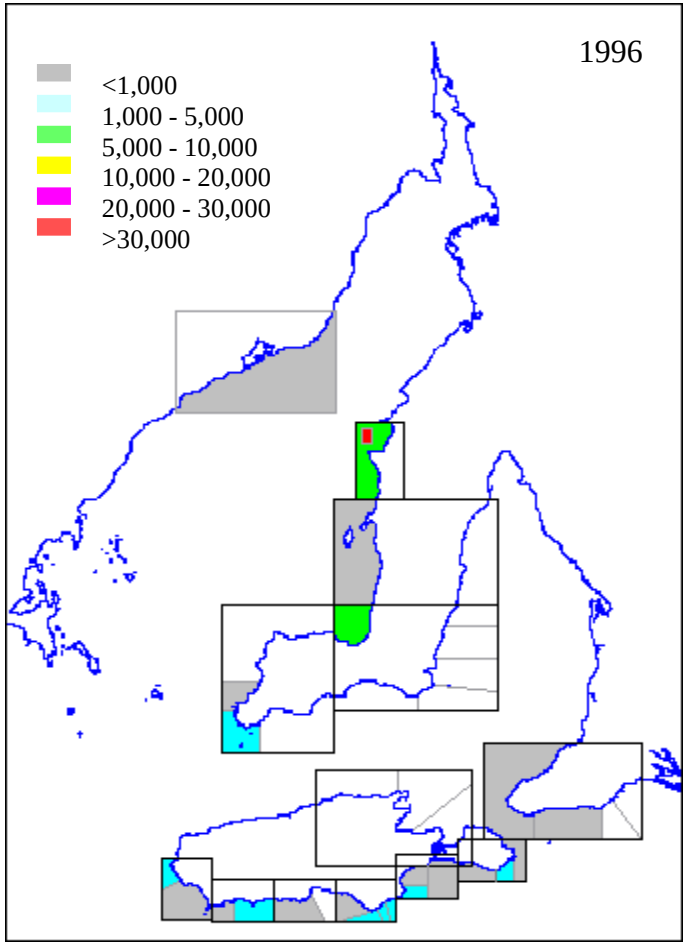


Figure 4.121: The distribution of total greenlip abalone catch (kg) by mapcode in the central Zone - 1996

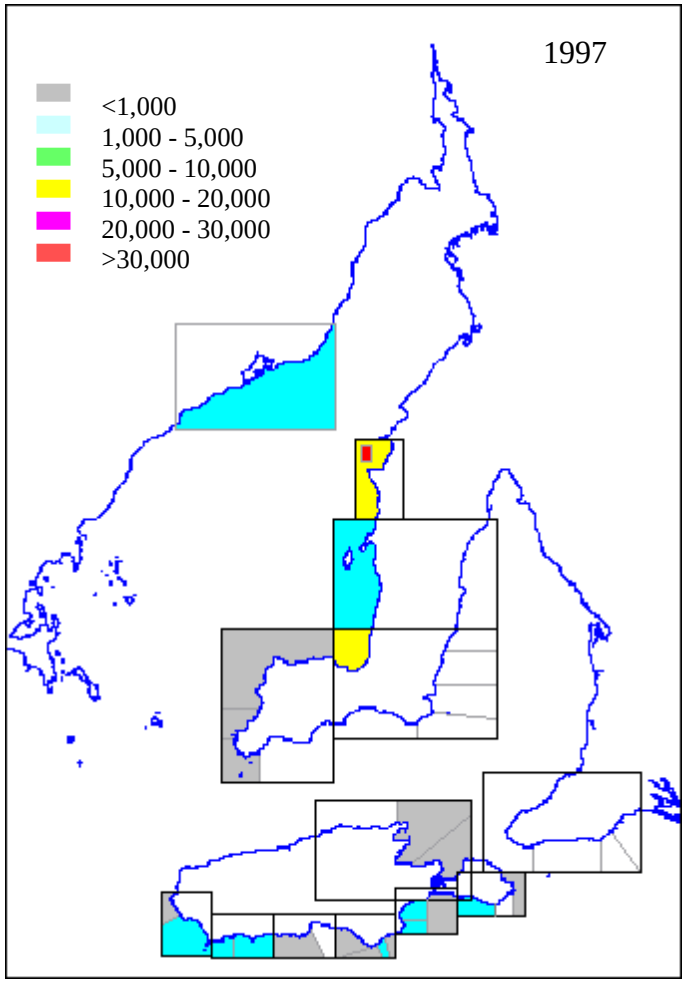


Figure 4.122: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1997

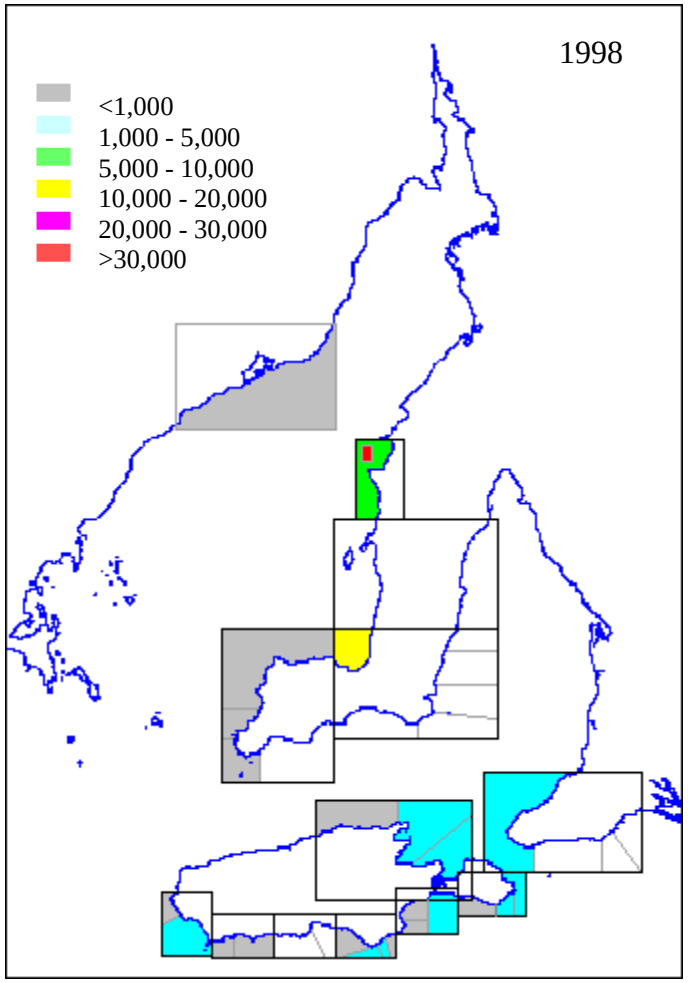


Figure 4.123: The distribution of total greenlip abalone catch (kg) by mapcode in the Central Zone - 1998

4.3.2 Assessment of Spatial trends in blacklip abalone catches since 1980

Figures 4.125 to 4.142 provide an overview of the broad patterns of blacklip abalone catch distribution between 1980 and 1998.

The Central Zone blacklip catch is about 40 tonnes per annum at present. Over the past five years 32 to 39 tonnes of this has come from southern Kangaroo Island. The largest part of the catch comes from the Cape Bedout (26B) to Cape Bouger (27B) on the south-western part of the island. The area immediately south of Cape Bedout (26B) has produced more than 7 tonnes for 9 of the last 10 years. Consistent catches also come from the Cape Gantheaume area (map 29).

During 1987 to 1989 the total Central Zone blacklip catches were in excess of 50 tonnes. These came from the same areas as those reported more recently indicating fairly stable catching patterns for blacklip in the Central Zone.

Figure 4. 124 shows the typical pattern of blacklip catch distribution from the Central Zone.

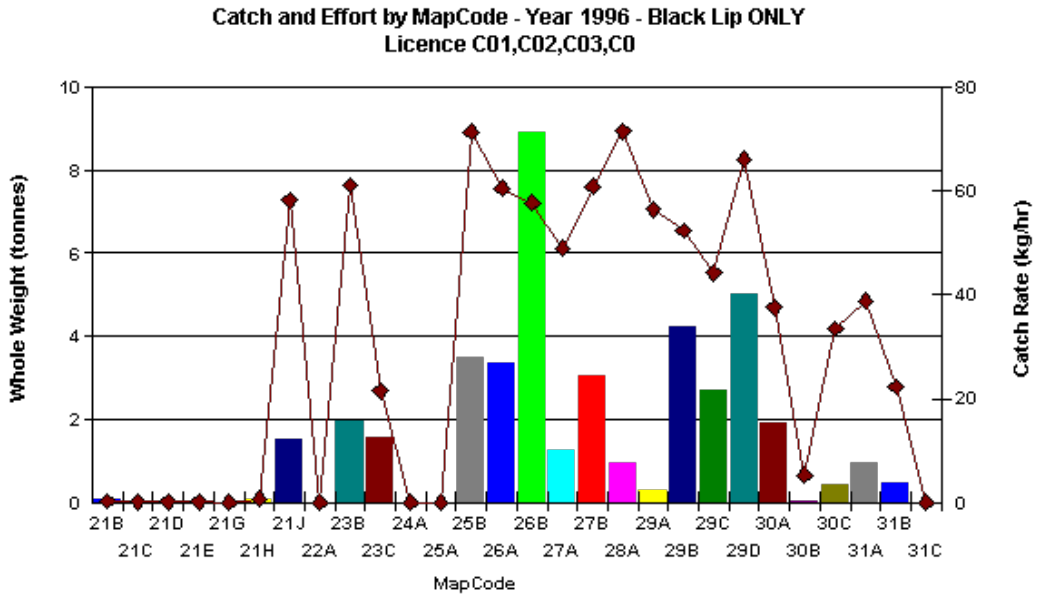


Figure 4.124: The 1996 blacklip abalone catch and effort by mapcode within the Central Zone fishery.

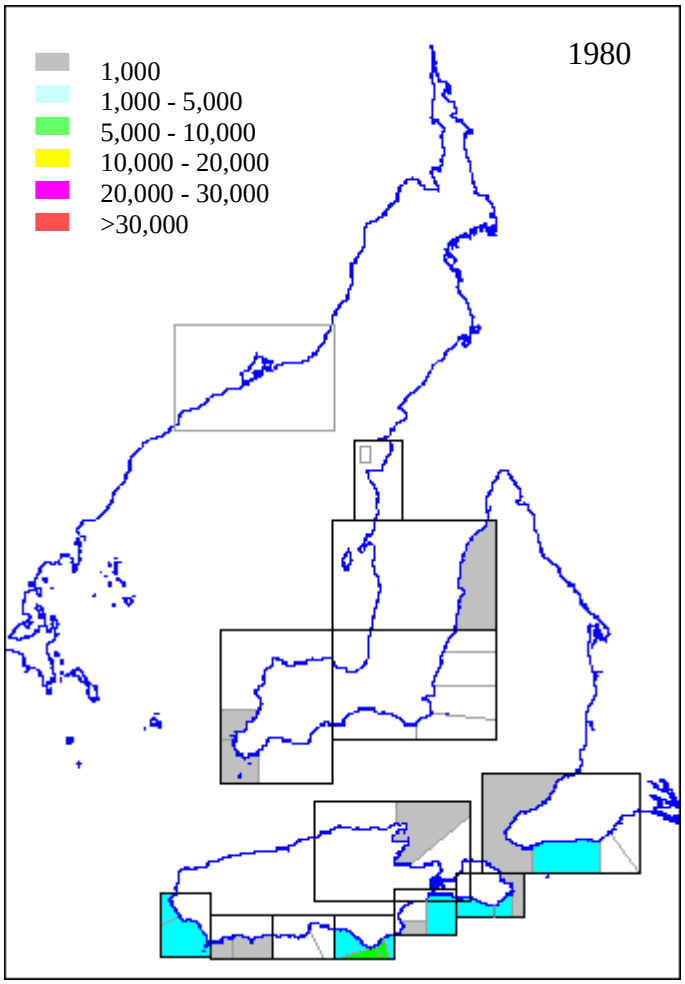


Figure 4.125: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1980

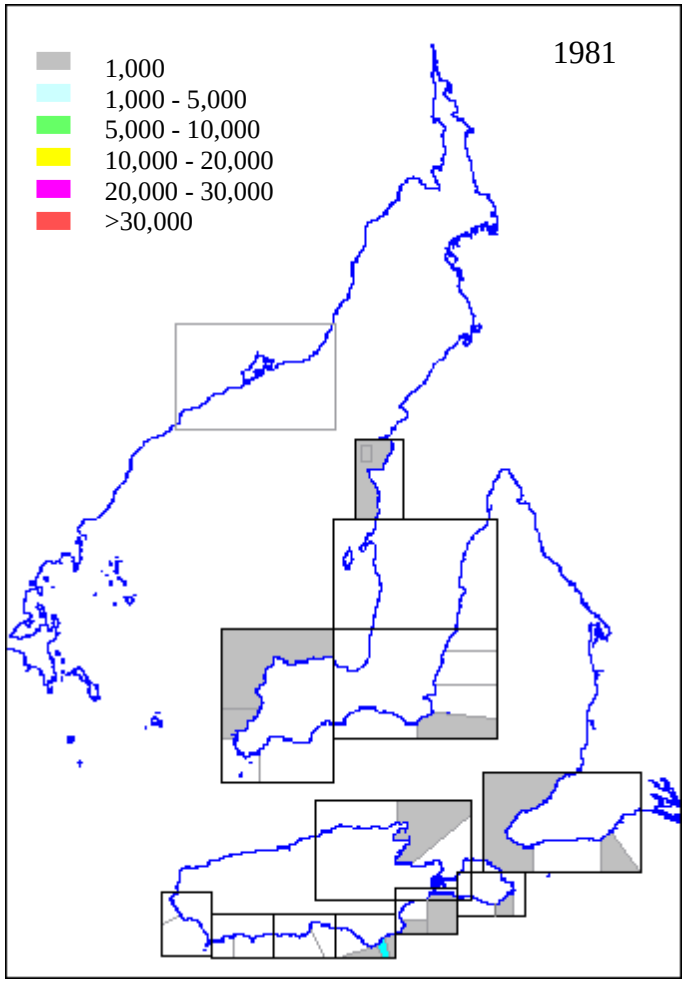


Figure 4.126: The distribution of total blacklip abalone catch (kg) by mapcode in the central Zone - 1981

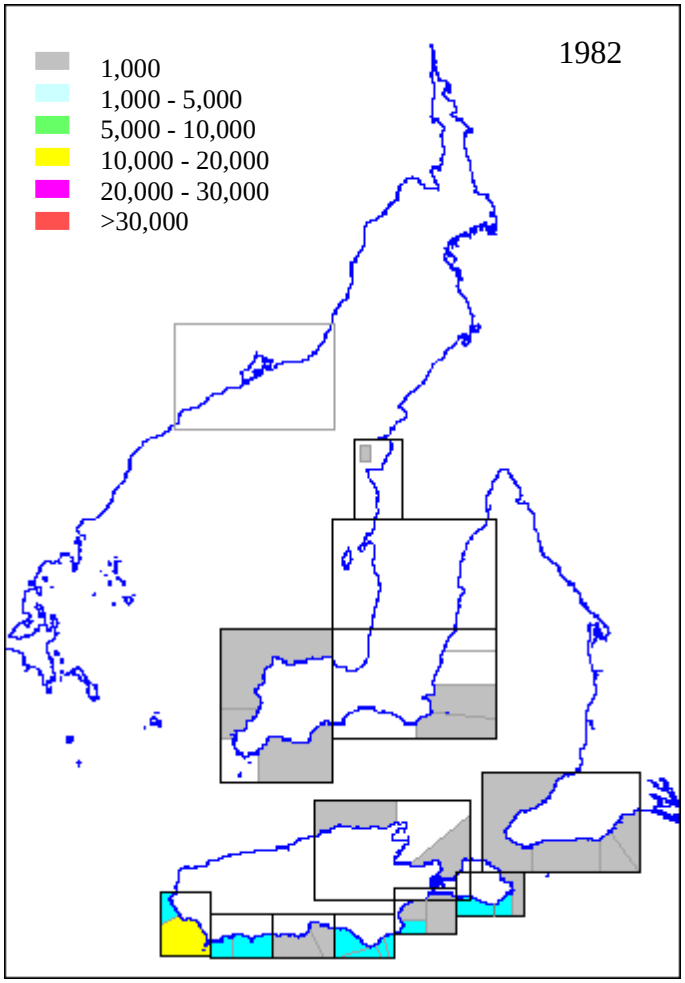


Figure 4.127: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1982

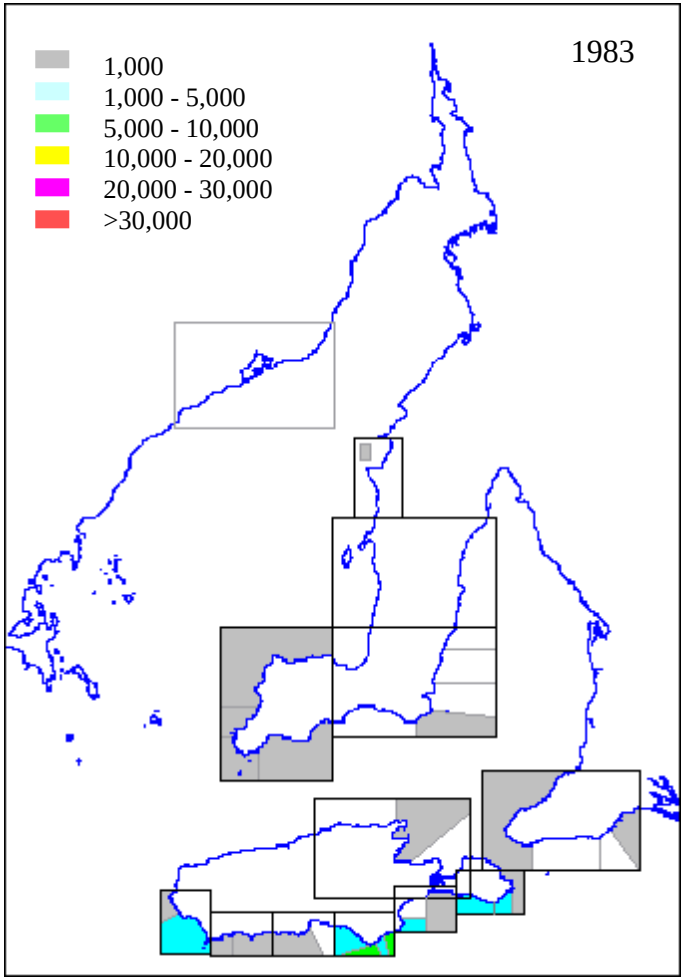


Figure 4.128: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1983

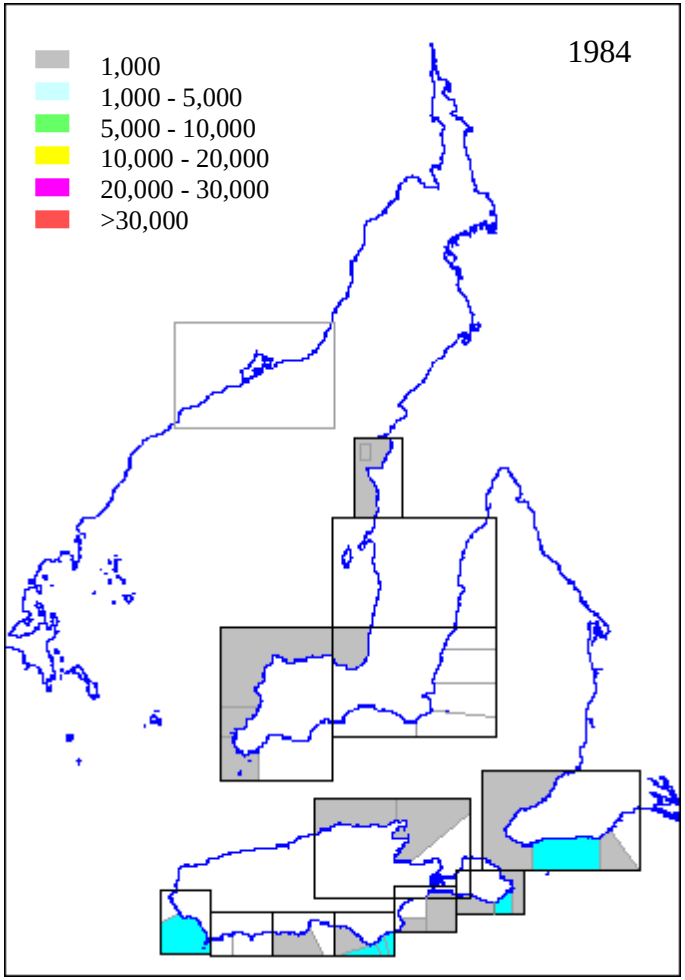


Figure 4.129: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1984

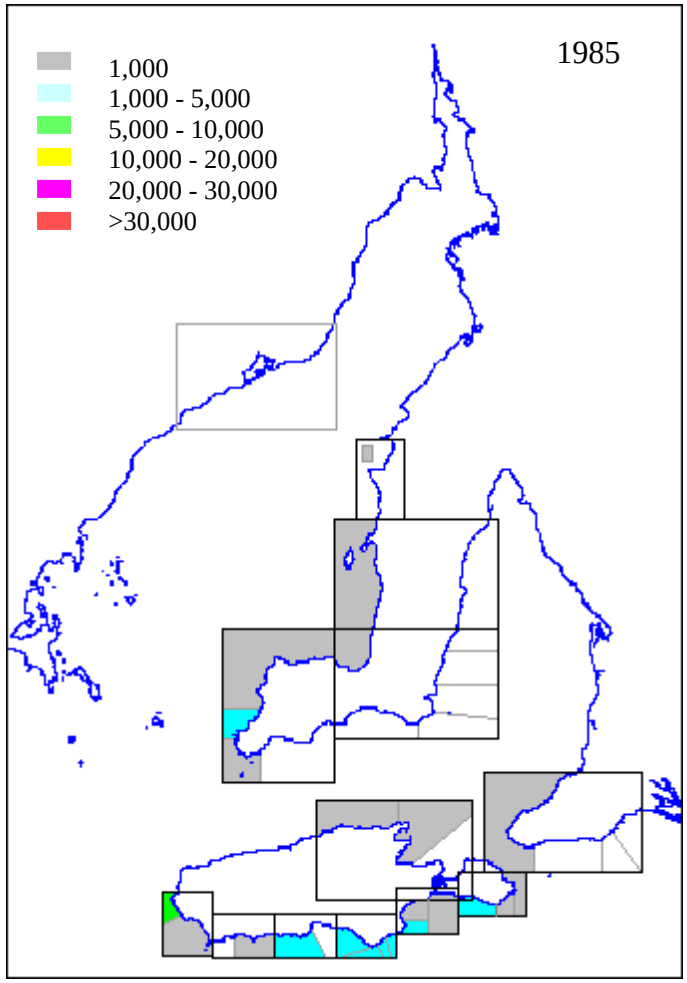


Figure 4.130: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1985

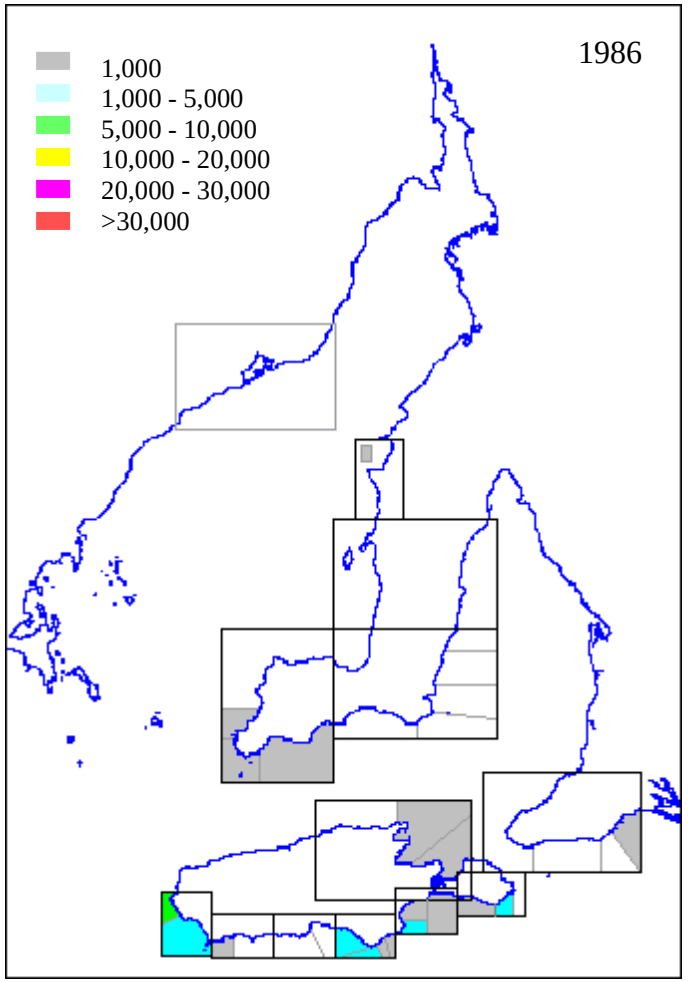


Figure 4.131: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1986

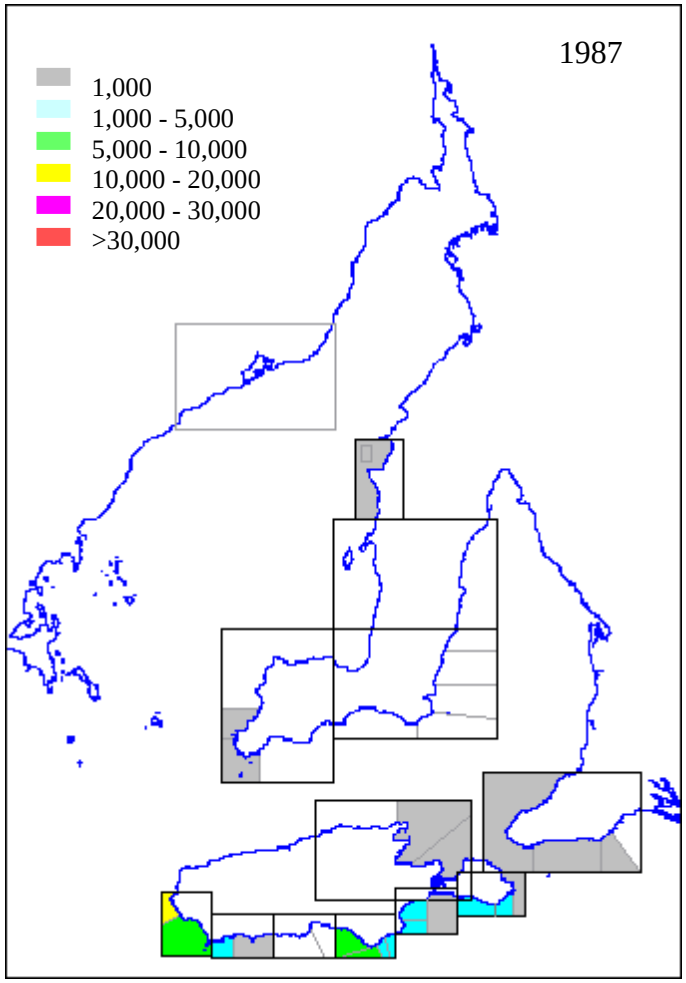


Figure 4.132: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1987

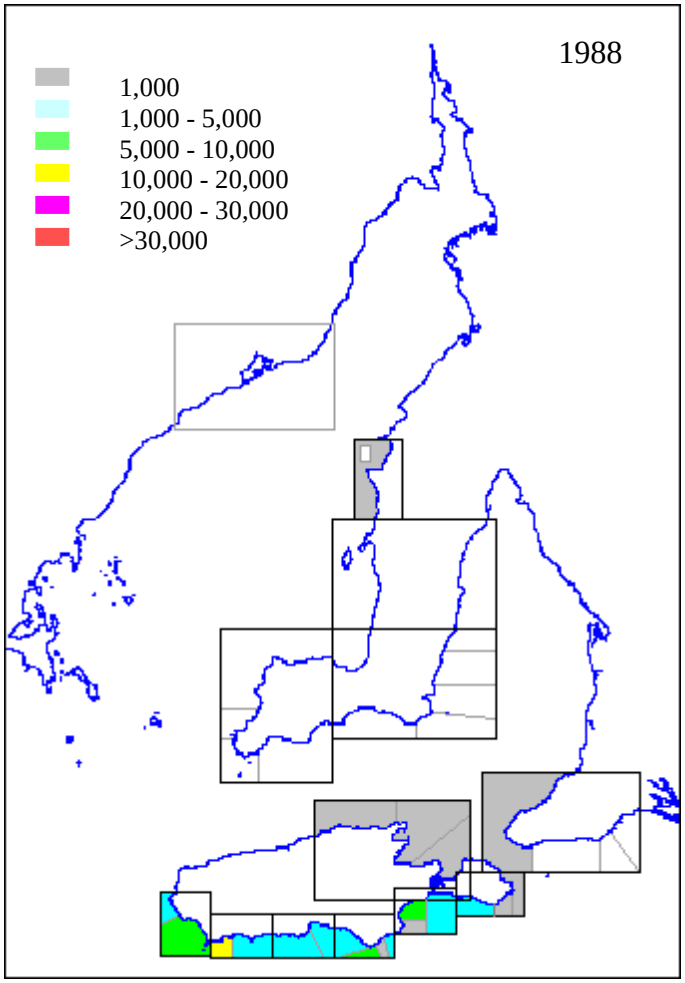


Figure 4.133: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1988

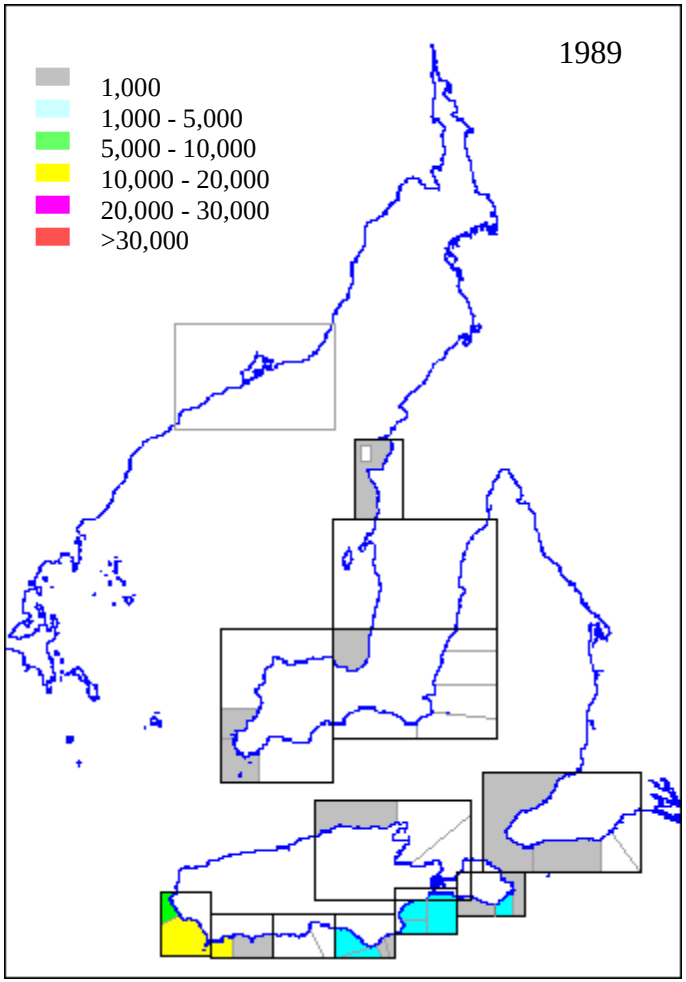


Figure 4.134: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1989

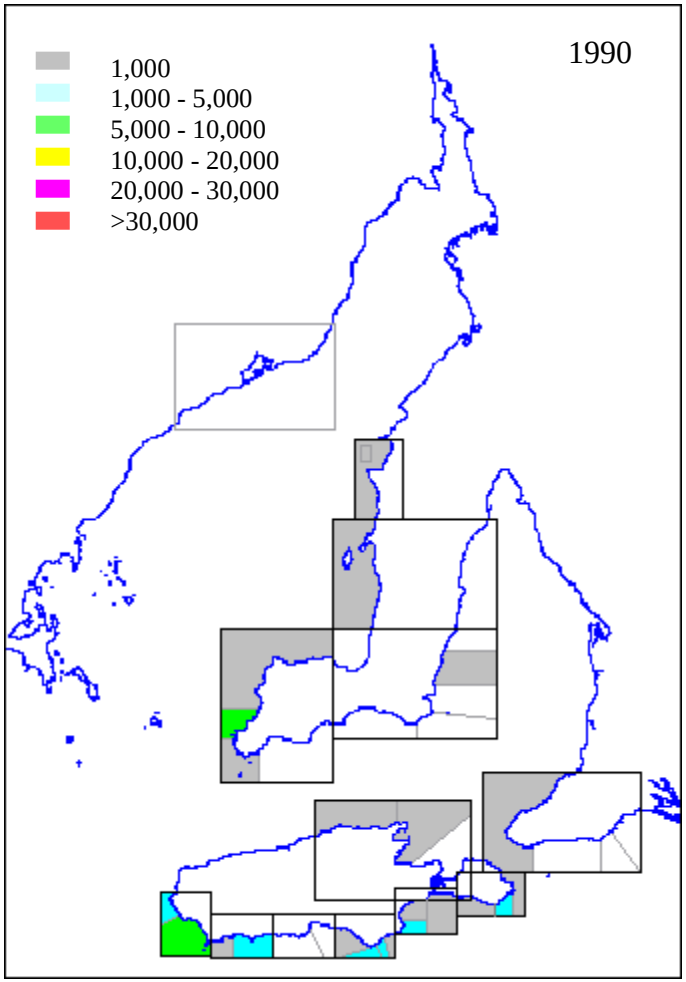


Figure 4.135: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1990

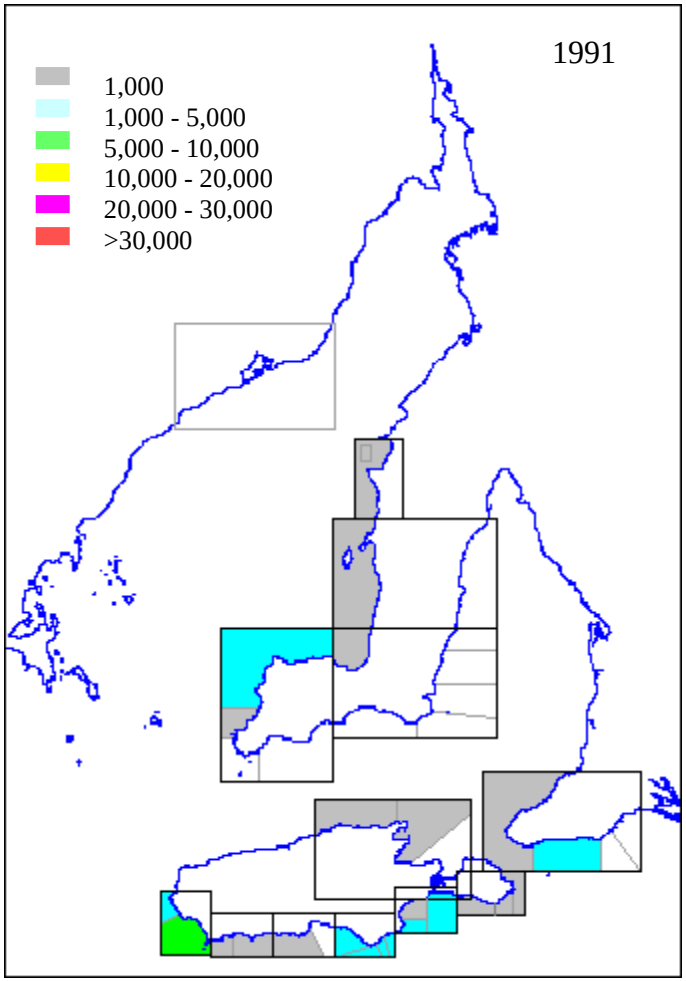


Figure 4.136: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1991

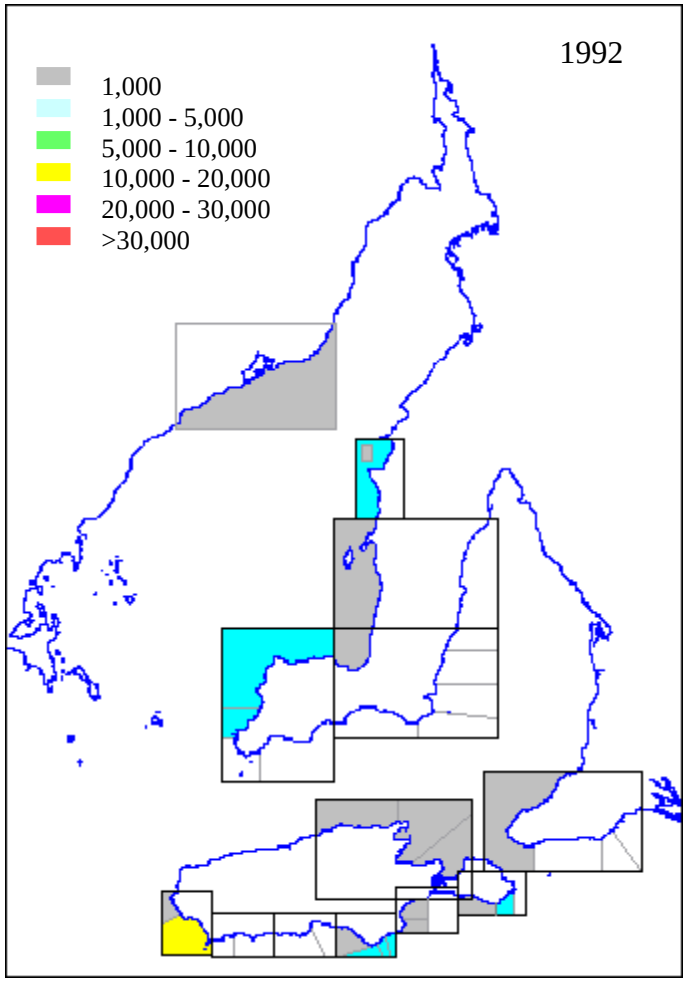


Figure 4.137: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1992

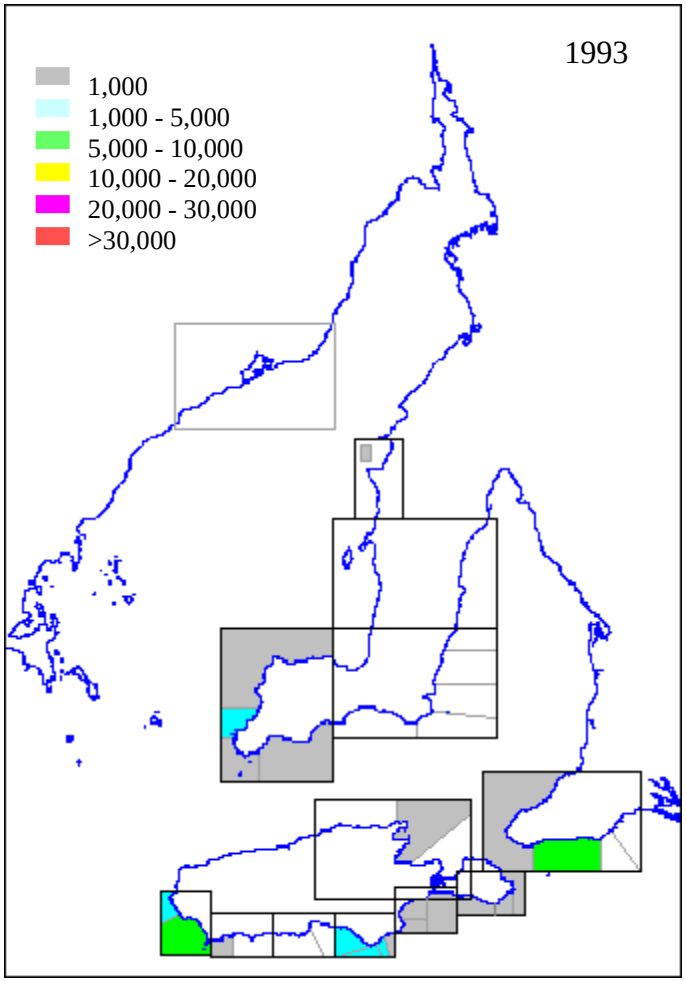


Figure 4.138: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1993

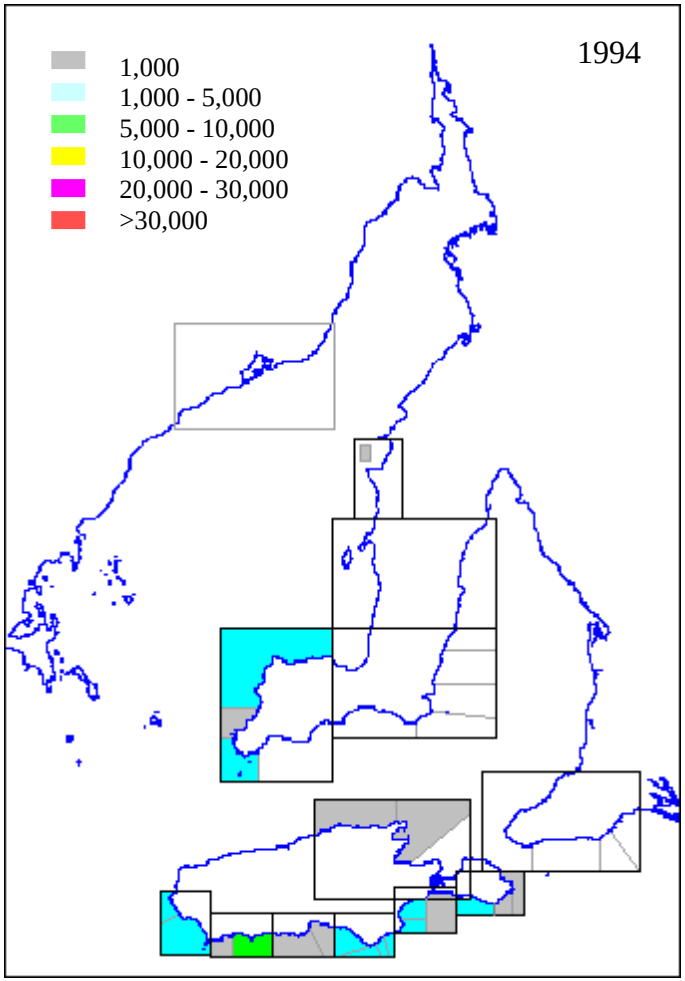


Figure 4.139: The distribution of total abalone catch (kg) by mapcode in the Central Zone - 1994

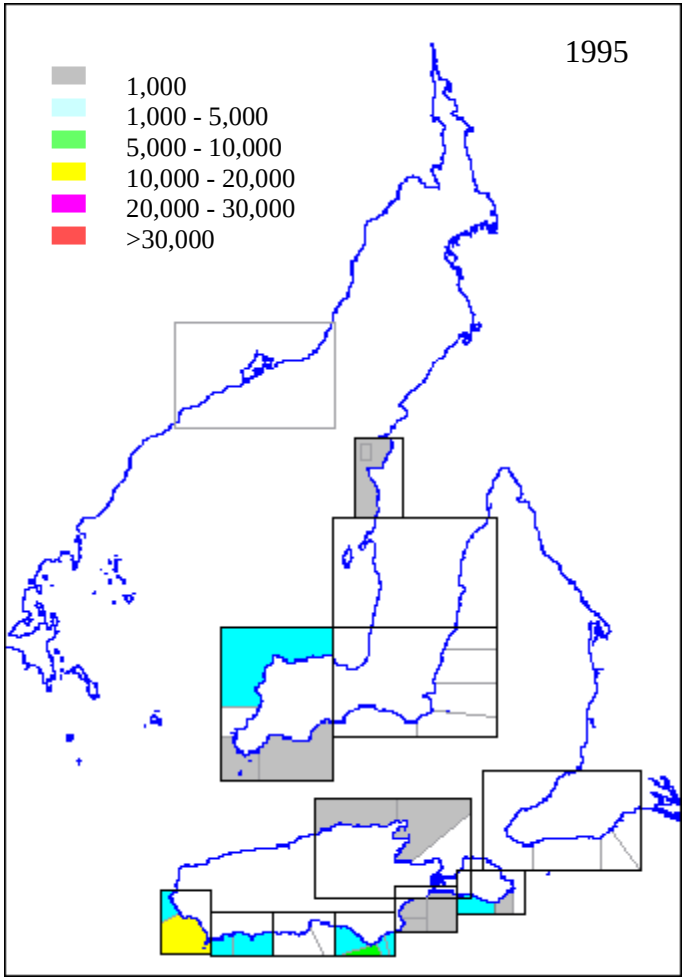


Figure 4.140: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1995

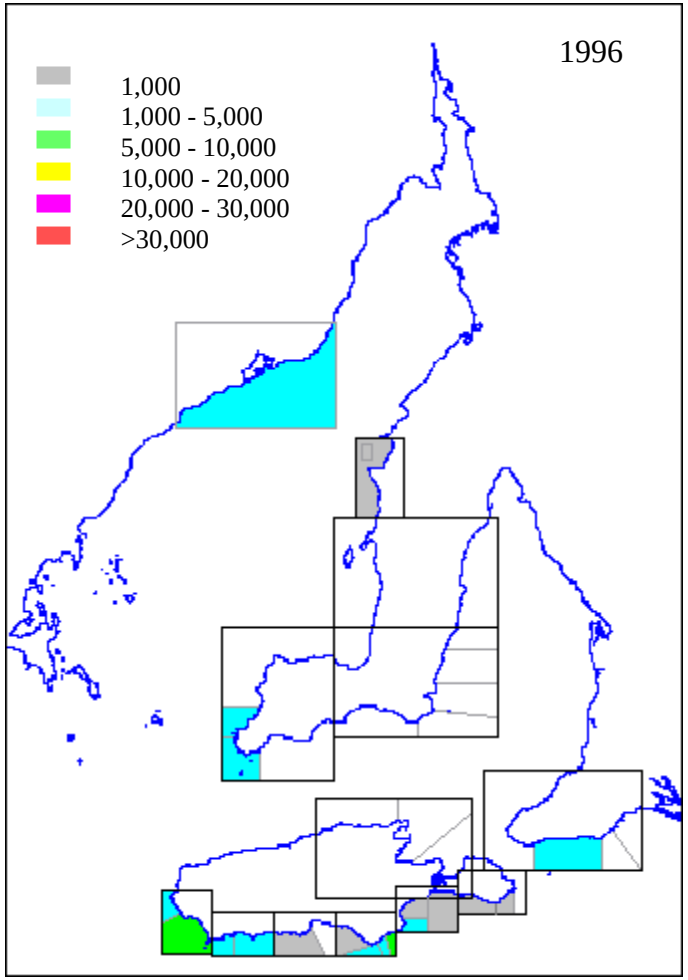


Figure 4.141: The distribution of total blacklip abalone catch (kg) by mapcode in the central Zone - 1996

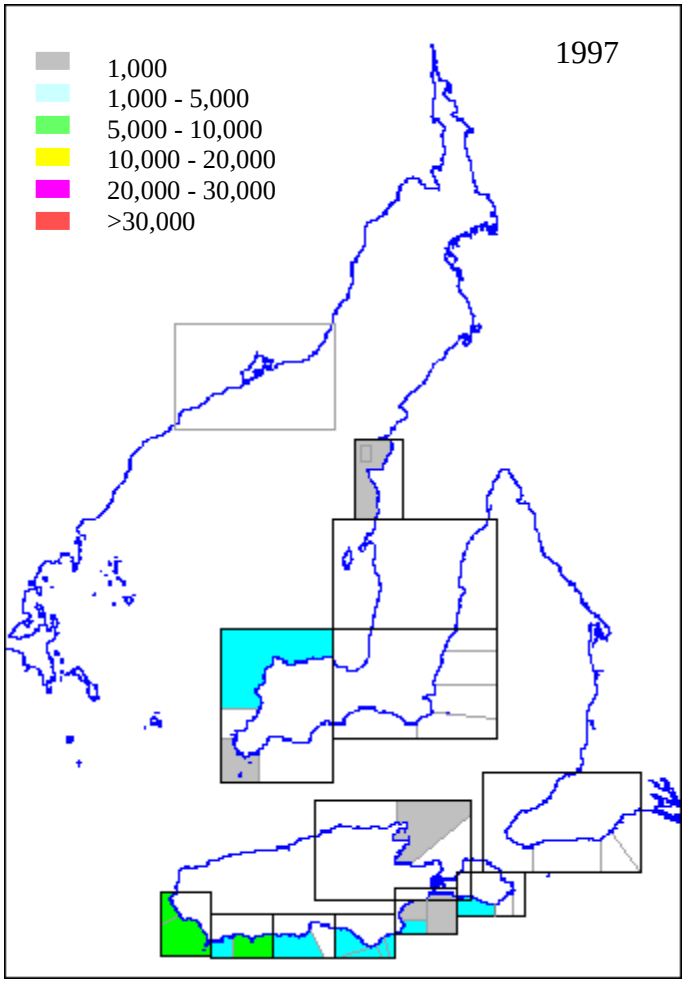


Figure 4.142: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1997

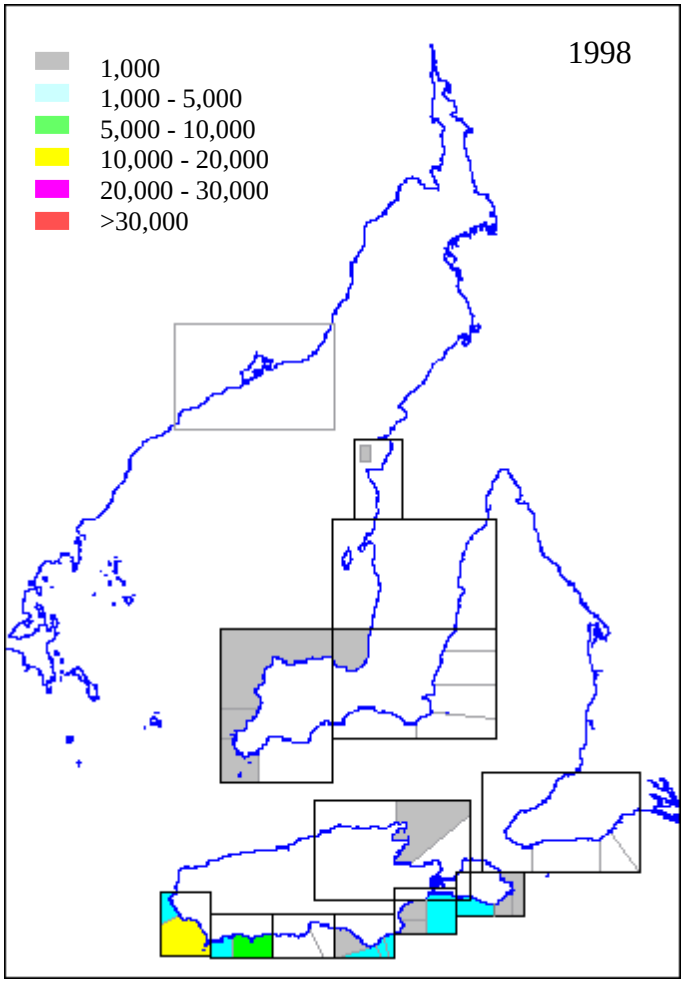


Figure 4.143: The distribution of total blacklip abalone catch (kg) by mapcode in the Central Zone - 1998

4.3.3 Temporal changes in greenlip abalone catches, 1990 - 1998 (Table 4.3, figures 4.144 to 4.155)

Analyses for 12 greenlip abalone metapopulation areas with total catches averaging 130 tonnes over each of 9 years showed a significant decrease in catches in 1 or 8.3 % of metapopulations and a significant increase in 1 (8.3 %).

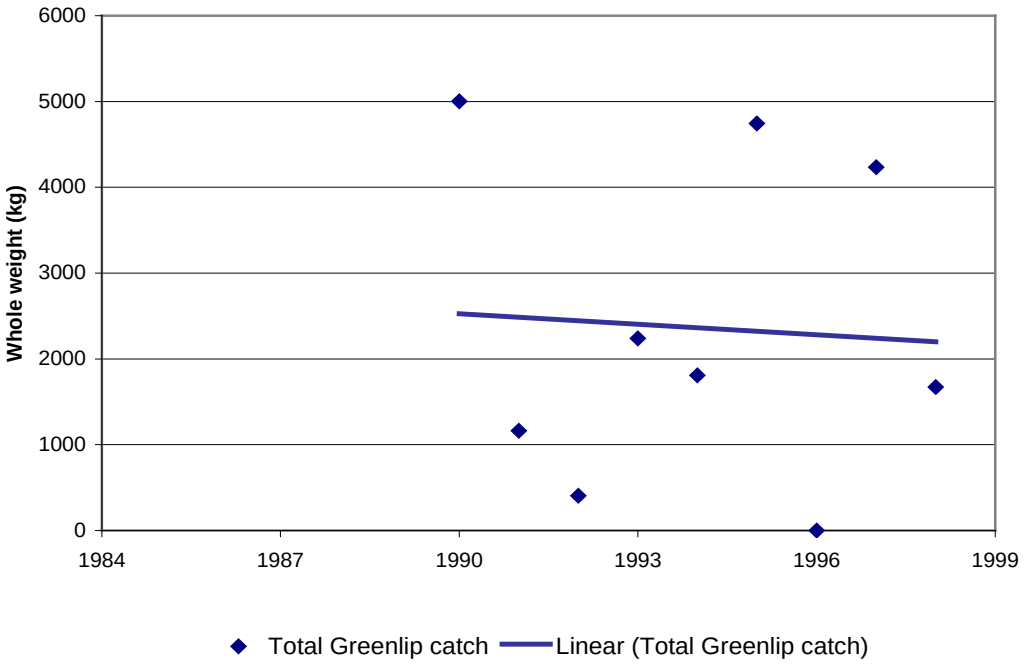
The area with a significant increase in catch was the Main Tiparra Reef (3198 kg per year) with the Total Tiparra Reef area also increasing in catch significantly (6939 kg per year). These increases represent 17.4 % and 8.4 % increases respectively of the mean catches in these areas.

The area with a significant decline in catch was Western Yorke Peninsula (4225 kg per year) which represents a 16.3 % decline from the mean catch.

Greenlip -Central Zone							
Slope is average change in annual catch in kg over 8 years							
Probability is chance that there has been no significant change (up or down) in catch over 8 years							
A probability of less than 0.05 means that there is 95% certainty that there is a significant trend either up or down in the catch							
			NON-CORRECTED DATA				
REGION	**SLOPE**	**MEAN CATCH**	**PERCENT OF MEAN**	**PROBABILITY**	**SIGNIFICANT CHANGE**		
TIPARRA REEF - NORTH BOTTOM	-41	2363	-1.74	0.8791			
TIPARRA REEF - OUTER MAIN REEF	875	19489	4.49	0.3675			
TIPARRA REEF - OUTSIDE BOTTOM	1887	25411	7.43	0.1271			
TIPARRA REEF - MAIN REEF	3198	18407	17.37	0.0186	increase		
TIPARRA REEF - MIDDLE BOTTOM	752	14195	5.11	0.5595			
TIPARRA REEF - TOTAL	6939	82421	8.42	0.038	increase		
CAPE ELIZABETH	994	6973	14.25	0.1728			
SOUTH EASTERN YORKE PENINSULA	30	758	3.96	0.7332			
WESTERN YORKE PENINSULA	-4225	25897	-16.31	0.0406	decrease		
CAPE JERVIS - ENCOUNTER BAY	-53	480	-11.04	0.5238			
SOUTH WEST KANGAROO ISLAND	-898	5429	-16.54	0.2234			
SOUTH EASTERN KANGAROO ISLAND	-1230	9890	-12.44	0.1381			
NORTH EAST KANGAROO ISLAND	-243	2061	-11.79	0.1672			
TOTALS	7958	213774	3.72				

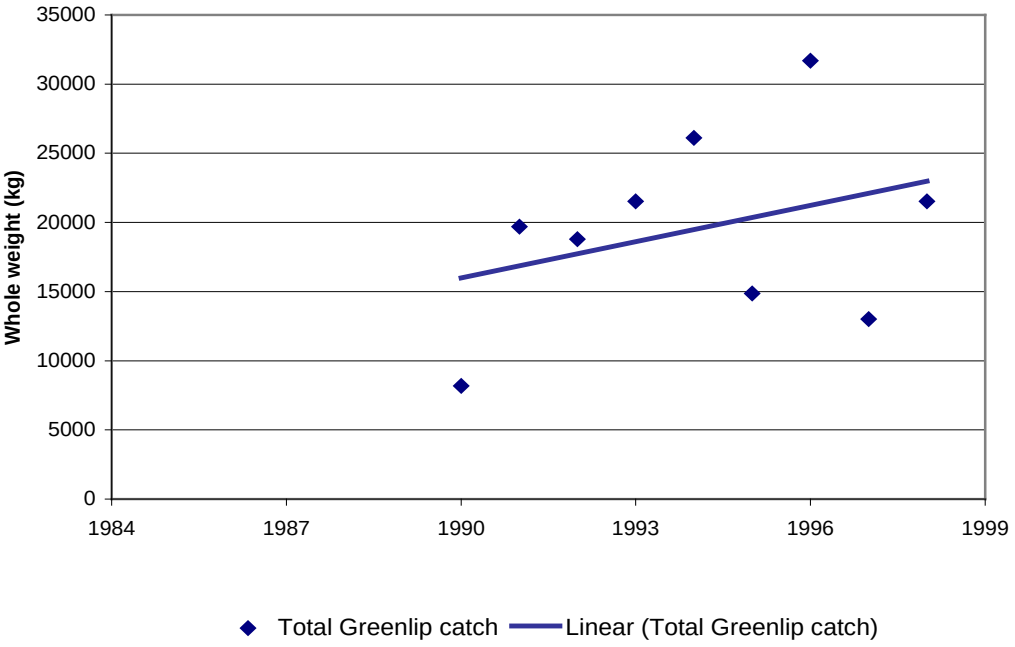
Table 4.3 : Summary table showing significance and direction of change in greenlip abalone catches between 1990 and 1998 in the Central Zone.

Figure 4.144: Regression analysis of temporal change in greenlip abalone catches at Tiparra Reef - North bottom from 1990 - 1998



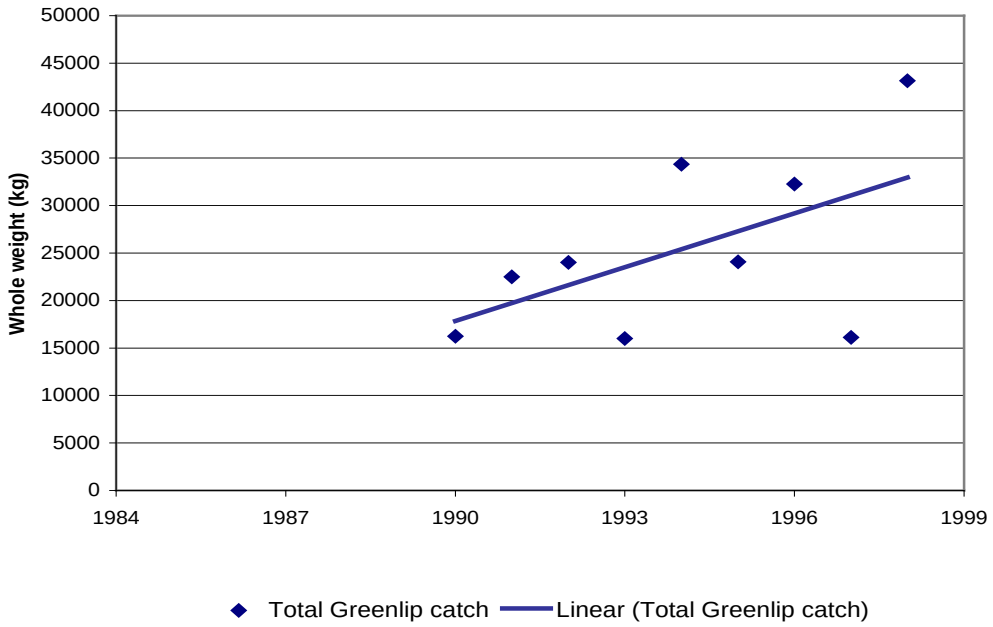
The slope of the regression for Tiparra Reef - North Bottom of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = -40.5; $r^2 = 0.003$; p = 0.879)

Figure 4.145: Regression analysis of temporal changes in greenlip abalone catch at Tiparra Reef - Outer Main Reef from 1990 to 1998



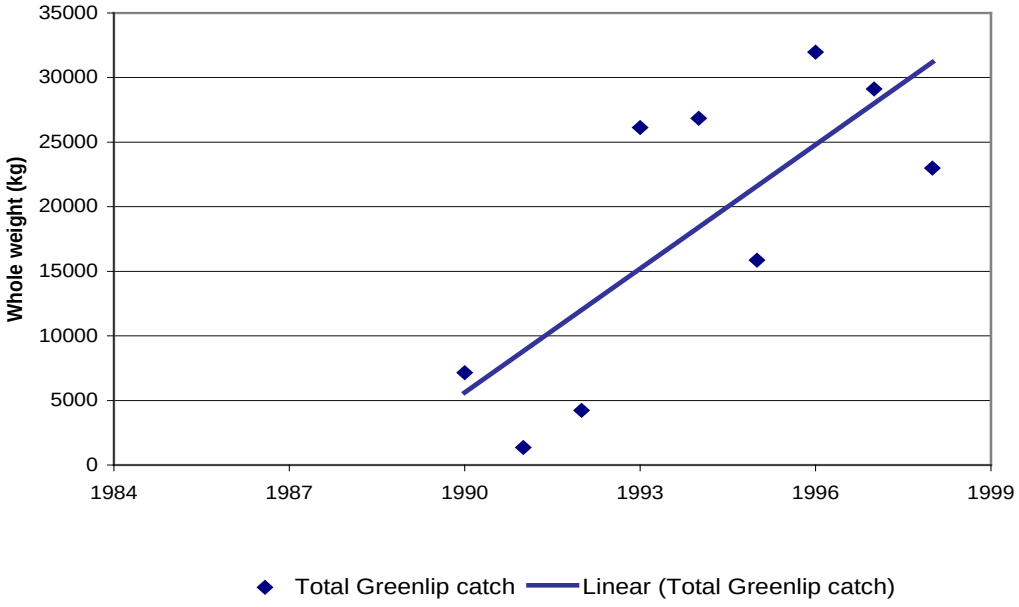
The slope of the regression for Tiparra Reef - Outer Main Reef of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = 875.2; r^2 = 0.117; p = 0.367)

Figure 4.146: Regression analysis of temporal changes in greenlip abalone catches at Tiparra Reef - Outside Bottom from 1990 - 1998



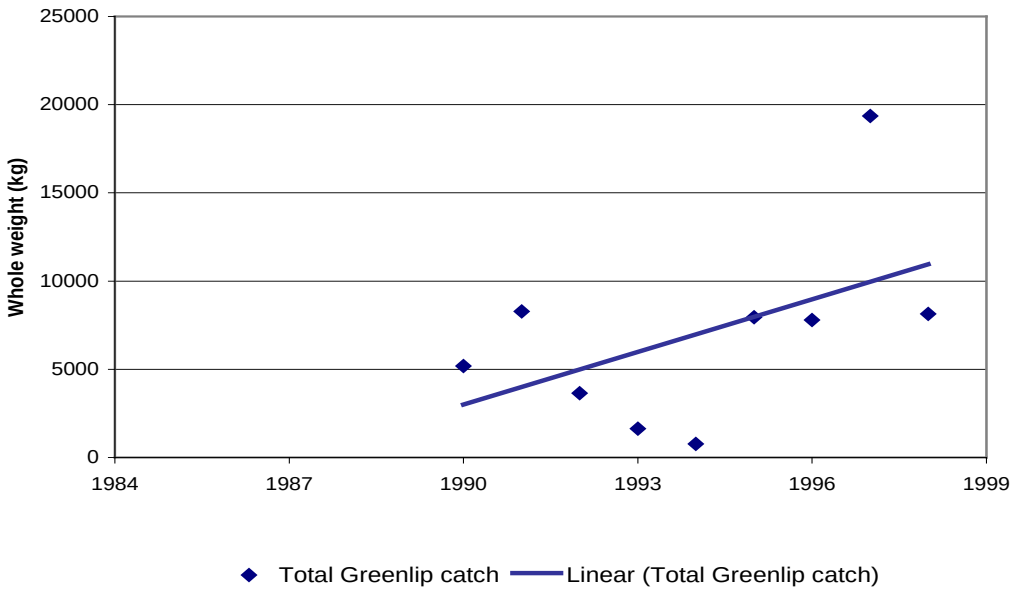
The slope of the regression for Tiparra Reef - Outer Bottom of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = 1887.3; r^2 = 0.299; p = 0.127)

Figure 4.147: Regression analysis of temporal changes in greenlip abalone catches at Tiparra Reef - Main Reef from 1990 - 1998.



The slope of the regression for Tiparra Reef - Main Reef of total greenlip abalone catch (whole weight - kg) versus time (year) is significant (slope = 3198.1; r^2 = 0.570; p = 0.018). There is an increase in greenlip abalone catches at Tiparra Reef - Main Reef by 3198 kg per year during the period analysed.

Figure 4.148: Regression analysis of temporal changes in greenlip abalone catches at Tiparra Reef - Middle Bottom from 1990 - 1998.



The slope of the regression for Tiparra Reef - Middle Bottom of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = 752.2; r^2 = 0.050; p = 0.559).

Figure 4.149: Regression analysis of temporal changes in greenlip abalone catches at Cape Elizabeth from 1990 - 1998.

The slope of the regression for Cape Elizabeth of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = 994; r^2 = 0..247; p = 0.172).

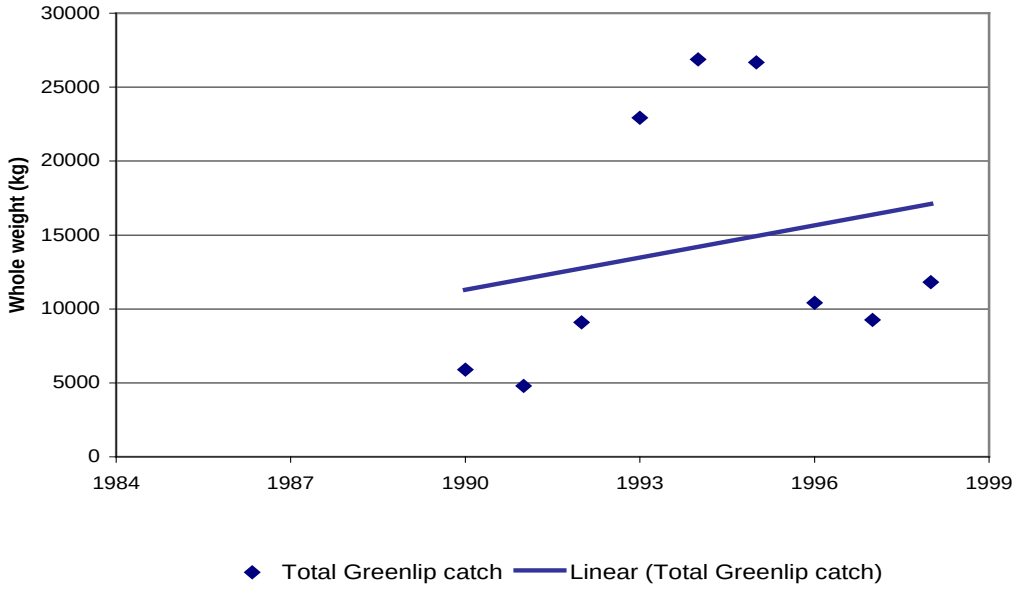
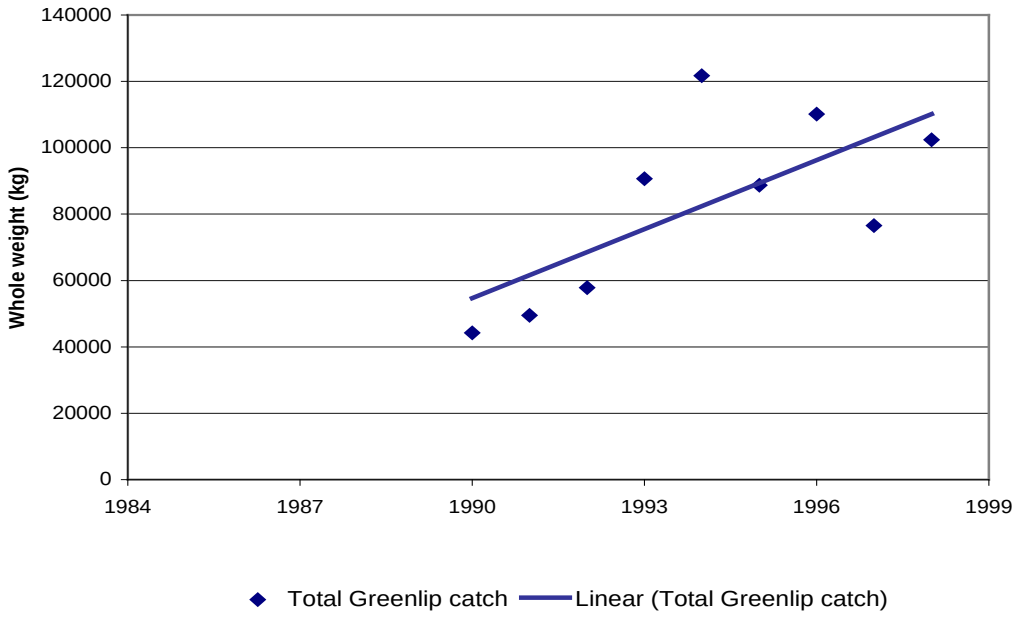
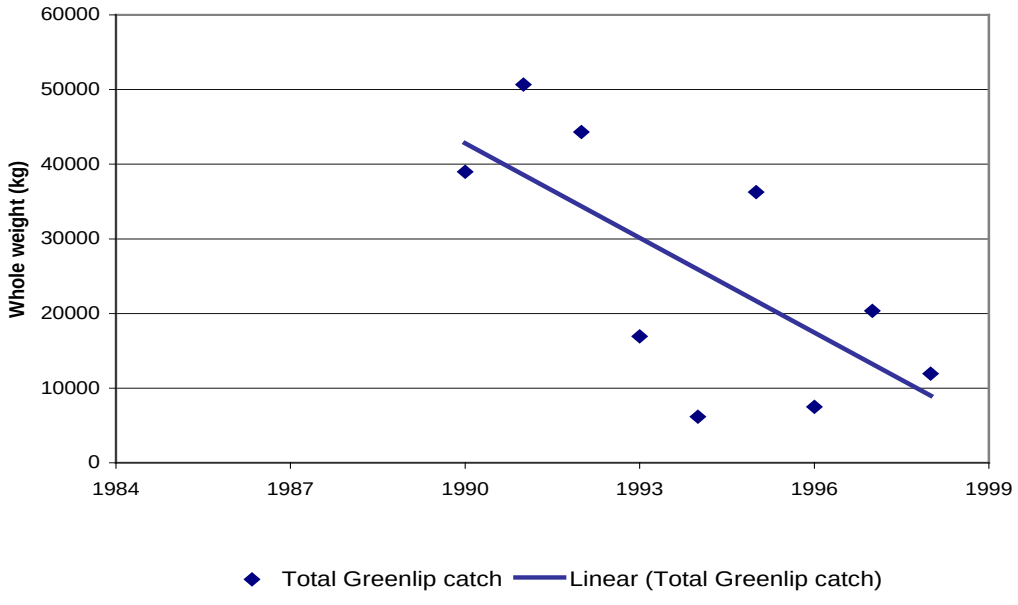


Figure 4.150: Regression analysis of temporal changes in greenlip abalone catches for Tiparra Reef - Total from 1990 - 1998.



The slope of the regression for Tiparra Reef - Total of total greenlip abalone catch (whole weight - kg) versus time (year) is significant (slope = 6939.2; r^2 = 0..481; p = 0.038). There is an increase in greenlip abalone catches at Tiparra Reef - Total by 6939 kg per year during the period analysed.

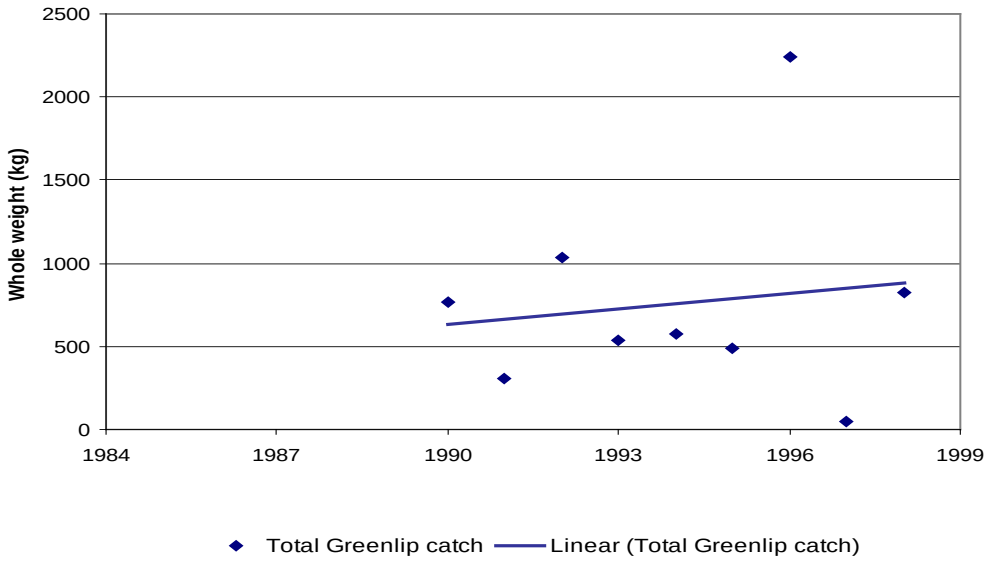
Figure 4.151: Regression analysis of temporal changes in greenlip abalone catches for Western Yorke Peninsula from 1990 - 1998.



The slope of the regression for Western Yorke Peninsula of total greenlip abalone catch (whole weight - kg) versus time (year) is significant (slope = -4225.1; r^2 = 0..472; p = 0.040).

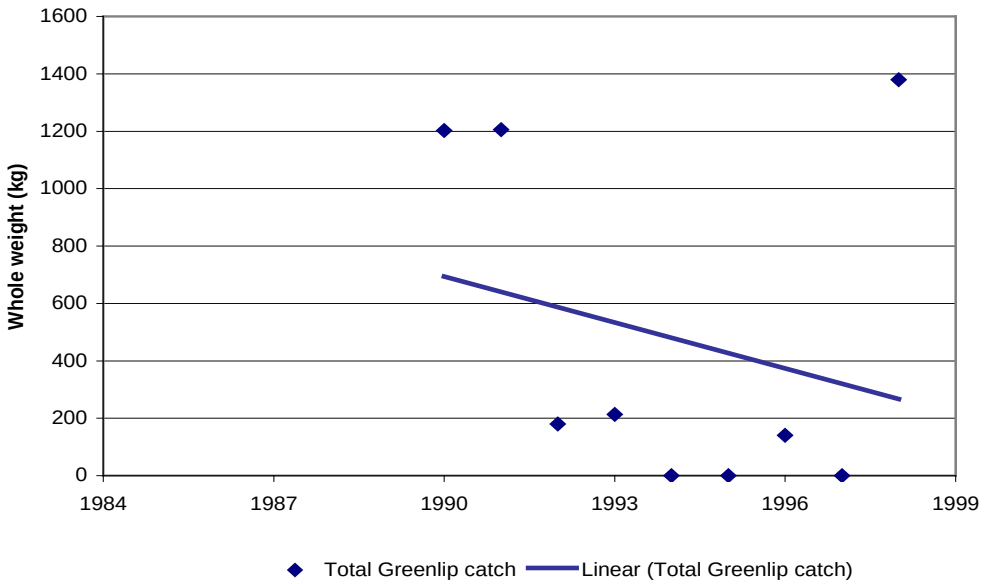
There is a decrease in greenlip abalone catches at Western Yorke Peninsula by 4225 kg per year during the period analysed.

Figure 4.152: Regression analysis of temporal changes in greenlip abalone catches for South Eastern Yorke Peninsula from 1990 - 1998.



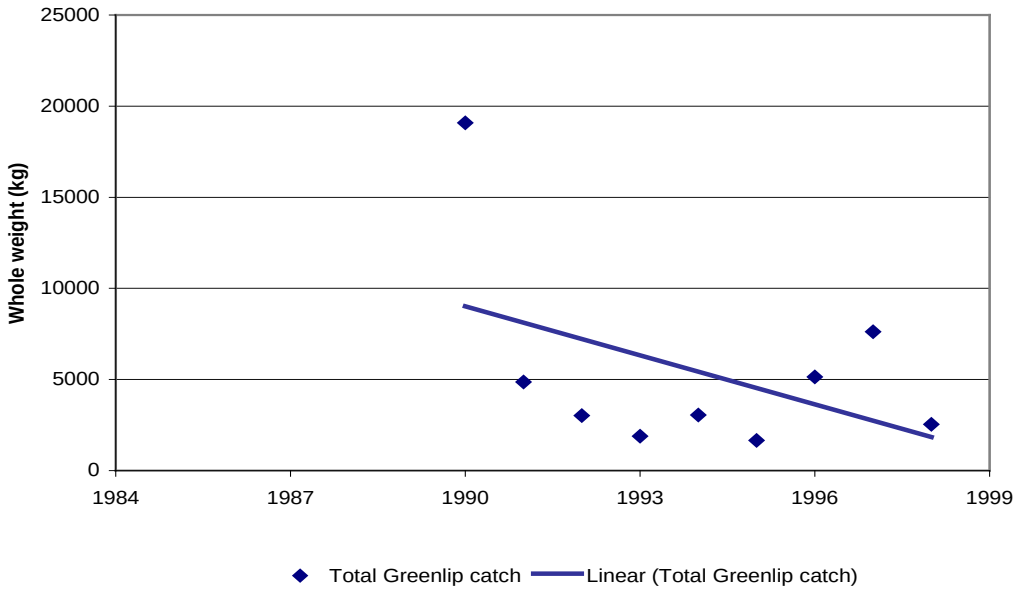
The slope of the regression for South Eastern Yorke Peninsula of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = 30.4; r^2 = 0..176; p = 0.733).

Figure 4.153: Regression analysis of temporal changes in greenlip abalone catches at Cape Jervis - Encounter Bay from 1990 - 1998.



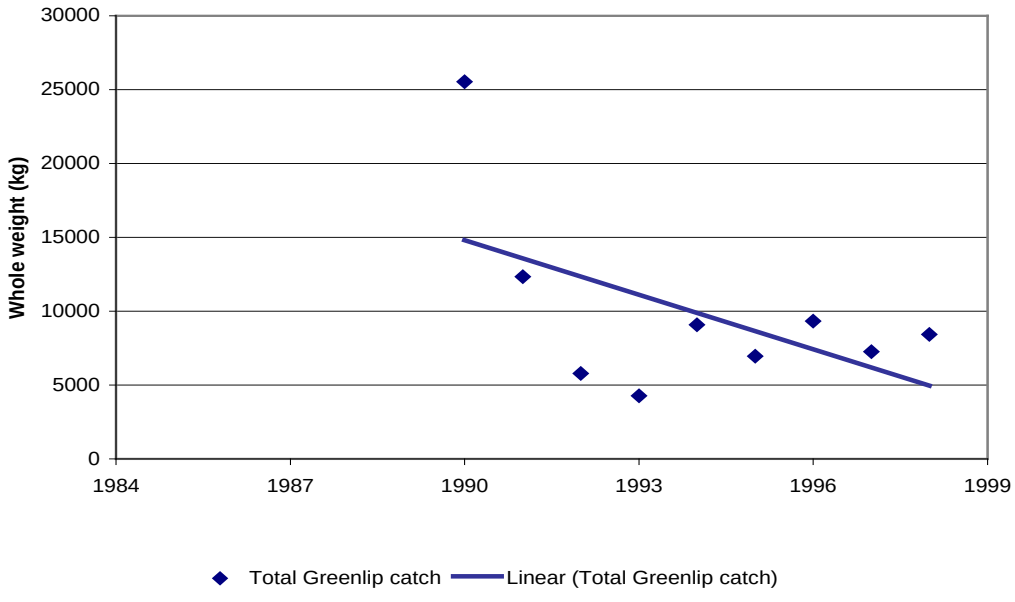
The slope of the regression for Cape Jervis - Encounter Bay of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = -53.3; r^2 = 0..060; p = 0.523).

Figure 4.154: Regression analysis of temporal changes in greenlip abalone catches at South West Kangaroo Island from 1990 - 1998.



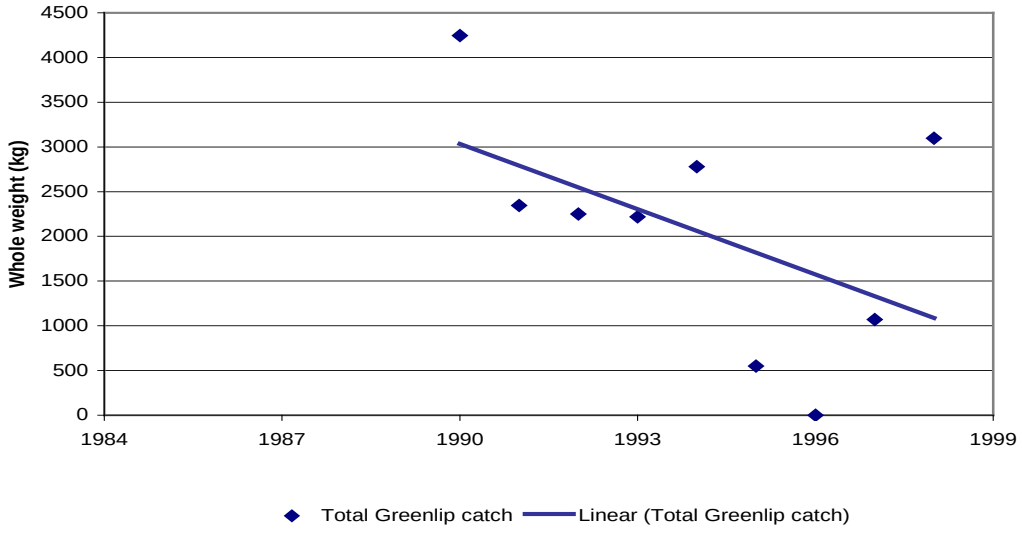
The slope of the regression for South West Kangaroo Island of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = -897.6; r^2 = 0..203; p = 0.223).

Figure 4.155: Regression analysis of temporal changes in greenlip abalone catches at South Eastern Kangaroo Islnad from 1990 - 1998.



The slope of the regression for South Eastern Kangaroo Island of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = -1230.0; r^2 = 0..285; p = 0.138).

Figure 4.156: Regression analysis of temporal changes in greenlip abalone catches at North East Kangaroo Island from 1990 - 1998.



The slope of the regression for North East Kangaroo Island of total greenlip abalone catch (whole weight - kg) versus time (year) is not significant (slope = -243.2; r^2 = 0..253; p = 0.167).

4.3.4 Temporal changes in blacklip abalone catches, 1990 - 1998 (Table 4.4, figures 4.157 to 4.159)

Analyses for just 3 blacklip abalone metapopulation areas with total catches averaging 36 tonnes over each of 9 years showed a significant decrease in catches in 1 or 33 % of metapopulations and significant increases in 1 (33 %).

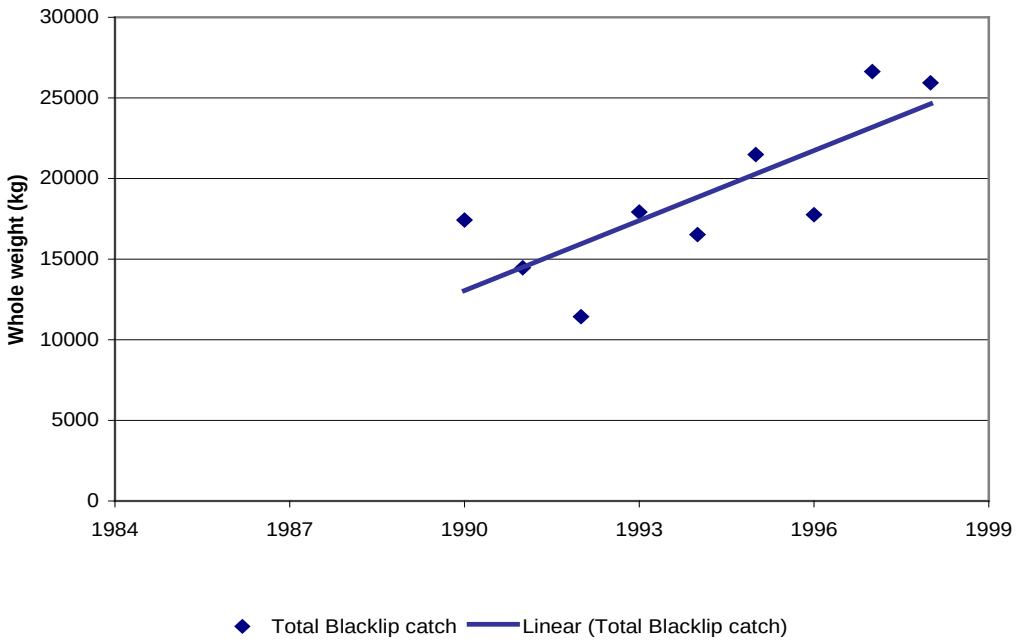
The area with a significant increase in catch was Southern Kangaroo Island (1446 kg per year) which represents 7.7 % of the mean catch over the period.

The area with a significant decline in catch was Yorke Peninsula (572 kg per year) which represents a 13.0 % decline from the mean catch.

Blacklip -Central Zone							
Slope is average change in annual catch in kg over 8 years							
Probability is chance that there has been no significant change (up or down) in catch over 8 years							
A probability of less than 0.05 means that there is 95% certainty that there is a significant trend either up or down in the catch							
			NON-CORRECTED DATA				
REGION	**SLOPE**	**MEAN CATCH**	**PERCENT OF MEAN**	**PROBABILITY**	**SIGNIFICANT CHANGE**		
YORKE PENINSULA	-572	4394	-13.02	0.0198	decrease		
SOUTHERN KANGAROO ISLAND	1446	18841	7.67	0.0115	increase		
SOUTH EASTERN KANGAROO ISLAND	256	12515	2.05	0.4968			
TOTALS	1130	35750	3.16				

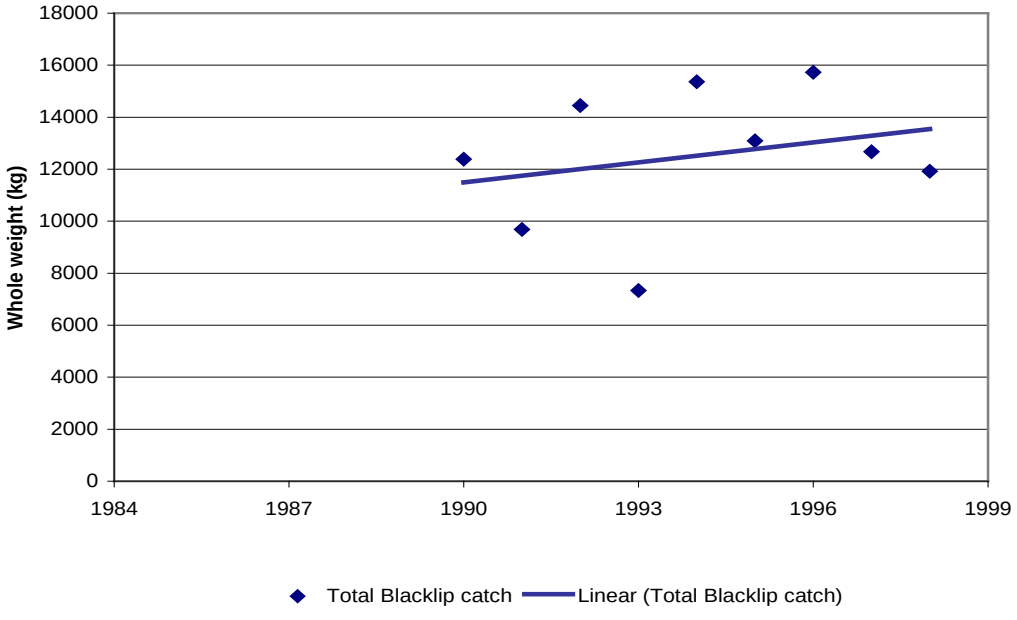
Table 4.4. Summary table showing significance and direction of change in blacklip abalone catches between 1990 and 1998 in the Central Zone.

Figure 4.157: Regression analysis of temporal changes in blacklip abalone catches in the southern Kangaroo Island region (Mapcodes 26A, 26B, 27A, 27B, 28A, 28B, 29A) from 1990 - 1998.



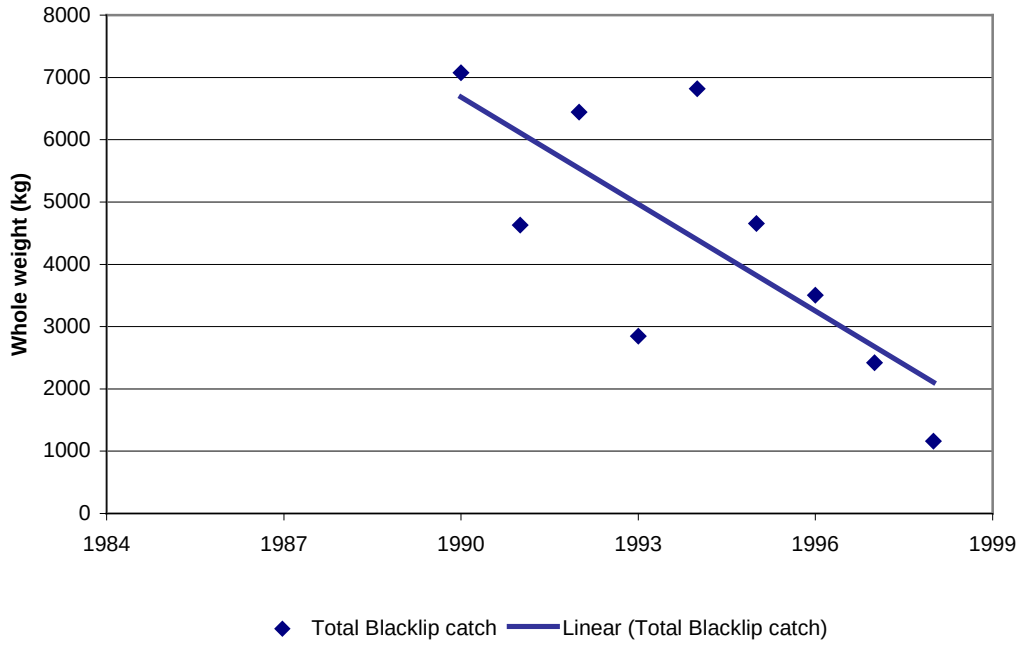
The slope of the regression for the southern Kangaroo Island region of total blacklip abalone catch (whole weight - kg) versus time (year) is significant (slope = 1446; r^2 = 0..622; p = 0.011). The total blacklip abalone catches in this region have increased by 1446 kg per year over the period analysed.

Figure 4.158: Regression analysis of temporal changes in blacklip abalone catches in the south eastern Kangaroo Island region (Mapcodes 29B-D, 30A-C, 31A-C) from 1990 - 1998.



The slope of the regression for the south eastern Kangaroo Island region of total blacklip abalone catch (whole weight - kg) versus time (year) is not significant (slope = 256.4; r^2 = 0..068; p = 0.496).

Figure 4.159: Regression analysis of the temporal changes in blacklip abalone catches in the Yorke Peninsula region (Mapcodes 23A-D) from 1990 -1998.



The slope of the regression for the Yorke Peninsula region of total blacklip abalone catch (whole weight - kg) versus time (year) is significant (slope = -572.3; r^2 = 0..563; p = 0.019). The blacklip abalone in this region have been declining by 572 kg per year over the period analysed.

4.3.5 Analysis of size composition of greenlip abalone catches in the Central Zone

Although caution is required, the composition of greenlip abalone catches may assist in interpretting structural changes in the population at a local scale.

In the Central Zone gradings of greenlip catches, figures 4.160 to 4.172, are likely to be less instructive than in the Western Zone principally because in most populations the maximum size is much greater in the Western Zone and thus less differentiation is evident in the catch. The greenlip populations, with a declining catch at Cape Gantheaume and D'Estree Bay, have shown a consistently declining proportion of the 3-5 size grade, whereas that at Cape Jervis (which has almost completely collapsed) has given, at best, an ambiguous signal in respect of change in size gradings.

Figure 4.160: Catch per grading by year for greenlip abalone from 1978 to 1998 for Tiparra Reef - North Bottom. 100% of the greenlip abalone catch in each year was graded.

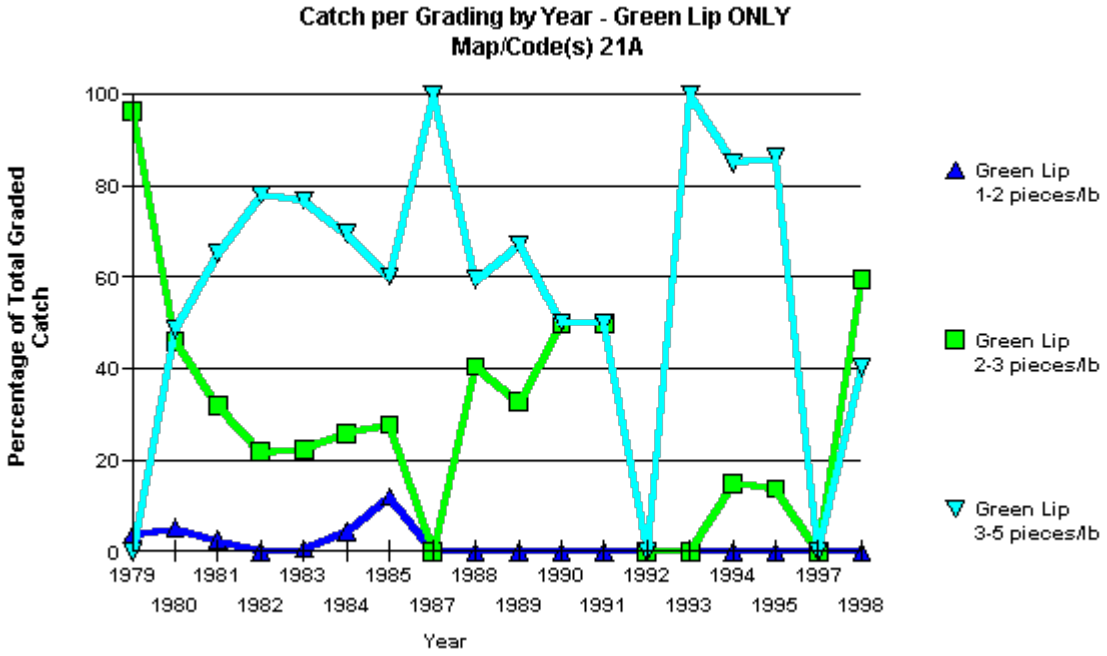


Figure 4.161: Catch per grading by year for greenlip abalone from 1978 to 1998 for Tiparra Reef - Outer Main Reef. 100% of the greenlip abalone catch in each year was graded.

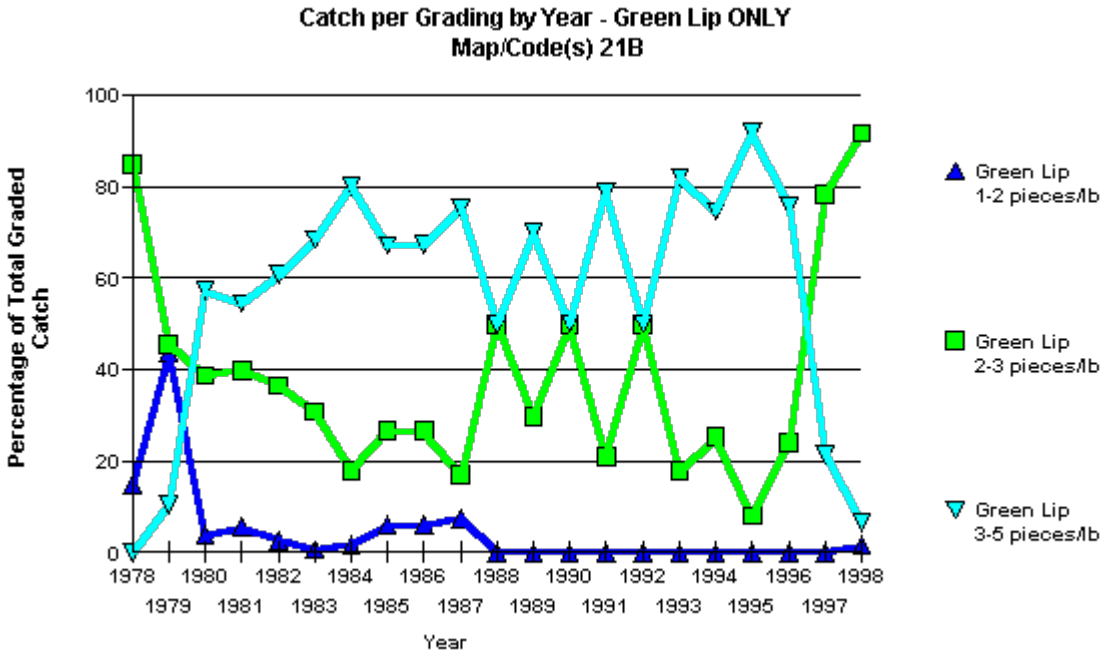


Figure 4.162: Catch per grading by year for greenlip abalone from 1978 to 1998 for Tiparra Reef - Outside Bottom. 100% of the greenlip abalone catch in each year was graded.

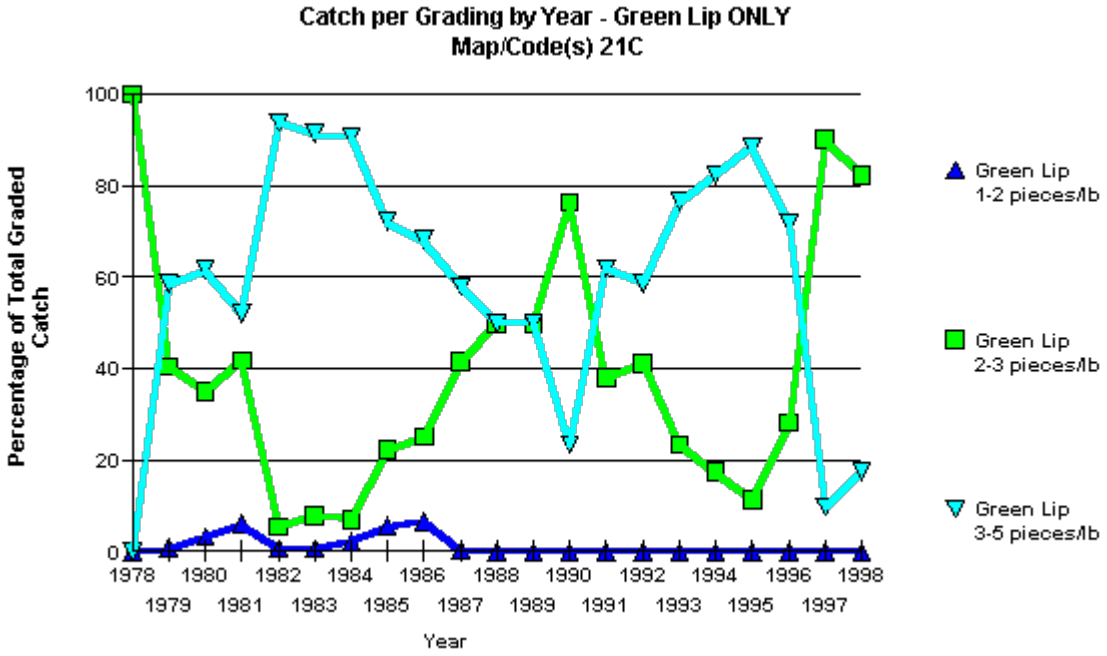


Figure 4.163: Catch per grading by year for greenlip abalone from 1978 to 1998 for Tiparra Reef - main Reef. 100% of the greenlip abalone catch in each year was graded.

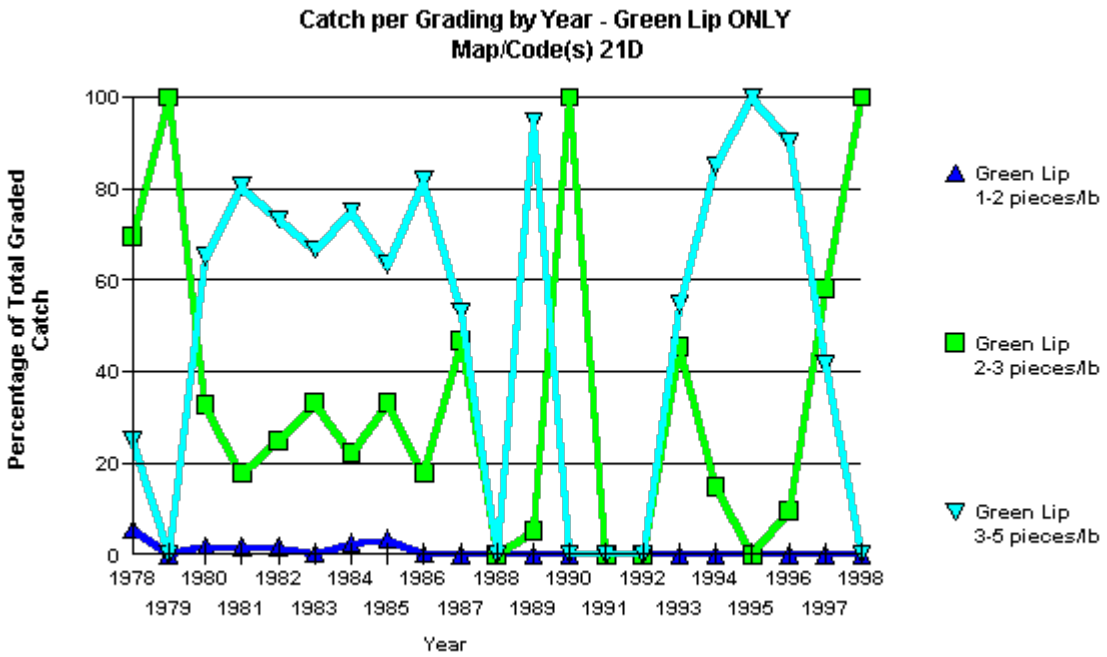


Figure 4.164: Catch per grading by year for greenlip abalone from 1978 to 1998 for Tiparra Reef - Middle Bottom. 100% of the greenlip abalone catch in each year was graded.

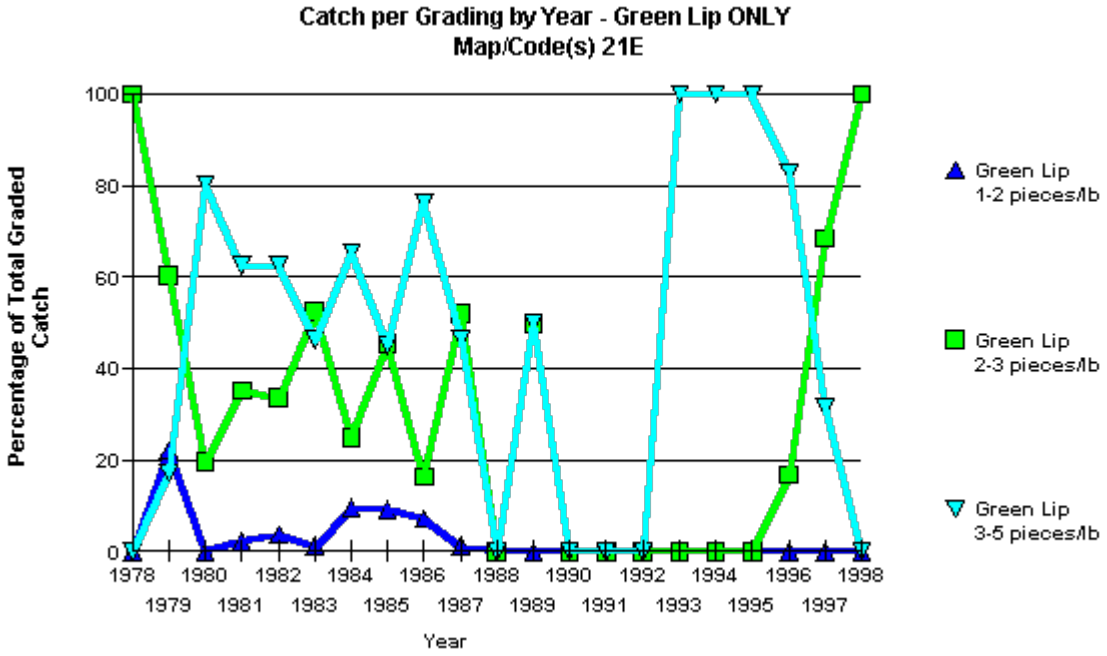


Figure 4.165: Catch per grading by year for greenlip abalone from 1978 to 1998 for Tiparra Reef - Total. 100% of the greenlip abalone in each year was graded.

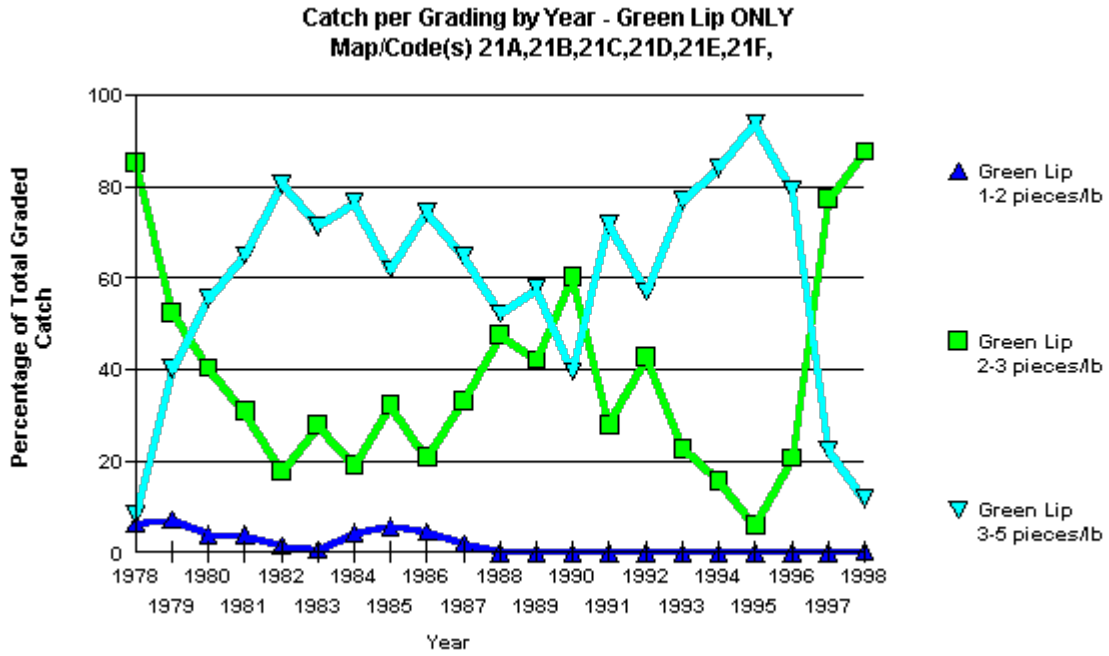


Figure 4.166: Catch per grading by year for greenlip abalone from 1978 to 1998 for Cape Elizabeth. 100% of the greenlip abalone in each year was graded.

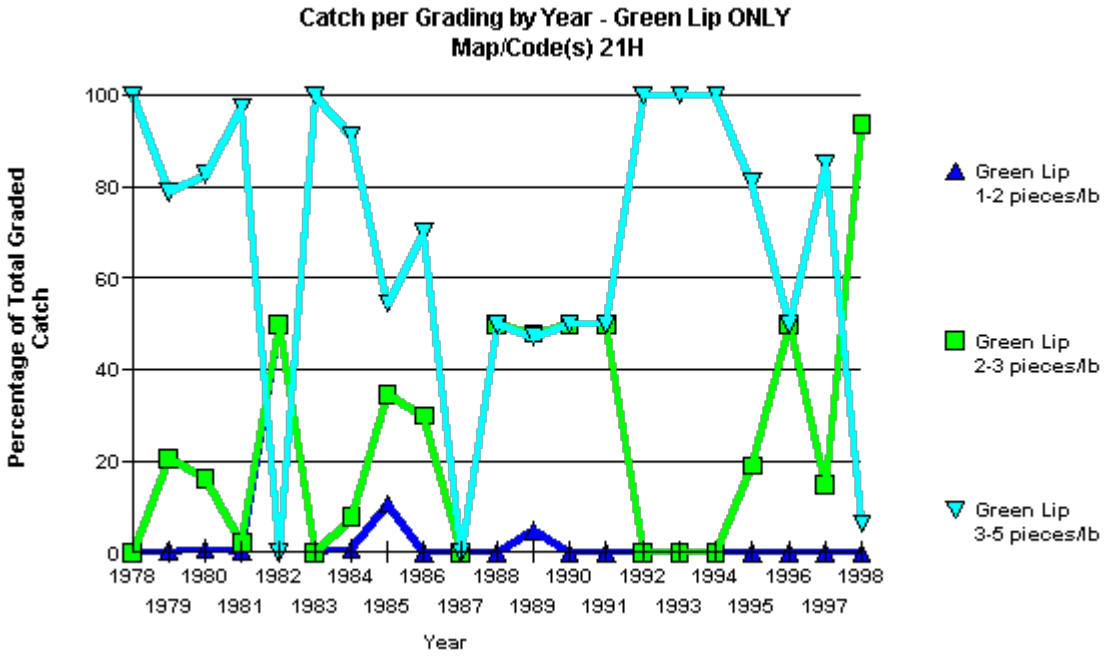


Figure 4.167: Catch per grading by year for greenlip abalone from 1978 to 1998 for Hardwicke Bay and Formby Bay. 100% of the greenlip abalone in each year were graded.

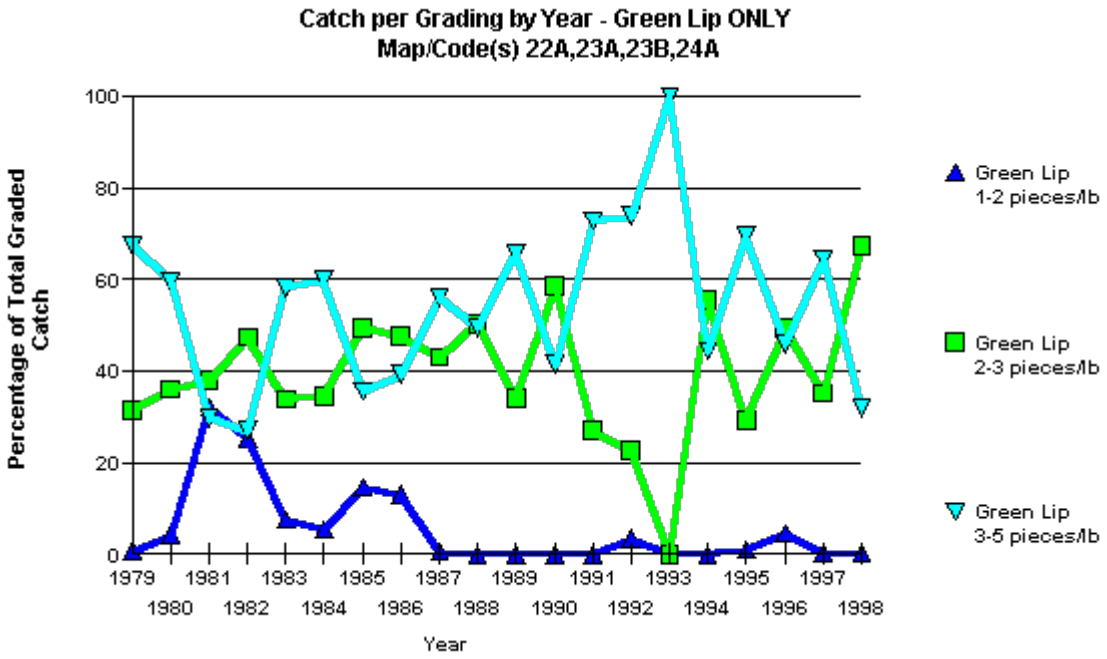


Figure 4.168: Catch per grading by year for greenlip abalone from 1978 to 1998 for SW Yorke Peninsula, Stansbury and Moorowie (Marion Reef). 100% of the greenlip abalone in each year were graded.

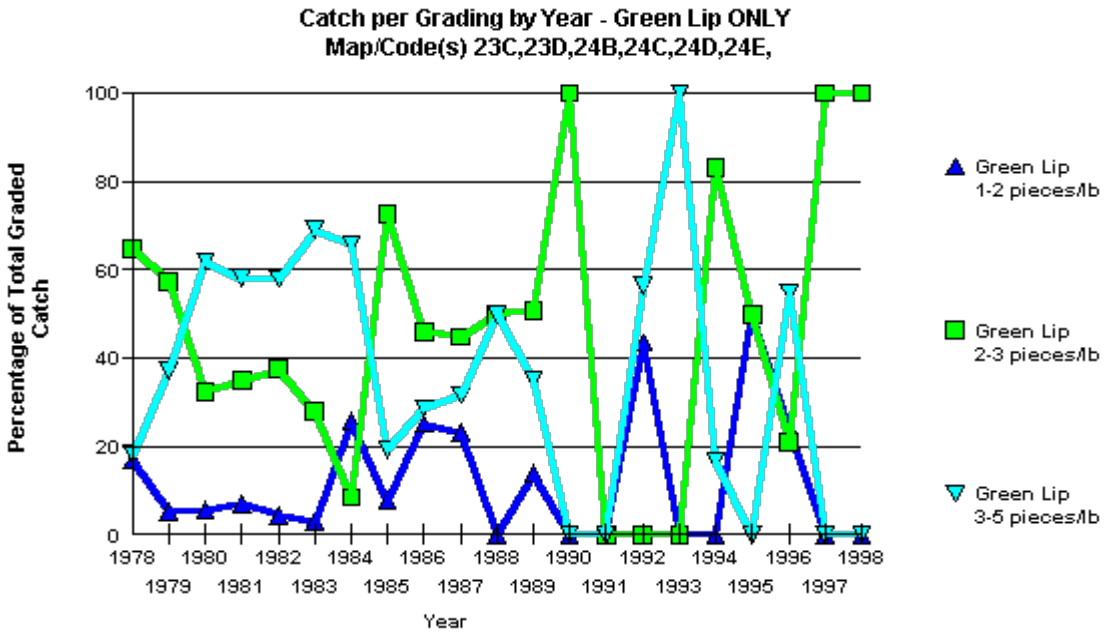


Figure 4.169: Catch per graded by year for greenlip abalone and the percentage of total catch of greenlip abalone graded in each year from 1978 to 1998 for the Cape Jervis - Encounter Bay region.

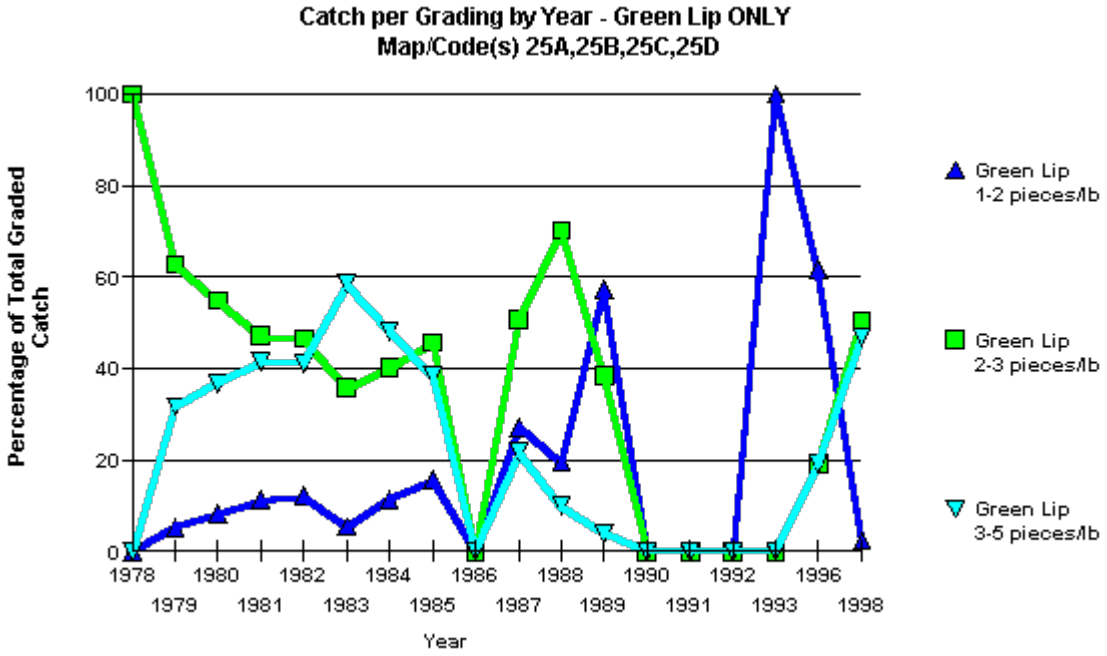


Figure 4.170: Catch per grading by year for greenlip abalone from 1978 to 1998 for West Bay (Cape du Couedic), Hanson Bay and Vivonne Bay. 100% of the greenlip abalone in each year was graded.

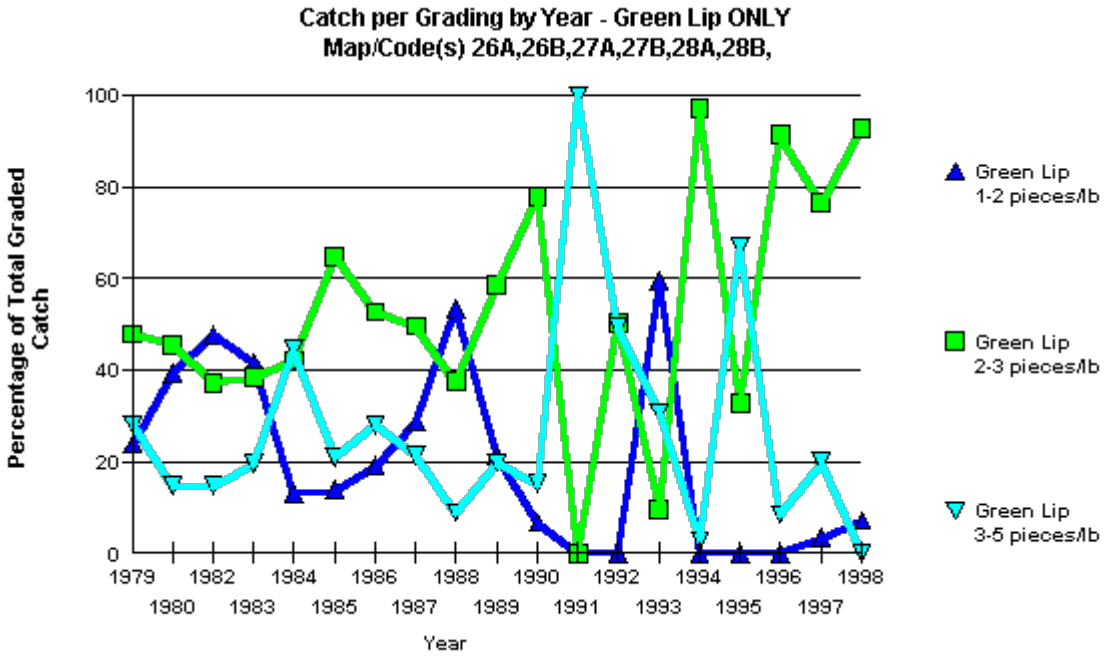


Figure 4.171: Catch per grading by year for greenlip abalone for 1978 to 1998 for Cape Gantheaume, D'Estrees Bay and Cape Willoughby (Cape St Alban). 100% of the greenlip abalone between 1978 and 1996 were graded. 0% of the greenlip abalone were graded in 1997 and 1999.

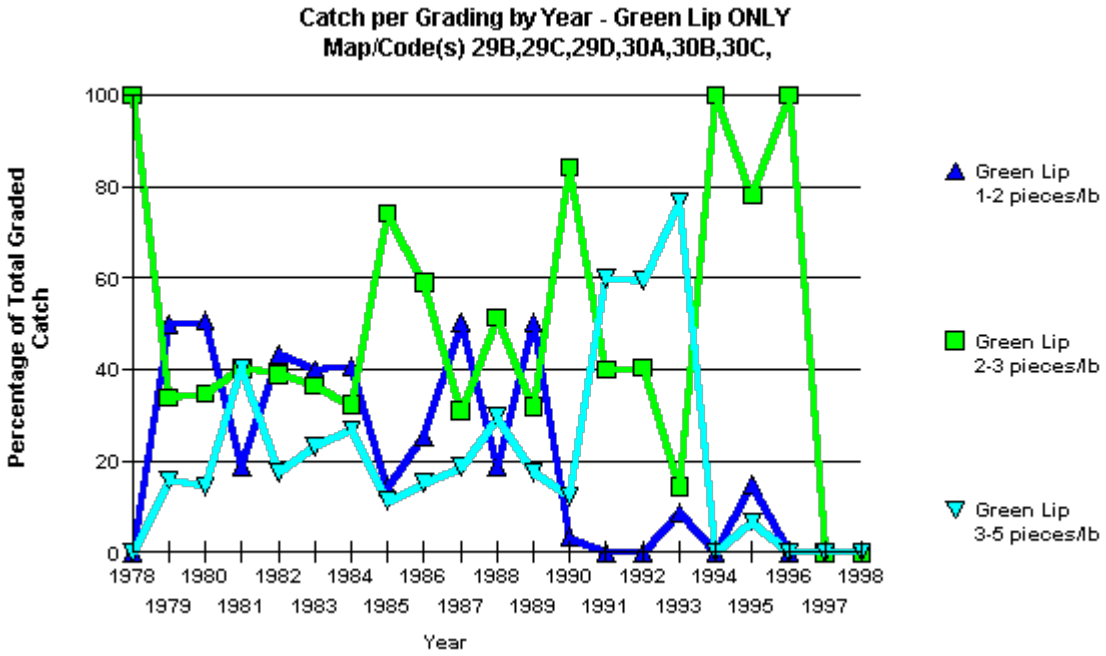
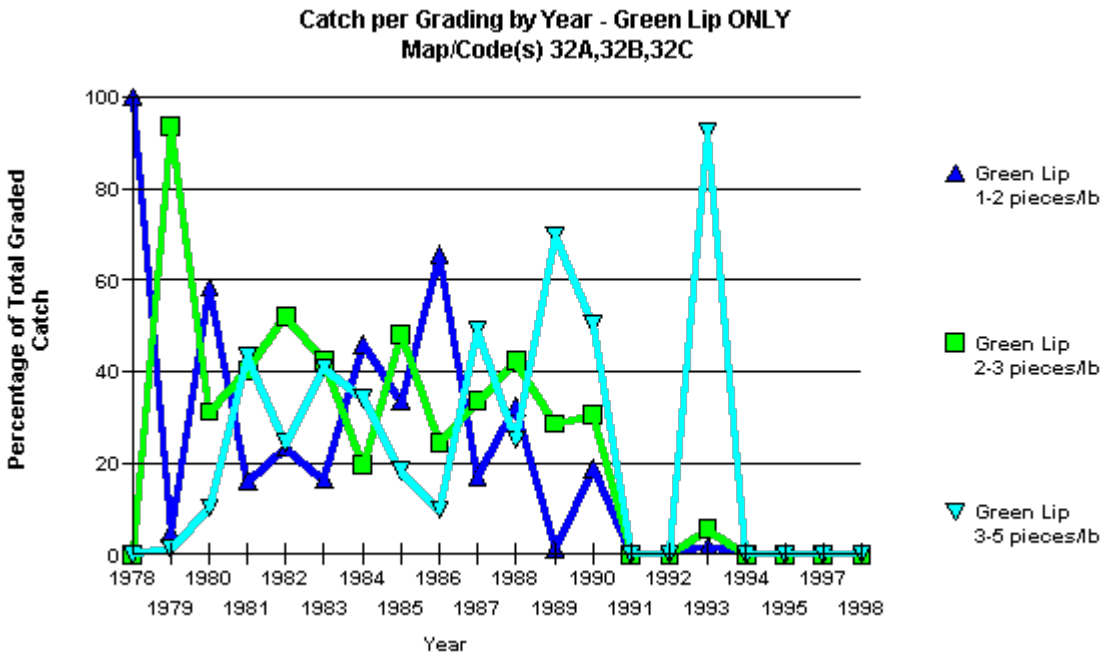


Figure 4.172: Catch per grading by year for greenlip abalone and the percentage of total catch of greenlip abalone graded in each year from 1978 to 1998 for North East Kangaroo Island region.

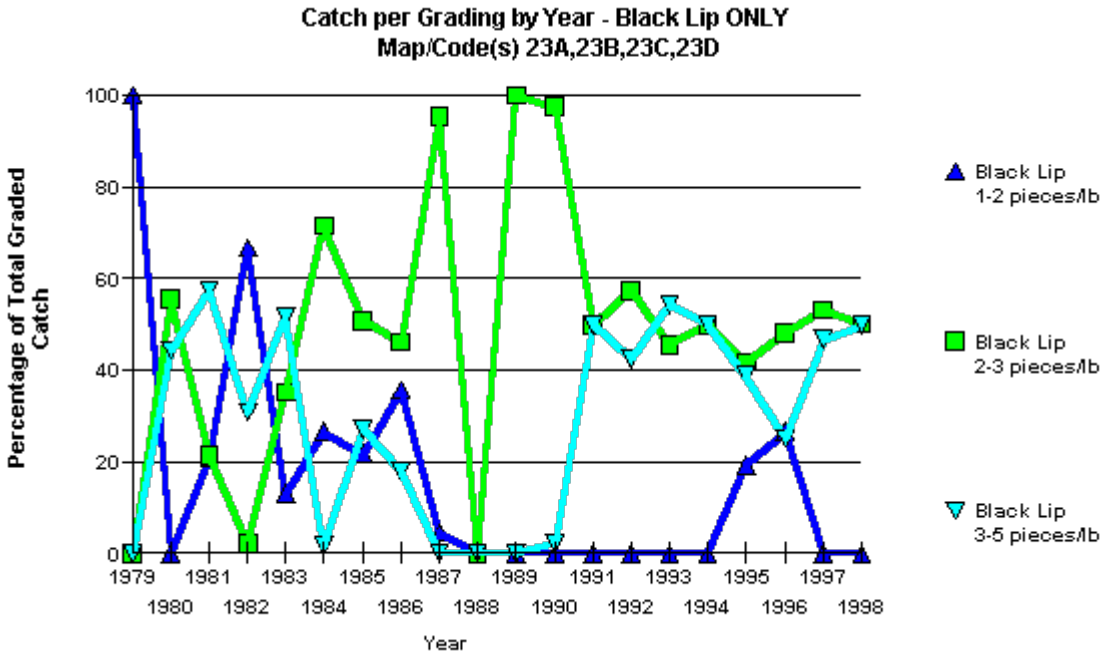


Year	Percentage of total catch graded
1978	100
1979	100
1980	100
1981	100
1982	100
1983	100
1984	100
1985	100
1986	100
1987	100
1988	100
1989	100
1990	100
1991	0
1992	0
1993	100
1994	0
1995	0
1997	0
1998	0

4.3.6 Analysis of size composition of blacklip abalone catches in the Central Zone

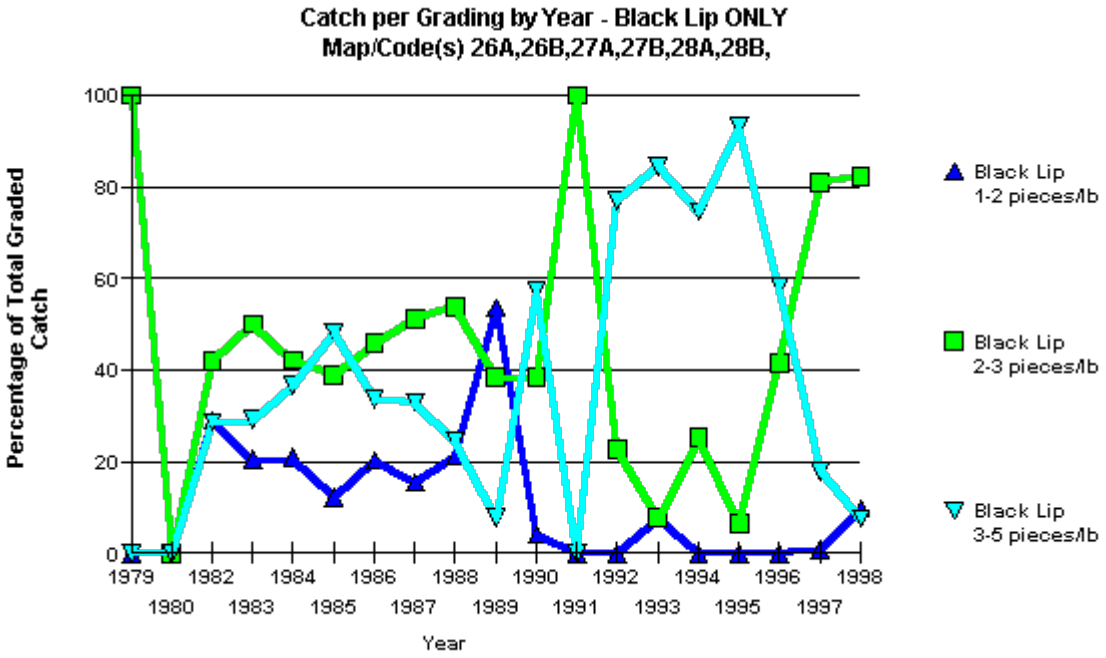
In the Central Zone the decline of the 1-2 gradings, figures 4.173 to 4.175, at SW Yorke Peninsula, West Bay, Hanson Bay, Vivonne Bay and Cape Gantheaume and the accompanying increase of the 3-5 grading in most of them are consistent with the known decline of large individuals in those populations but, in the absence of other evidence, do not imply recruitment overfishing.

Figure 4.173: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1979 to 1998 for the South West Yorke Peninsula region.



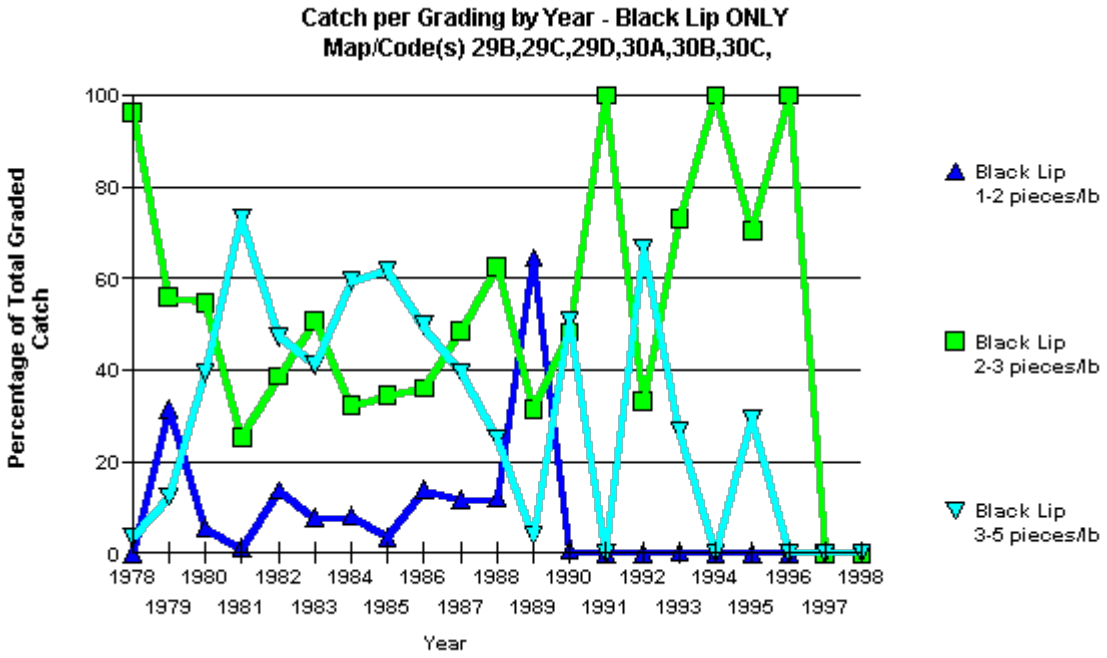
Year	Percentage of total catch graded
1979	79.37
1980	20.45
1981	100
1982	100
1983	100
1984	100
1985	100
1986	96.56
1987	20
1988	0
1989	14.49
1990	45.34
1991	81.53
1992	75.78
1993	67.23
1994	99.38
1995	100
1996	100
1997	100
1998	100

Figure 4.174: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1979 to 1998 for West Bay (Cape du Couedic), Hanson Bay and Vivoone Bay.



Year	Percentage of total catch graded
1979	74.53
1980	0
1982	100
1983	100
1984	100
1985	100
1986	100
1987	82.34
1988	55.06
1989	48.30
1990	57.19
1991	20.64
1992	22.76
1993	54.78
1994	56.76
1995	54.45
1996	61.10
1997	50.06
1998	76.69

Figure 4.175: Catch per grading by year for blacklip abalone and the percentage of total catch of blacklip abalone graded in each year from 1979 to 1998 for the Cape Gantheaume, D'Estrees Bay and Cape Willoughby (Cape St Alban) region.



Year	Percentage of total catch graded
1978	100
1979	35.28
1980	21.52
1981	85.73
1982	100
1983	100
1984	100
1985	99.95
1986	99.98
1987	64.95
1988	37.03
1989	49.86
1990	48.04
1991	40.38
1992	29.18
1993	53.01
1994	1.91
1995	37.28
1996	13.62
1997	0
1998	0

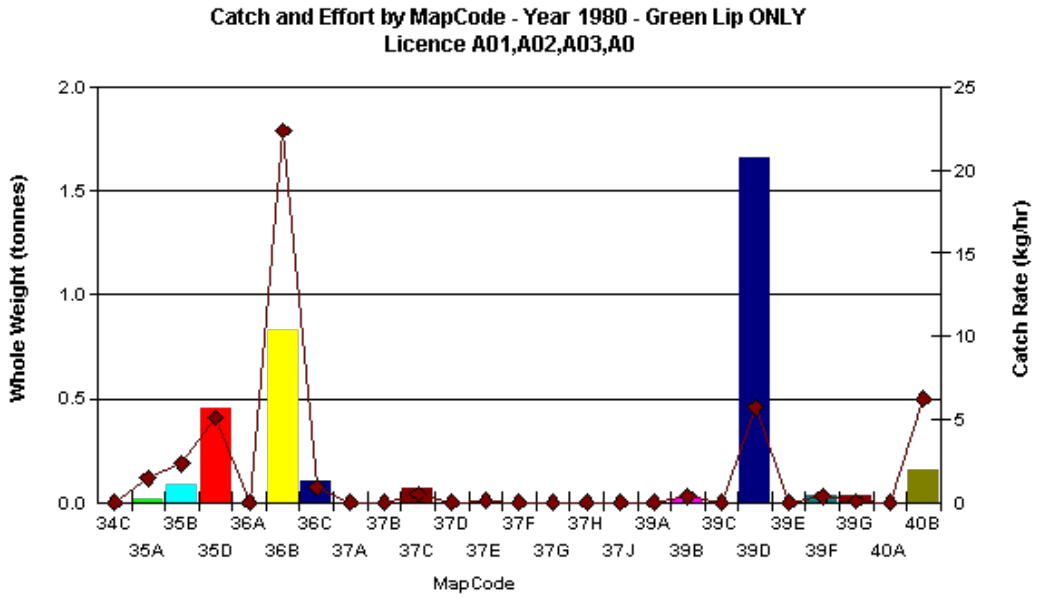
4.4 SOUTHERN ZONE

4.4.1 Assessment of Spatial trends in greenlip abalone catches since 1980

Figure 4.177 to 4.195 provide an overview of the broad patterns of greenlip abalone catch distribution between 1980 and 1998.

Greenlip abalone have never been a major component of the catch in the Southern Zone except for a brief period in the late 1960s. While greenlip has been taken throughout the zone the main areas during the last 20 years have been in areas of Ringwood Reef (36B) and south of Carpenter's Rocks (39D). Most areas produce few greenlip abalone as shown in the graph below. Of the fished mapcode areas only one produces more than one tonne regularly.

Figure 4.176: The 1980 greenlip abalone catch and effort by mapcode within the Southern Zone fishery.



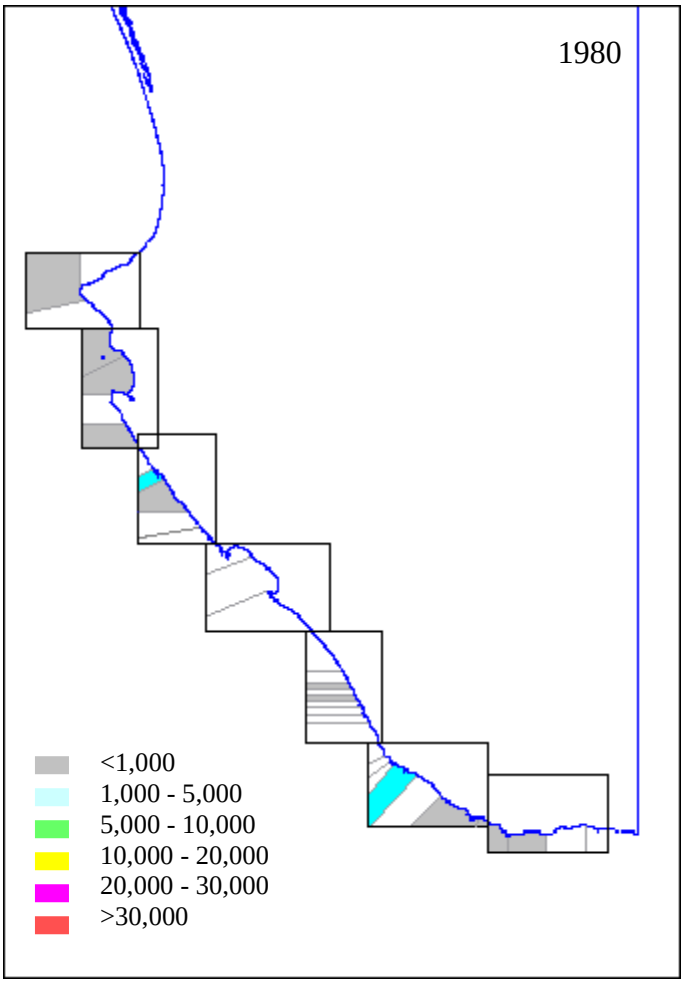


Figure 4.177: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1980

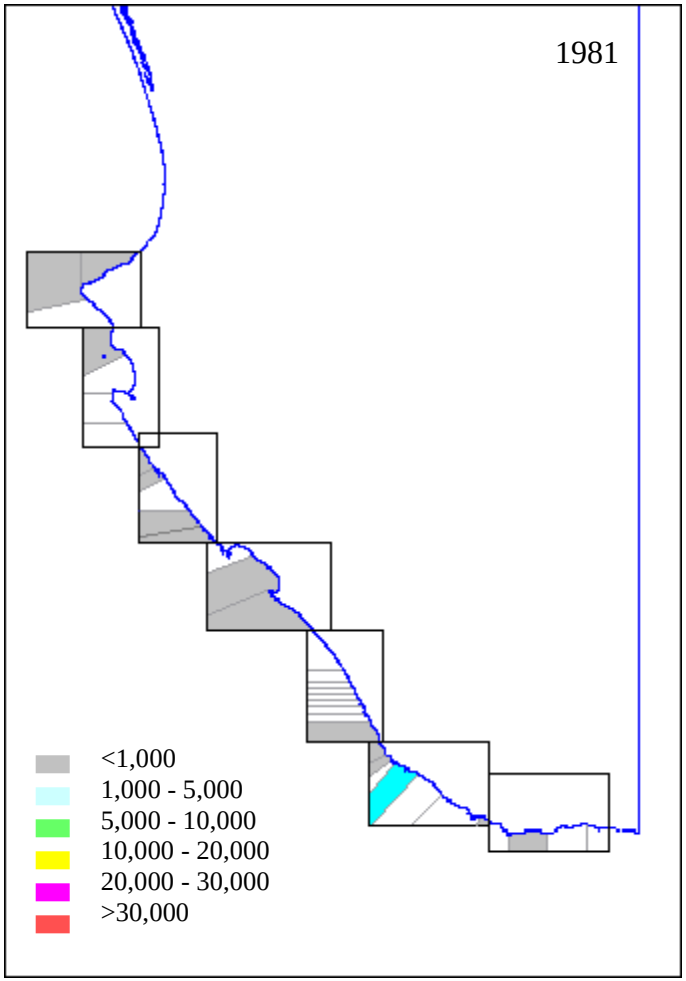


Figure 4.178: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1981

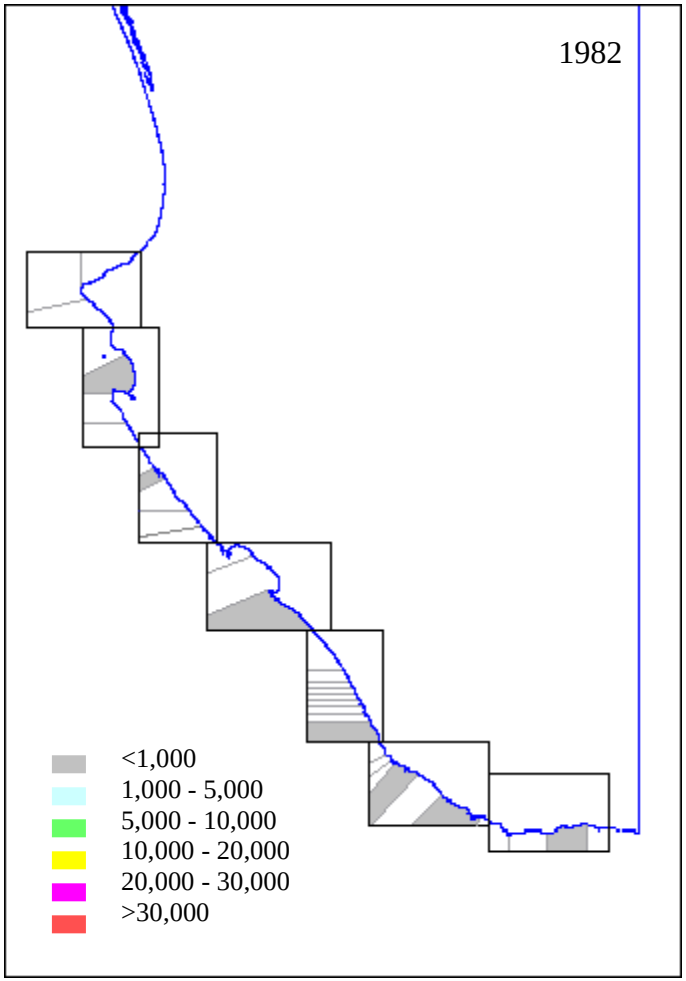


Figure 4.179:The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1982

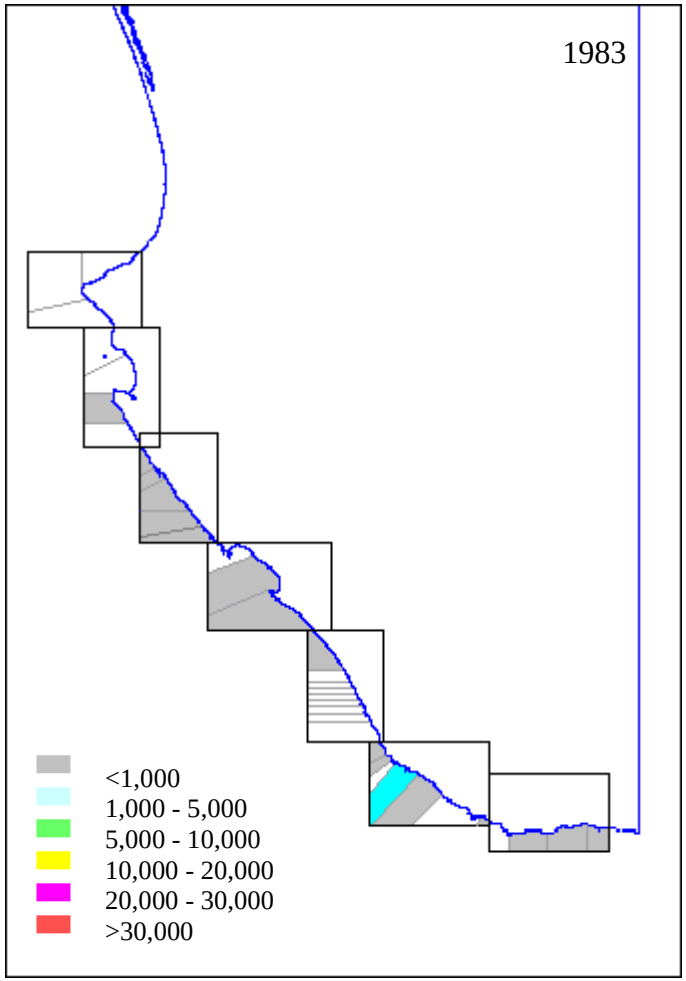


Figure 4.180: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1983

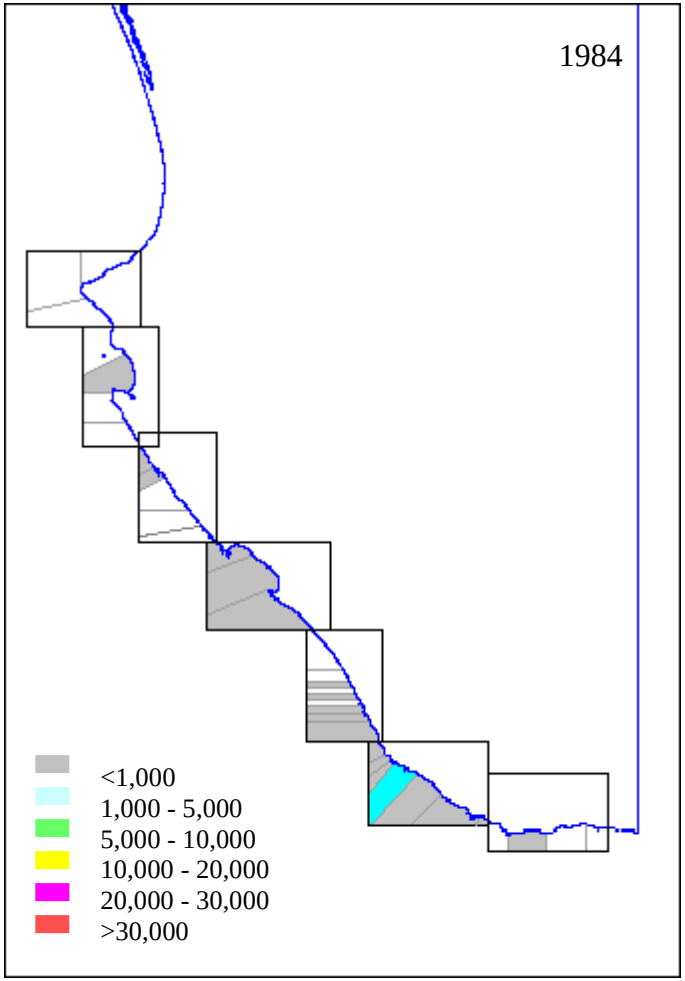


Figure 4.181: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1984

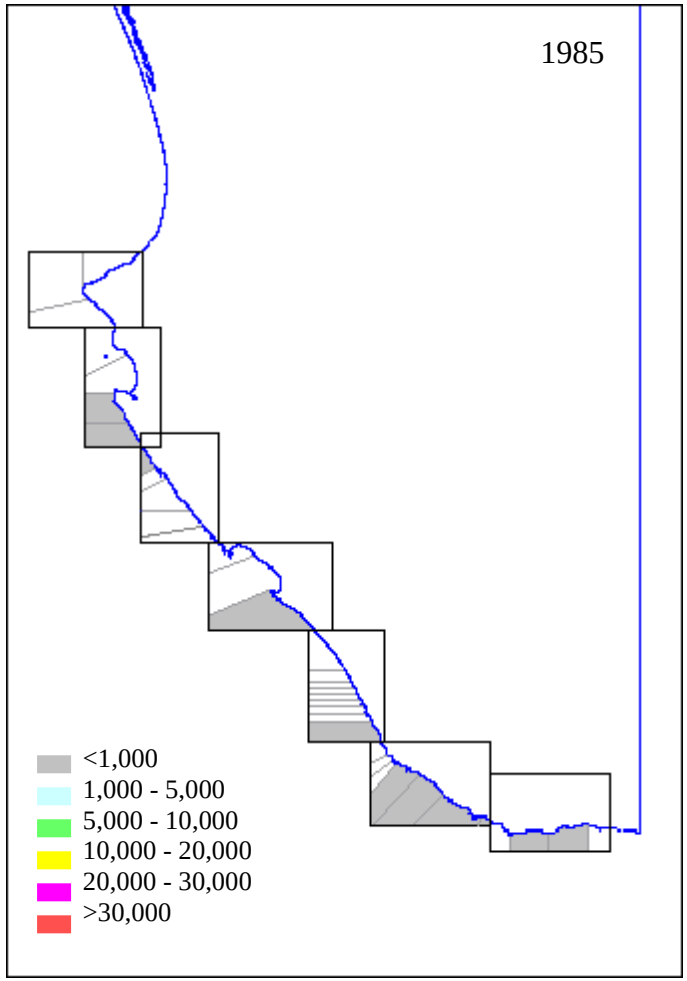


Figure 4.182: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1985

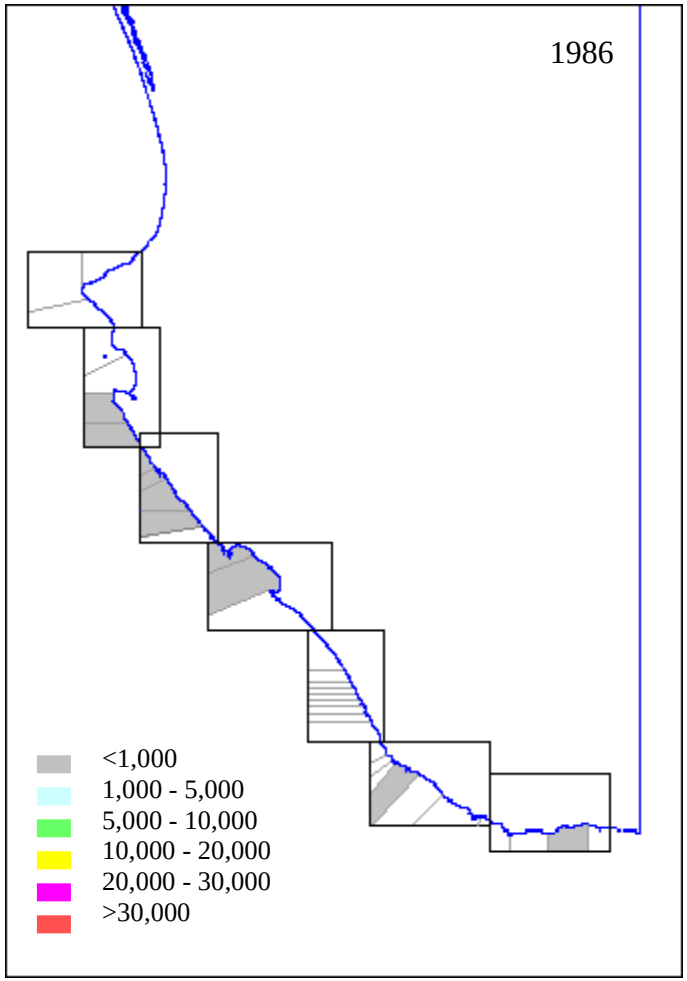


Figure 4.183: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1986

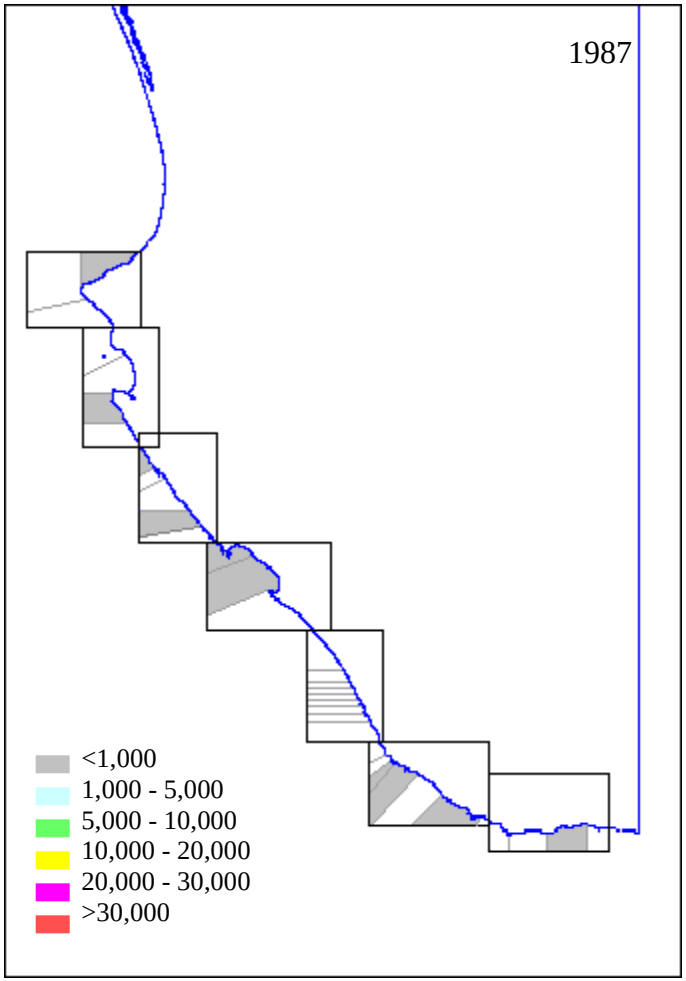


Figure 4.184: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1987

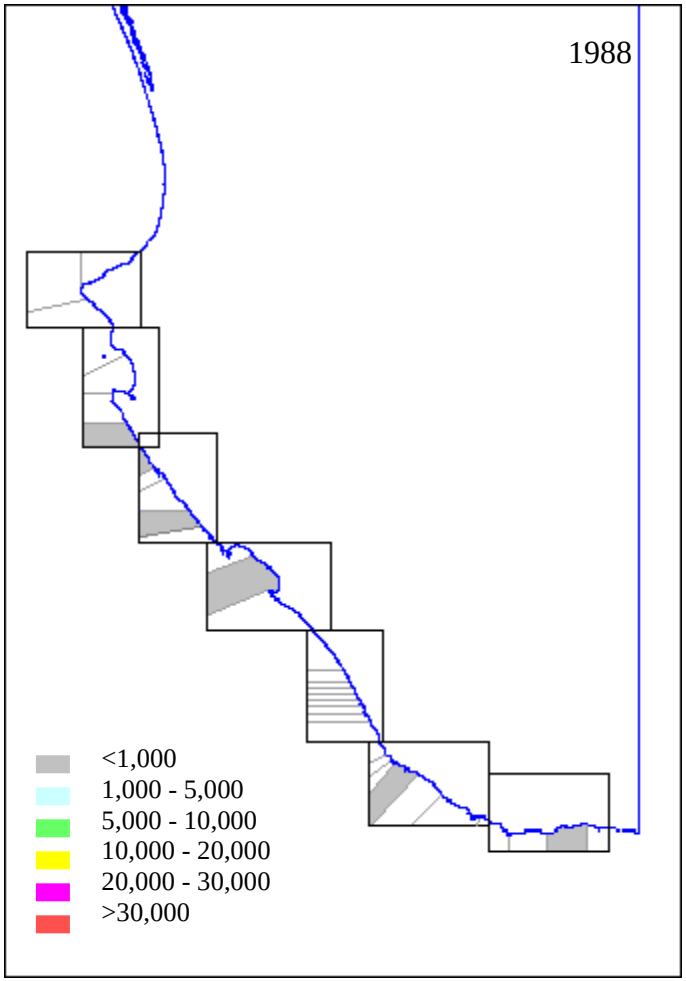


Figure 4.185: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1988

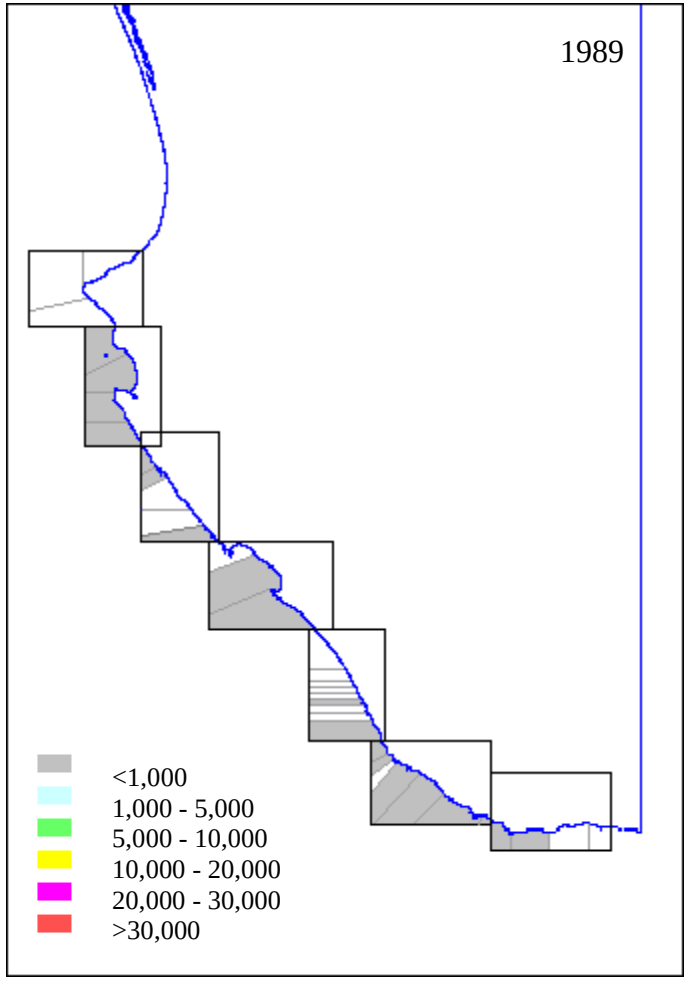


Figure 4.186: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1989

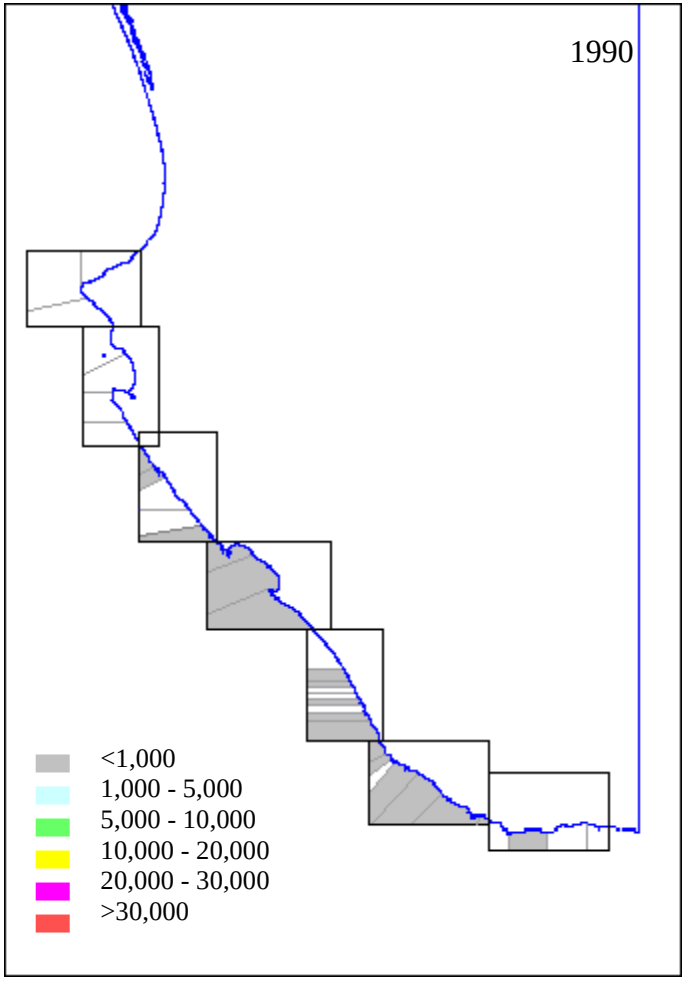


Figure 4.187: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1990

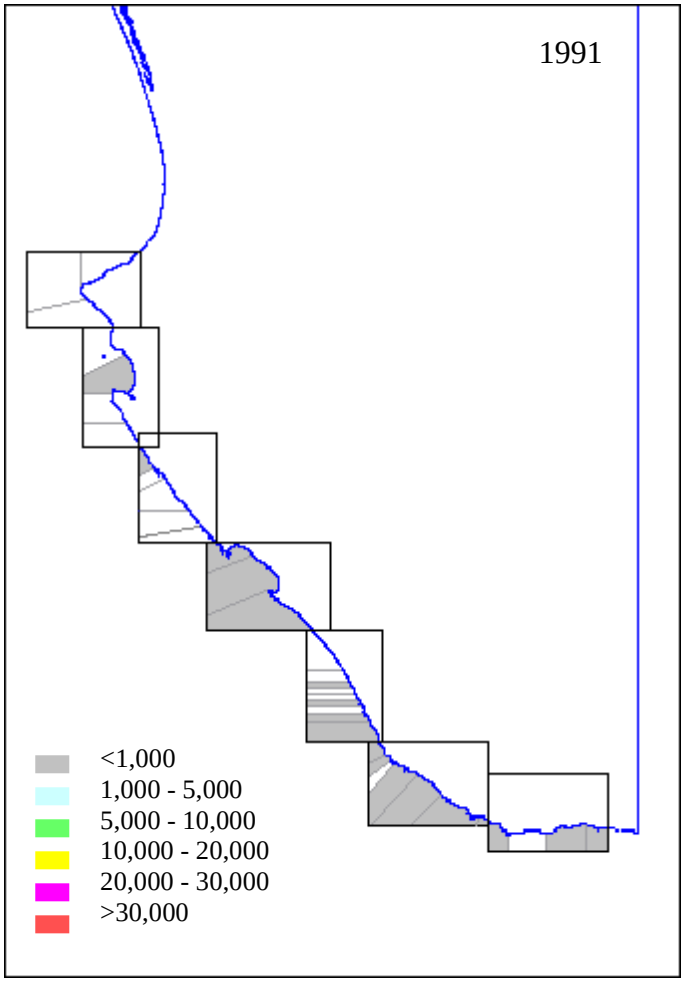


Figure 4.188: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1991

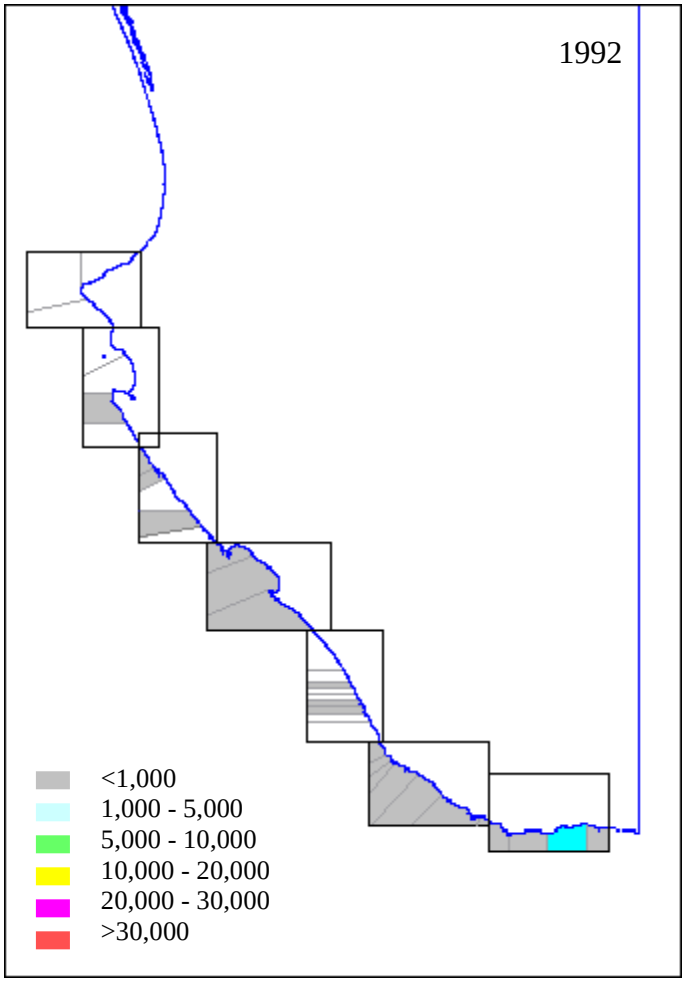


Figure 4.189: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1992

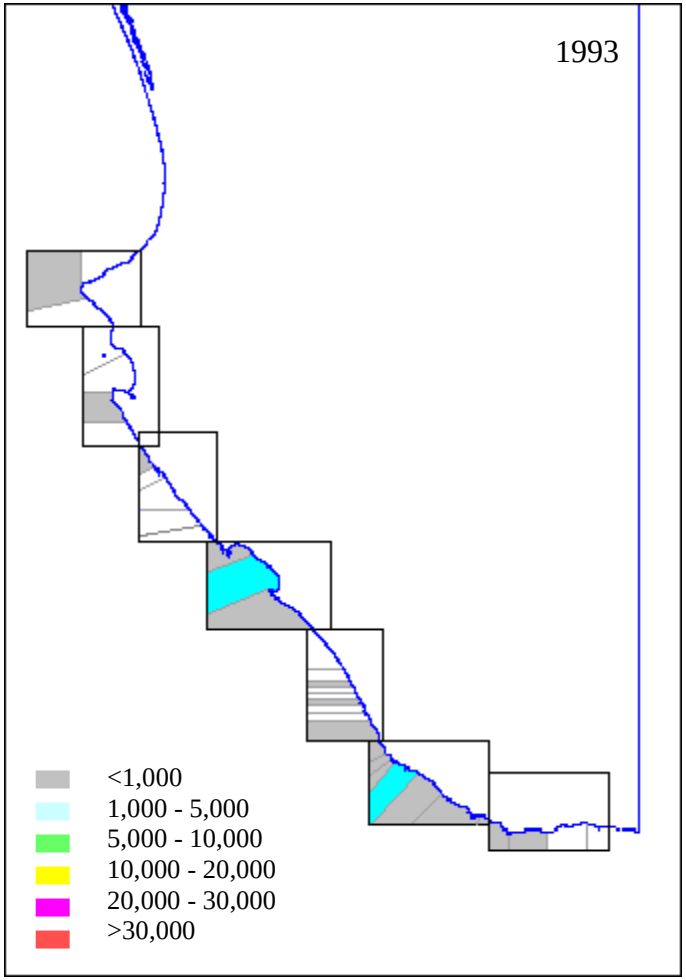


Figure 4.190: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1993

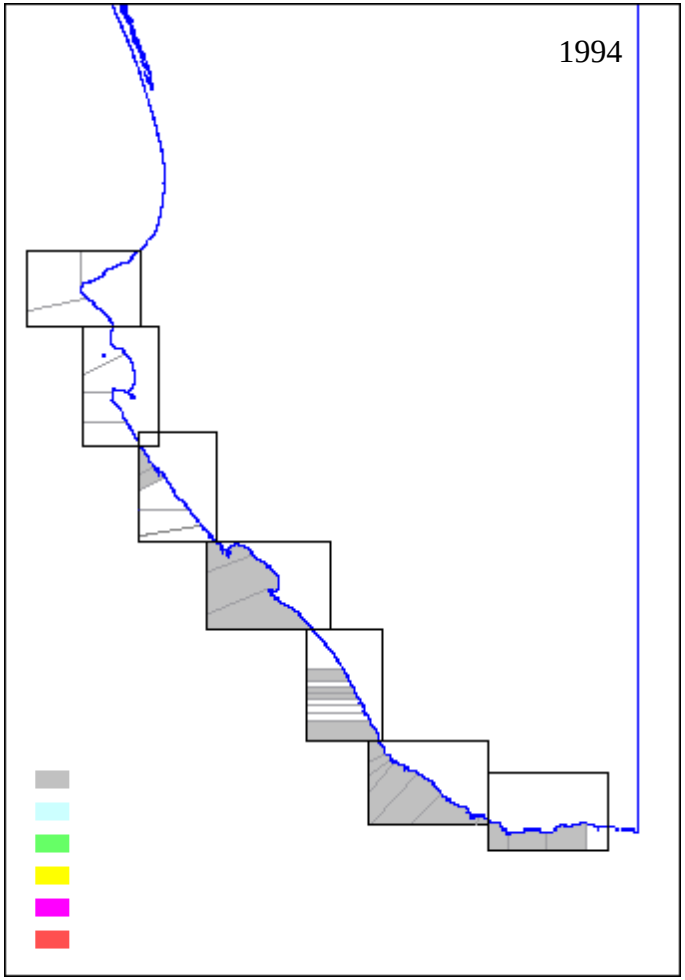


Figure 4.191: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1994

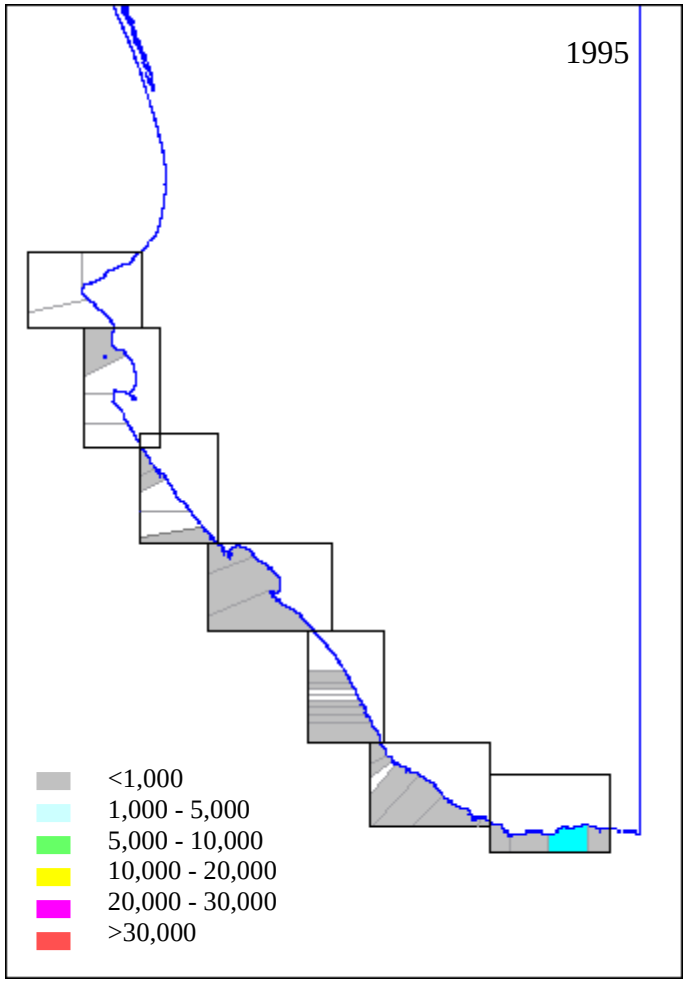


Figure 4.192: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1995

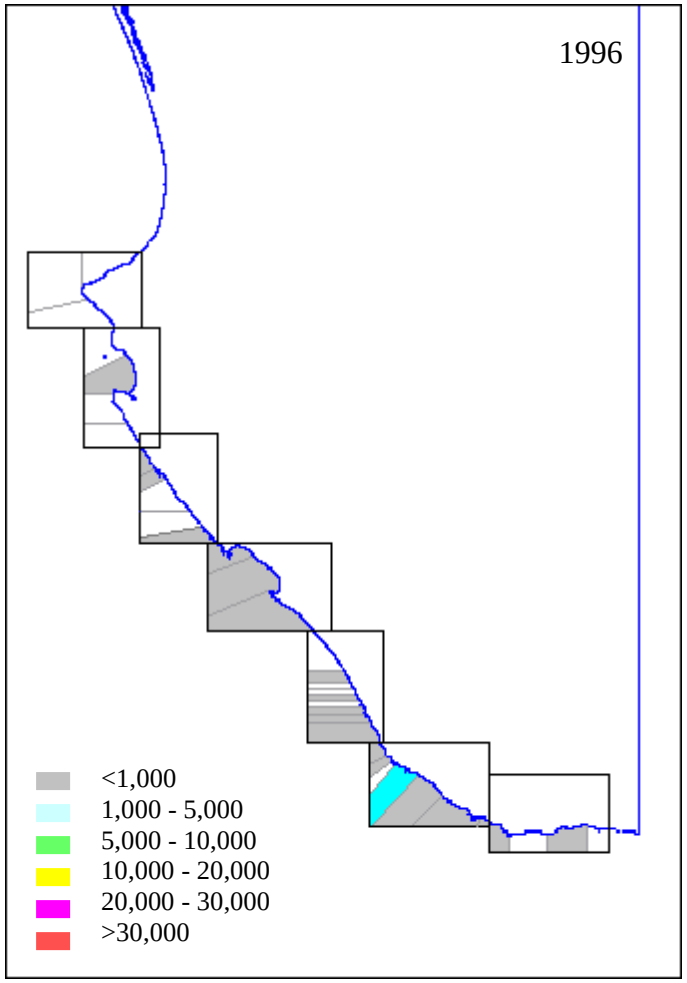


Figure 4.193: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1996

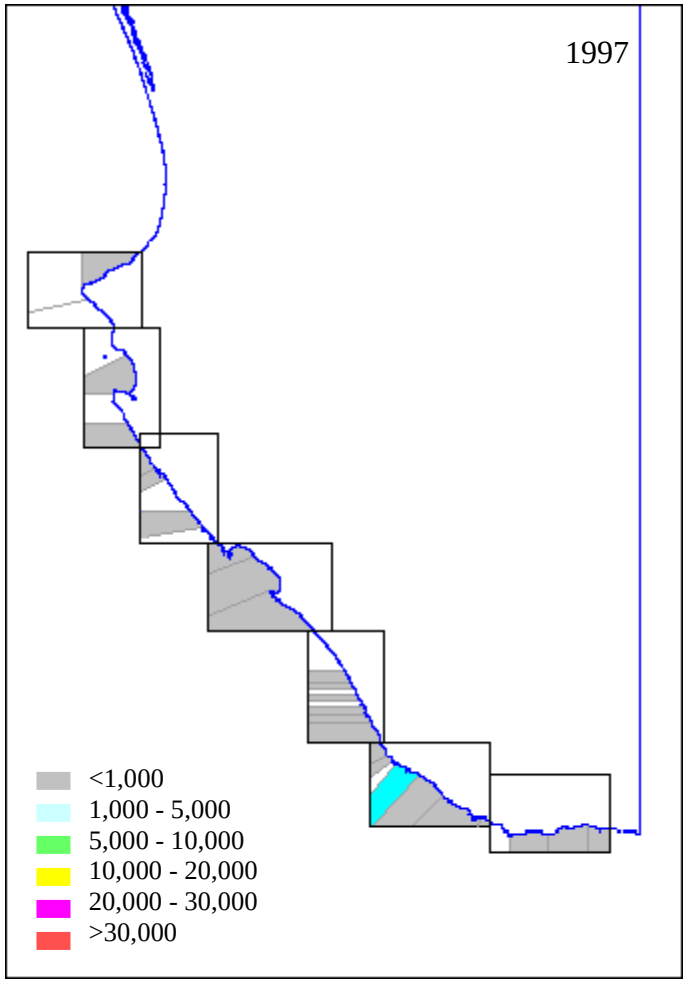


Figure 4.194: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1997

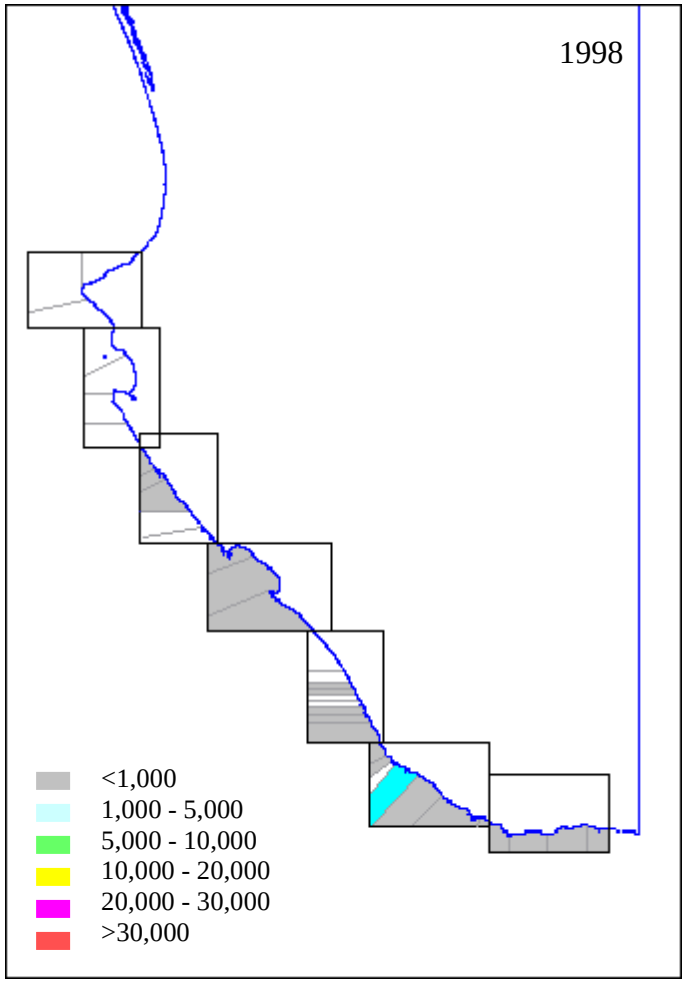


Figure 4.195: The distribution of total greenlip abalone catch (kg) by mapcode in the Southern Zone - 1998

4.4.2 Assessment of Spatial trends in blacklip abalone catches since 1980

Figures 4.196 to 4.214 provide an overview of the broad patterns of blacklip abalone catch distribution between 1980 and 1998.

Blacklip is the mainstay of the Southern Zone fishery and catches are made throughout the zone. By far the largest component of the catch comes from the south of Cape Martin. The majority of the catch is taken in areas such as Ringwood Reef and Lipson Rock (36 B) in the middle part of the zone and the far southern part of the zone south of Carpenter's rocks (maps 39,40).

An important feature of the Southern Zone is "fishdowns" of high density stunted stocks, which are undertaken in different parts of the zone (eg. Ringwood Reef 36B, Bungaloo Bay 39D, Nene Valley 39F and East Port MacDonnell 40A) in different years. This has resulted in a less spatially consistent pattern of catches than in the Western and Central Zones.

Figure 4.196 shows a typical distribution of catches for blacklip in the Southern Zone.

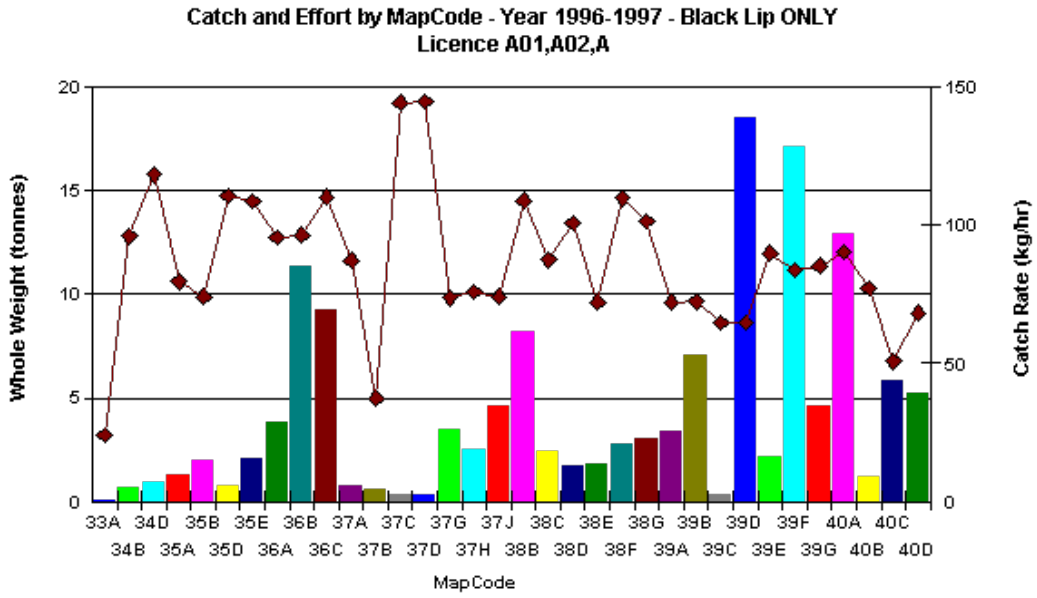


Figure 4.196: The 1996/97 blacklip abalone catch and effort by mapcode within the Southern Zone fishery.

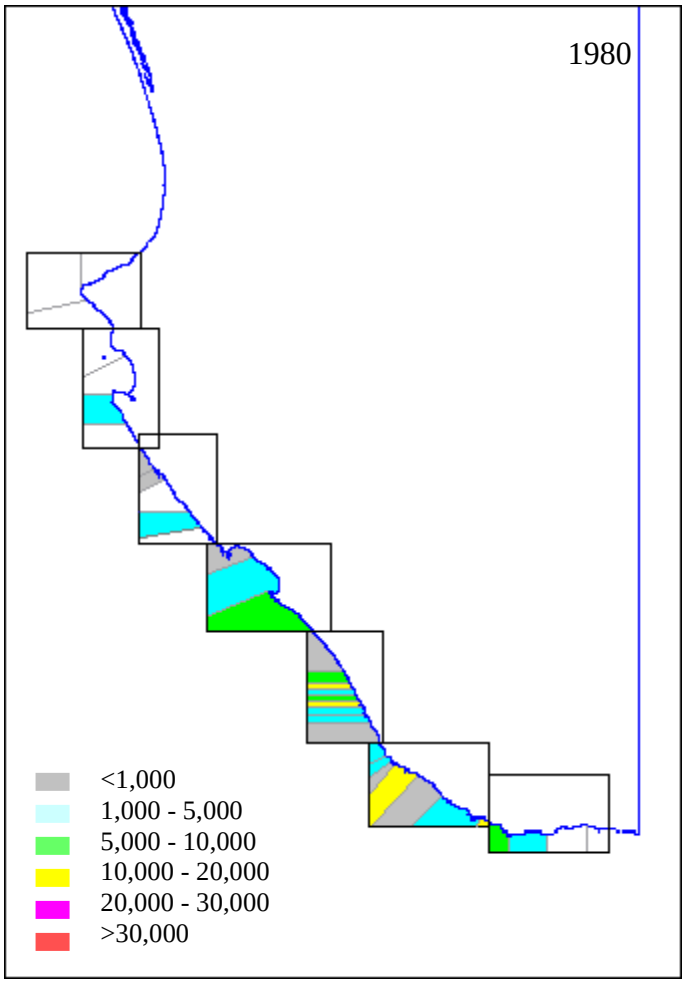


Figure 4.197: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1980

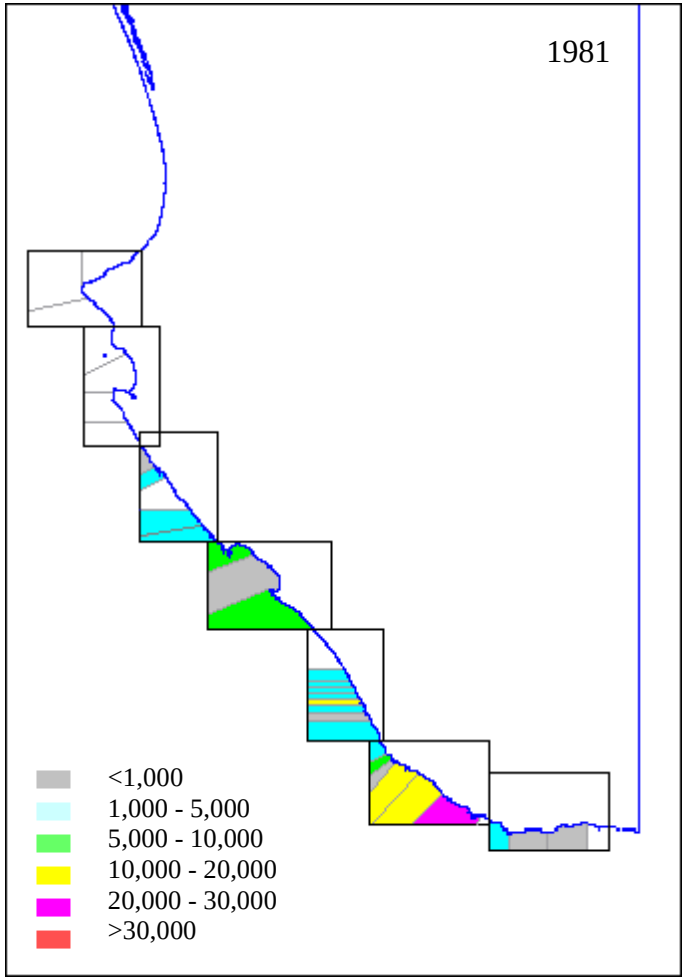


Figure 4.198: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1981

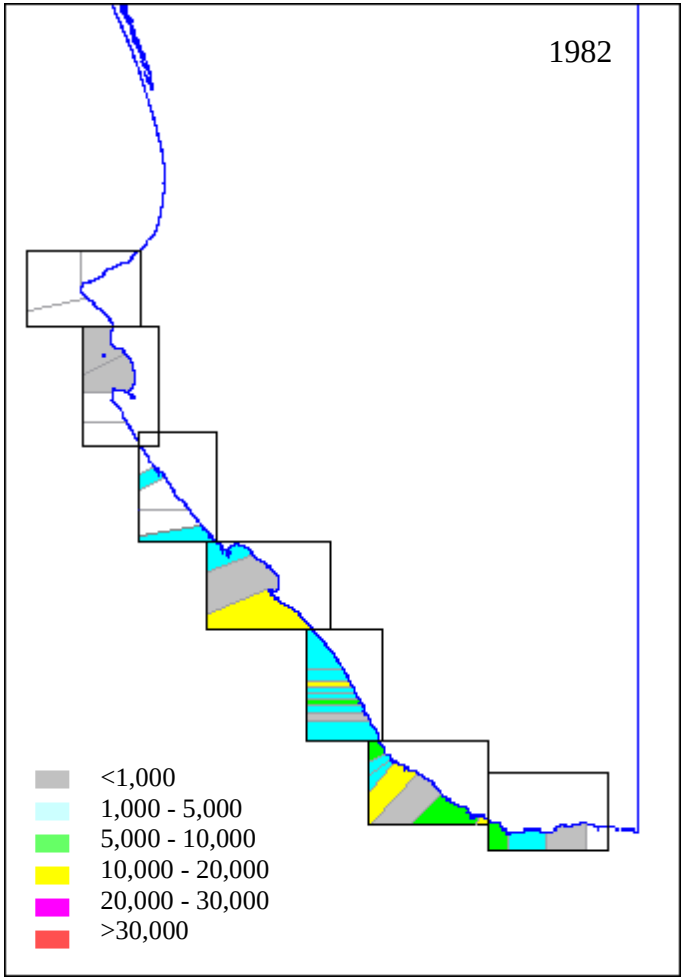


Figure 4.199: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1982

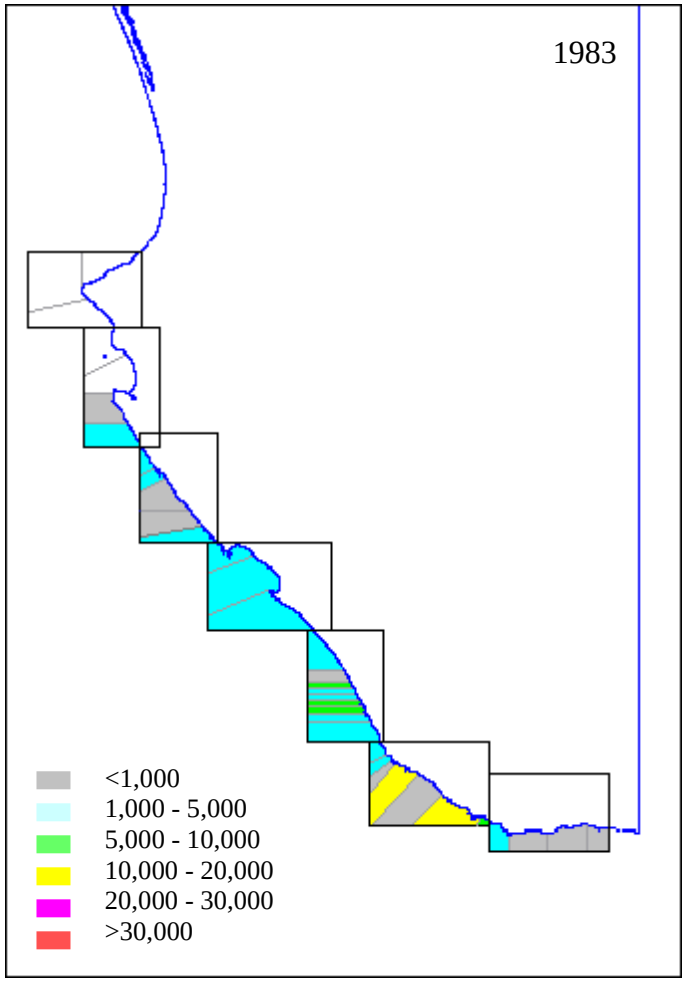


Figure 4.200: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1983

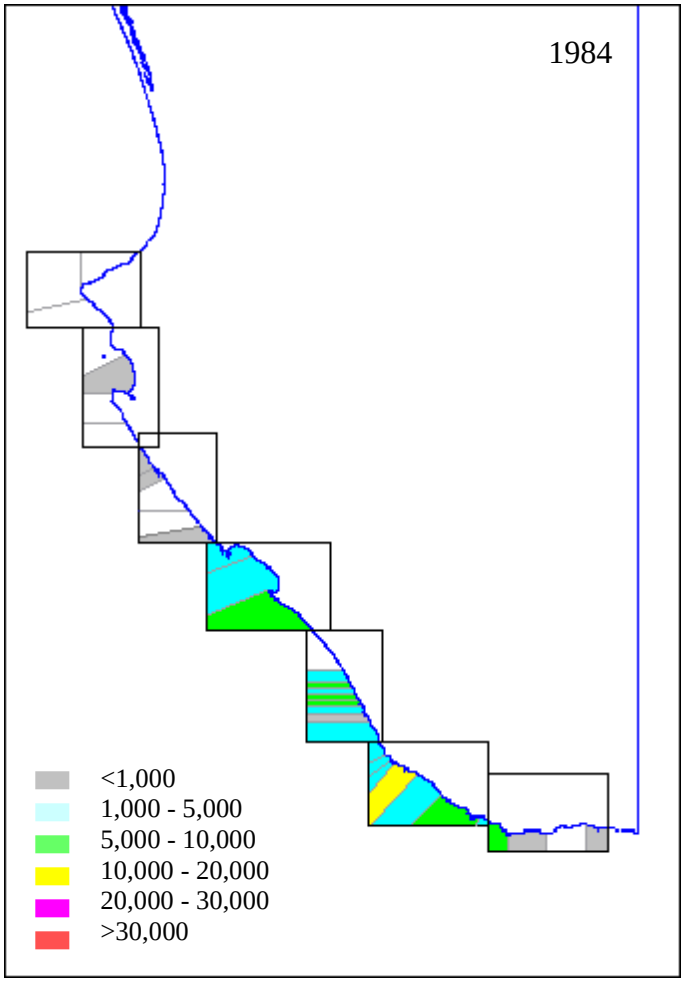


Figure 4.201: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1984

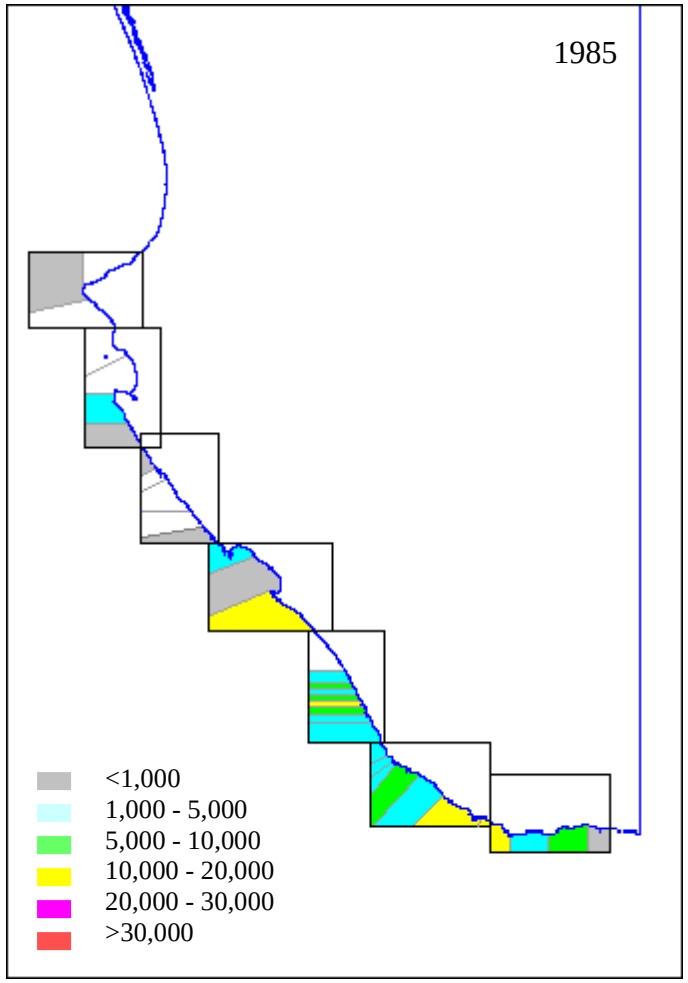


Figure 4.202: The distribution of total blacklip abalone catch (kg) in the Southern Zone - 1985

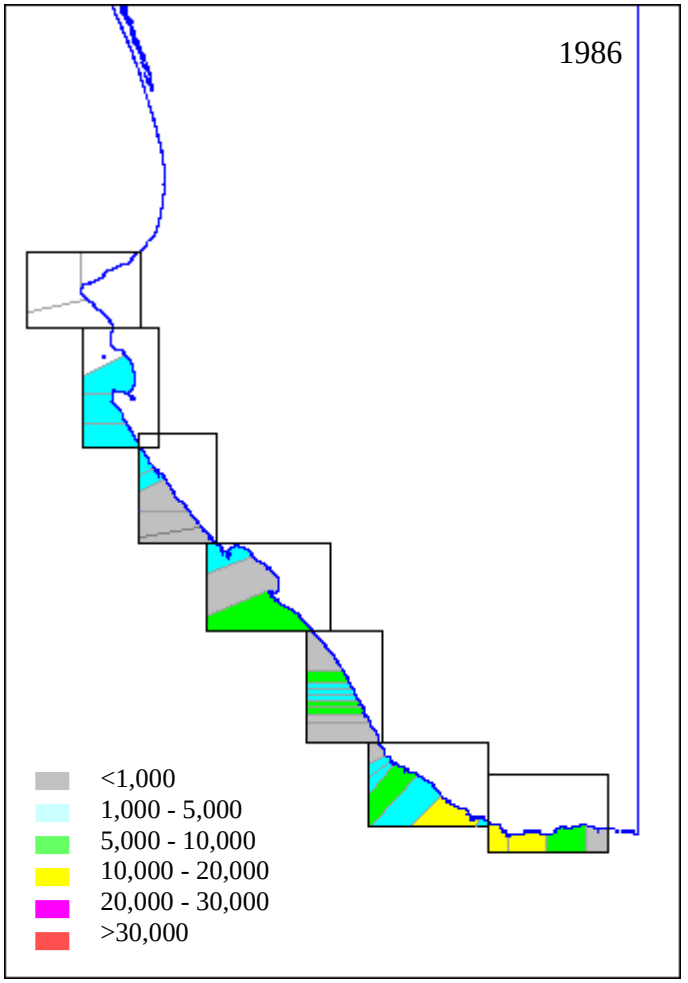


Figure 4.203: The distribution of total blacklip abalone catch (kg) in the Southern Zone - 1986

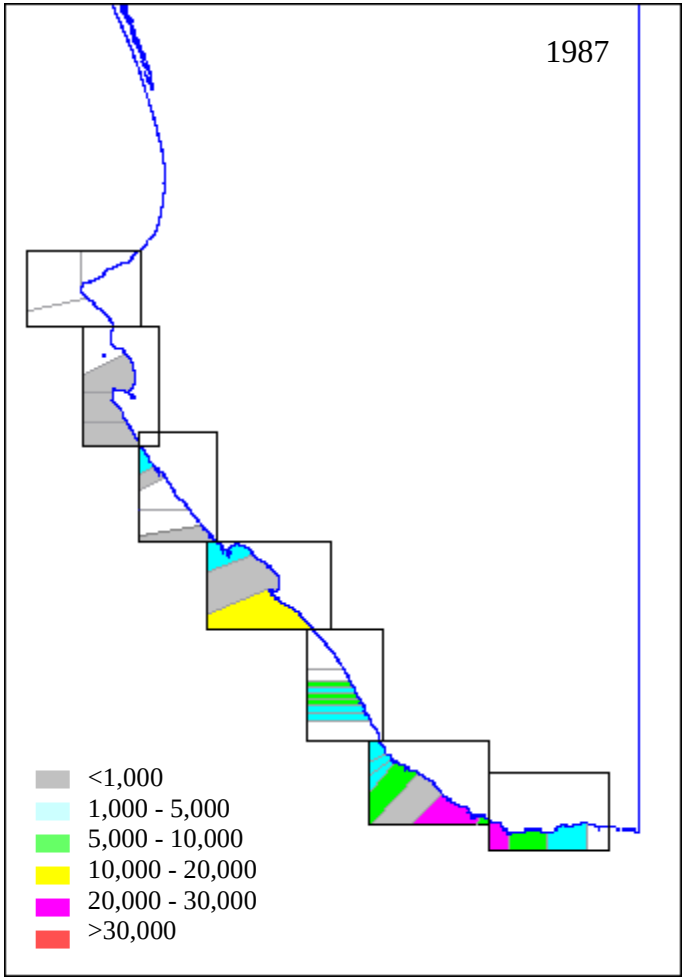


Figure 4.204: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1987

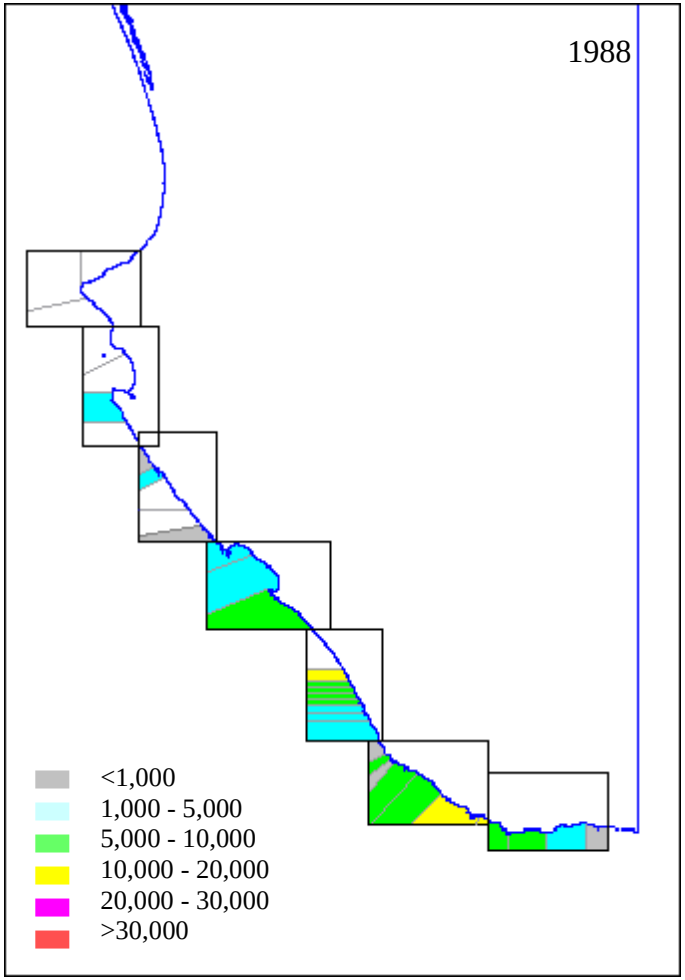


Figure 4.205: The distribution of blacklip abalone catch (kg) by mapcode in the Southern Zone - 1988

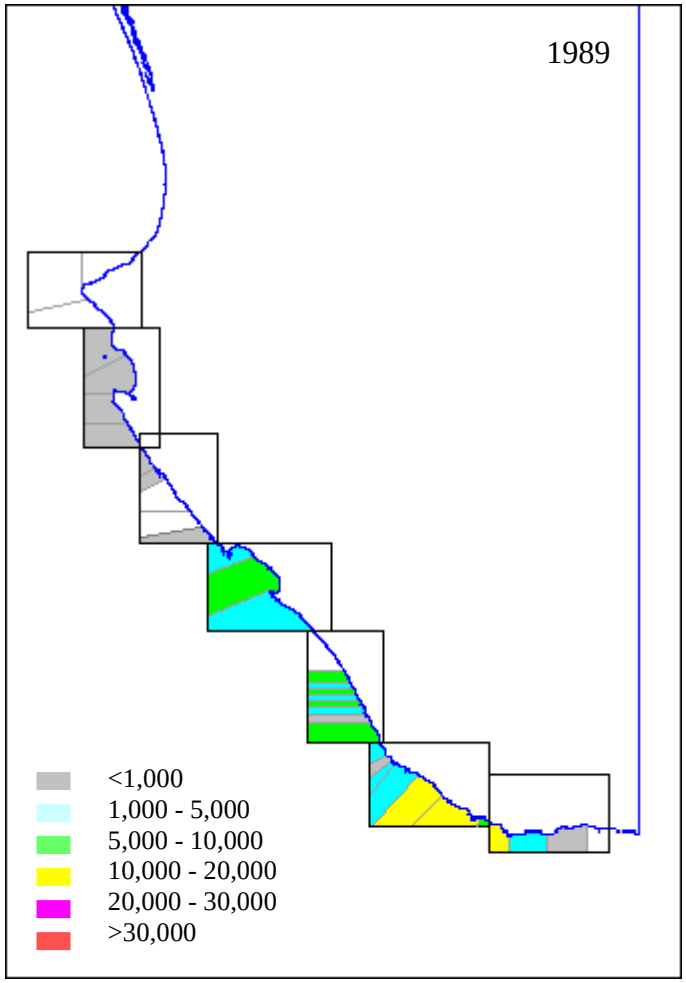


Figure 4.206: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1989

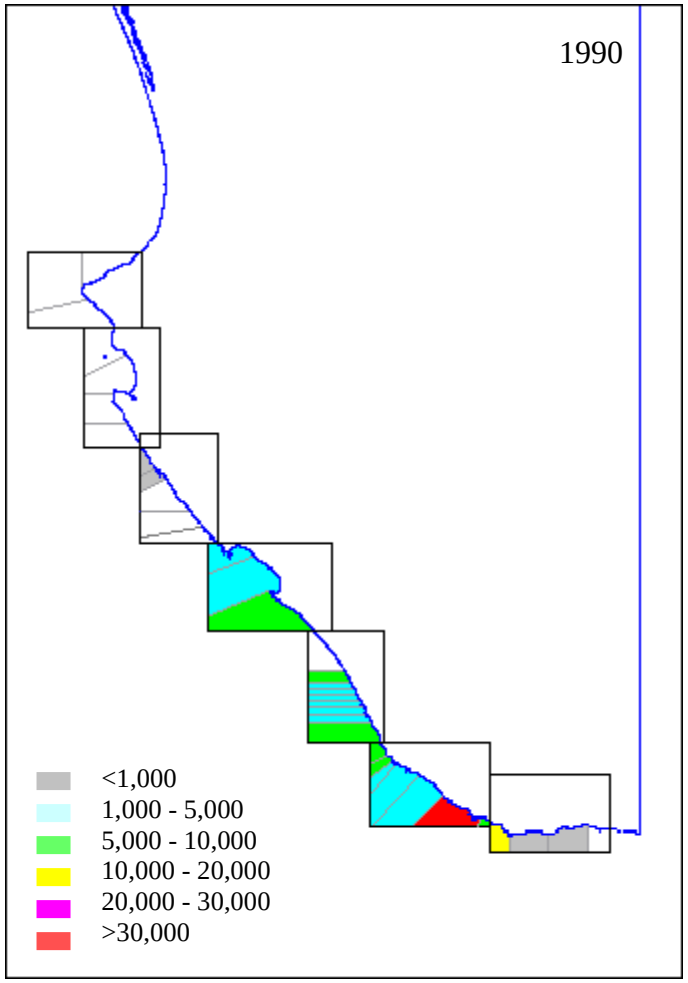


Figure 4.207: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1990

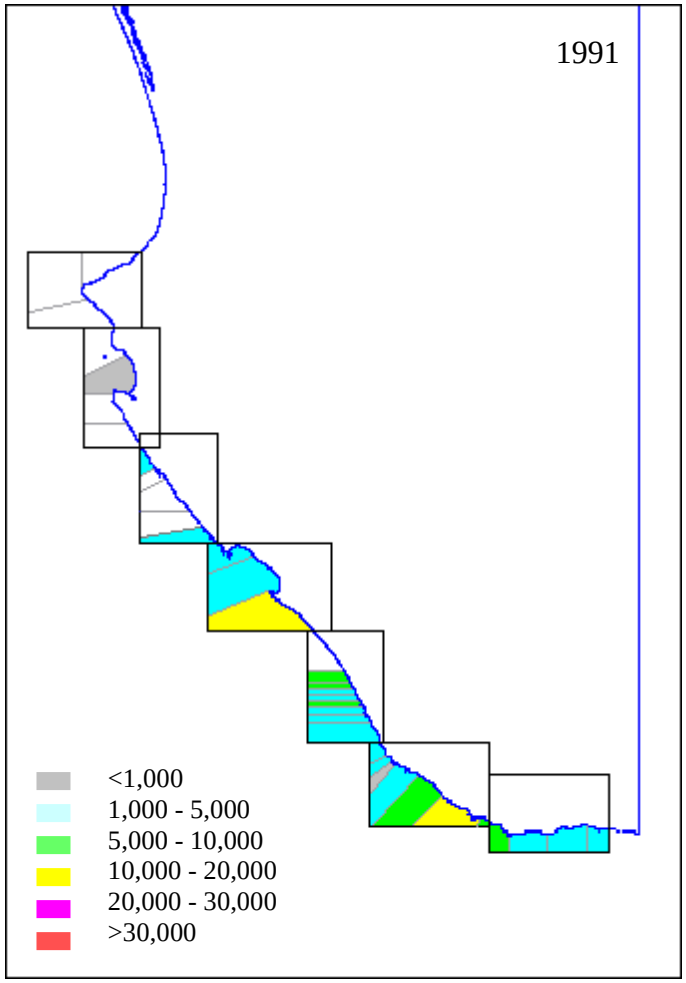


Figure 4.208: The distribution of blacklip abalone catch (kg) by mapcode in the Southern Zone - 1991

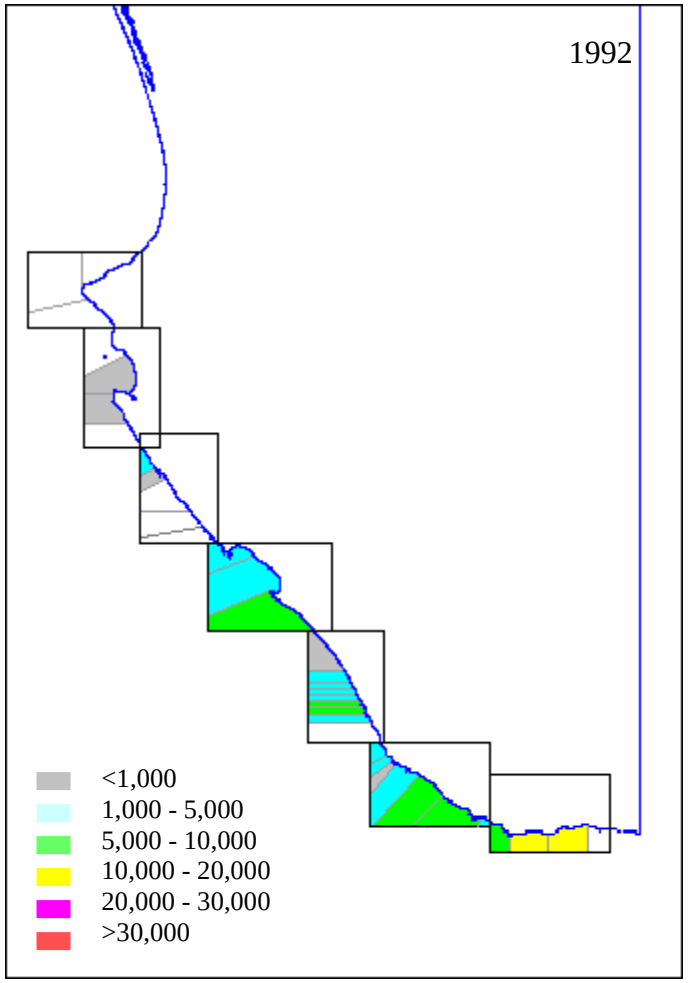


Figure 4.209: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1992

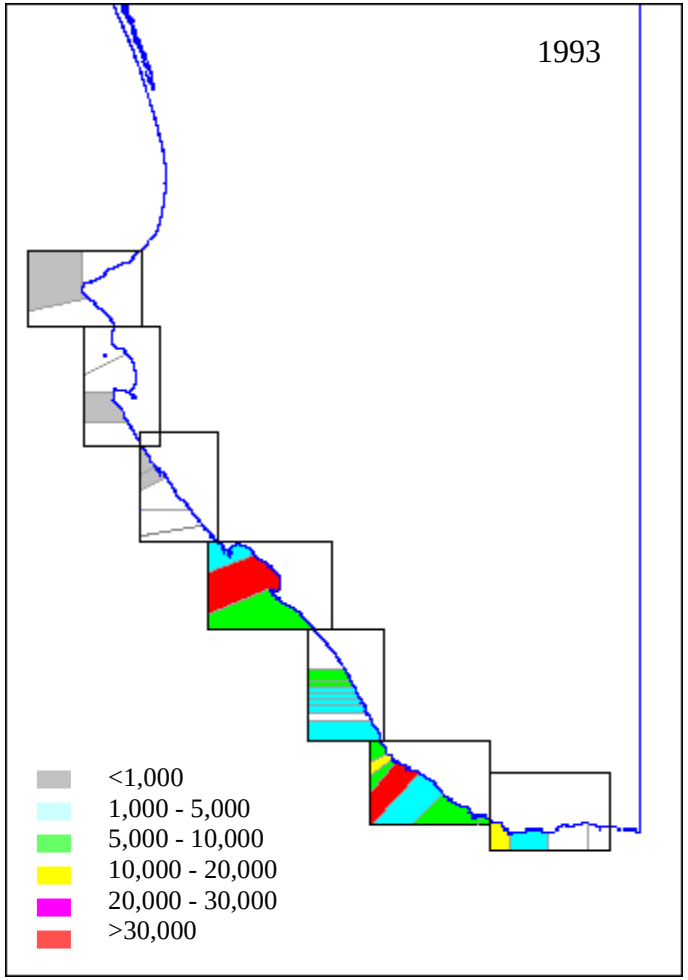


Figure 4.210: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1993

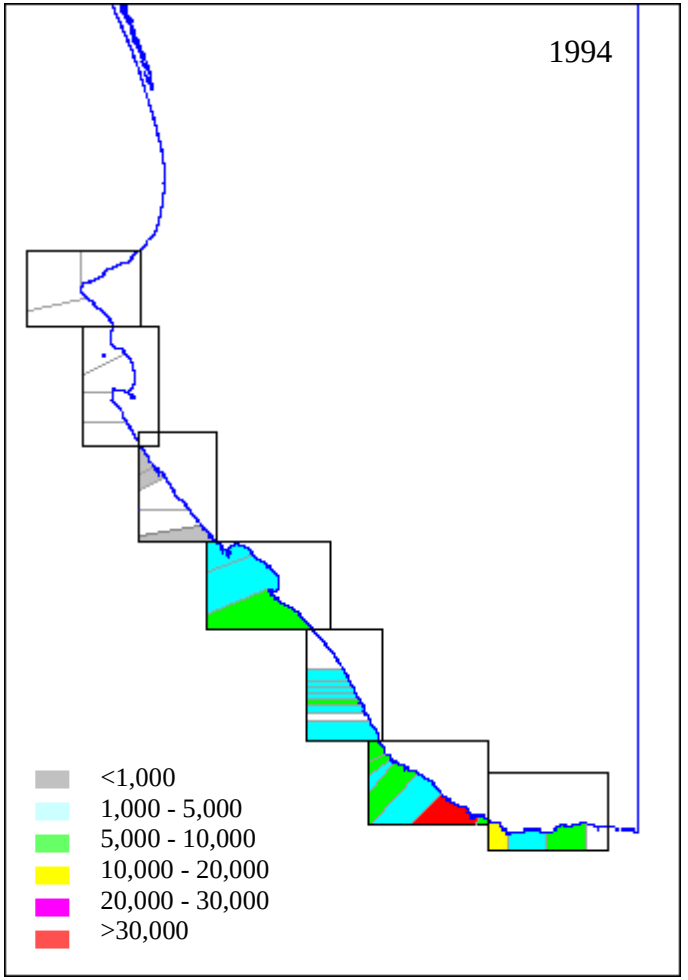


Figure 4.211: The distribution ot total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1994

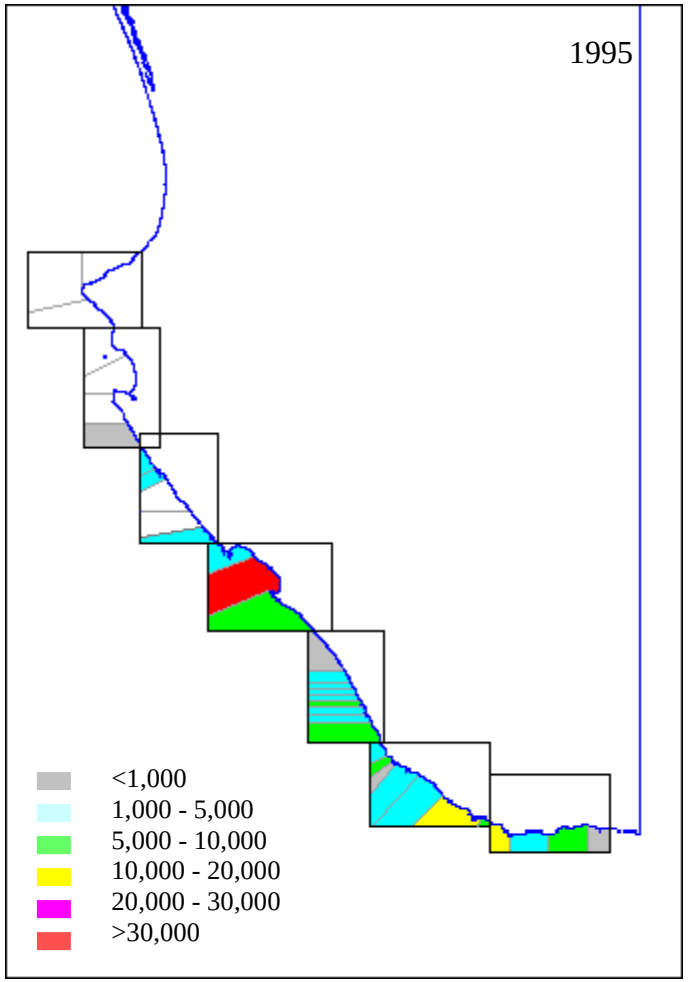


Figure 4.212: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1995

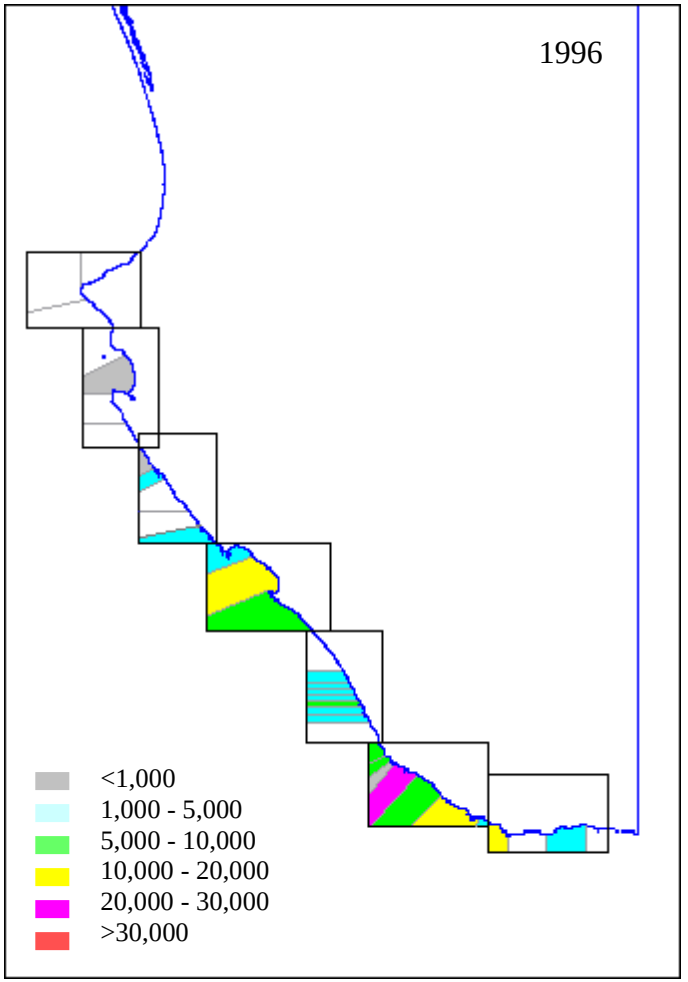


Figure 4.213: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1996

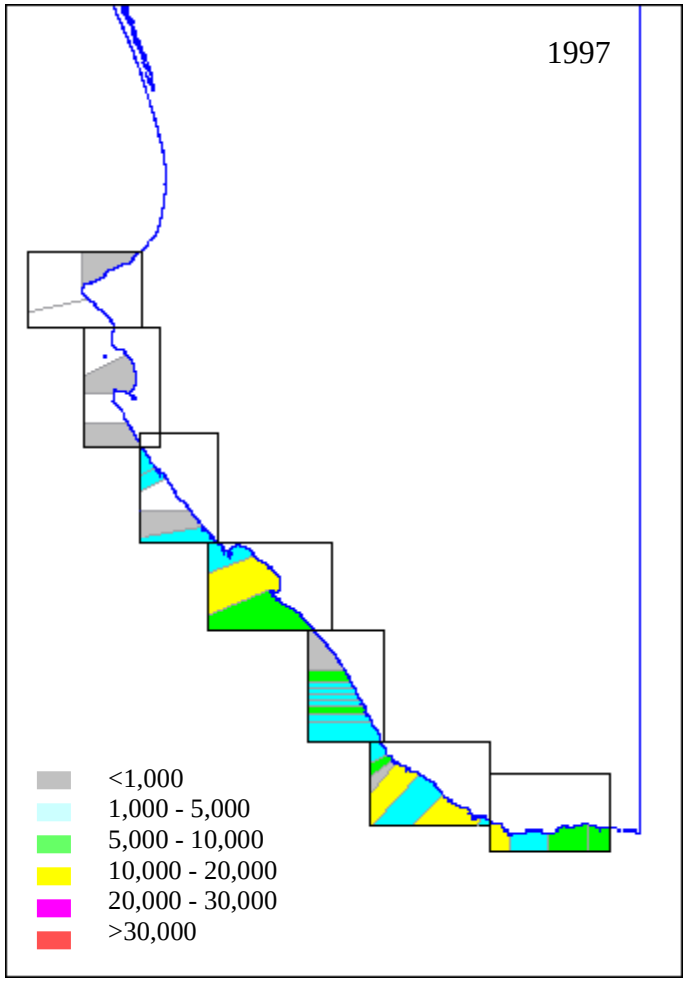


Figure 4.214: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1997

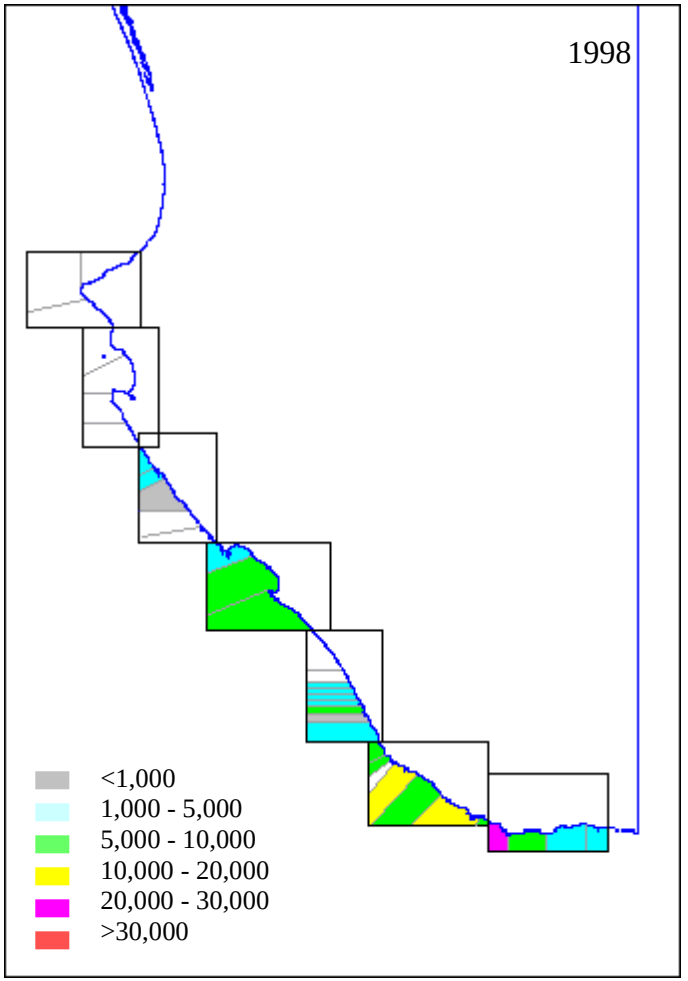


Figure 4.215: The distribution of total blacklip abalone catch (kg) by mapcode in the Southern Zone - 1998

5 SECTION FIVE

"History of fishing" record for licence holders

Objective

Produce a "history of fishing" document of the activity of each licence holder in the fishery for confidential use by that licence holder.

This objective has been exceeded by production of an CD containing individual fishers catch data together with an interactive interface enabling them to examine the temporal and spatial characteristics of their own activities in the fishery. Some fishers declined the offer. CD's were only provided to those who accepted the offer.

5.1 BENEFITS

The outcomes of this project unlock a vast information resource to fishers, researchers and managers. The detailed temporal and spatial analysis of catch patterns will enhance stock assessment within the fishery. Furthermore the analysis can be undertaken at a scale most critical to management of the abalone resource: the metapopulation level. The provision of detailed spatial data to the fishers should enhance their understanding of the resource and assist in maintaining the long term sustainability of this economically important fishery.

Other fisheries should gain a better appreciation of the "value" of not only being able to analyse long term data sets but also data at spatial scales applicable to the populations being exploited. Hence there is potential application of the reporting system not only to abalone fisheries in other states but also to fisheries exploiting spatially discrete aggregations.

5.2 FURTHER DEVELOPMENT

This project can be further developed in 3 areas:

Minor improvements to the output through further programming to deal better with zero data (empty cells in the time/space matrix).

The shell of the ADMRS could be adapted to any fishery with long term data collected on a fine spatial scale.

The project has enabled rapid exploratory data analysis that should be followed by dedicated spatial modelling to further analyse the spatial and temporal interactions in the fishery.

5.3 CONCLUSION

The development of the Abalone Data Management and Reporting System (ADMRS) provides a tool for the storage, retrieval, analysis and reporting of spatial and temporal catch and effort data. Analyses of the South Australian abalone fishery catch and effort data at the finest scale provides an in sight to trends occurring within the fishery. Furthermore it provides information for management at a level most applicable to the sustainabiltity of the fishery, that is, at the meta-population level.

In the Western Zone, the most important areas for greenlip abalone are Thorny Passage, Ward Island, The Hotspot, Pearson Island, Baird Bay, Sheringa and the Avoid Point/Avoid Bay area. Other areas including the Whidbey Isles, Golden and Price Islands and Coffin Bay Peninsula show declining catches in recent years. The most important areas for blacklip catches within this zone are Ward Island, Sheringa, High Cliff, Point Labatt and Venus Bay. Since the introduction of quotas in this zone, catches taken from the Watchers, Drummond and Fishery Bay have declined.

In the Central Zone shows that up to 1984 significant catches of greenlip abalone came from the Edithburgh area however, since 1985 the catches from this area have been almost zero. Declining catches from Cape Jervis are also evident. However the fishing grounds near Point Turtin and Tiparra Reef, Spencer Gulf have become more important in sustaining the fishery. Southern Kangaroo Island, particularly from Cape Bedout to Cape Bouger, is an important source of blacklip abalone within the zone.

In the Southern Zone the main species landed is blacklip. Whilst catches are made throughout the Southern Zone, the largest component of the catch comes from south of Cape Martin especially in Ringwood Reef and Lipson Rock areas.

The ability of ADMRS to enable researchers to extract individual licence holder data and provide these to the respective fisher as a "history of fishing" record will be of benefit for ongoing collaboration between fishers, researchers and managers.

6 SECTION SIX

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7 SECTION SEVEN - APPENDICES

7.1 APPENDIX 1: INTELLECTUAL PROPERTY

The data contained in the ADMRS remains the property of the South Australian government with access defined under the Fisheries Act 1982 and associated policies of the South Australian Research and Development Institute.

The software comprising the ADMRS is the copyright of the South Australian Research and Development Institute. The intellectual property developed in this project is shared between the South Australian Research and Development Institute and the Fisheries Research and Development Corporation and this is defined under an agreement between SARDI and the FRDC. Both SARDI and the FRDC encourage further development of this software for use in other fisheries in Australia and elsewhere. Inquiries should be directed in the first instance to the Executive Director of the South Australian Research and Development Institute.

7.2 APPENDIX 2: STAFF

In addition to the authors, a range of staff have been employed on or otherwise associated with the project. The authors thank:

Mr Fred Brunnings for bringing life to the data through clever and innovative interface and database programming

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Kate Rodda and Brian Foureur for their assistance to JKK with this project and others over many years.

7.3 ACRONYMS AND ABBREVIATIONS

ADMRS	Abalone Data Management and Reporting System
EPR	Egg-per-recruit
FRDC	Fisheries Research and Development Corporation
SARDI	South Australian Research and Development Institute
SAS	Scoresby A. Shepherd
TAC	Total AllowableCatch
TOTCATCH	Total Catch