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FRDC FINAL REPORT

ASSESSMENT OF BROAD SCALE EXPLOITATION RATES AND BIOMASS ESTIMATES FOR THE TASMANIAN SOUTHERN ROCK LOBSTER FISHERY

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1. NON TECHNICAL SUMMARY:

97/101	**Assessment of broad scale exploitation rates and biomass estimates for the Tasmanian southern rock lobster fishery**

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OBJECTIVES:

1. To assess the precision of exploitation rates and biomass estimates derived from broad scale sampling using fishery independent and fishery dependent sampling.

2. To evaluate both the precision and cost effectiveness of biomass estimation from fishery dependent and fishery independent derived exploitation rates and recommend future monitoring methodology for the rock lobster fishery.

A 12-month extension was requested in October 2000 to expand on the initial objectives of the project. Apart from providing us with an additional year worth of data, the following new objectives expanded on objective one.

3. Evaluate the use of fisheries independent lobster pots fitted with escape gaps as a preseason sample for comparison with fisheries dependent catches from the mid and end of the season.

4. To evaluate the potential for multi-year tagging models to provide estimates of exploitation rate.

OUTCOMES:

- The CIR and IR methods could not provide consistent and accurate estimates of exploitation rate under changing management scenarios. The need for accurate estimates of biomass to update and validate the assessment model remains a high priority for Industry and Government. As a result of this project, a review of the Tasmanian rock lobster catch sampling project by Industry, Government and Researchers adopted and endorsed a new sampling strategy.

- Government and Industry endorsed evaluating multi-year tagging methods as they overcome the catchability and moulting (recruitment) issues that were found to bias estimates using the CIR and IR methods.
- Funding proposals are being developed to evaluate the suitability of multi-year tagging models to provide accurate estimates of exploitation rate from all regions of the fishery.The poor participation by fishers in this project highlighted to Industry and Management that participation by fishers in research was difficult when income was being compromised. Based on these results, the Crustacean Fishery Advisory Committee recommended that an allocation of 1% of the total allowable commercial catch be made available to compensate fishers for loss of income when undertaking research. Industry and Government have accepted this allocation.
- This project identified the need to improve fisher co-operation in returning tags and strategies to improve tag return rate are being adopted in association with Industry.

NON TECHNICAL SUMMARY:

Exploitation rate is an important fishery assessment parameter linking catch to legal-sized biomass, the portion of the stock available for harvest. Relative change in legal-sized biomass is a crucial performance indicator for the fishery as it measures the success of management outcomes. Under the recently introduced Individual Transferable Quota Management System (ITQMS) in the Tasmanian rock lobster fishery, rebuilding of legal-sized biomass is a key management objective. The assessment model that produces biomass estimates for this fishery is primarily dependent on commercial catch and effort data.

The use of commercial catch and effort data for stock assessment relies on its *de facto* relationship with stock abundance. However, the relationship between catch and effort data and abundance is not always constant or linear. Improvements in fishing gear and technology can result in greater catch for a given amount of effort, unrelated to changes in the biomass. Management changes and fishers' behaviour can also affect the relationship between catch rates and biomass. Under the new ITQMS introduced in 1998, catch is fixed and improved profits can be made by improving the return per unit of fish caught rather than by increasing the amount of catch through increased effort. Thus fishing during periods when catch rates are low but price is high can change the catch effort relationship independent of biomass change.

Fishery independent surveys, using established sampling protocols and standardised fishing gear are a way in which catch rates can be standardised irrespective of gear efficiencies or fisher's behaviour. If these surveys can also produce accurate estimates of exploitation rate then accurate estimates of biomass can be achieved, provided the exploitation rate estimates are representative of the fishing grounds. Fishery independent estimates of exploitation rate are thus a valuable way of validating model biomass estimates especially with the introduction of an ITQMS where the relationship between catch rates and legal-sized biomass was likely to change pre- and post-quota.

This project aimed to trial change-in-ratio (CIR) and index-removal (IR) techniques to obtain estimates of exploitation rate and biomass from broad scale regions in the fishery. To compliment fishery independent sampling, the fishing industry agreed to provide data that could also be used to estimate exploitation rate using these

techniques. It was anticipated that if the accuracy and precision of estimates from fishery derived data was comparable to fishery independent data then this would be a more cost-effective way of obtaining this important assessment parameter.

Initial appraisal of the exploitation rate determined that the CIR and IR methods produced variable and different estimates. A concurrent study undertaken in the Crayfish Point Scientific Reserve demonstrated that catchability varied markedly throughout the year, which violates an important assumption of the IR technique. Changes in catchability between surveys do not affect the CIR technique provided both size classes used to estimate exploitation rate are affected equally. To minimise possible changes in catchability affecting the undersized and legal-sized components we used narrow size classes on either side of the minimum size limit. Two simple diagnostic tests were developed to determine the extent of catchability change and its impact on exploitation rate estimates for both methods.

After applying these diagnostic tests to surveys undertaken on the south and east coasts, nearly 50% of the estimates were biased by catchability changes between sampling periods. Comparing the two methods, the CIR method was found to be a more reliable estimator of exploitation rate than the IR method because it was less affected by changes in catchability of lobsters within the fishing season. The CIR technique provided greater certainty in the estimates from southern and western regions of the fishery than it did for the eastern regions that were affected by smaller sample sizes associated with lower catch rates. Differences in exploitation rate estimates were also found with depth on the south coast.

These results showed that future stock assessments would need to separate deep and shallow water fishing grounds when determining exploitation rate and biomass estimates. In addition, size-specific catchability changes occurred over small size groupings and compromised the use of the CIR estimator.

While exploitation rate estimates were obtained for most fishing seasons there was a change in the length of the fishing season during the course of the study. Extending the fishing season into part or all of September allowed fishers to target recently moulted lobsters. Prior to the September opening the annual male moult occurred during the closed season and thus pre-season surveys sampled the rock lobster population after full recruitment to legal size. With the fishing of new recruits in September, pre-season surveys undertaken in late October/early November sampled a population that was already partially exploited. This compromised the CIR method.

Due to the inconsistent results obtained using the CIR and IR methods as well as the impact of the extended opening of the fishing season, a new objective was added to the project. This objective was to validate the use of multi-year tagging models as a method of determining exploitation rate. These tagging models follow the fate of tagged legal sized individuals and are therefore unaffected by recruitment (moulting from sub-legal to legal size). To test the method a substantial increase in the number of tagged animals was undertaken. Despite the potential of the method, it failed due to the very poor co-operation of the industry in returning tags.

Industry cooperation in research is perceived to be a way in which research costs can be minimised. The fishing industry was approached to provide catches of sized and undersized lobsters with the intention of using this data to derive fishery dependent catch rates using the CIR and IR techniques. Initial trials showed promise although fishers found it difficult to fish in the same location when catch rates were higher in other regions of the fishery. Despite attempts to improve fisher participation, by increased awareness and personal contact the number of participants did not increase. However, in the last year the amount of data obtained from the few fishers that did participate increased and we were able to analyse this data. Exploitation rate estimates obtained from fisher's data were lower than research estimates and this was considered to be due to fisher's maintaining hyper-stable catch rates by shifting to a new location as catch rates declined in the existing location. This highlighted the need for pre- and post-season sampling to be focused on the same area. With the introduction of quota, fishers no longer went to sea at the start of the fishing season, rather they waited until the 'price was right' before commencing fishing. As the start of season sample (equivalent to fishery independent pre-season survey) is crucial for estimating exploitation rate we considered matching pre-season fishery independent surveys undertaken using research pots with escape gaps with middle or end of season fisher's samples. Unfortunately, the bias in the pre-season fishery independent survey by the extension of the fishing season made this comparison inappropriate.

The lack of participation by industry in this project highlighted to the fishing community that industry cooperation cannot be guaranteed. Based on the lack of participation in this project, the industry approved a research quota allocation of 1%. This allocation is to be used to compensate fishers undertaking research surveys. Thus, fishers would be compensated for fishing in regions of lower catch rates or when their legal sized catch was returned to the sea (eg. tagging and/or fishing in closed season).

Results from this project formed the basis of a review into future catch sampling in the Tasmanian rock lobster fishery. The review panel, which consisted of scientists, Industry and Government, met in May 2002. The panel reiterated the need for accurate and reliable estimates of exploitation rate as its foremost priority. Based on the results of this project, further trials using multi-year tagging models were recommended. Research quota will be used to ensure regional estimates are obtained and deep and shallow water areas will be targeted. Dorsal tagging and increased contact with fishers through regular port visits are two options being adopted to improve tag-reporting rate.

KEYWORDS: southern rock lobster, change-in-ratio, index-removal, exploitation rates, tagging.

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2. Background

There has been considerable effort to develop models to assess rock lobster stocks (Walters *et al*., 1993; Walters *et al*., 1997; Punt and Kennedy, 1997). These models are however still dependent on catch and effort data from the commercial fishery as a primary data source. Although these models have proven to be extremely useful assessment tools, they assume that a change in catch and effort reflects a change in abundance. However, improvements in fishing gear (synthetic ropes, metal fabrication etc.) and technology (pot haulers, echo sounders, GPS) have enabled fishers to improve the efficiency of each trap set. Fernandez *et al* (1997) found colour echo sounders and GPS to have improved the efficiency of catching deeper water rock lobster in Western Australia by 15 to 20%. Management changes can also affect the meaning of CPUE data. The change to an Individual Transferable Quota Management System (ITQMS) in the Tasmanian rock lobster fishery in 1998 has the potential to substantially change the relationship between CPUE and abundance. Under an ITQMS, fishers are maximising profits by maximising the value per kilogram of lobster landed rather than by maximising catch. This has the potential to radically alter the relationship that CPUE had with lobster abundance prior to implementation of the ITQMS. While the impact of the ITQMS on the fishery is being explored in a separate FRDC project (1999/140), ways of comparing pre- and post- quota catch rates are considered crucial. Fishery independent sampling is a way in which both the impact of effort efficiencies and profit maximisation on CPUE data can be standardised.

Exploitation rates are considered an important parameter in assessing the status of fish resources. In most fisheries, catch is often accurately known through logbooks or landing documentation and, when combined with accurate estimates of exploitation rate, accurate estimates of biomass are available. The importance of exploitation rate lies in its link to biomass. Although biomass is a common fishery performance indicator, it is extremely difficult to estimate accurately without knowledge of exploitation rate.

Biomass estimates in the Tasmanian rock lobster fishery are obtained from the rock lobster assessment model (Punt and Kennedy, 1997). Biases in these estimates are likely to occur if changes in commercial catch rate data are unrelated to abundance changes. Fishery independent estimates of biomass are therefore crucial in a fishery where catch rates are likely to be affected by fisher behaviour rather than stock abundance. Such is the case with implementation of the ITQMS in the Tasmanian rock lobster fishery. Fishery independent estimates of exploitation rate are considered important both for addressing performance indicators of the fishery (i.e. estimating biomass) and for validating model outputs.

Validating model outputs against fishery independent data is crucial in ensuring that both the current assessment and future quota scenarios are robust. The harvest strategy evaluation component of the assessment model is the primary input into setting of quota amounts in the Tasmanian rock lobster fishery.

In 1992, the Tasmanian Government implemented a fishery independent catch sampling project with two major aims. The first was to establish a standardised fishing protocol that could be used in the future as a control to compare changes in catch rates in the fishery. The second was to evaluate methods to estimate exploitation rates and thus biomass in the fishery. This project is focused on the second major aim.

In southern regions of the Tasmanian rock lobster fishery, there is an annual moult for males (September/October) and females (May). The fishery for both sexes closes prior to the respective moult (31st August for males and 30th April for females) and opens in November for both sexes (Figure 1 – see Section 5.1.1.2). Thus, both sexes have full recruitment to the fishery at the start of the fishing season and no further recruitment occurs until after the fishing season for each sex. Observed changes in catch rates are thus related to depletion of the resource.

Trials using catch curve and depletion analyses, which are based on fishery dependent data, were of limited success in determining exploitation rate due to insignificant variation in fisher's catch rates through out the year, inability to age lobsters, and lack of discrete age-classes due to the high level of exploitation. Although a decline in fisher's catch rates is observed in the fishery, these declines are considered underestimates as the region that fishers report their catch in is large and thus catch rates could be maintained by serial stock depletion within the reporting areas.

Fishery independent surveys overcome this concern by using identical pots fished in the same region in both pre- and post-season fishing surveys. Thus, methods such as the change-in-ratio (CIR: Paulik and Robson, 1969) and index-removal (IR: Eberhart, 1982) that measure declines in the ratio of two components of the fishery (CIR) or catch rates (IR) appeared suited to the fishery and were evaluated.

Both the decline in the ratio of legal-sized to undersized (CIR) and the decline in catch rates (IR) between the start and end of the fishing season are considered to be due to exploitation. An evaluation of these techniques is presented in Chapter 5.1.

During the course of this FRDC project, Hoenig *et al* (1998) and Hearn *et al* (1998) published papers which used multi-year tagging data to estimate fishing and natural mortality rates. By combining the approaches of these authors, we were able to develop a model that could be used on tag recapture data obtained from tagging legal-sized lobsters in northwestern Tasmania from 1992 to 1995 (Frusher and Hoenig, 2001, in review). Unfortunately, too few legal-sized lobsters had been tagged in southern and eastern regions of the fishery for similar analyses to be undertaken. This was because the tagging project was focused on growth and movement and it was considered that legal-sized tagged lobsters would be caught before they moulted or moved due to the high exploitation rates. Based on the success in estimating precise fishing mortalities (relative standard error of <0.2), we commenced tagging larger numbers of legal-sized lobsters and requested a twelve-month extension to the project to enable three years of tagging to be undertaken. A comparison of these estimates and those obtained from the CIR and IR methods could then be undertaken. This work is reported in Chapter 5.2.

Industry cooperation in research is perceived to be a way in which research costs can be minimised. The fishing industry was approached to provide catches of legal-sized and undersized lobsters with the intention of using this data to derive fishery dependent catch rates using the CIR and IR techniques. Hyper-stability in fisher's catch rates can occur when fishers move to regions of improved catch rates as catch rates decline in existing fishing sites. To minimise this scenario, fishers who volunteered to participate in this component of the project were asked to obtain their end of fishing season sample from the same location that they obtained their start of fishing season sample (Chapter 6.1).

Although fishers report the total number of sized and undersized lobsters, their pots have mandatory escape gaps, which result in the size range of undersized lobsters being 5mmCL or less under the legal size limit. Thus, as with the size classes used in the fishery independent component of this project, behavioural difference between the undersized and legal-sized components used to estimate exploitation rate by the CIR method would be minimal. Exploitation rate estimates obtained from fishers data are outlined in Chapter 6.1.

3. Need

Management of Tasmania's valuable rock lobster fishery is based on annual fishery assessments. These assessments utilise a spatially explicit size structured assessment model as a primary assessment tool. This model also enables harvest strategies (i.e. different quota amounts) to be evaluated against changes in egg production and legal-sized biomass. Although the model uses a number of inputs such as regional growth and size structure, it is strongly dependent on catch and effort data (CPUE) derived from commercial logbooks. The use of CPUE data relies on its *de-facto* relationship with lobster abundance (legal-sized biomass). Increases in CPUE are considered to reflect increases in legal-sized biomass. Increases are related to either improved recruitment or decreased fishing mortality (and thus more legal-sized lobsters remaining in the fishery after the fishing season). However, other factors can affect CPUE, which are independent of changes in abundance. These include technological improvements that have increased the efficiency of sampling (e.g. if an echo sounder enables a fisher to set all his pots in prime habitat then his catch rates would increase compared to setting a portion of his pots in poor lobster habitat without an echo sounder). Changes in management of a fishery can also influence fishers behaviour. This is particularly the case in the Tasmanian rock lobster fishery where management changed from effort (input) control to quota (output) control. Under input controls, CPUE was based on fishers maximizing their total catch. In contrast, under output controls where total catch is predetermined, fishers are expected to alter their fishing behaviour to maximise the return (dollars per kilogram) from their catch. In the Tasmanian southern rock lobster fishery, the beach price of lobsters increases from the opening of the season in November to the close of the season in September. During this period, the price of lobsters virtually doubles. In contrast, catchability of lobsters is higher in summer after their annual moult (Ziegler, pers. comm.). Thus, there is significant potential to alter fishing patterns to maximise economic return, especially through seasonal shifts in effort. Effort may no longer reflect the abundance of legal sized lobsters but rather a balance between the economics of the fishery operation and the beach price of lobster. This would be expected to vary from operator to operator. For instance, vessels whose operation costs are high may favour fishing in periods where catch rates are highest. While vessels whose operation costs are low may prefer to undertake more trips to catch higher priced lobsters in August.

To ensure that outputs from the assessment model that influence management decisions are appropriate, estimates of biomass produced independently from the model are necessary. Fishery independent estimates would be ideal, however, the cost associated with such estimates is high. Using fishery derived data that is 'quasi-controlled' (i.e. constraining fishing times and locations) would be a cost-effective option.

This project was aimed at evaluating fishery independent and dependent means of deriving exploitation rate and biomass estimates and by determining the precision of these estimates, demonstrate their suitability as biological reference points.

4. Objectives

Two objectives were initially proposed with the intention of focussing the project on the estimation of exploitation rate and biomass.

1. To assess the precision of exploitation rates and biomass estimates derived from broad scale sampling using fisheries independent and fishery dependent sampling.

2. To evaluate both the precision and cost effectiveness of biomass estimation from fisheries dependent and fisheries independent derived exploitation rates and recommend to future monitoring methodology for the rock lobster fishery.

A 12-month extension was requested in October 2000 to expand on the initial objectives of the project. Apart from providing us with an additional year worth of data, the following new objectives expanded on objective one.

3. Evaluate the use of fisheries independent lobster pots fitted with escape gaps as a preseason sample for comparison with fisheries dependent catches from the mid and end of the season.

4. To evaluate the potential for multi-year tagging models to provide estimates of exploitation rate.

5. Fishery Independent Estimates of Exploitation and Biomass

5.1. Change-in-Ratio and Index-Removal

5.1.1. Sampling Design

5.1.1.1. Introduction

The CIR technique looks at the change in ratio of the relative abundance of two discrete components of a population between two sampling times. It assumes (i) that all factors, such as emigration, natural mortality, etc., that affect the population, affect the two components of the population under study equally; (ii) the population can be divided into two distinct and non-overlapping components; and (iii) that the probability of capturing animals does not vary by component for each sampling period. However, the probability of capturing animals can change from one sampling period to the next.

The IR technique looks at the change in catch rate between sampling periods and attributes this change to removals from the fishery (i.e., harvested lobsters). Hoenig and Pollock (1995) outline the assumptions of this method as follows: (i) the population is closed except for removals; (ii) all animals have the same probability of capture in surveys and this probability does not vary from survey to survey; and (iii) sampling is with replacement or the fraction of the population taken in the survey is negligible.

A major advantage of the CIR technique over the IR technique was that the probability of capturing animals could change from one sampling period to the next. Thus, catchability, emigration or immigration and natural mortality could change between sampling periods providing it affected both components used in determining the CIR estimate equally.

The rock lobster fishery has a mandatory size limit for each sex and thus the catch can be split into ‘legal size and above’ (legal-sized lobsters) and ‘below legal size’ (under-sized lobsters) for each sex. The ratio of legal sized and under-sized components of each sex recorded during research surveys is used for estimation of exploitation rates using the CIR technique. To minimise any size-specific differences in catchability, natural mortality or behaviour between the legal-sized and undersized components, Frusher *et al*., 1998 suggested using small size grouping either side of the minimum legal size limit to estimate exploitation rate. In this study, the undersized category of males corresponded to the size class from 106.5 to 109.9 mmCL and the legal sized class was 110.0 to 113.5 mmCL for the south coast. The undersized class and legal sized classes corresponded to 101.5 to 104.9 and 105.0 to 108.5 for females and 101.5 to 109.9 and 110.0 to 118.5 for males respectively on the East Coast. Catch rates (number per pot) of the legal sized component of each sex are used in the IR technique.

Migrations have been shown to be minimal in southern regions of the Tasmanian rock lobster fishery and natural mortality estimates are considered to be low (<0.15; Frusher and Hoenig, 2001; R. B. Kennedy, personal communication) and to affect both components of each sex equally.

5.1.1.2. Sampling design

The first sample (pre-season) was taken in late October/early November of each year, which is after the male and female moults and before the start of the fishing season (Figure 1). The second sample was taken each March prior to the female moult to determine female exploitation rates and partial male exploitation rates. A final sample was undertaken in July/August prior to the male moult to determine male exploitation rate.

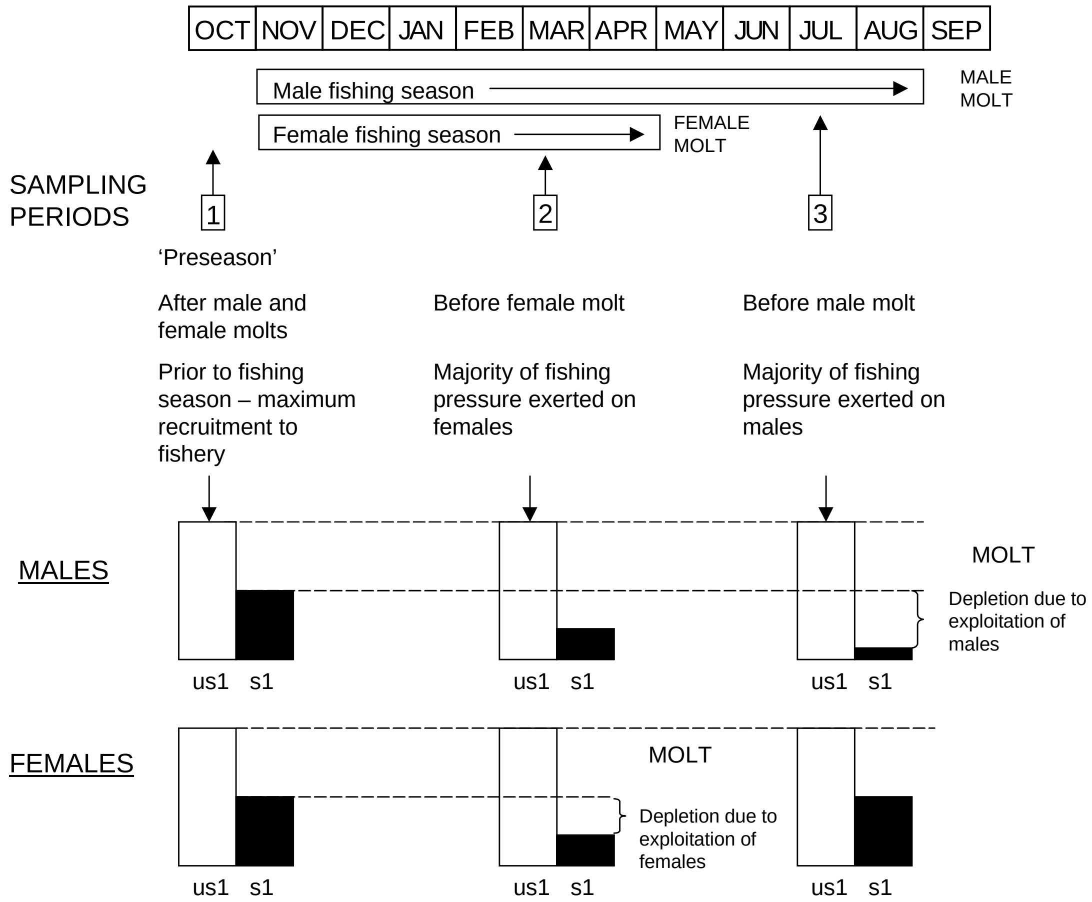

Figure 1. Sampling strategy used to determine exploitation rates with hypothetical ratios of undersized (us_1) and legal-sized (s_1) lobsters to illustrate the change-in-ratio technique. From Frusher *et al*. (1998).

Lobsters were caught in trapezoid-shaped pots with a square base of 0.6 m^2, a top of 0.5 m^2, and a height of 0.4 m (Figure 2). These measurements are similar to those used in the commercial fishery. All lobsters caught were sexed, carapace length (CL) recorded and any damage noted. All legal sized male (> 110mm CL) and female (>105mm CL) lobsters along with a sub-sample of undersized lobsters were tagged (see Chapter 5.2.2.1). All lobsters were released as close as possible to their respective capture locations. By-catch was also recorded for individual pots and immediately released. All data collected was entered and archived in an Oracle database called 'Craybase'.

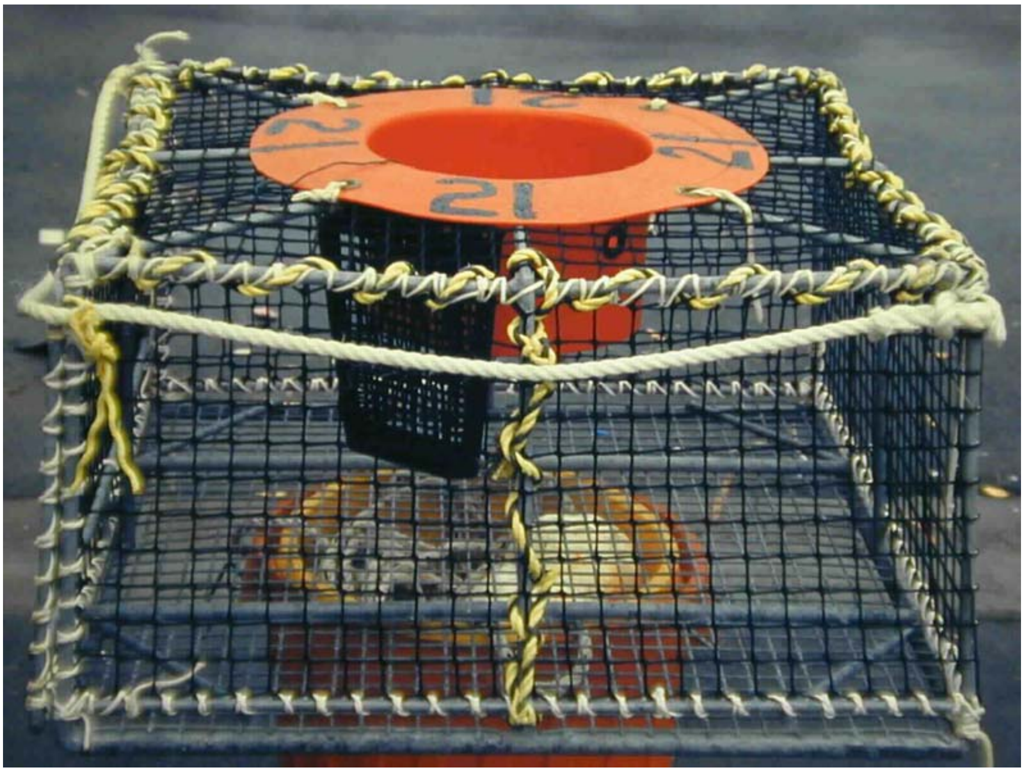

Figure 2. Baited steel research rock lobster pot used during catch sampling surveys. Each pot is individually numbered so that pot location and catch can be matched. Research pots have no escape gaps.

5.1.1.3. Change-in-ratio technique

The proportion (p) of legal-sized lobster caught at each sampling period within each site is given by:

$$[1] \qquad p = \frac{N_s}{N_s + N_{us}}$$

where N is the number of lobsters in the legal-sized (s) and undersized (us) categories. The estimated proportion of legal-sized lobsters at the beginning of the season (October in Figure 1), mid-season (March), and end of season (August) were called $\hat{p}_1$, $\hat{p}_2$, and $\hat{p}_3$, respectively.

Although on occasions the August sample could not be used due to early moulting, the October to March period corresponded to the period when over 85% of the fishing was undertaken and exploitation rates would represent the period when the bulk of the catch was taken.

Exploitation rates $(\hat{U})$ for the November to March period were determined using Paulik and Robson's equation

[2] $$\hat{U} = \frac{\hat{p}_1 - \hat{p}_2}{\hat{p}_1(1 - \hat{p}_2)}$$

For estimating exploitation rate for the November to August period $\hat{p}_2$ was replaced with $\hat{p}_3$.

5.1.1.4. Index-removal technique

Catch rate (c) of legal-sized lobsters caught at each sampling period within each site is given by:

[3] $$c = \frac{N_s}{P}$$

where N_s is the total number of legal-sized lobsters and P is the number of pots used to obtain the sample.

Exploitation rates $(\hat{U})$ for the November to March period were determined using Eberhardt's equation

[5] $$\hat{U} = \frac{\hat{c}_1 - \hat{c}_2}{\hat{c}_1}$$

where $\hat{c}_1$ and $\hat{c}_2$ refer to the catch rates obtained in October and March sampling periods respectively. To obtain the exploitation rate estimate for the November to August period $\hat{c}_2$ is replaced with $\hat{c}_3$.

5.1.1.5. Bootstrapping

To determine the precision of exploitation rate estimates, a bootstrapping procedure was used. For each actual exploitation rate estimate, 10 000 bootstrap simulations were conducted. The number of pots used in each simulation was the same as that of the original sample. For each simulation, the appropriate number of pots (with associated data) was randomly selected (with replacement) from each sample period. This provided simulated $\hat{p}_1$, $\hat{p}_2$ and $\hat{p}_3$ values (CIR technique) and $\hat{c}_1$, $\hat{c}_2$ and $\hat{c}_3$ values (IR technique) which were then combined to obtain a distribution of exploitation rates.

Confidence limits of 95% were obtained using the percentile method of Efron and Tibshirani (1986). Confidence limits take into account the asymmetric nature of derived exploitation rates. Differences in exploitation rate estimates were considered significant when there was no overlap of the 95% confidence limits. The distribution of exploitation rates can contain negative values where there is an overlap between distributions of $\hat{p}_1$ and $\hat{p}_2$, $\hat{p}_1$ and $\hat{p}_3$ or $\hat{c}_1$ and $\hat{c}_2$, $\hat{c}_1$ and $\hat{c}_3$ values. This occurred in some of the results where the distribution of simulated exploitation rates was broad but was never included in the lower 95% confidence limits.

5.1.2. Tests for validating the assumptions of catchability

5.1.2.1. Introduction

Biomass and fishing mortality estimates are commonly used as reference points and performance indicators in fishery management. It is thus surprising that the change-in-ratio (CIR)(see review Pollock and Hoenig, 1998) and index removal (IR)(see review Hoenig and Pollock, 1998) methods, which provide estimates of exploitation rate, have received only limited attention in the fisheries literature (Dawe *et al*., 1993, Frusher *et al*., 1997, 1998, Chen *et al*., 1998). This is despite various authors suggesting their potential use in fisheries (Chapman 1961, Paulik and Robson 1969, Ricker 1975). While it is uncertain why there has been a reluctance to use these methods, we suggest that concerns over the assumption of constant catchability over time in the IR method, and equal catchability between the two components used in the CIR method, may discourage scientists from testing these methods.

We propose a series of simple diagnostic tests that can be applied to the data to determine its suitability. We test these methods against data obtained from a fisheries independent study of the Tasmanian rock lobster fishery in which pre-season and post-season surveys were conducted from 1992 to 1998.

5.1.2.2. The IR and the CIR Methods

Index-Removal

The IR estimator of exploitation rate (U_{IR}) is

(1) $$U_{IR} = \frac{c_1 - c_2}{c_1}$$

where c_1 and c_2 are the catch rates of legal sized animals in the pre-season and post-season surveys, respectively. Hoenig and Pollock (1998) listed the assumptions for the IR method: 1) the population is closed between surveys except for harvest and thus there is no net change to the population through immigration, emigration or recruitment (in crustaceans this includes a stipulation that no moulting occurs between surveys), and 2) animals are equally catchable during each survey and among surveys.

In most lobster fisheries, there is a mandatory minimum size limit. If the above assumptions hold then lobsters below this limit would be expected to have the same catch rate during both surveys. Comparison of the catch rates of the sub-legal components over time would indicate whether the IR method could be validly applied to the data. We propose that a table of deviations be constructed based on the survey-to-survey differences between the catch rates for each of the sublegal size classes. To standardise the catch rates so results can be compared across regions and years, we divided the differences in the catch rates by the pre-season catch rate. The standardized deviation for the ith sublegal size class is

$$(2)\quad d_i = \frac{c_{1i} - c_{2i}}{c_{1i}}$$

where c_{1i} and c_{2i} are the catch rates of animals in the i^{th} size class in surveys 1 and 2 respectively. The catch rates from the second survey are always expected to be smaller than in the first.

In different regions, different numbers of undersized size classes may be used to provide adequate sample sizes. We have divided the summed value of the deviations by the number of size classes to account for the number of size classes. This allows one to compare data from different regions and years. The aggregated deviation is

$$(3)\quad \bar{d}_{IR} = \frac{\sum_{i=1}^{K} d_i}{K}$$

where K is the number of size classes.

To determine if the results from the deviation analysis were providing meaningful and consistent results we compared the deviation analysis to plots of the undersized catch rates for each of the surveys. Lower deviation values would be expected to occur when trends in the plots of sublegal catch rates were similar during each of the surveys. Although subjective, visual observation appeared the best way of validating the deviation analysis.

Change-in-ratio

The CIR method is based on changes in the ratio of abundance of two or more components of the population over time (Kelker 1940; Pollock and Hoenig 1998). Applications involving estimation of population size are found primarily in the wildlife literature, although recently it has been used in fisheries studies by Chen *et al*. (1997), Dawe *et al*. (1993), Frusher *et al*. (1997, 1998). Paulik and Robson (1969) derived a CIR estimator of exploitation rate but there has been limited attention given to this approach. The CIR estimator of exploitation rate (U_{CIR}) of the legal sized component when the sublegal component of the fishery is unharvested is:

(4) $$U_{CIR} = \frac{p_1 - p_2}{p_1(1 - p_2)}$$

where p_1 and p_2= proportion of legal sized animals in the catch in the first and second survey respectively. survey 1 is undertaken at the start of the period of exploitation and survey 2 at the end of the period of exploitation. We show (Appendix 3) that, if the two components of the population have a constant ratio of catchability over time, then the estimate of exploitation rate will be unbiased. This implies that, for the special case where one component is not harvested, it is not necessary to assume equal catchability of the two components. However, if the ratio of catchabilities varies between surveys then a bias is created in the estimate of exploitation rate. For any change in the ratio of catchabilities over time, the bias is greater the lower the exploitation rate (Appendix 3).

To determine the suitability of survey data for analysis with the CIR method we propose that a table of deviations be constructed based on the differences between the standardized length frequency distributions based on numbers caught per size interval. Standardisation is achieved by dividing the catch in each size class by the catch from the sublegal class with the highest catch from the corresponding survey. The standardised number of lobsters caught in the i^{th} sublegal size class is

(5) $$n_i = \frac{l_i}{\max l_i}$$

where l_i is the number of lobster caught in the i^{th} non-legal size class. A legal-sized size class cannot be used to standardise the data as the legal sized catch is affected by exploitation once the fishing year commences. The standardised deviation for the i^{th} sublegal size class is

(6) $$d_i = \frac{n_{1i} - n_{2i}}{n_{1i}}$$

where n_{1i} and n_{2i} are the standardised number of lobsters caught in the i^{th} size class in surveys 1 and 2 respectively. To account for different size classes being used in the analysis we have divided the sum of the standardised deviations by the number of size classes. The aggregated deviation is

(7) $$\bar{d}_{CIR} = \frac{\sum_{i=1}^{K} d_i}{K}$$

where K is the number of size classes.

To determine if the results from the deviation analysis were providing meaningful and consistent results we compared the deviation analysis to plots of the sublegal standardised numbers between the surveys. Lower deviation values would be expected to occur when plots of the standardised numbers of sublegal animals caught are similar during each of the surveys. When the patterns of standardised numbers caught versus size for sublegal-sized animals differ between the two surveys, there is evidence that size-specific catchability has changed and the method may produce biased results. Once again, although subjective, visual observation appeared the best way of validating the deviation analysis.

Although the absolute values of residuals, or the squares of residuals, are normally summed to give an indication of goodness of fit of a model, violations in the assumption of constant catchability, inherent in the CIR and IR methods, are demonstrated by patterns in the differences, rather than the magnitudes of the differences. Thus, standardised curves that are either consistently above or below the pre-season curve indicate a catchability problem (Figure 3A). On the other hand, a curve that is inconsistently above and below the pre-season curve suggests noise associated with, for instance, low sample sizes rather than a catchability violation (Figure 3B). However, while summing the differences between two curves may lead to detection of some problems, it is also possible it will obscure some problems. For example, observation of three successive size classes with negative differences followed by three successive size classes with positive differences might be suggestive of a trend over size and thus indicate a problem; but the sum of these differences might be close to zero and thus not reflect the problem. For this reason, the proposed criterion for detecting problems should only be used in conjunction with a visual examination of the two curves.

When the assumptions for both the CIR and IR methods are met, the estimates should be identical except for sampling errors. It is interesting to consider what happens when natural mortality and recruitment occur during the fishing season. The IR method is based on total removals (including recruitment, which can be considered a negative removal) and thus estimates the proportional change in the legal-sized population due to fishing and natural mortality and recruitment. In contrast, the CIR method is based on the change in legal-sized animals relative to the change in sublegal animals. For example, if natural mortality is equivalent for both components used in the estimation of exploitation rates, and there is no recruitment, then the removal (change) only includes fishing mortality. Hence, the CIR method would estimate the proportional change in population due to fishing. (Effects of recruitment are more complicated because it depends on the relative recruitment to each of the two groups.) In determining exploitation rates in the Tasmanian rock lobster fishery, Frusher *et al* (1998) used lobsters just below and just above the minimum legal size. Natural mortality can be assumed equal for these two components because their sizes are so similar. Recruitment (through individuals moulting and growing from one size class into another) in southern regions of the Tasmanian rock lobster fishery normally occurs during the closed season although, as will be demonstrated, it can also occur just prior to the closure of the fishing season. Tagging data indicate migrations of lobsters to be negligible (Pearn, 1994). Thus, the population is essentially closed and the assumption of equal catchability is the most likely assumption to cause any bias in exploitation rate estimates. As the CIR method is unaffected by change in catchability between surveys (provided the ratio of catchability remains constant over time), the weaker assumption of the CIR method is more likely to be met in practice than the IR assumption.

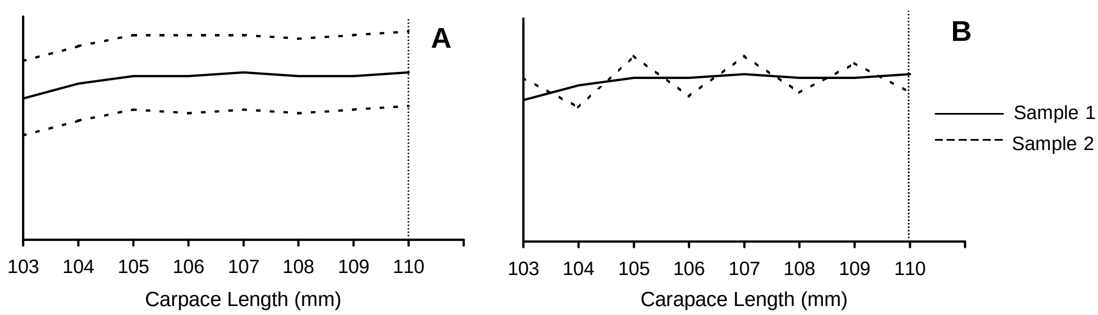

Figure 3. Examples of standardised curves used for determining violating of the assumption of catchability. **A** – when curves (second sample) are consistently above or below the pre-season curve (first sample), a catchability problem exists. **B** - a curve that is inconsistently above and below the pre-season curve suggests noise.

5.1.2.3. Application to Southern Rock Lobster in Tasmania

We now apply these tests to fishery independent catch sampling surveys undertaken at the start, middle and end of the rock lobster fishing season in southern and eastern Tasmania.

South Coast

In southern Tasmania, the fishery is primarily based on males because few females grow to legal size (Frusher, 1997). The exploitation rates obtained by both the IR and CIR methods were similar for several fishing years (e.g., first and second halves of the 92/93 fishing season and first half of the 95/96 season) but varied substantially for others (e.g., second half of most fishing seasons)(Figure 4). In all six years, the IR estimate was higher than the CIR estimate for the second half of the fishing season. In contrast, for the first half of the fishing year the IR estimate was higher than the CIR estimate in the 93/94, 94/95 and 97/98 fishing seasons and lower in the 92/93, 95/96 and 96/97 fishing seasons. Only in March 92/93 and 95/96 was their general agreement between the CIR and IR estimates.

For the IR method, comparison of the size-specific catch rates shows that there was only one occasion when the catch rate of sublegal lobsters was equivalent between surveys (start and middle of 1995/96 fishing year)(Figure 5). This is supported by the low deviation value of 0.091 for this pair of surveys (Table 1). The next lowest value is -0.161, which was obtained from the first half of the 1993/1994 fishing season. There is an obvious deviation between the plots of the catch rates for this value. We therefore suggest that a value of 0.100 may be an appropriate benchmark for judging when the catchability assumption is tenable.

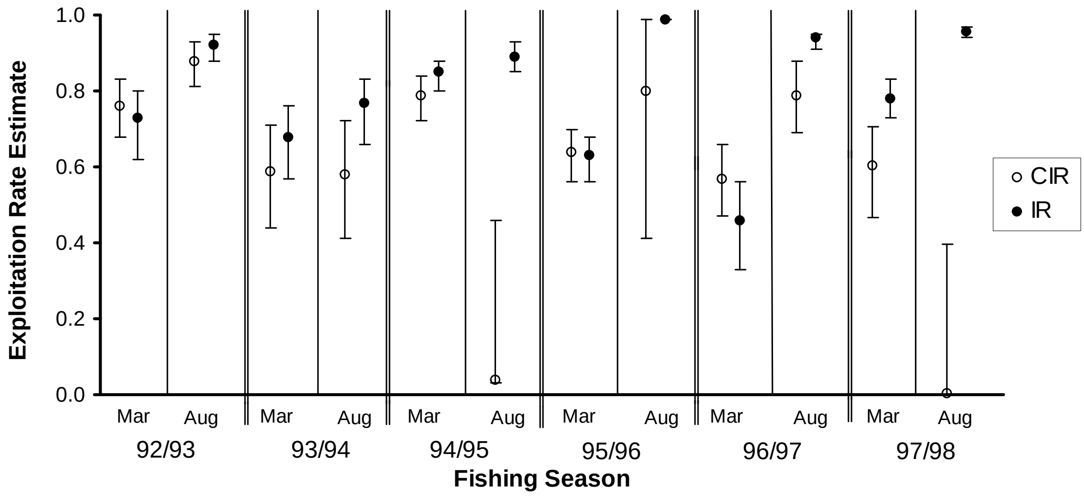

Figure 4. Exploitation rates for male rock lobsters estimated for the first (Mar) and second (Aug) halves of the fishing season by the CIR (open circle) and IR (closed circle) methods in southern Tasmania for the 1992/1993 to 1997/1998 fishing years. Error bars are 95% confidence limits.

In comparison, for the CIR method, the plots of standardised numbers caught per size class show that there was a similarity between the sublegal portions of the catch on more occasions (e.g., start and middle for all except the 1993/94, 1994/1995 and 1995/1996 fishing years and start and end for 1992/93, 1993/94 and 1996/97 fishing years) (Figure 6). Although the sublegal standardised size frequency is similar for the start and end of the 1997/98 fishing year, there is an increase in the number of legal sized lobsters caught at the end of year survey compared to the middle of year survey. This is evident in the increased standardised legal-sized component of the graphs and in the negative residuals of the legal-sized component between the middle and end of year survey. This implies that either the sublegal size classes were under-represented in the end of year catch (e.g., because of moulting affecting availability to the gear) or there had been recruitment to the fishery (e.g., lobsters having completed a moult from undersized to legal sized and now being available to the fishing gear). The latter appears to have been the case as the annual male moult occurred early near the end of the 1997/98 fishing year. Both fishers and processors reported soft-shelled lobsters at that time indicating that moulting had recently occurred. It also occurred in the 1994/95 fishing year where legal sized catch also increased after the middle of year survey (Figure 6).

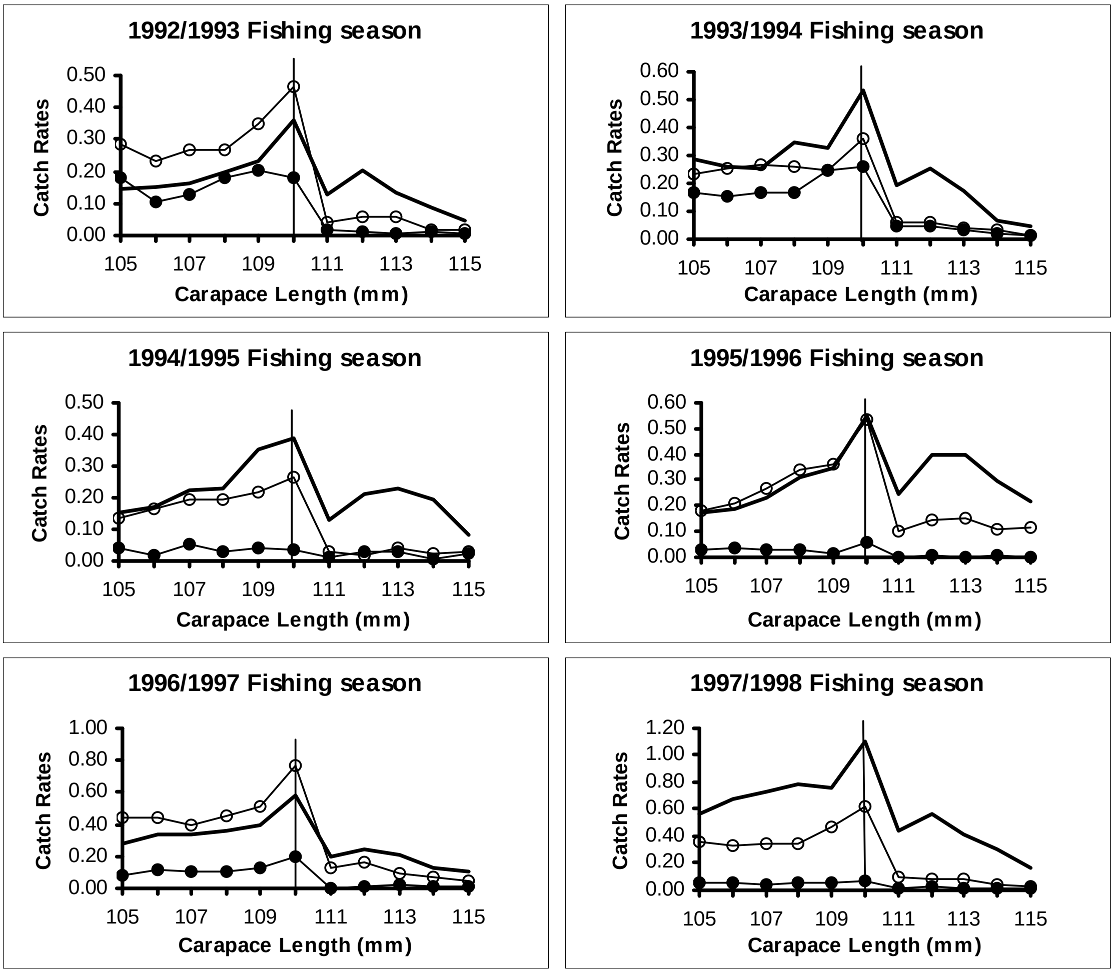

Figure 5. Comparison of catch rates (numbers/trap lift) of male lobsters taken in southern Tasmania during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/1993 to 1997/1998. Vertical line shows the minimum legal size limit.

The table of deviations shows that the highest value for the plots assumed to be valid was 0.050 (Table 2). The next highest value (0.057) is for the first half of the 1994/1995 fishing season where there is an observed difference between the graphs. Therefore, the suggested deviation value to support use of the CIR method is considered to be 0.050 or less. A value of –0.015 was obtained when comparing the surveys at the start and end of the 1995/1996 fishing season (supporting the use of the CIR method). However, a visual comparison of the trend in the graphs for these surveys in 1995/96 (Figure 6) did not support the use of the CIR method. In this case, the deviations are both positive and negative and cancel each other. The different signs in the column for the undersized portion of the catch in Table 2 are more likely to indicate sampling variation than a bias due to catchability (see Figure 3). This sampling variation would account for the broad 95% confidence intervals found around the CIR exploitation rate estimate (Figure 4) obtained from bootstrapping the data (Frusher *et al*., 1998).

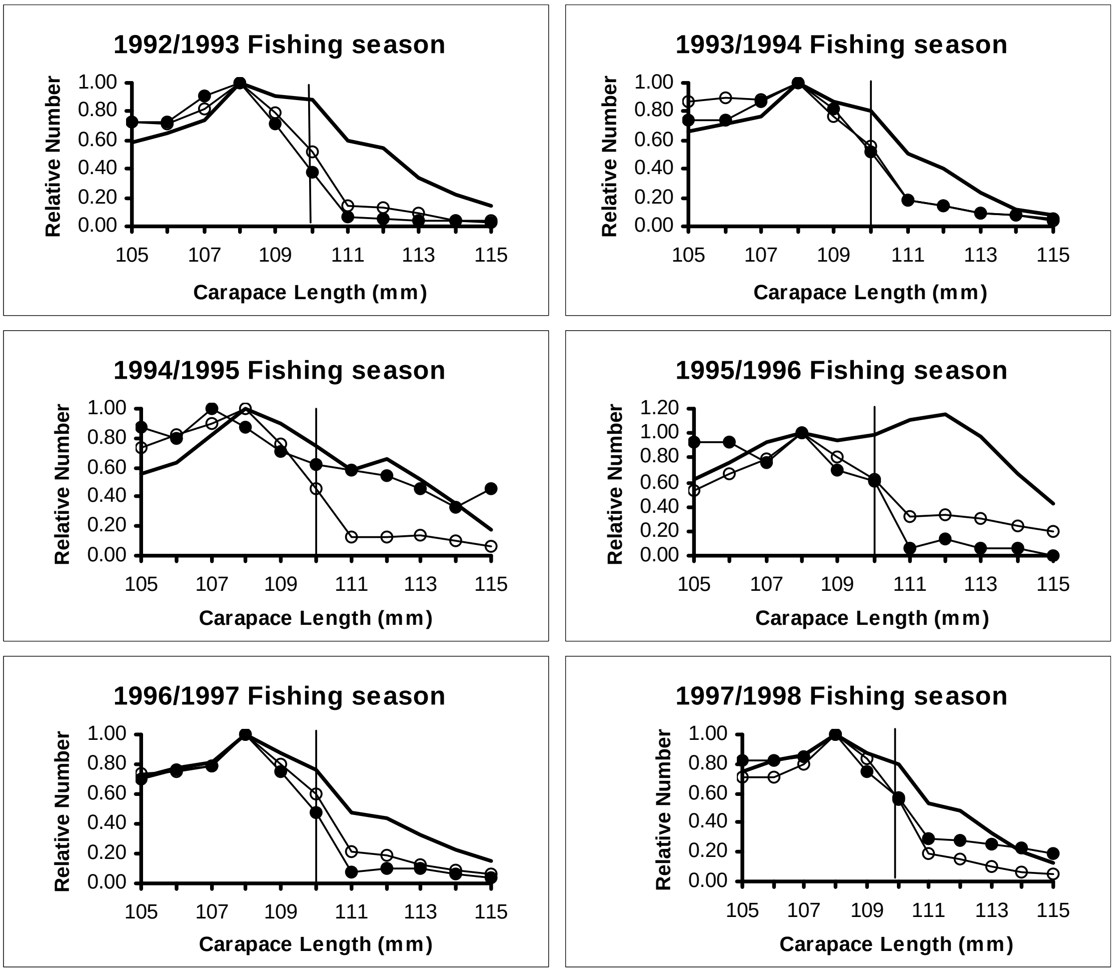

Figure 6. Standardised size frequency distribution of male rock lobsters caught in southern Tasmania from 105mmCL to 115mmCL for surveys at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing year from 1992/93 to 1997/98. Relative number is obtained by dividing the catch in each sized class by the maximum catch in the sublegal size class for each survey. Vertical lines show the minimum legal size limit.

A low value of 0.010 was also obtained for the start and end surveys for the 1997/1998 fishing season. Analysis of the deviations in the legal sized component of the catch shows that the values are negative. Therefore, an increase in the number of legal sized lobsters has occurred between the middle and end of season surveys. This highlights the importance of checking the legal sized deviations for any systematic pattern that may indicate a violation of the assumptions. Although the information cannot be used to estimate exploitation rate it does provide additional information about the population of lobsters. In this case, the population wasn't closed and recruitment (moulting to legal size) was occurring. Thus information is gained regarding the timing of the moult or, as is the case in the Tasmanian fishery, that an earlier than expected moult was occurring.

East Coast

We now test the cut off values of the deviations established for the south coast on the exploitation rate data from the east coast. Advantages of using the east coast data are that they are from a different region, both males and females are harvested, exploitation rates are obtained for each sex separately, and the number of sublegal size classes used to estimate exploitation rates are greater than for the south coast region.

For the IR method, only four of the aggregated deviations using the catch rates for males are below 0.100 (SE-1992/1993; SM and SE-1996/1997; SM-1997/1998, Table 3). The use of the IR method in these seasons was also deemed valid from an inspection of the graphs comparing catch rates between surveys (Figure 7). The inspection shows the expected pattern of catch rates such that the catch rates of undersized lobsters are approximately equivalent between surveys. Thus the start to middle of the 1996/1997 and 1997/1998 fishing seasons and the start to end of the 1992/1993 and 1996/1997 fishing seasons are suitable for estimating exploitation rate of males lobsters on the east coast using the IR method. None of the catch rate deviations were below 0.100 for female lobsters (Table 5) and graphs of the catch rates also indicated substantial changes in the catch rate of sublegal lobsters between the start and middle surveys (Figure 8) (Female lobsters moult in May after the middle of year surveys and the fishing season closes. Hence, there are no estimates of exploitation for the second half of the season). The IR method appears to be inappropriate for estimating exploitation rate for female lobsters on the east coast of Tasmania.

Five sampling periods for males (Table 4) and four sampling periods for females (Table 6) were found to be below the 0.050 criterion established for using the CIR method from the south coast analysis. The use of the CIR method was also deemed valid from an inspection of the graphs comparing relative numbers of lobsters between surveys (Figure 9 and Figure 10). The inspection shows the expected pattern of relative numbers such that the relative number of undersized lobsters is approximately equivalent between sampling periods. For males, the start and end surveys for the 1994/1995 and 1995/1996 surveys had values just above the 0.050 cut off value of 0.063 and 0.067 respectively. These graphs indicate an observable difference between the undersized distributions and thus support our cut off value.

There are three occasions when both the CIR and IR method passed their respective diagnostic tests for the same period. Exploitation rates estimated by both methods are very close for each of these periods (Figure 11).

Although the analysis supports the CIR estimates of exploitation rate off the East Coast for the start to middle and start to end of the 1996/1997 fishing year, the exploitation rates appear erroneous as they are identical. A small change in exploitation rates would be expected as approximately 20% of the annual harvest is undertaken during the second part of the fishing season. However the east coast region, where the exploitation rate estimates apply, accounts for around 5 % of the total TACC (Frusher and Gardner, 1999) and thus 20% of the catch in this region does not represent a large number of lobsters. It is therefore possible that the effort expended by the commercial fleet between March and August may not have occurred in the survey areas. Unfortunately, the detail available in the commercial fishing logbooks is not sufficient to determine the amount of effort directed at the specific survey sites.

After application of the diagnostic tests 39 of the possible 60 estimates of exploitation rate were found to be invalid due to catchability changes. Despite this, exploitation rates were available for at least part of the fishing season in five of the six fishing seasons on the south (unavailable for 1994/1995) and east (unavailable for 1993/1994) coasts. Exploitation rates for females were available for four of the six fishing seasons.

Although our empirical approach appears somewhat arbitrary, it does provide a basis for discerning whether the assumptions of catchability are being violated. Further attention should be devoted to developing improved diagnostic procedures.

We conclude that with the application of a couple of simple diagnostic tests it is possible to determine the suitability of size structure data for determination of exploitation rates using the CIR and IR methods. Given the importance of fishing mortality and biomass estimates as fishery reference points and performance indicators, it is considered prudent to obtain estimates from as many different sets of data as possible. It is not uncommon for exploitation rate estimates to have broad confidence limits and thus confidence in the robustness of the point estimates is then obtained from the similarity of the point estimates from different data sources using different methods.

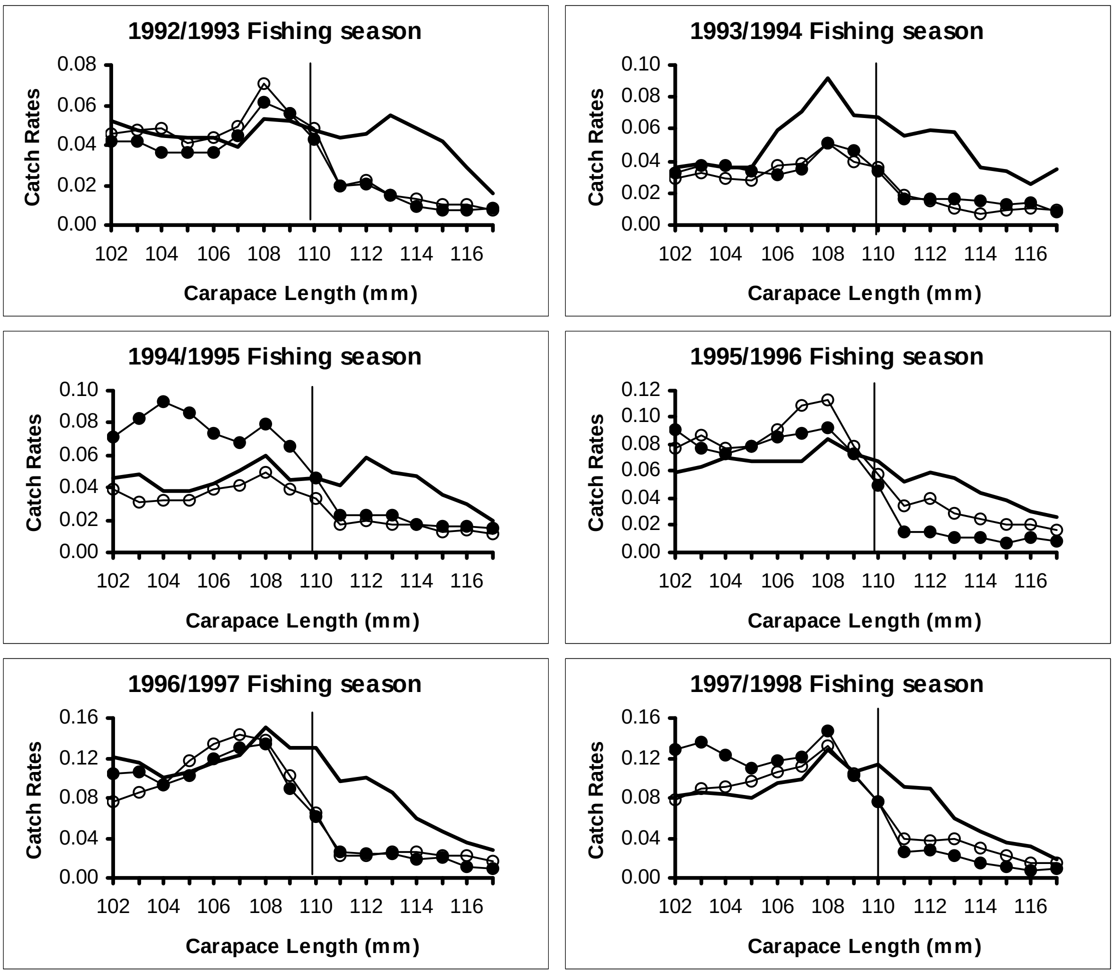

Figure 7. Comparison of catch rates of male lobsters taken on the east coast during surveys conducted at the start (no symbol), middle (open circles) and end (closed circles) of the 1992/1993 to 1997/1998 fishing seasons. Vertical line indicates the minimum legal size.

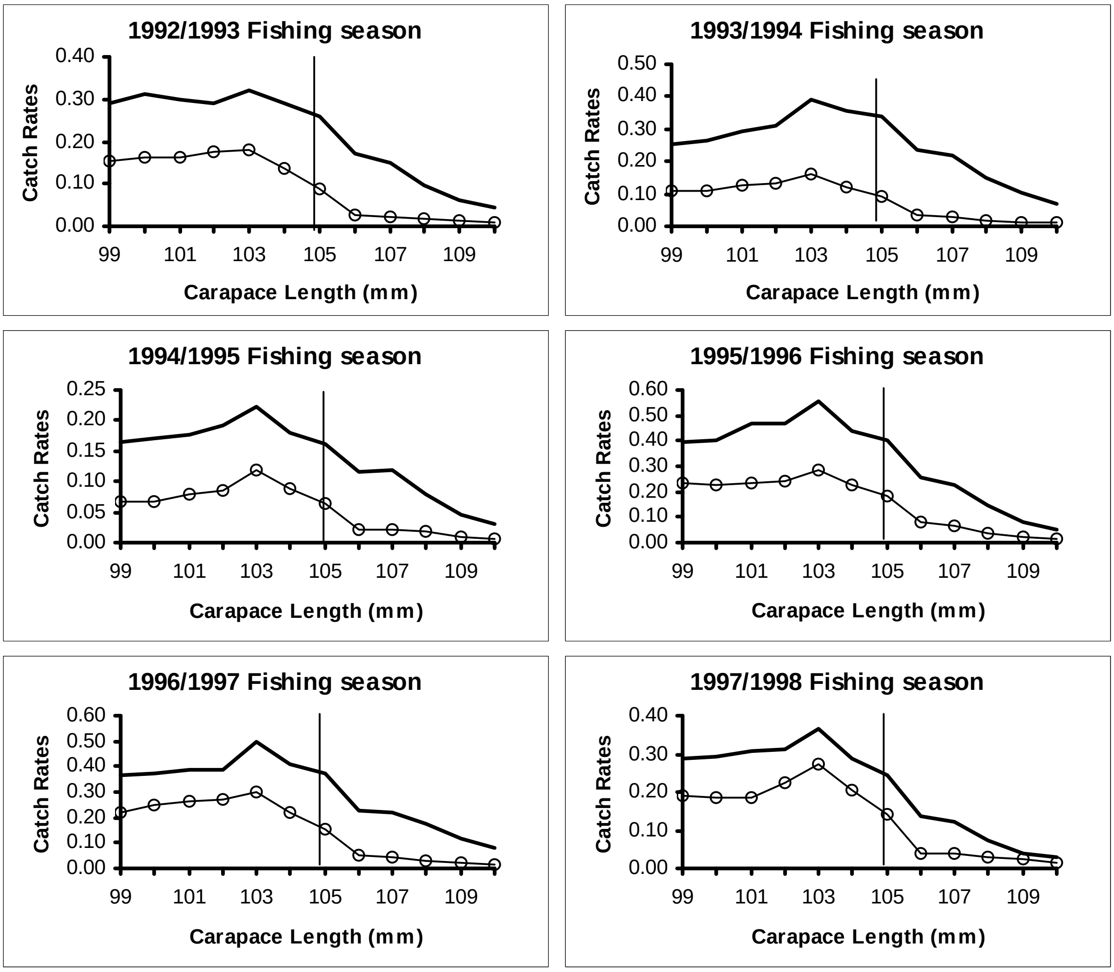

Figure 8. Comparison of catch rates (numbers/trap lift) of female lobsters taken on the east coast during surveys conducted at the start (no symbol) and middle (open circles) of the 1992/1993 to 1997/1998 fishing seasons. Vertical line indicates the minimum legal size.

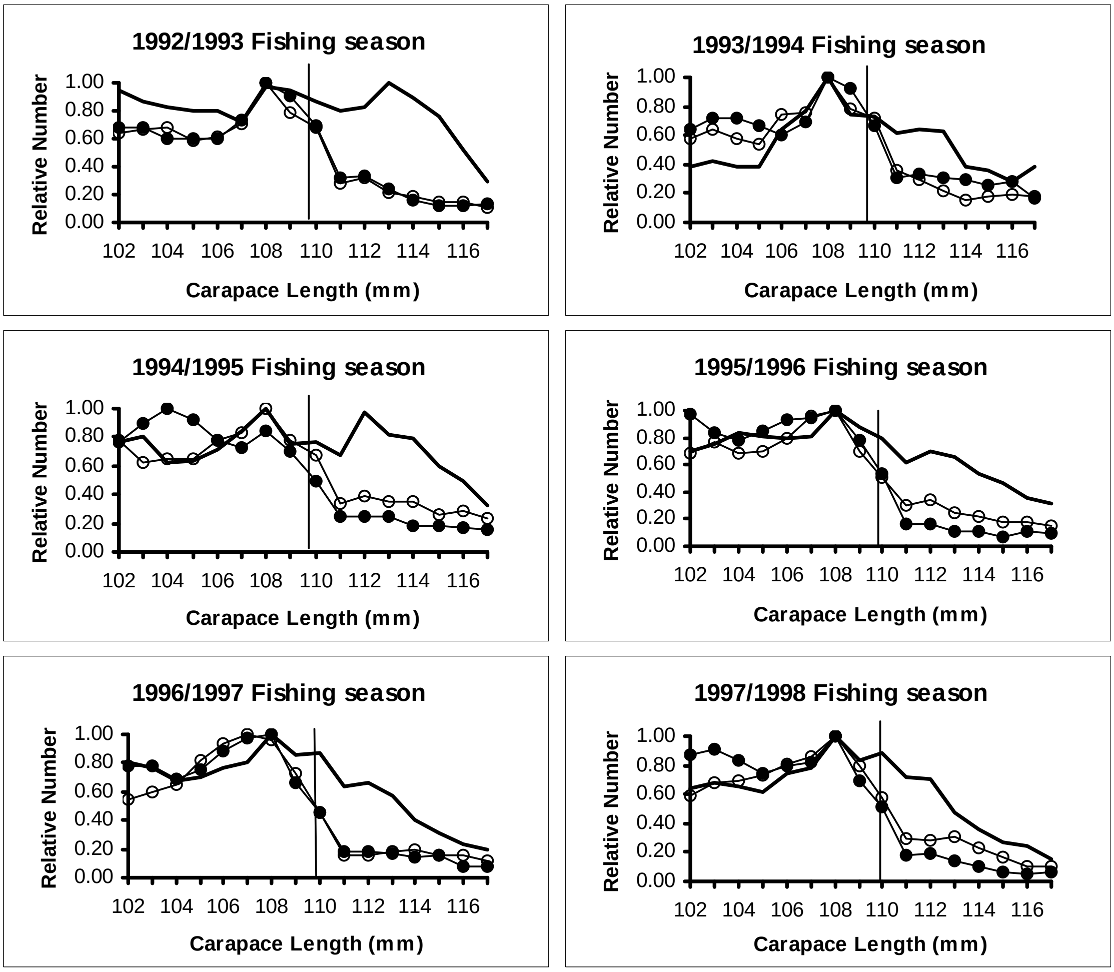

Figure 9. Comparison of the relative number of male lobsters caught on the east coast during surveys conducted at the start (no symbol), middle (open circles) and end (closed circles) of the 1992/1993 to 1997/1998 fishing seasons. Relative number is obtained by dividing the catch in each sized class by the maximum catch in the sublegal size class for each survey. Vertical line indicates the minimum legal size.

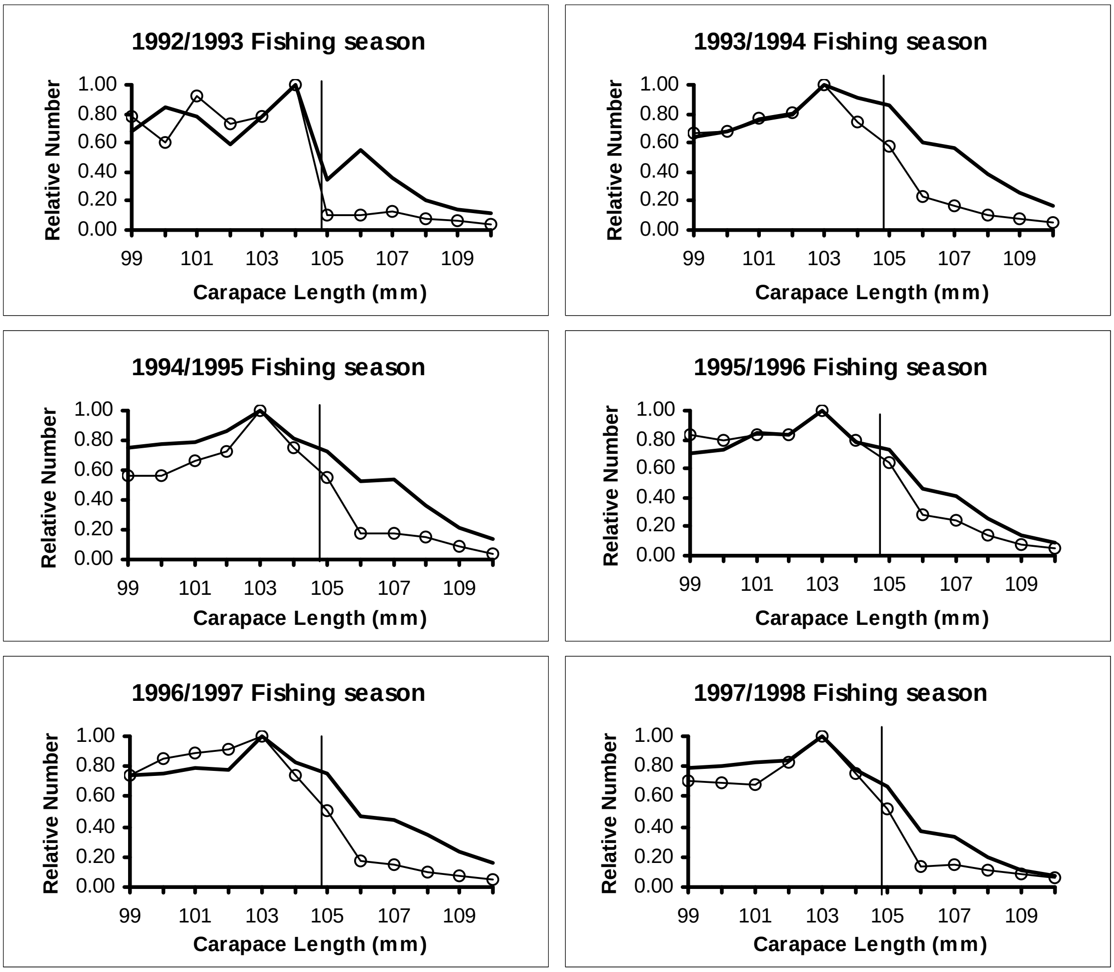

Figure 10 Comparison of the relative number of female lobsters caught on the east coast during surveys conducted at the start (no symbol) and middle (open circles) of the 1992/1993 to 1997/1998 fishing seasons. Relative number is obtained by dividing the catch in each sized class by the maximum catch in the sublegal size class for each survey. Vertical line indicates the minimum legal size.

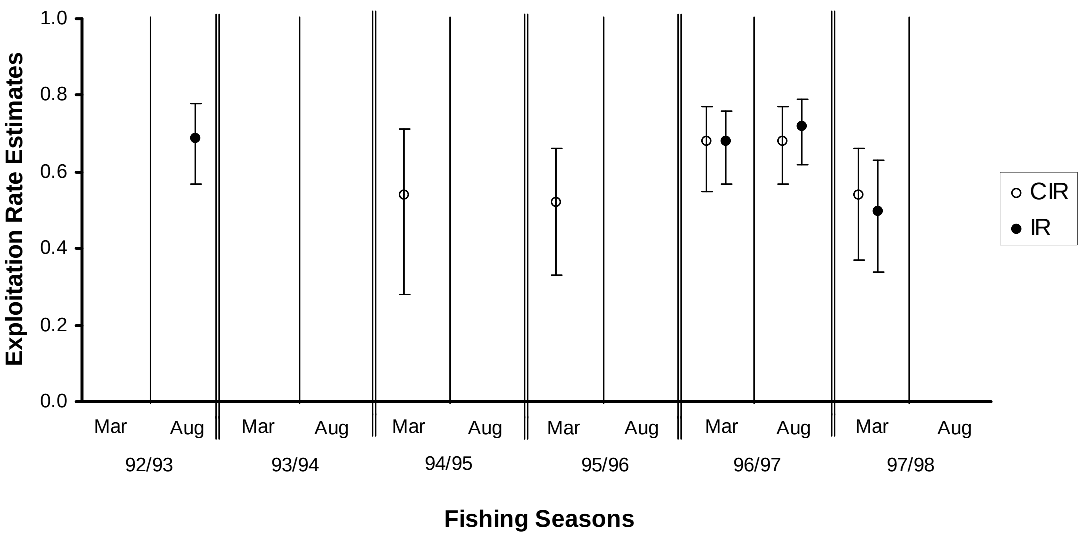

Figure 11. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for the east coast of Tasmania for the 1992/1993 to 1997/1998 fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

Table 1. Index-removal diagnostics for the 1992/1993 to 1997/1998 fishing seasons. Deviations are size specific differences in the catch rates of lobsters caught between the start and middle of season surveys (SM), start and end of season surveys (SE) standardised by the catch rate in the start of season survey, and the middle and end of season surveys (ME) standardised by the catch rate in the middle of season in survey.

	1992/1993			**1993/1994**			**1994/1995**			**1995/1996**			**1996/1997**			**1997/1998**		
Size class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME
105	0.531	-0.317	-0.554	-0.021	-0.402	-0.389	-0.038	-0.909	-0.905	0.154	-0.811	-0.836	0.322	-0.655	-0.739	-0.516	-0.926	-0.847
106	0.646	-0.218	-0.525	0.035	-0.341	-0.364	-0.118	-0.765	-0.734	0.175	-0.862	-0.883	0.168	-0.693	-0.737	-0.534	-0.941	-0.874
107	0.384	-0.074	-0.331	-0.254	-0.520	-0.356	-0.147	-0.864	-0.840	0.108	-0.898	-0.908	0.273	-0.694	-0.760	-0.565	-0.923	-0.824
108	0.518	-0.114	-0.417	-0.236	-0.245	-0.011	-0.382	-0.883	-0.810	0.050	-0.949	-0.952	0.282	-0.679	-0.749	-0.379	-0.927	-0.882
109	0.273	-0.503	-0.609	-0.328	-0.519	-0.284	-0.324	-0.907	-0.862	-0.032	-0.898	-0.895	0.298	-0.669	-0.745	-0.438	-0.937	-0.887
Sum of undersized	2.352	-1.227	-2.436	-0.805	-2.027	-1.404	-1.009	-4.327	-4.151	0.456	-4.418	-4.472	1.343	-3.390	-3.730	-2.432	-4.654	-4.313
Sum of undersized/ no. of size classes	0.470	-0.245	-0.487	-0.161	-0.405	-0.281	-0.202	-0.865	-0.830	**0.091**	-0.884	-0.894	0.269	-0.678	-0.746	-0.486	-0.931	-0.863
110	0.087	0.107	0.020	0.132	0.144	0.012	0.098	0.117	0.018	0.148	0.249	0.100	0.071	0.194	0.124	0.347	0.432	0.085
111	0.145	0.196	0.051	0.191	0.205	0.014	0.192	0.180	-0.013	0.252	0.390	0.138	0.084	0.234	0.150	0.473	0.536	0.064
112	0.076	0.126	0.050	0.138	0.143	0.005	0.189	0.200	0.010	0.247	0.397	0.150	0.112	0.180	0.068	0.328	0.392	0.063
113	0.070	0.077	0.006	0.032	0.046	0.014	0.170	0.188	0.018	0.192	0.293	0.101	0.063	0.125	0.062	0.269	0.299	0.030
114	0.030	0.045	0.015	0.038	0.038	0.000	0.053	0.060	0.008	0.098	0.215	0.118	0.060	0.093	0.032	0.139	0.144	0.005
115	0.023	0.029	0.005	0.011	0.009	-0.002	0.056	0.053	-0.003	0.048	0.121	0.073	0.035	0.056	0.021	0.055	0.066	0.011

Table 2. Difference between standardised catches of male lobsters caught on the south coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to 1997/1998. Bold figures in the legal-sized portion of the catch (>=110mmCL) highlight negative differences.

	1992/1993			**1993/1994**			**1994/1995**			**1995/1996**			**1996/1997**			**1997/1998**		
Size class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME
105	0.140	0.144	0.003	0.198	0.067	-0.131	0.174	0.315	0.140	-0.088	0.308	0.397	0.032	-0.013	-0.045	-0.029	0.084	0.113
106	0.065	0.082	0.016	0.179	0.019	-0.160	0.180	0.153	-0.028	-0.097	0.170	0.267	-0.019	-0.006	0.013	-0.123	-0.002	0.121
107	0.074	0.160	0.085	0.118	0.099	-0.019	0.073	0.173	0.100	-0.145	-0.165	-0.020	-0.027	-0.024	0.003	-0.054	-0.004	0.050
108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.125	-0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
109	-0.127	-0.198	-0.071	-0.100	-0.049	0.051	-0.141	-0.187	-0.046	-0.133	-0.238	-0.105	-0.070	-0.132	-0.061	-0.041	-0.128	-0.086
Sum of undersized	0.153	0.187	0.034	0.395	0.135	-0.259	0.286	0.329	0.042	-0.463	0.075	0.539	-0.085	-0.175	-0.090	-0.248	-0.051	0.197
Sum of undersized/ no. of size classes	**0.031**	**0.037**	**0.007**	**0.079**	**0.027**	**-0.052**	**0.057**	**0.066**	**0.008**	**-0.093**	**0.015**	**0.108**	**-0.017**	**-0.035**	**-0.018**	**-0.050**	**-0.010**	**0.039**
110	0.363	0.510	0.148	0.255	0.286	0.031	0.291	0.124	**-0.167**	0.364	0.395	0.030	0.158	0.292	0.134	0.234	0.230	**-0.004**
111	0.446	0.526	0.080	0.332	0.324	-0.007	0.456	0.003	**-0.453**	0.785	1.039	0.254	0.261	0.398	0.137	0.348	0.237	**-0.111**
112	0.416	0.492	0.076	0.257	0.262	0.005	0.531	0.113	**-0.419**	0.833	1.027	0.194	0.247	0.333	0.086	0.336	0.199	**-0.137**
113	0.256	0.305	0.049	0.146	0.147	0.001	0.382	0.063	**-0.320**	0.663	0.901	0.238	0.209	0.228	0.018	0.231	0.076	**-0.155**
114	0.173	0.181	0.008	0.047	0.043	-0.003	0.257	0.020	**-0.237**	0.432	0.607	0.175	0.141	0.162	0.021	0.146	-0.022	**-0.168**
115	0.105	0.114	0.009	0.035	0.021	-0.014	0.111	-0.278	**-0.389**	0.223	0.424	0.201	0.089	0.110	0.021	0.076	-0.067	**-0.143**

Table 3. Index removal diagnostics for east coast males for the 1992/1993 to 1997/1998 fishing seasons. Deviations are size specific differences in the catch rates of lobsters caught between the start and middle of season surveys (SM), start and end of season surveys (SE) standardised by the catch rate in the start of season survey, and the middle and end of season surveys (ME) standardised by the catch rate in the middle of season in survey.

	1992/1993			**1993/1994**			**1994/1995**			**1995/1996**			**1996/1997**			**1997/1998**		
Size class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME
102	0.432	0.190	-0.426	0.081	-0.066	-0.160	0.592	0.113	-1.171	-0.475	-0.583	-0.073	0.394	0.039	-0.586	0.130	-0.394	-0.603
103	-0.571	-0.148	0.269	0.166	0.214	0.058	-0.003	-1.261	-1.255	-0.420	-0.225	0.137	0.261	0.229	-0.043	-0.027	-0.599	-0.557
104	-0.121	0.256	0.337	0.238	-0.072	-0.407	0.311	-1.618	-2.799	-0.219	0.115	0.274	0.072	-0.054	-0.136	-0.297	-0.771	-0.365
105	0.305	0.367	0.090	0.190	-0.357	-0.675	0.141	-1.565	-1.985	0.269	-0.024	-0.400	-0.145	0.029	0.151	0.030	-0.098	-0.132
106	-0.145	-0.283	-0.120	0.271	0.372	0.139	0.060	-0.559	-0.658	-0.621	-0.659	-0.023	-0.208	0.111	0.264	-0.445	-0.320	0.086
107	-0.298	0.256	0.427	0.469	0.757	0.543	0.093	-0.283	-0.414	-0.803	-0.225	0.321	-0.121	-0.250	-0.115	-0.018	-0.286	-0.263
108	-0.360	-0.493	-0.098	0.604	0.204	-1.010	0.373	-0.247	-0.990	-0.416	-0.064	0.248	-0.171	-0.093	0.067	-0.046	-0.085	-0.037
109	-0.331	-0.189	0.107	0.347	0.299	-0.074	0.072	-0.404	-0.512	-0.021	-0.058	-0.037	0.324	0.398	0.109	-0.029	-0.098	-0.067
Sum of undersized	-1.090	-0.043	0.586	2.366	1.352	-1.586	1.639	-5.823	-9.785	-2.705	-1.722	0.447	0.406	0.409	-0.288	-0.701	-2.650	-1.938
Sum of undersized/ no. of size classes	-0.136	**-0.005**	0.073	0.296	0.169	-0.198	0.205	-0.728	-1.223	-0.338	-0.215	0.056	**0.051**	**0.051**	-0.036	**-0.088**	-0.331	-0.242
110	0.029	0.023	-0.006	0.010	0.020	0.010	-0.008	-0.017	-0.010	0.018	0.013	-0.005	0.026	0.040	0.014	0.018	0.038	0.021
111	-0.006	0.006	0.012	0.045	0.048	0.002	0.040	0.045	0.005	0.013	0.046	0.033	0.097	0.078	-0.018	0.098	0.089	-0.009
112	0.049	0.043	-0.006	0.058	0.053	-0.005	0.040	0.025	-0.015	0.023	0.052	0.029	0.098	0.096	-0.002	0.045	0.068	0.023
113	0.025	0.026	0.002	0.028	0.025	-0.003	0.038	0.038	0.000	0.023	0.033	0.010	0.036	0.053	0.017	0.015	0.028	0.013
114	0.044	0.049	0.005	0.055	0.048	-0.008	0.017	0.018	0.000	0.035	0.050	0.015	0.045	0.038	-0.007	0.000	0.020	0.020
115	0.037	0.041	0.005	0.003	-0.010	-0.013	0.035	0.035	0.000	0.003	0.019	0.016	0.017	0.030	0.013	0.033	0.044	0.011
116	0.013	0.013	-0.001	0.015	0.023	0.007	0.018	0.005	-0.012	0.018	0.027	0.009	0.013	0.013	0.000	0.005	0.011	0.006
117	0.005	0.010	0.005	0.030	0.023	-0.008	-0.005	0.003	0.008	0.010	0.014	0.004	0.009	0.033	0.023	0.015	0.019	0.004

Table 4. Difference between standardise catches of male lobsters caught on the east coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to 1997/1998. Bold figures in the legal-sized portion of the catch (>=110mmCL) highlight negative differences.

	1992/1993			**1993/1994**			**1994/1995**			**1995/1996**			**1996/1997**			**1997/1998**		
Size class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME
102	0.310	0.271	-0.038	-0.183	-0.248	-0.066	-0.016	-0.004	0.012	0.019	-0.279	-0.298	0.258	0.024	-0.234	0.052	-0.234	-0.286
103	0.202	0.188	-0.014	-0.221	-0.303	-0.082	0.178	-0.087	-0.266	-0.010	-0.075	-0.065	0.165	-0.021	-0.187	-0.010	-0.243	-0.233
104	0.143	0.227	0.084	-0.183	-0.330	-0.148	-0.019	-0.375	-0.356	0.149	0.046	-0.102	0.022	-0.017	-0.039	-0.036	-0.179	-0.142
105	0.214	0.203	-0.011	-0.150	-0.281	-0.131	-0.005	-0.281	-0.276	0.114	-0.046	-0.159	-0.120	-0.052	0.068	-0.113	-0.120	-0.007
106	0.179	0.203	0.025	-0.092	0.039	0.131	-0.071	-0.077	-0.006	0.000	-0.128	-0.128	-0.174	-0.122	0.052	-0.059	-0.052	0.007
107	0.012	-0.025	-0.037	0.019	0.084	0.066	0.017	0.115	0.098	-0.153	-0.138	0.015	-0.190	-0.159	0.031	-0.077	-0.047	0.029
108	-0.024	-0.024	0.000	0.000	0.000	0.000	0.000	0.152	0.152	0.000	0.000	0.000	0.034	0.000	-0.034	0.000	0.000	0.000
109	0.167	0.039	-0.127	-0.041	-0.173	-0.131	-0.030	0.054	0.083	0.174	0.086	-0.087	0.137	0.192	0.054	0.045	0.144	0.099
Sum of undersized	1.202	1.084	-0.119	-0.852	-1.213	-0.361	0.054	-0.504	-0.558	0.291	-0.533	-0.825	0.132	-0.156	-0.289	-0.198	-0.731	-0.533
Sum of undersized/ no. of size classes	0.150	0.135	-0.015	-0.107	-0.152	-0.045	0.007	-0.063	-0.070	**0.036**	-0.067	-0.103	0.017	-0.020	-0.036	**-0.025**	-0.091	-0.067
110	0.190	0.173	**-0.017**	0.015	0.064	0.049	0.086	0.273	0.187	0.289	0.264	**-0.025**	0.406	0.410	0.003	0.307	0.371	0.065
111	0.524	0.479	**-0.045**	0.248	0.298	0.049	0.342	0.431	0.089	0.316	0.455	0.139	0.480	0.455	-0.025	0.428	0.537	0.109
112	0.512	0.500	**-0.012**	0.341	0.308	**-0.033**	0.582	0.731	0.149	0.352	0.535	0.183	0.503	0.484	-0.019	0.421	0.511	0.090
113	0.786	0.754	**-0.032**	0.414	0.316	**-0.098**	0.464	0.578	0.115	0.408	0.547	0.138	0.387	0.395	0.007	0.167	0.324	0.157
114	0.702	0.733	0.031	0.243	0.096	**-0.148**	0.436	0.604	0.168	0.315	0.417	0.101	0.207	0.253	0.045	0.132	0.255	0.123
115	0.619	0.646	0.027	0.183	0.101	**-0.082**	0.343	0.419	0.076	0.282	0.388	0.106	0.157	0.163	0.005	0.104	0.205	0.101
116	0.381	0.408	0.027	0.085	0.003	**-0.082**	0.212	0.330	0.118	0.182	0.247	0.064	0.078	0.159	0.081	0.141	0.199	0.059
117	0.190	0.167	**-0.023**	0.201	0.218	0.016	0.082	0.159	0.077	0.172	0.227	0.055	0.075	0.115	0.040	0.043	0.087	0.045

Table 5. East coast females. Deviations are differences in the catch rates of lobsters caught in survey 1 and survey 2 standardised by the catch rate in survey 1.

Size class	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
99	0.397	0.473	0.615	0.400	0.355	0.227
100	0.626	0.622	0.547	0.434	0.406	0.548
101	0.379	0.647	0.661	0.474	0.176	0.326
102	0.346	0.470	0.453	0.552	0.351	0.328
103	0.470	0.629	0.548	0.413	0.325	0.189
104	0.472	0.629	0.414	0.474	0.476	0.266
Sum of undersized	2.689	3.470	3.238	2.748	2.089	1.884
Sum of undersized/ no. of size classes	0.448	0.578	0.540	0.458	0.348	0.314
105	0.838	0.773	0.769	0.660	0.758	0.730
106	0.899	0.873	0.850	0.613	0.763	0.658
107	0.810	0.878	0.811	0.776	0.824	0.804
108	0.815	0.876	0.806	0.751	0.815	0.411
109	0.784	0.965	0.582	0.540	0.824	-0.069
110	0.838	0.752	0.923	0.889	0.824	0.847

Table 6. Difference between standardise catches of female lobsters caught on the east coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to 1997/1998. Bold figures in the legal-sized portion of the catch (>=110mmCL) highlight negative differences.

Size class	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
99	-0.097	-0.022	0.187	-0.120	0.001	0.088
100	0.247	0.003	0.210	-0.067	-0.099	0.112
101	-0.138	-0.019	0.126	0.014	-0.104	0.152
102	-0.141	-0.011	0.137	0.004	-0.140	0.021
103	-0.004	0.000	0.000	0.000	0.000	0.000
104	0.000	0.157	0.063	-0.001	0.096	0.027
Sum of undersized	-0.132	0.108	0.723	-0.170	-0.247	0.399
Sum of undersized/ no. of size classes	**-0.022**	**0.018**	0.120	**-0.028**	**-0.041**	0.066
105	0.307	0.318	0.184	0.110	0.302	0.187
106	0.540	0.440	0.354	0.236	0.350	0.313
107	0.283	0.472	0.413	0.199	0.345	0.222
108	0.160	0.343	0.239	0.149	0.284	0.100
109	0.105	0.211	0.142	0.075	0.193	0.027
110	0.097	0.139	0.101	0.046	0.125	0.019

5.1.3. Fishery Independent Catch Sampling

5.1.3.1. Introduction

In the early 1990's, the Tasmanian Government and the rock lobster industry formed a working group to consider options for halting the steady decline in catch rates in the fishery (Anon, 1993). There was concern over the accuracy of the catch and effort data and it was considered important to obtain this information independent of the fishery. It was anticipated that establishing long-term sites in regions representative of fishing pressure would allow for data quality checks of fishery derived data. In addition, it was hoped that the data could be collected in a manner that would optimise its potential use. In particular, accurate regional estimates of exploitation rate and biomass were considered crucial for monitoring the performance of the fishery. Collection of fishery independent information became more important after the Tasmanian State Government announced its intention to manage the southern rock lobster fishery by output control, based on individual transferable quotas (ITQs). With this change, there was the potential for the CPUE to substantially change as fishers began to target the dollar return per unit of lobster caught rather than maximising their individual catches. Changes in CPUE, which is used in most fisheries assessments as a *de-facto* measure of change in relative abundance, had the potential to measure factors unrelated to abundance after quota implementation. Standardised fishery independent techniques were considered essential to validate any changes in CPUE that may occur.

From 1992 to 1997, the Tasmanian State Government funded a fishery independent catch sampling project. One of the major objectives was to develop methods for obtaining accurate estimates of exploitation rates in the fishery. The project tested both the change-in-ratio (CIR) and index-removal (IR) methods. These methods were able to provide both estimates of exploitation rates and indicate the sample sizes required to achieve specified precision in these estimates (Frusher *et al*., 1998). However, in trialling these methods only small areas of the fishery were sampled. Biomass estimates could not be obtained accurately as the areas used to estimate exploitation rates were considerably smaller than the resolution of commercial logbooks (30 nautical miles by 30 nautical miles). More importantly, the fishery is assessed on eight larger assessment areas (Gardner *et al*., 2002) using a spatially explicit assessment model (Punt and Kennedy, 1997) where fishery independent exploitation rate and biomass estimates are important for validating the assessment model's outputs.

A major objective of this current project was to extend the techniques developed for determining exploitation rates to broad regions of the fishery and by combining commercial catch data, provide regional estimates of biomass.

5.1.3.2. Materials and Methods

Sampling Design

From the start of the 1997/98 fishing season until March 2001, fisheries independent catch sampling was continued with the aim of providing broad-scale estimates of exploitation rate and biomass. Several sites surveyed in the initial catch sampling project were maintained to provide continuity of data. New sites were selected on both the east and south coasts to represent broader regions of the commercial rock lobster fishery (Figure 12). The size of the sites varied depending on available lobster habitat. Sites were selected to fit into various depth ranges to determine if exploitation rate estimates varied with depth: south coast (deep water >40m, shallow water <40m), east coast (deep water 30-50m, shallow water <30m). The number of pots used varied between sites. At the four Maatsuyker Island sites, 25 pots were used per site. While at all other south coast sites, and all east coast sites, 50 pots were used. When catch rates were low and time and weather permitted, sites were resampled to increase the number of lobsters caught.

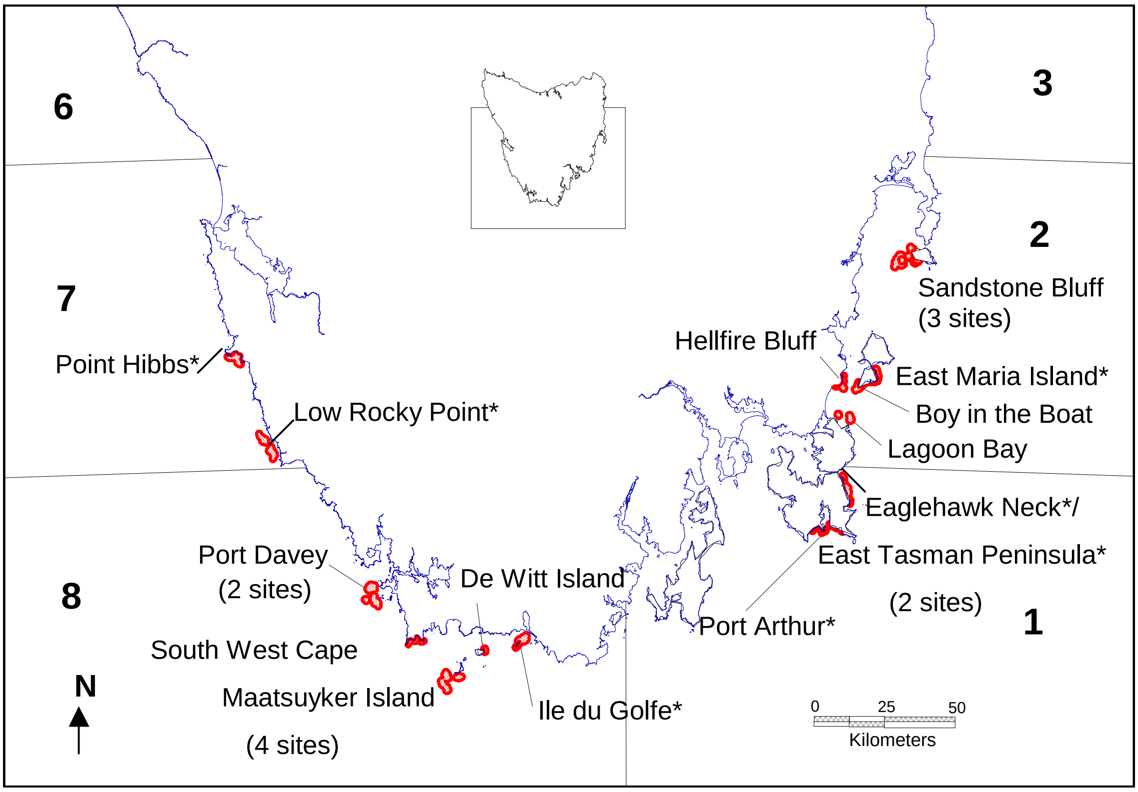

Figure 12. Map indicating research survey locations within their respective stock assessment areas for the project duration, 1997-2001. Sites marked with an * are an expansion from the original sites sampled in the previous catch sampling project, 1992-97.

Exploitation Rate Techniques

A series of simple diagnostic tests (see Chapter 5.1.2) were applied to all catch sampling data to determine its suitability for use by both methods.

5.1.3.3. Results and discussion

General

From the start of the 1997 fishing season until March 2001 (three and a half fishing seasons), approximately 105,000 lobsters were measured from over 8,500 individual pot lifts (Appendix 4.). A total of 32,725 lobsters were tagged and released, with 7,647 recaptures recorded.

Exploitation Rate Estimates – South Coast

During this project, exploitation rates using the CIR and the IR methods were estimated for several sites on the south coast of Tasmania. When data collected in the previous independent catch sampling project (Frusher *et al*., 1998) was added, it provided us with the opportunity to look at nine fishing seasons. As the fishery in southern Tasmania is primarily based on males (Frusher *et al*., 1997), exploitation rate estimates were not available for females for this region.

When data collected from all sites surveyed in Stock Assessment Area 8 were combined, exploitation rate estimates differed between the CIR and IR methods (Figure 4). Application of the diagnostic tests found that the assumptions of catchability to be violated for several of the sampling periods (Appendix 5 and 7). Of the 17 possible exploitation rate estimates for each method, only 9 CIR estimates and 2 IR estimates were not affected by changes in catchability (Figure 13). Despite this, exploitation rate estimates were available for all seasons sampled, except 1997/98. When both the CIR and IR methods passed the diagnostic tests, as occurred for the partial season (March) estimate in 1995/96, there was good agreement between estimates using both methods.

Both the previous catch sampling project (Frusher *et al*., 1998) and data reported in Chapter 5.1.2.3, have used the CIR and IR methods to determine exploitation, but have not selected for depth. As fishing in the Tasmanian rock lobster fishery occurs over a wide depth range (0-200m), estimates of exploitation were determined for deep (>40m) and shallow water (<35m) sites to test if exploitation varied with depth.

When data collected from shallow water survey sites from Stock Assessment Area 8 (South West Cape, Ile du Golfe and De Witt Island) were combined consistently high exploitation rate estimates resulted (Figure 14). The majority of fishing pressure appears to be exerted during the first half of the season (November to March), with only a slight increase recorded for the full year sample (November to August). The high exploitation recorded at these sites may reflect their location. All shallow water research sites were sheltered from the prevailing westerly weather pattern and thus were near safe anchorages. As such, they tended to be heavily fished and therefore highly exploited.

The high exploitation rates indicated for shallow water in Area 8 were not evident for deep-water sites (Maatsuyker Island and Port Davey)(Figure 15 and Figure 16). In deep water, the exploitation rate estimates tended to be lower and more variable both between and within the fishing season. Only one full season (August) estimate passed the diagnostic tests for deep water. This was an estimate using the CIR method for the 1998/99 fishing season for Port Davey. The failure of these other August estimates can be explained when the diagnostic graphs and tables for these sites are examined (Appendix 5 and 7). For the IR method, comparison of the size-specific catch rates for the start and end of season surveys indicates the catchability assumption has been violated. An increase in the size-specific catch rates of legal-sized lobsters and the negative residuals of the legal-sized component between the middle and end of year surveys resulted in the failure of the CIR method. This implies that either the under-size lobsters were under-represented in the catch (eg. moulting affecting catchability) or there had been an increase in legal-sized lobsters by recruitment to the fishery (eg. lobsters moulting from sublegal to legal size).

The partial season (November to March) exploitation rate estimates for Maatsuyker Island and to a lesser extent Port Davey, show considerable variability. Estimates for the 1996/97, 1998/99 and 1999/00 season for Maatsuyker Island and the 1999/00 season for Port Davey were lower than expected. Estimates for the 1998/99 and 1999/00 seasons may have been due to the impact of the extended season that occurred in September of 1998 and 1999.

Moulting of male lobsters in southern regions occurs during September and October, when the season has previously been closed. With the advent of quota, the fishing season was extended into September to enable fishers to take advantage of higher prices (Gardner and Frusher, 2000). However, in September 1999 a substantial number of newly moulted lobsters were landed by fishers (Gardner *et al*., 2001). The actual magnitude of recruits landed was unknown although it was sufficient to cause the processors to drop the price for newly moulted lobsters (“new shellers” or soft fish) and request a review of the extended opening of the season. Harvesting new recruits during this period resulted in a reduction in the legal biomass prior to the start of the following season (November). The fishery independent survey undertaken prior to the commencement of the fishing season in late October to early November would no longer reflect full recruitment to the fishery. Exploitation rate estimates for the season following the September opening would represent partial exploitation rates as a portion of the legal-sized biomass was harvested in September. Maintaining a September opening is likely to compromise the use of the CIR and IR techniques.

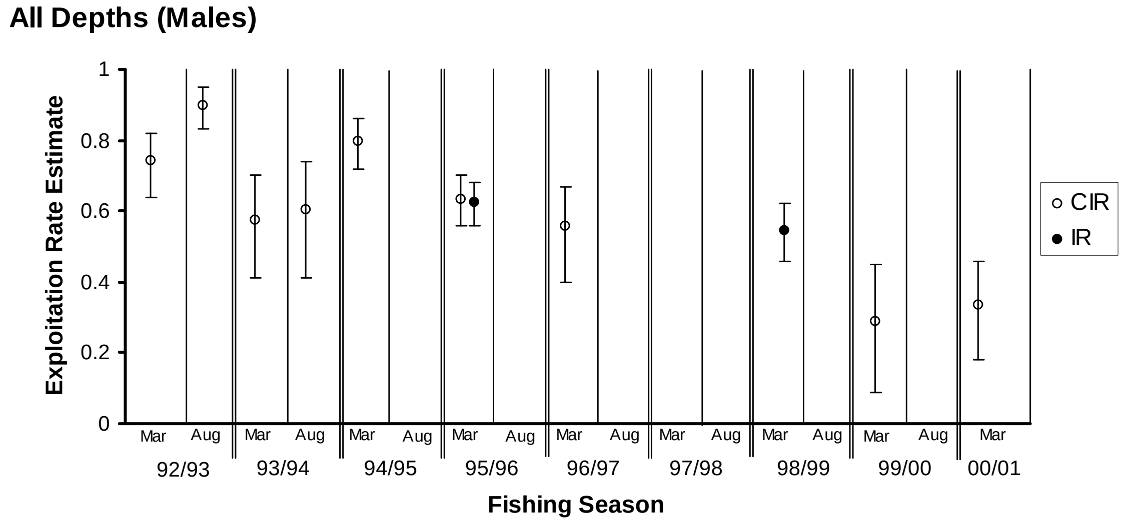

Figure 13. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from all depths (Stock Assessment Area 8), south coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

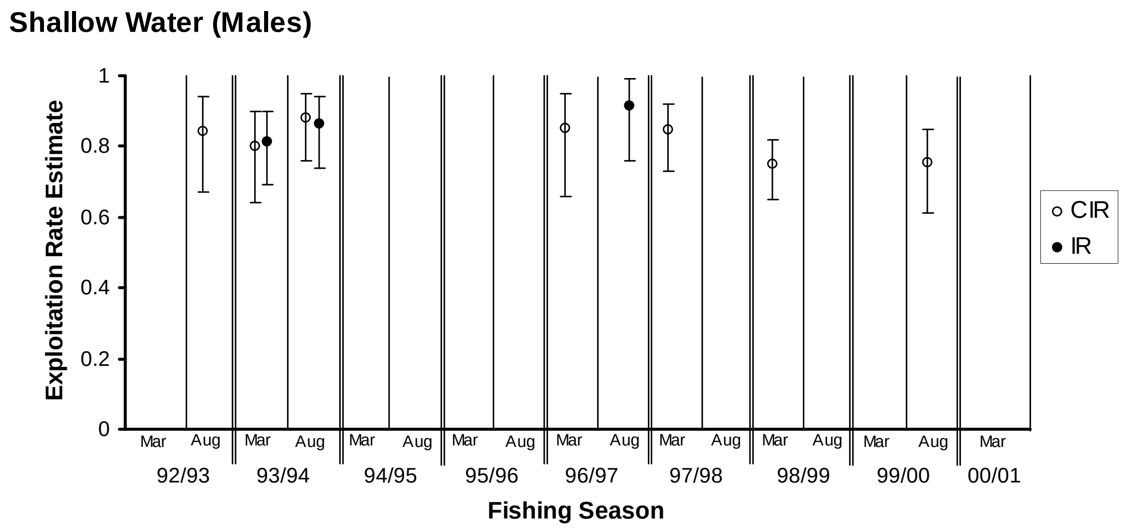

Figure 14. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from shallow water (<35m)(Stock Assessment Area 8), south coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits. Note no shallow water sites sampled in 1995/96.

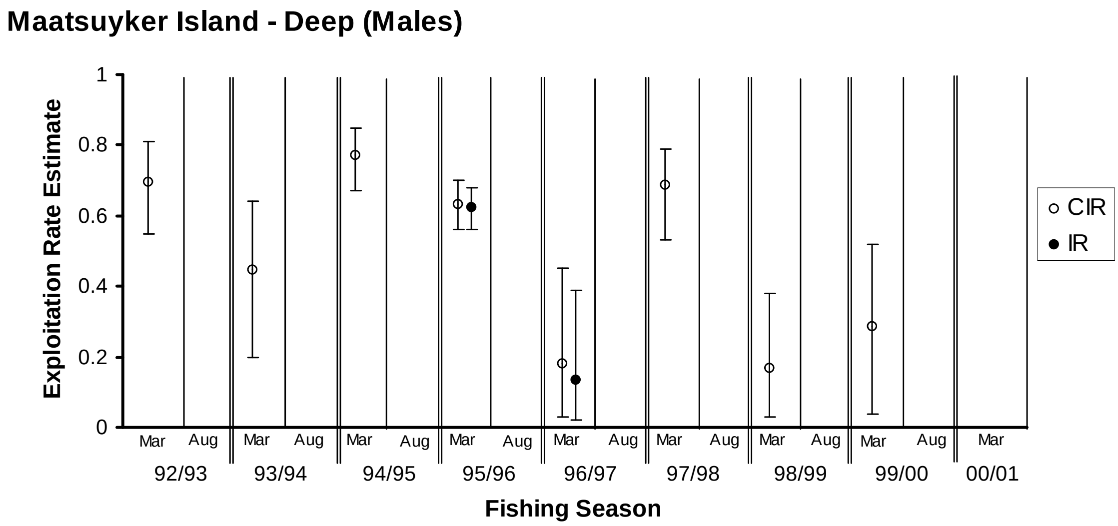

Figure 15. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from Maatsuyker Island (deep water >40m) (Stock Assessment Area 8), south coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

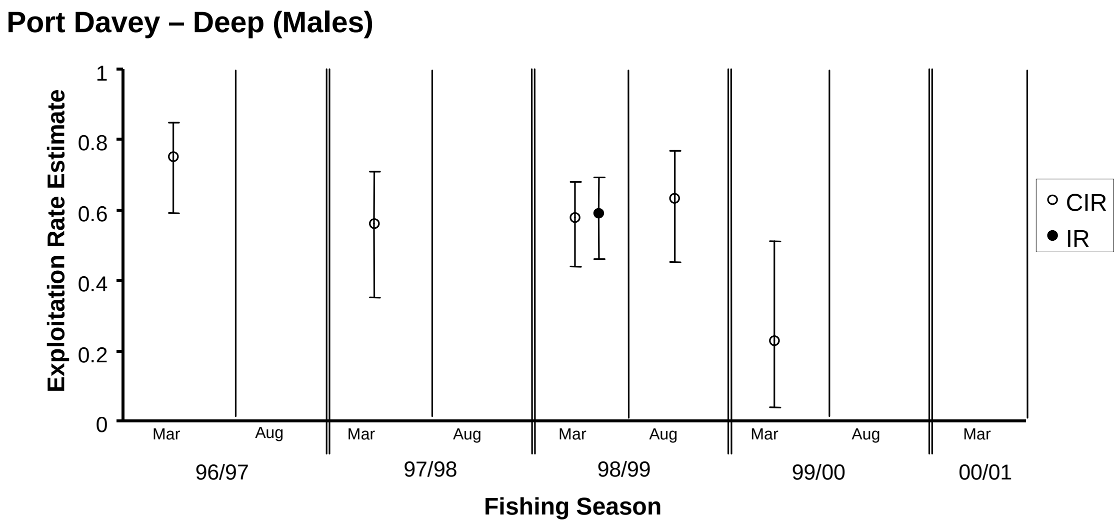

Figure 16. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from Port Davey (deep water >40m) (Stock Assessment Area 8), south coast of Tasmania. Estimates are for the 1996/1997 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

Neither the 1996/1997 nor the 1998/1999 fishing seasons were affected by a September opening and exploitation rate estimates at both the Maatsuyker Island sites and Port Davey passed the diagnostic tests. Port Davey was selected at the start of the 1996/97 season to extend our coverage of the deep-water fishery on the south coast of Tasmania. There is considerable variation between the exploitation rate estimates obtained for the two areas, which reflects the mobility of the fishing fleet. The Maatsuyker region being less heavily fished than the Port Davey region. While both regions are exposed, the Port Davey region is adjacent to the only large anchorage on the southwest coast. Fishing intensity adjacent to this anchorage would be expected to be higher than many other regions. This confirms that a broad coverage of regions within each stock assessment area is required to obtain a true representation of the extent of fishing pressure.

In comparison to shallow water sites, the greater variability in the deeper water sites is not surprising as these sites are more weather dependent and changes in exploitation rates may partially reflect differences in the available fishing days due to weather limitations. While adverse weather would have a more profound impact on shallower exposed sites, the shallow sites monitored in this project were less exposed and adjacent to anchorages. The majority of fishing occurs in deeper waters, which were considered typical of the region. The shallow sites were primarily chosen to obtain information on growth and to have a place to sample during inclement weather.

Catch sampling was extended for the 1999/00 fishing season to extend into Stock Assessment Area 7. Sampling in this area at the start of the project was not possible due to poor weather and time constraints. Two sites were surveyed; a deep-water site at Low Rocky Point and a shallow water site at Point Hibbs. This allowed us to determine exploitation rates for both deep and shallow water from this area to compare to estimates from Stock Assessment Area 8.

Estimates for the deep-water site at Low Rocky Point were available for all the survey periods (Table 7). The IR method was again not as successful, only the partial 2000/01 estimate passed the diagnostic tests. When the two methods are compared for the only period when they both passed the diagnostic tests, the CIR estimate was slightly higher than the IR estimate. Both estimates had large confidence limits, possibly due to low sample sizes.

Due to a lack of estimates for Area 7, only one (Mar 1999/00) can be compared to estimates generated for deep-water sites in Area 8. The CIR estimate from Low Rocky Point, Area 7 (Table 7) is higher than estimates determined for the deep-water sites in Area 8, Maatsuyker Island (Figure 15) and Port Davey (Figure 16). This may reflect greater fishing pressure in this area or be a result of the extended opening into September. The early moult that biased the preseason sample in Area 8 may not have occurred in Area 7. This is supported by fishers and processors reporting that the taking of ‘soft fish’ or new recruits in September was primarily from southern deeper water regions (i.e. Area 8)(Gardner *et al*., 2001).

Only one estimate was available for the shallow water site at Point Hibbs, Area 7 (Table 7). The partial 1999/00 season CIR estimate of 0.373 was significantly lower than recorded for shallow water sites surveyed in Area 8 (Figure 14). Even though no estimate was available for Area 8 for the same period, the consistently high exploitation recorded for shallow waters in Area 8 would indicate there to be a significant difference in exploitation between the areas. Point Hibbs is typical of Area 7, where the fishing grounds are more isolated and exposed with few safe anchorages, this may account for the lower exploitation.

The change-in-ratio method was more reliable than the index-removal method when determining exploitation rate estimates for the south coast. Differences in catch rates highlighted in diagnostic graphs (Appendix 5) would suggest there was a significant difference in catchability between the majority of survey periods. This is a direct violation of the assumptions associated with the IR method. When IR estimates were available, there was a high level of agreement with CIR derived estimates. This was evident at all sites and depth categories.

The CIR estimator of exploitation rate appears suited for the south coast providing there has been no harvesting of recruits at the end of the previous fishing season. Results suggest that several regions of the fishery need to be surveyed to obtain representative samples and special attention needs to be given to depth (shallow and deep) and fishing patterns (adjacent to anchorages etc.). Further work is required in Stock Assessment Area 7 although results did appear promising. Particularly in more heavily exploited deeper water site (Low Rocky Point) where exploitation rate estimates were obtained for all sampling periods. However, the remoteness of this region and the probability of undertaking regular surveys will need to be assessed.

Table 7. Exploitation rate estimates using the change-in-ratio and index-removal methods for male rock lobsters from Low Rock Point (deep water >40m) and Point Hibbs (shallow water >35m) (Stock Assessment Area 7), south west coast of Tasmania. Estimates are for the 1999/2000 (partial - March and full year – August) and 2000/2001 (March) fishing seasons when the diagnostic tests were satisfied. Included in brackets are the 95% confidence limits.

Site	**Fishing Season**	**Exploitation Rate Estimates**			
		March		**August**	
		CIR	IR	CIR	IR
Low Rocky Point	1999/2000	0.572 (-0.23, +0.77)	-	0.746 (-0.5, +0.88)	-
	2000/2001	0.366 (-0.07, +0.62)	0.291 (-0.03, +0.58)	-	-
Point Hibbs	1999/2000	0.373 (-0.07, +0.58)	-	-	-

Exploitation Rate Estimates – East Coast

Exploitation rates were determined for several sites on the east coast of Tasmania using the change-in-ratio (CIR) and the index removal (IR) methods. As for the south coast, data were added to that collected in the previous independent catch sampling project (Frusher *et al.*, 1998). This provided up to nine fishing seasons of exploitation rate estimates. Unlike the fishery in the south, both males and females are harvested on the east coast of the state. Therefore, exploitation rates are available for each sex.

When data collected from all sites surveyed on the east coast (Stock Assessment Area 2) are combined, exploitation rate estimates determined using the CIR and IR methods were available for every fishing season (Figure 17). Due to differences found on the south coast, exploitation rate estimates were also determined by depth for the east coast. Sites were pooled into two groups, medium/deep water sites (35 to 55m) and shallow water sites (<30m), all from Stock Assessment Area 2. For males, unlike the south coast there was no major difference in exploitation with depth recorded on the east coast (Figure 18 and Figure 19). This is not surprising as the gap in depth between medium/deep and shallow water is not as great as that on the south coast. Because of the low catch rates found in shallow water sites several sites were amalgamated and this would account for the broad 95% confidence intervals found around the exploitation rate estimates.

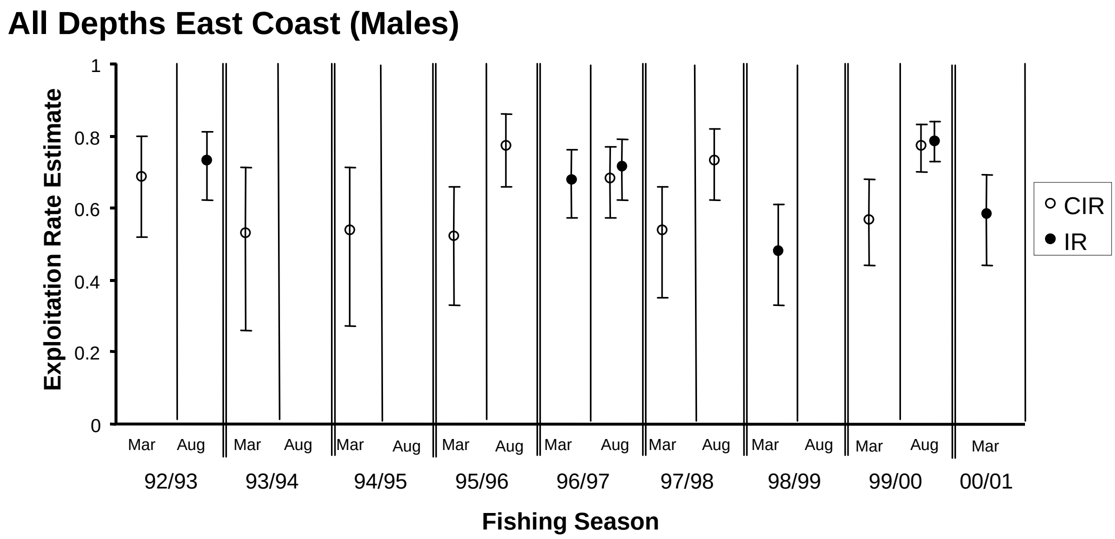

Figure 17. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from all sites surveyed on the east coast of Tasmania (Stock Assessment Area 2). Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

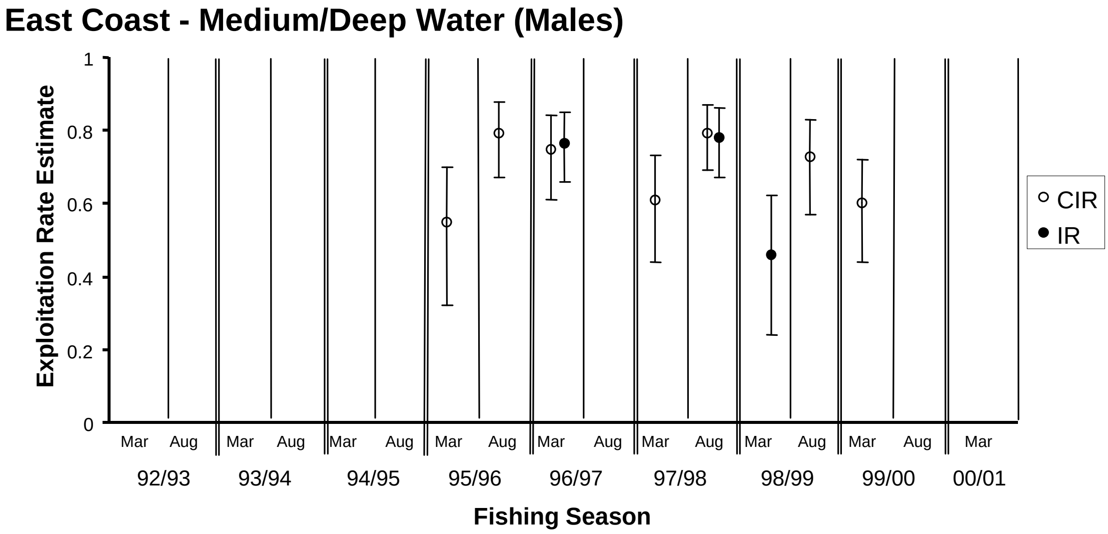

Figure 18. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from Sandstone Bluff (medium/deep water 35-60m) (Stock Assessment Area 2), east coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

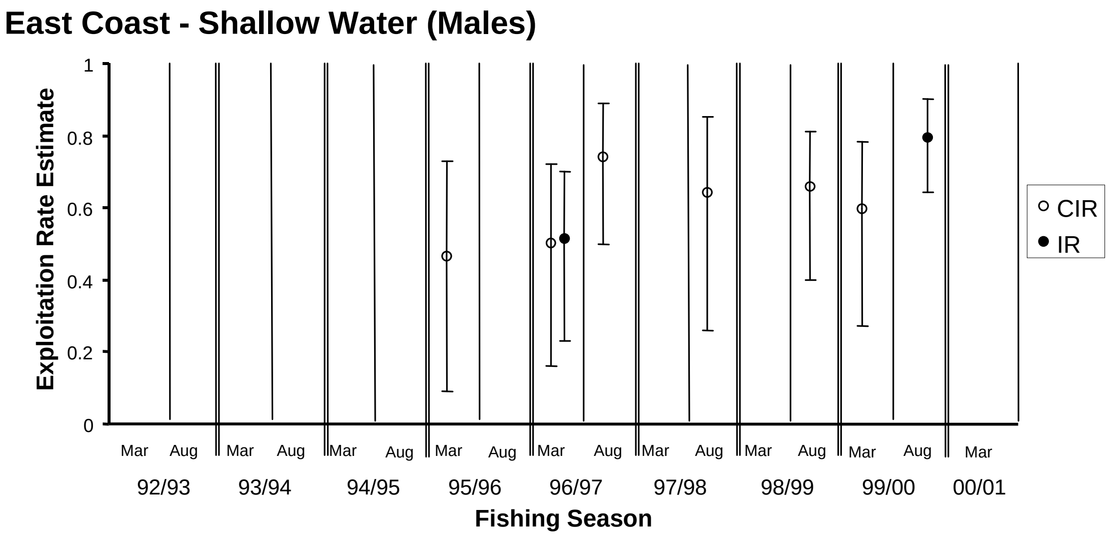

Figure 19. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from shallow water (<35m) (Stock Assessment Area 2), east coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

Females were more problematic as only one estimate is available for each season. This is due to the closure of the season after the mid season (March) survey. This closure is to protect females that tend to moult and be sexually responsive in autumn (Gardner *et al*., 2001). Hence, there are no estimates available for the second half of the season. The IR method failed to produce a valid estimate when all sites were pooled (Figure 20), medium/deep (Figure 21) or shallow water (Figure 22), as there was always a large difference in catchability between survey periods (Appendix 6 and 8). This is not surprising as females are preparing for their moult and subsequent mating and brooding period.

As was the case for males, CIR estimates for females for shallow water indicated broad 95% confidence limits. This again was probably the result of the low sample sizes and amalgamation of sites. As catch rates are significantly lower on the east coast compared to the south coast, a greater sampling effort would be required to gain an adequate sample size.

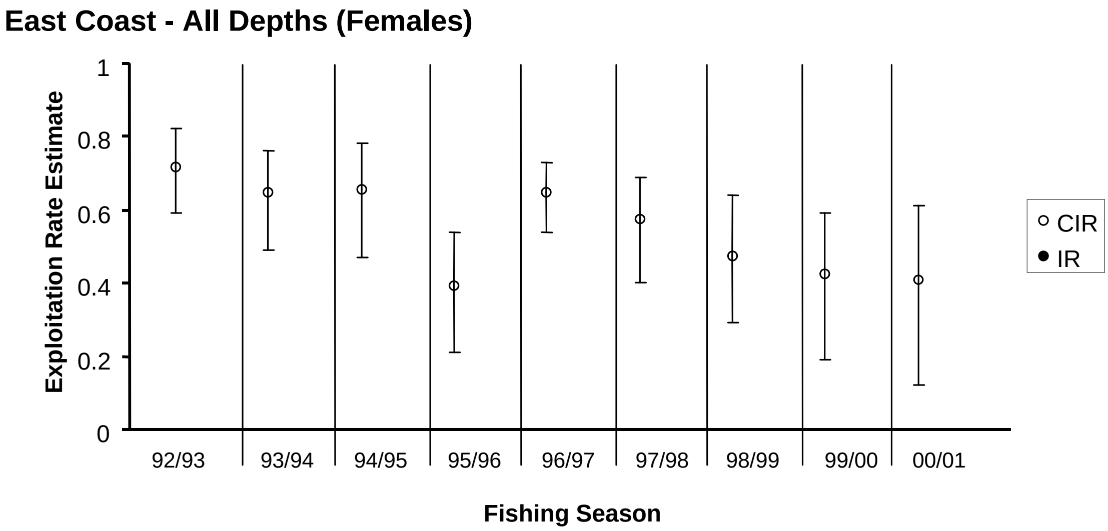

Figure 20. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for female rock lobsters from all sites surveyed on the east coast of Tasmania (Stock Assessment Area 2). Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

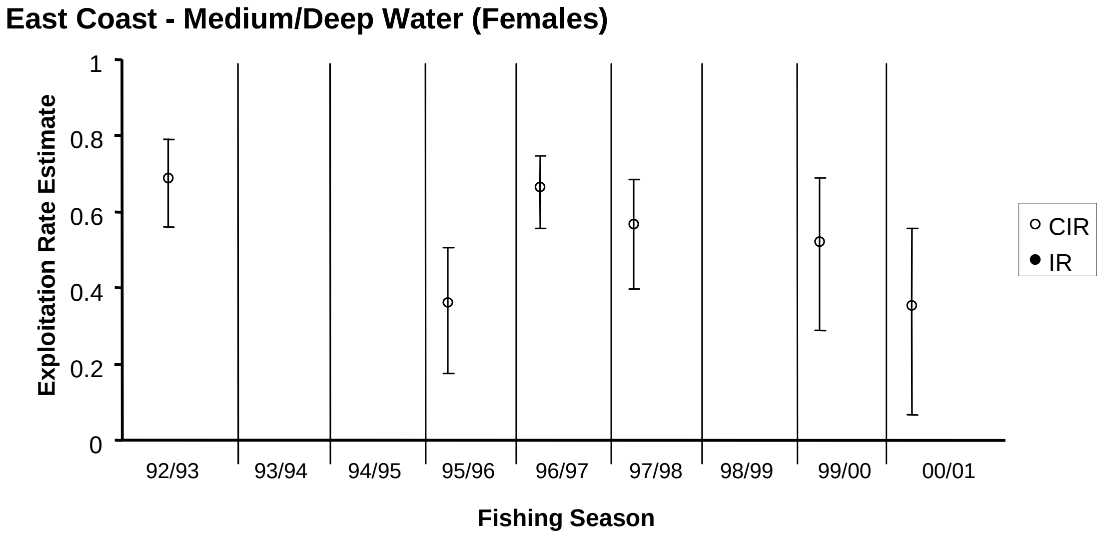

Figure 21. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for female rock lobsters from Sandstone Bluff (medium/deep water 35-60m) (Stock Assessment Area 2), east coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

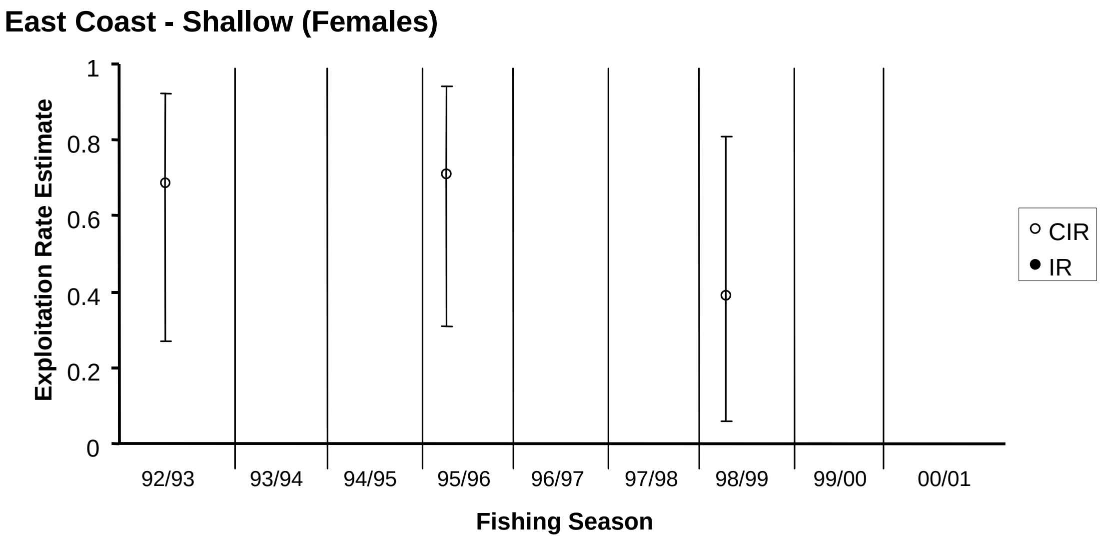

Figure 22. Exploitation rate estimates using the change-in-ratio (open circle) and index-removal (closed circles) methods for male rock lobsters from shallow water (<35m) (Stock Assessment Area 2), east coast of Tasmania. Estimates are for the 1992/1993 to 2000/2001 (partial - March and full year - August) fishing seasons when the diagnostic tests were satisfied. Error bars are 95% confidence limits.

Biomass

Biomass estimates were determined for Stock Assessment Areas 2, 7 and 8. As a difference in exploitation rates was found with depth for Area 8, biomass was estimated for shallow (<35m) and deep (>40m) water respectively. Deep-water biomass estimates have shown fluctuations, but are relatively stable (Figure 23). The higher estimate recorded in 1995/96 was due to a substantial increase in catch rates for the southwest region (Area 7 and 8) that corresponded to a large pulse of recruitment (Frusher, 1996, 1997). The increase in biomass indicated from 1998/99 onwards corresponds to the introduction of quota management in March 1998. This is consistent with data obtained from the stock assessment model, which recognises a rebuilding of stock in this area since quota introduction. Unfortunately due to problems associated with the extended season, an estimate is not available for 2000/01.

Although only six estimates are available, there is no evidence to suggest that a significant change in biomass has occurred over the last eight fishing seasons for shallow waters in Area 8 (Figure 24). The high estimate recorded in 1996/97 was probably due to the recruitment pulse recorded in 1995/96. In 1995/1996 fishers concentrated their efforts in deeper waters targeting the new recruits associated with this recruitment pulse. In the following year, favourable weather conditions allowed fishers to focus on shallower waters (Figure 25). This is supported by improved catch rates recorded for shallow waters regions in the southwest for the 1996/97 season (Frusher, 1997).

When Area 8 deep-water biomass estimates obtained from fisheries independent data using the change-in-ratio method and from the rock lobster assessment model (Gardner, 1999) are compared there appears general agreement (Figure 26). Although the model is not depth explicit, the majority of the commercial catch is derived from deeper water regions in Area 8. As previously mentioned and noted by Gardner *et al*. (2001), there is concern that the pre-season catch rates are being reduced by the September opening that has been in place since 1998. As these catch rates have been reduced by a portion of the new recruits being fished in September at the end of the previous fishing period, exploitation rates would appear to be lower which would result in over-estimates of biomass. Therefore, there is doubt over the accuracy of the CIR derived estimates for the 1998 and 1999 seasons. Continued use of both legal-sized catch rates and exploitation rate estimates derived using the change-in-ratio and index removal methods for biomass estimation need to be reviewed if September is to remain open to fishing.

Estimates of biomass for Stock Assessment Area 2 were problematic as both males and females are harvested. The commercial catch that is used to determine biomass is not separated by sex. For our estimates of biomass, the catch for each sex was determined from the ratio of the sexes from fishery independent sampling. Due to the problems associated with this method and a lack of valid exploitation rate estimates, biomass estimates for this area are not described in detail. While estimates for Stock Assessment Area 7 do not have the problem of splitting the commercial catch between sexes, they do suffer from a short time series (Table 8). No trend can be assumed although the increase in biomass in the deep-water site at Low Rocky Point is promising as it fits the pattern of a rebuilding stock since the implementation of quota management (Gardner *et al*., 2001).

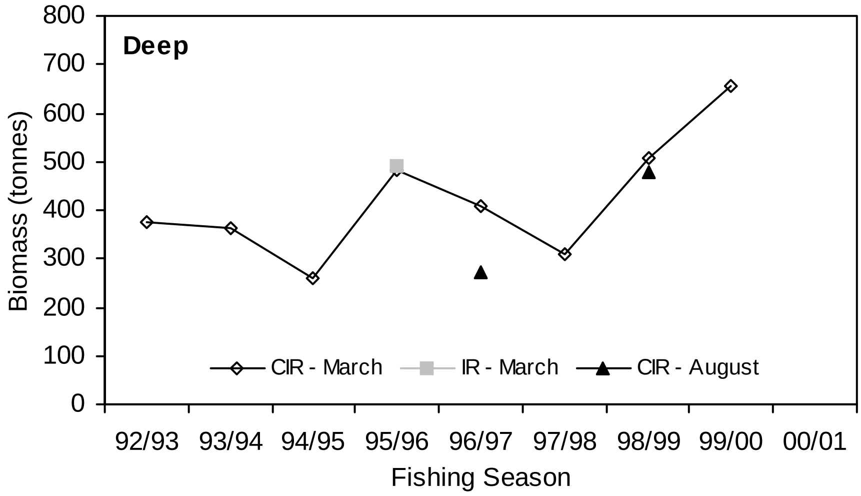

Figure 23. Estimates of legal-sized biomass for deep water (>40m) Area 8 using both the change-in-ratio and index removal methods. Estimates are derived from exploitation rate estimates determined for the partial season – March or the whole season – August. Only exploitation rate estimates that pass the diagnostic tests are used. All biomass estimates are at the beginning of the open season in November.

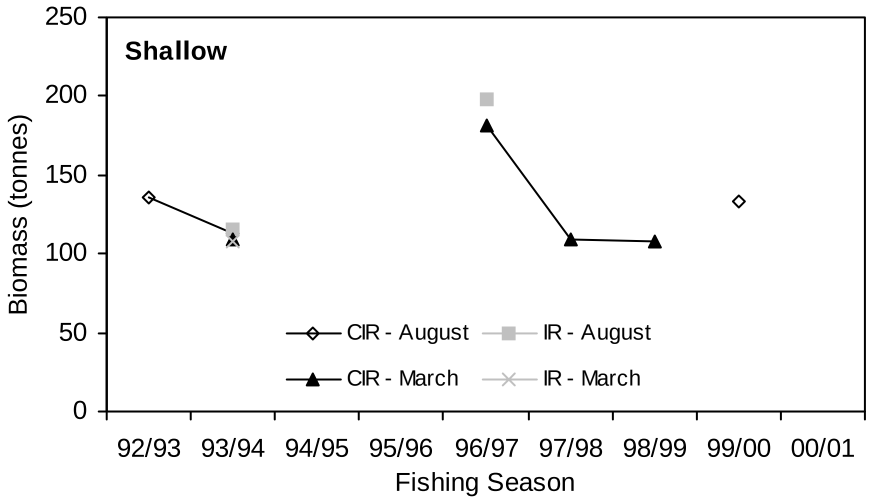

Figure 24. Estimates of legal-sized biomass for shallow water (<35m) Area 8 using both the change-in-ratio and index removal methods. Estimates are derived from exploitation rate estimates determined for the partial season – March, or the whole season – August. Only exploitation rate estimates that pass the diagnostic tests are used. All biomass estimates are at the beginning of the open season in November.

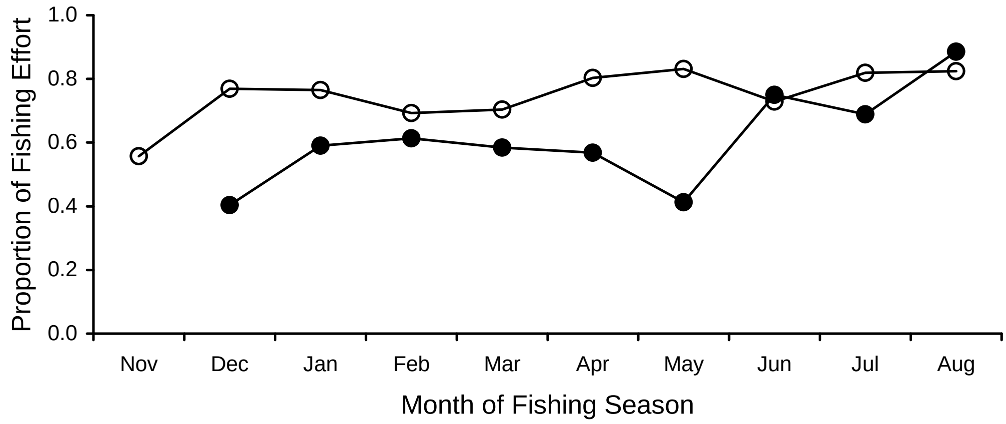

Figure 25. Proportion of lobster caught in shallow water (<=20 fathoms [36m]) during the 1995/1996 (solid circles) and the 1996/1997 (open circles) fishing seasons.

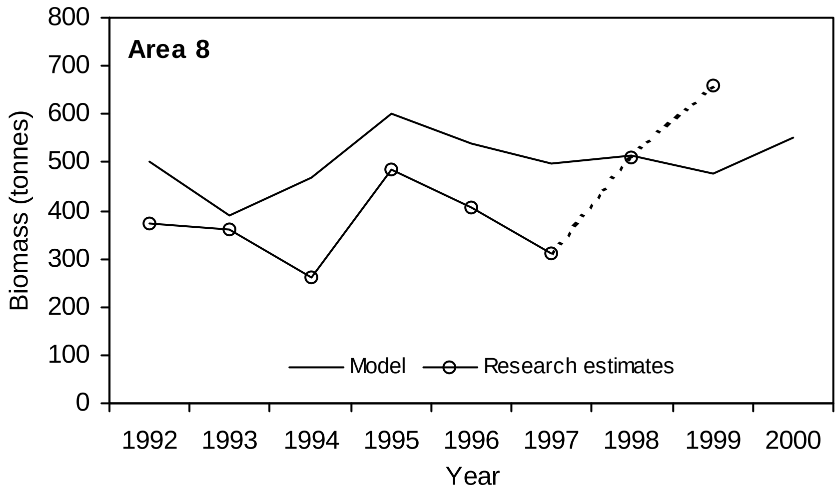

Figure 26. Estimates of legal-sized biomass using the change-in-ratio method (research) and the rock lobster assessment model (Model) for Stock Assessment Area 8 (deep water). All biomass estimates are for the beginning of the open season in November. Research estimates using the change-in-ratio method are based on partial year sampling to March. Dashed lines represent years when research biomass estimates were compromised by the September opening.

A comparison of biomass estimates derived from partial (November – March) and full (November – August) season exploitation rate estimates indicate good agreement for shallow and deep-water regions of Area 7 and 8 (Table 9). Apart from CIR estimates in 1996/97 for deep water in Area 8, the difference between partial and full season estimates was below 10%. This was not apparent for Area 2 where problems associated with separating the commercial catch by sex resulted in the large percentage differences between estimates[1].

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[1] Note that commercial catch is not separated by sex. Fishers are not required to supply catch details for each sex, just a combined total.

The agreement between the partial and end of season estimates indicates that appropriate biomass estimates can be obtained for southern regions (Area 7 and 8) from just two surveys, a pre-season and a mid-season survey. This would minimise the use of periods when behaviour may influence estimates (e.g. moulting and recruitment) by violating the assumptions associated with exploitation rate methods and thus failing their diagnostic tests. Naturally, the greater the amount of exploitation that can occur between sampling surveys the better the estimate.

Catchability, or the proportion of legal sized animals present taken with one unit of effort, is best described as a function of the water temperature, moulting and mating (Ziegler *et al*., in prep). When monthly patterns in catchability for an unfished population are compared to the cumulative catch from the fishery (Figure 27), distinct trends emerge. Mating reduces catchability of males in April/May, followed by heightened catchability afterwards. The peak that occurs in June is considered to be due to post-reproductive activity. A sample during this peak in catchability would maximise the amount of exploitation (over 80% of the total catch taken by June) while avoiding the problems associated with an early moult. However, a sample taken in March may be more appropriate. It would take advantage of a period of relatively high catchability whilst still representing 70% of the total catch. In comparison, lower catchability in June (winter) would result in greater effort to obtain the appropriate sample size, thus leading to greater costs.

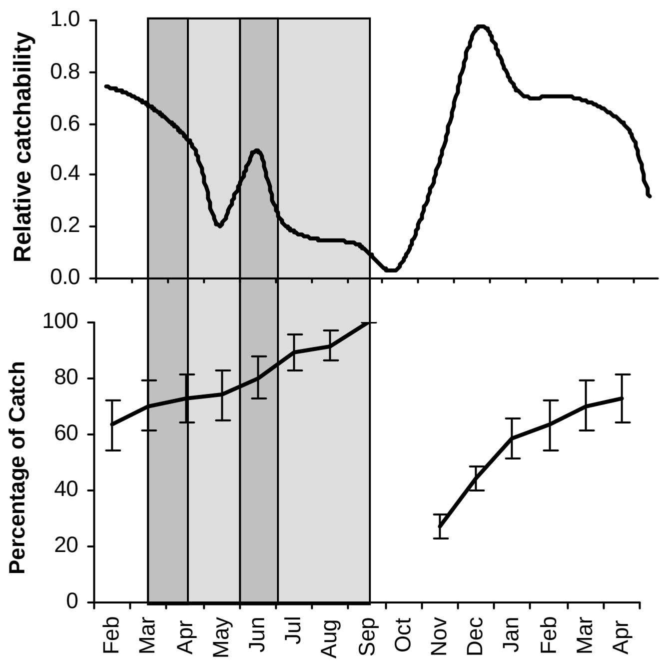


Figure 27. Monthly patterns of catchability compared to the cumulative percentage of catch for male rock lobsters. The catchability patterns are from an unfished population at Crayfish Point (Taroona) (Ziegler *et al*., in prep). The cumulative catch is for Stock Assessment Area 8 from February 1999 until April 2000. The dashed line indicates 70% of the catch, while the light shaded area indicates when >70% of the catch has been taken. The dark shaded area represents periods when the total percentage catch is >70% and catchability is high. Note the Tasmanian rock lobster fishing season runs from November until September the following year.

Table 8. Estimates of legal sized biomass for Low Rock Point (deep water >40m) and Point Hibbs (shallow water <35m) for the 1999/00 and 2000/01 fishing seasons when exploitation rate estimates passed their respective diagnostic techniques. Biomass derived from the change-in-ratio (CIR) and the index-removal methods for the partial season (March) and for the full season (August).

Site	Fishing Season	Biomass (tonnes)			
		March		August	
		CIR	IR	CIR	IR
Low Rocky Point	1999/2000	64.43	-	68.07	-
	2000/2001	94.43	118.76	-	-
Point Hibbs	1999/2000	102.15	-	-	-

Table 9. A comparison of legal sized biomass estimates for the partial season (March) and the full season (August). Biomass derived from exploitation rate estimates using the change-in-ratio (CIR) and/or the index-removal methods. Estimates are for Stock Assessment Area 8 (shallow water <35m and deep water >40m), Area 7 (deep water >40m) and Area 2 (medium 35-60m).

Year	Area	Depth	Biomass (tonnes)				% Biomass Difference
			March		August		
			CIR	IR	CIR	IR	
1993/94	8	Shallow	109.20	-	112.62	-	3
1993/94	8	Shallow	-	107.59	-	114.97	7
1996/97	8	Shallow	180.90	-	-	198.39	10
1996/97	8	Deep	406.78	-	273.12	-	-33
1998/99	8	Deep	508.14	-	478.10	-	-6
1999/00	7	Deep	64.43	-	68.06	-	6
1995/96	2	Medium	27.25	-	48.91	-	79
1997/98	2	Medium	15.40	-	29.44	-	91
1997/98	2	Medium	15.40	-	29.89	-	94

5.1.3.4. Conclusion

The CIR technique was found to be a more reliable estimator of exploitation rate than the IR technique due to changes in catchability of lobsters within the fishing season. A recent study by Ziegler (pers comm.) found catchability to vary substantially within the fishing season in a scientific reserve in southeastern Tasmania. Thus, the CIR technique with weaker assumptions regarding catchability is the more appropriate technique.

The CIR technique provided greater certainty in the estimates from southern and western regions of Tasmania compared to eastern regions. A combination of smaller sample sizes and amalgamation of sites affected estimates from eastern regions.

Confidence limits associated with exploitation rate estimates have a tendency to be broad as was noted for estimates determined for both the south and east coast of the fishery. The strength of these estimates is thus determined by the similarity of estimates derived using different methods. The use of both the change-in-ratio and the index-removal methods provide two estimates to compare. When estimates from both methods passed their diagnostic techniques, there was always a high level of agreement in exploitation rates.

The use of both the change-in-ratio and the index-removal techniques will be continually compromised however if the fishing season is to be extended into September. This is especially relevant for deeper water southern regions of the fishery where the majority of the fishing occurs during this period.

Differences in exploitation rate estimates were found with depth on the south coast. This would suggest that future stock assessments would need to separate deep and shallow water fishing grounds when determining regional exploitation rate and biomass estimates.

5.1.4. Sampling power of CIR Method

To improve the precision of estimates of both population size and exploitation rate using the CIR method, larger sample sizes are required when the change in proportions of sized animals to undersized decreases (p_1-p_2, see Section 5.1.1.2; Frusher *et al*., 1997, Paulik and Robson, 1969). Frusher *et al*. (1997) found a negative linear relationship between the average 95% confidence interval and the exploitation rate estimate for a given number of pots sampled. As the number of pots used to estimate exploitation rate increased, the precision of the estimate improved.

For each of the exploitation rate estimates that passed the diagnostic tests (Section 5.1.2) we ran a series of simulations to construct the catch based upon sampling efforts of 250, 500, 750 and 1000 pots. Simulations used the data obtained for each pot during the actual surveys required to obtain the exploitation rate estimate. The increased sample size was obtained by randomly selecting (with replacement) a specified number of pots (with the associated catch of lobsters). This simulated sample data was then bootstrapped to determine the 95% confidence limit. The average 95% confidence interval from these simulations were plotted against the exploitation rate estimate for the South and East Coasts (all depths combined), deep and shallow water regions on the South Coast and for separate deep water sites on the South Coast (Figures 28 – 30 respectively). The extent to which an inverse linear regression line for each of the sample sizes describes the variation in the data is presented in Table 10. With the exception of the shallow water sites on the South Coast, the regressions provide a reasonable fit (r^2>0.6).

The level of precision required for detecting changes in exploitation rates, and thus biomass, often needs to be weighed against the cost in improving the precision. For example, to detect a change in exploitation rate between 0.5 and 0.6, the average 95% confidence interval would have to be less than 0.05 (i.e. to ensure no overlap of confidence limits). This would require approximately 400 pots to be sampled on the

South Coast and 750 pots on the East Coast. In addition, for each of the deep-water sites this would require sampling approximately 250 pots.

As expected from the broad confidence limits found for estimates on the East Coast (see Section 5.1.3), almost twice the sampling effort is required to obtain comparable precision to South Coast estimates. Using the example above, up to 15 days of sampling would be required to detect a change in exploitation rate from 0.5 to 0.6 on the East Coast. To obtain representative exploitation rates, sampling needs to be undertaken twice per year at different sites and different depths. The costs and time for fishery independent sampling would be substantial. Careful consideration is required to balance the precision required for a management decision with the cost of sampling

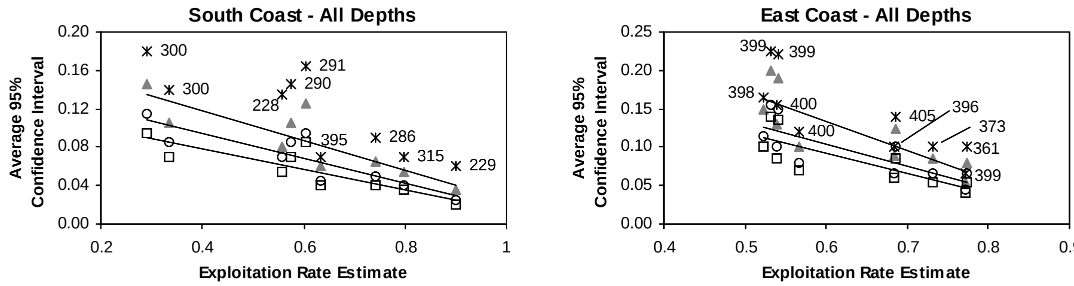


Figure 28. Relationship between the average 95% confidence interval and the exploitation rate for different simulated numbers of pots sampled (grey triangles – 500 pots; black open circles – 750 pots; black open squares – 1000 pots) for all depths on both the east and south coasts. Also included is the relationship for the actual number of pots sampled (black star – actual number of pots written beside). Regression lines are shown for the simulated data. Note horizontal axes do not start at zero.

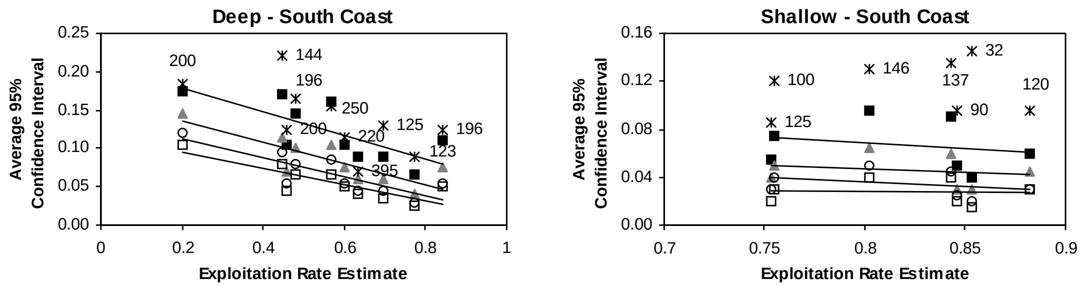


Figure 29. Relationship between the average 95% confidence interval and the exploitation rate for different simulated numbers of pots sampled (black closed squares – 250 pots; grey closed triangles – 500 pots; black open circles – 750 pots; black open squares – 1000 pots) for deep-water sites and shallow water sites on the south coast of Tasmania. Also included is the relationship for the actual number of pots sampled (black star – actual number of pots written beside). Regression lines are shown for the simulated data. Note shallow water horizontal axis does not start at zero.

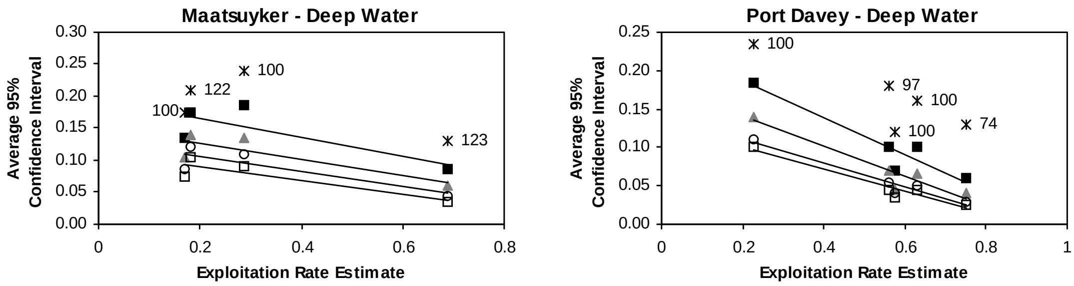


Figure 30. Relationship between the average 95% confidence interval and the exploitation rate for different simulated numbers of pots sampled (black closed squares – 250 pots; grey closed triangles – 500 pots; black open circles – 750 pots; black open squares – 1000 pots) for the deep-water sites at Maatsuyker Island and Port Davey on the south coast of Tasmania. Also included is the relationship for the actual number of pots sampled (black star – actual number of pots written beside). Regression lines are shown for the simulated data.

Table 10. R^2 values for the linear regressions of exploitation rate estimates and confidence intervals shown in Figure 28, Figure 29, Figure 30.

Explained Variation				
	Number of Pots			
Area	**250**	**500**	**750**	**1000**
South	-	0.7126	0.7617	0.7162
East	-	0.6677	0.6466	0.6373
South – Deep	0.5494	0.6616	0.6894	0.6817
South – Shallow	0.0544	0.0461	0.1104	0.0003
South – Deep – Port Davey	0.8935	0.9015	0.9423	0.9384
South – Deep - Maatsuyker	0.6145	0.7098	0.7127	0.7795

5.2. Multi-year Tagging Models

5.2.1. Introduction

Brownie *et al*. (1985) presented a series of multi-year tagging models aimed at estimating survival of animals tagged over successive years (Figure 10). Essentially, the expected number of recoveries is a function of the initial number tagged, the number that have survived up to the harvest period and the fraction of tags recovered and reported during the harvest period.

Hoenig *et al*. (1998) re-parameterised the multiyear tagging models of Brownie *et al*. (1985) in a very general formulation that expresses survival in terms of instantaneous rates of fishing and natural mortality.

The survival term in year *i* (S_i) was replaced by $S_i = \exp(-F_i - M_i)$ and the recovery rate term (f_i) by

$$\lambda(1-\exp(-F_i - M_i))\left(\frac{F_i}{F_i + M_i}\right)$$

where

F_i = instantaneous fishing mortality rate in year *i*,

M_i = instantaneous natural mortality rate in year *i*,

λ = a composite parameter that represents the joint probability of three events: the probability that a tag will be found and reported to the fisheries biologist, given that the tagged animal has been harvested; the probability that a tagged animal does not die from the tagging process; and the probability that a tag is not shed immediately. λ is assumed constant over time.

The term $(1-\exp(-F_i - M_i))$ represents the fraction of animals alive at the start of the period that died in period *i*. Because the animals are returned by fishers and represent fishing mortality only, this term is multiplied by

$\left(\frac{F_i}{F_i + M_i}\right)$ which is the fraction of the deaths attributable to fishing in year *i*.

Substituting for *S* and *f* in Table 11, the following expected recoveries are obtained over the four years of the tagging program for the animals tagged at the start of the first year:

$N_1 f_1 = N_1 \lambda (1 - \exp(-F_1 - M_1)) \left(\frac{F_1}{F_1 + M_1} \right)$

$N_1 S_1 f_2 = N_1 \exp(-F_1 - M_1) \lambda (1 - \exp(-F_2 - M_2)) \left(\frac{F_2}{F_2 + M_2} \right)$

$N_1 S_1 S_2 f_3 = N_1 \exp(-F_1 - M_1 - F_2 - M_2) \lambda (1 - \exp(-F_3 - M_3)) \left(\frac{F_3}{F_3 + M_3} \right)$

These expectations can be converted into a set of probabilities for a tag being recovered in any particular year. There are a range of possible tag recovery outcomes for each observation within a cohort, thus these tag recovery outcomes represent a sample from a multinomial distribution (Haddon, 2001).

In practice, the natural mortality rate is assumed not to vary over time and $M_i = M$ for all years in order to reduce the number of parameters in the model. Although tag reporting rate (λ) can theoretically be estimated from the models, Hoenig *et al*. (1998) found that tag reporting rate estimates were unreliable (even if M is assumed constant over all years) unless there are many years of tagging with a wide range of fishing mortality rates.

Hearn *et al*. (1998) described a model that used data from a twice-a-year tagging study to estimate fishing and natural mortality. They were also able to obtain improved estimates of tag reporting rate over that obtainable from the models of Hoenig *et al*. (1998). The Hearn *et al*. (1998) model has a fishing period where both fishing and natural mortality affect survival and a closed period of the year where only natural mortality affects survival. For example, if we assume that a fishing season operates for 6 months of the year and we tag at the start of the fishing season (**s**) and also at the end of the fishing season (**e**) we obtain expected recoveries as described in Table 12.

If we divide the expected returns in year 2 from animals tagged at the end of the fishing season in year 1 by the expected returns from animals tagged at the start of the fishing season in year 2 we get:

$$\frac{N_{1e} \lambda \exp(-0.5M_1)(1 - \exp(-F_2 - 0.5M_2)) \left(\frac{F_2}{F_2 + 0.5M_2} \right)}{N_{2s} \lambda (1 - \exp(-F_2 - 0.5M_2)) \left(\frac{F_2}{F_2 + 0.5M_2} \right)} = \frac{N_{1e} \exp(-0.5M_1)}{N_{2s}}$$

If this is equated with the ratio of tag recoveries from these two cohorts, the result is easily solved for an estimate of M_1.

By dividing the expected recaptures in year 2 from tagging at the start of year 1 by the expected recaptures from tagging at the end of year 1 we get:

$$\frac{N_{1s}\lambda \exp(-F_1 - M_1)(1-\exp(-F_2 - 0.5M_2))\left(\dfrac{F_2}{F_2 + 0.5M_2}\right)}{N_{1e}\lambda \exp(-0.5M_1)(1-\exp(-F_2 - 0.5M_2))\left(\dfrac{F_2}{F_2 + 0.5M_2}\right)} = \frac{N_{1s}\exp(-F_1 - M_1)}{N_{1e}\exp(-0.5M_1)}$$

Again, if this is equated with the observed ratio of recaptures from the 2 cohorts the result is easily solved for an estimate of F_1 when M_1 is known.

Substituting estimated values for F_1 and M_1 into the expected recaptures in year one from tagging at the start of year 1 and equating with the observed number of recaptures allows estimation of λ.

Frusher and Hoenig (2001) combined the approaches of Hoenig *et al*. (1998) and Hearn *et al*. (1998), and applied the method to the data from the fishery for southern rock lobster (*Jasus edwardsii*) in Tasmania, Australia. They found the most parsimonious model utilized all three within year tagging events and was based on combined sexes. Their model produced reasonably precise estimates of fishing mortality and tag reporting rate but imprecise and extremely low estimates of natural mortality.

In the models of Frusher and Hoenig (2001), information on fishing effort was used merely to apportion fishing mortality in a year to periods of the year. Information on fishing effort was not functionally linked to year-to-year changes in mortality (so that a doubling of fishing effort from one year to the next did not force the predicted fishing mortality to be doubled). Hoenig *et al*. (1998) termed this use of fishing effort data the “weak effort assumption”. They also suggested that annual fishing mortality might be modelled as being proportional to fishing effort, and termed this the “strong effort” assumption. Latour *et al*. (2001) applied this idea in the context of the models of Hoenig *et al*. (1998). However, their data were sparse and their results were highly dependent on externally supplied information of tag reporting rate. Consequently, they were not able to develop and compare a suite of competing models.

Frusher and Hoenig (in prep) extended their models based on the strong effort assumption. Again, because of the large number of parameters to be estimated, tag reporting rate, λ, and natural mortality rate, M, were held constant over all years. To further reduce the number of parameters and make use of auxiliary data on fishing effort, the equation $F_{ijk} = q_{jk}e_{ij}$ was substituted for each of the F’s in the basic model. Here, F, q and e represent fishing mortality, catchability and effort respectively and the subscripts i, j and k refer to the year, period of the year and sex, respectively.

To minimise the number of catchability parameters being estimated, Frusher and Hoenig (in prep) kept catchability constant for the same period of the year among different years. They allowed catchability to vary between tagging events within a year as Zeigler *et al*. (in prep) found substantial changes in catchability to occur throughout the fishing season. Thus the timing of fishing effort within a fishing season and between fishing seasons will influence the number of lobsters captured and thus the probability of tagged lobsters being caught.

The most parsimonious model based on seasonal variation in catchability was when a non-sex-specific q was estimated separately for each period (Frusher and Hoenig, in prep). Parsimony was determined as for methods described by Burnham and Anderson (1998).

Fishing mortality estimates were similar for the fishing years while tagging was ongoing (1992/1993 to 1995/1996), when fishing effort was apportioned by either the period of year as relative fishing effort (Frusher and Hoenig, 2001) or when actual effort and seasonal catchability estimates were used (Frusher and Hoenig, in prep).

Natural mortality estimates from the catchability models (Frusher and Hoenig, in prep) were similar to Kennedy's (1992) estimates of 0.1. Kennedy's estimates were based on a limited number of long-term (5 to 18 years) tag recaptures from female rock lobsters in southern Tasmania. Although natural mortality is unknown, the estimates from the catchability model (0.12 - Frusher and Hoenig, in prep) were more precise and similar to literature values and thus considered an improvement over the zero estimates of Frusher and Hoenig (2001).

The incorporation of seasonal catchability parameters had virtually no impact on the precision of tag reporting rate estimates.

As the multi-year tagging models developed by Frusher and Hoenig (2001, in prep) had provided an alternative method to estimate fishing mortality, it was considered appropriate to trial these methods in conjunction with the CIR and IR methods. These models have the potential to address the concerns of seasonal variations in catchability and start or end of season moulting that affect the CIR and IR methods.

Table 11. Expected recoveries of tagged animals during 4 years of harvesting from animals tagged at the start of the first three years (from Brownie *et al*., 1985).

Year	Expected recoveries in Year			
	1	2	3	4
1	$N_1\ f_1$	$N_1\ S_1\ f_2$	$N_1\ S_1\ S_2\ f_3$	$N_1\ S_1\ S_2\ S_3\ f_4$
2		$N_2\ f_2$	$N_2\ S_2\ f_3$	$N_2\ S_2\ S_3\ f_4$
3			$N_3\ f_3$	$N_3\ S_3\ f_4$

f = probability that a tagged animal, alive at the start of a period, is recaptured and reported during the specified harvest period.
S_i = probability an animal, alive at the start of year i survives the year
N_i = number of animals tagged at the start of year i.

5.2.2. Materials and Methods

5.2.2.1. Tag and Recapture

From 1997 to 2000, all legal-sized lobsters were tagged during research cruises off the coast of southern Tasmania on the commercial fishing grounds. The same tagging sites were visited on all cruises. Lobsters were tagged immediately upon capture and released at the site of capture. Lobsters were tagged ventrally with individually numbered T-bar tags (Hallprint T-bar anchor tag; TBA1, Hallprint Pty. Ltd., 27 Jacobsen Crescent, Holden Hill, South Australia 5088, Australia). A ventral tagging position was favoured for this project as Kennedy (pers. comm.) found less tag loss compared to the dorsal tagging position and lobster had been recaptured up to 18 years after tagging when tagged ventrally. The ventral position was considered to offer more protection to the tag compared to the dorsal position where it would be subject to abrasion as lobsters sheltered in crevices and dens in rocky reef. Lobsters were tagged in October/November at the start of the fishing season, in March just prior to the closure of the female fishing season and in August prior to the closure of the male fishing season.

Tagging sites were situated within the main fishing grounds. Gardner *et al*. (in prep) found that legal sized lobsters were primarily recaptured in the location of release. The entire available habitat for *J. edwardsii* is routinely fished each season.

Notices requesting return of tags were posted to all fishers and processors known to process Tasmanian rock lobsters. To encourage participation, a tag lottery was established. Each correctly completed tag return represented an entry into the lottery. Advertising of the tagging project was undertaken by regular articles in the fishing industry magazine (*Fishing Today*) and by regular oral presentations at the Tasmanian rock lobster fishermen's association meetings.

The Tasmanian rock lobster fishery opens in November for both males and females, although the exact date has varied slightly over the years from 1997 to 2000. The female fishing period closes at the end of April while the end of the male fishing season has varied between the end of August and the end of September. Although female lobsters are caught from May to the end of the male fishing period, it is mandatory that they be returned to the sea. These female lobsters are rarely checked for tags and any that were reported have not been included in the analysis. During the recapture periods, there were no reports of tagged legal-sized female lobsters that died due to the fishing activity (e.g., from predation by an octopus in the trap). Models utilised the methods of Frusher and Hoenig (in prep) that accounted for variation in seasonal catchability parameters

5.2.3. Results and Discussion

The number of tagged lobsters returned by the commercial fishery from each tagging event is shown for South Coast males (Table 13), East coast males (Table 14) and East Coast females (Table 15). Although several hundred lobsters were tagged each year, tag returns were poor with very few tags being returned after the first recapture period after tagging.

Despite the poor tag returns we developed models based on the data for the south and east coasts. Fishing mortality, natural mortality and tag reporting rate estimates from these models were clearly unrealistic, indicating that too few tags were returned. An analysis of the TAFI tagging database indicted that very few fishers were reporting tags (Gardner, 2001).

In 2000 and 2001, the rock lobster fishing season was extended into September of each year. During these periods, observers were placed on a number of vessels. For the September 2001 extension, fishers had to obtain a permit to fish during this period. Part of the permit required fishers to report on recently moulted lobsters and report tagged lobsters. The September fishing periods have heightened fisher's awareness of tagged lobsters and an increase in reported tags has been noted since September 2001. If sufficient tags are returned from the September 2000, November 2000, March 2001 and September 2001 tagging periods we will attempt to use the tagging models to estimate fishing mortality.

We strongly advocate continuing this research but recognise that there needs to be an increased willingness by fishers to check and report tagged lobsters. Concerns raised by several fishers have been the amount of data that fishers have been asked to record and the location of the tagging position on the lobster. The current tagging project was instigated to obtain information on growth and movement. For a recaptured tagged lobster to contribute useful information to this project, it is essential that information on tag number, location, size, date of recapture and sex are accurately recorded. In contrast, the only information that is required for estimating parameters using multi-year tagging models is the date of recapture and tag number so that the tag can be associated with a specific cohort of tagged animals.

The position of tagging should also be reviewed as the dorsal tagging position places the tag in a more visible location for fishers to see the tag when handling lobsters (transferring from the pot to the ship's 'live' well and from the 'live' well to processors bins). Although tag loss from the dorsal tagging position was considered to be greater compared to the ventral tagging position, Treble (1996) found dorsal T-bar tags to have higher retention rates although his 'reliable' data (obtained from researchers or trained fishers) did not support a difference between ventral or dorsal tagging positions. Treble (1996) stated that the dorsal tagging position should be favoured as it obtained higher reporting rates due to its improved visibility and improved tag reporting rate.

5.2.4. Conclusion

Before multi-year tagging models can be used to determine exploitation rates in the Tasmanian rock lobster fishery, greater certainty that tags will be returned by fishers needs to be obtained. The use of tag lotteries and addressing fisher's meetings did not provide sufficient impetus to improve tag reporting. Two areas that are worthy of consideration are positioning the tag so it is more visible (e.g. dorsally) and requiring fishers to report a minimum of data.

Table 12. Expected recoveries from tagging twice per year at the start and end of the harvesting period. This model assumes that the harvesting period is for six months of the year and that natural mortality in a time interval is proportional to the length of the interval. Thus for six months of the year, both fishing mortality and natural mortality affect survival and for six months of the year only natural mortality affects survival. N_{ij} is the number of lobsters tagged in year i and tagging period j. F_i and M_i are the instantaneous fishing and natural mortality rates, respectively, in year i. λ is a composite parameter which includes tag reporting rate, tag loss and tag induced mortality.

Year	Tagging period	Expected Recoveries in Year	
		1	2
1	s	$N_{1s}\lambda(1-\exp(-F_1-0.5M_1))\left(\dfrac{F_1}{F_1+0.5M_1}\right)$	$N_{1s}\lambda\exp(-F_1-M_1)(1-\exp(-F_2-0.5M_2))\left(\dfrac{F_2}{F_2+0.5M_2}\right)$
	E		$N_{1e}\lambda\exp(-0.5M_1)(1-\exp(-F_2-0.5M_2))\left(\dfrac{F_2}{F_2+0.5M_2}\right)$
2	S		$N_{2s}\lambda(1-\exp(-F_2-0.5M_2))\left(\dfrac{F_2}{F_2+0.5M_2}\right)$

Table 13. Tag and recapture details of male legal sized lobsters caught on the south coast of Tasmania from November 1997 to October 2000.

Tag date	No. tagged	Recapture period								
		1997	1998			1999			2000	
		21 Nov - 3 Mar	4 Mar - 19 Aug	20 Aug - 16 Sep	14 Nov - 2 Mar	3 Mar - 21 Jul	22 Jul - 16 Sep	13 Nov - 23 Mar	24 Mar - 19 Jul	20 Jul - 1 Oct
Nov-97	381	24	6	3	3	3	0	1	0	0
Feb-98	86		3	0	1	0	0	0	0	0
Aug-98	31			0	0	0	0	0	0	0
Nov-98	445				10	6	1	0	1	0
Feb-99	251					7	0	1	2	0
Jul-99	105						1	1	1	1
Nov-99	394							8	1	1
Mar-00	152								1	0
Jul-00	68									0

Table 14. Tag and recapture details of male legal sized lobsters caught on the east coast of Tasmania from November 1997 to October 2000.

Tag date	No. tagged	Recapture period								
		1997	1998			1999			2000	
		21 Nov - 20 Feb	21 Feb - 7 Aug	8 Aug - 16 Sep	14 Nov - 19 Mar	20 Mar - 12 Aug	13 Aug - 16 Sep	13 Nov - 9 Mar	10 Mar - 4 Aug	5 Aug - 1 Oct
Nov-97	172	4	1	0	0	1	0	0	0	0
Feb-98	92		0	0	0	0	0	1	0	0
Aug-98	46			0	0	1	0	0	0	0
Oct-98	184				3	1	0	1	0	0
Mar-99	93					1	0	1	0	0
Aug-99	64						0	0	0	0
Oct-99	426							15	27	0
Mar-00	137								16	0
Jul-00	96									0

Table 15. Tag and recapture details of female legal sized lobsters caught on the east coast of Tasmania from November 1997 to April 2000.

Tag date	No. tagged	Recapture period					
		1997	1998		1999		2000
		21 Nov - 20 Feb	21 Feb - 30 Apr	14 Nov - 19 Mar	20 Mar - 30 Apr	13 Nov - 9 Mar	10 Mar - 30 Apr
Nov-97	157	2	0	2	0	0	0
Feb-98	58		0	2	0	0	0
Aug-98	138			3	1	1	3
Oct-98	210			3	1	0	1
Mar-99	57				0	0	0
Aug-99	89					1	1
Oct-99	312					5	8
Mar-00	75						3

6. Fishery Dependent Estimates of Exploitation and Biomass

6.1. Fishery Dependent Catch Sampling

6.1.1. Introduction

Estimates of exploitation rates and biomass are important stock assessment parameters and biological reference points for sustainable management of fisheries. Since 1992, we have evaluated the change-in-ratio (CIR) and index-removal (IR) techniques to estimate these parameters for the southern rock lobster (*Jasus edwardsii*) in southern Tasmania (Frusher *et al*., 1997, 1998; Chapter 5.1.2.3). Data used to evaluate these techniques were derived from fishery independent sampling using *FRV Challenger*. The fishery independent sampling project enabled sites to be sampled at set times and independent of catch rates. However, fishery independent projects are costly, as they need to include the costs of operation and of labour associated with both the research vessel and the scientific field staff. They are also limited spatially as one vessel can only sample in one location at a time.

For both the CIR and the IR techniques, the main data requirement is a count of legal and sub-legal sized lobsters. Given the success of obtaining voluntary information from fishers in the South Australian (Prescott, 1992) and New Zealand (Starr and Vignaux, 1997) rock lobster fisheries, it was considered plausible to ask fishers to collect the appropriate data that could be used to estimate exploitation rates and biomass. Industry had previously demonstrated a willingness to be involved in research activities by tagging lobsters (Kennedy and Tarbath, 1992). Advantages of using the fishing industry include the increased spatial coverage and minimising costs. Recently, the State Government has indicated that it intends to pursue cost recovery for management and research and thus cost-effective ways of collecting data need to be evaluated.

This chapter evaluates the success of involving the fishing industry and the accuracy of data provided by the industry compared to fishery independent information.

6.1.2. Materials and Methods

6.1.2.1. Sampling Design – Initial

Rock lobster fishers were asked to volunteer to undertake surveys at three distinct times throughout the fishing season. Sampling was undertaken in November, March and July/August, in line with the sampling design used for independent catch sampling (see Chapter 5.1.1.2). Fishers were to set their pots in the March and July/August surveys in similar positions to where the November pots were set.

The number of pots sampled each day was at the discretion of each fisher with the aim of minimising interference with the fisher’s normal fishing operations. Fishers were given a plastic tag to mark pots they were going to sample before the pot was set, to avoid biases associated with selecting a pot because it 'had a large number of lobsters' and thus provide data which is more random in design. Participating fishers were issued with sampling kits which consisted of waterproof data sheets, plastic pot tags, an example data sheet and prepaid return addressed envelopes. For each pot sampled, fishers were asked to record the number of legal-sized and undersized lobsters of each sex, the pot location (latitude and longitude), depth (meters or fathoms) and pot type (wooden stick or steel).

To compare estimates between fishers data and fishery independent data, only fishers who were working deep waters sites (40-80m) on the south coast in the general vicinity of research sites were asked to participate (Figure 31).

To minimise any effects due to size-related variation in catchability, Frusher *et al*. (1998) restricted the extent of the legal-size and undersize groups to just below and just above the mandatory minimum legal-size limit. Unlike research pots, commercial pots are required to be fitted with escape gaps. A comparison of the size frequency of research pots with and without escape gaps demonstrates that the majority of undersized lobsters retained in pots with escape gaps are just below legal-size (Figure 32). Catch rates of legal-sized lobsters in pots with and without escape gaps were not significantly different (ANOVA, p=0.6982) whereas there were significant differences in catch rates of sub-legal lobsters (ANOVA, p=0.0005) (Figure 33). The broad standard deviations of the sub-legal catch rate in pots with escape gaps represents the variation in sub-legal lobsters found at different sites on the South Coast. Although the undersized component of the research and industry pots would not be identical, it was considered that they would be sufficiently similar to minimise any size-related behavioural differences in catchability of lobsters between fishing gears.

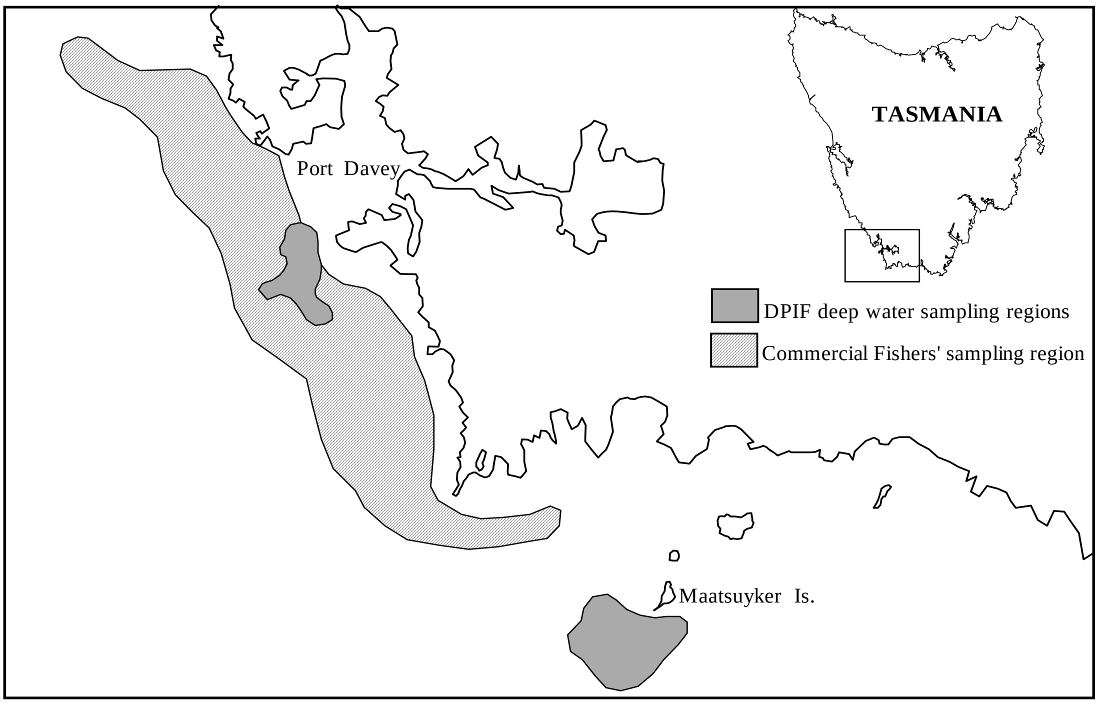


Figure 31. Independent (research) and dependent (commercial fishers) catch sampling survey regions for the 1997/98 rock lobster fishing season.

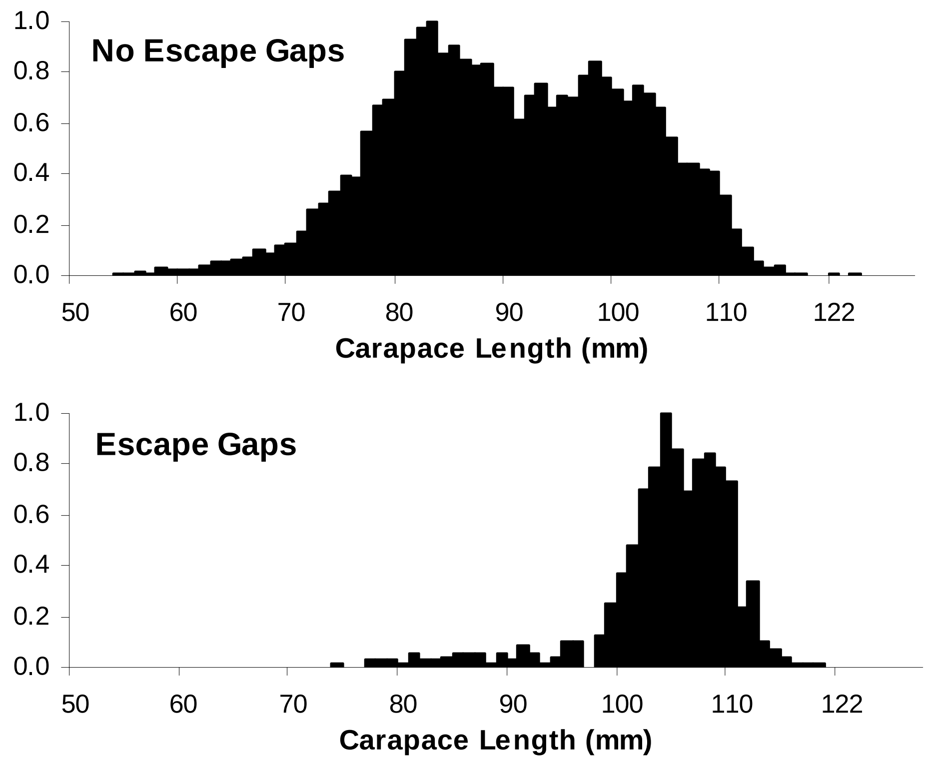


Figure 32. Comparison of the size frequency distribution of the catch of lobsters from research pots fitted with and without escape gaps in southern Tasmania.

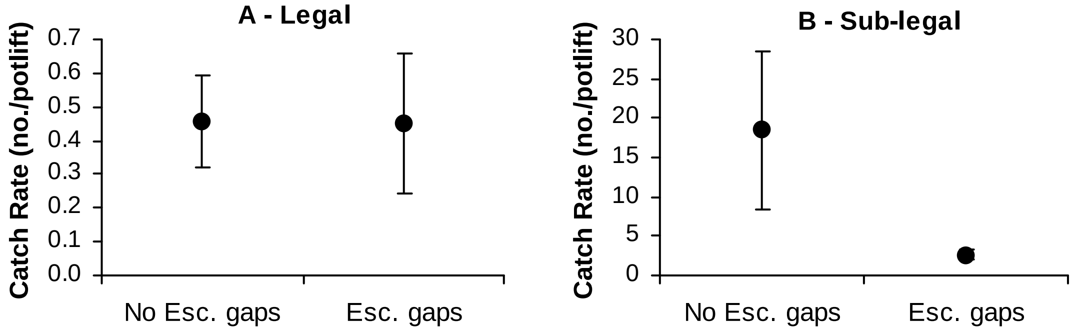


Figure 33. Comparison of mean catch rates for a) legal and b) sub-legal lobsters caught in research pots with and without escape gaps in southern Tasmania. Error bars are one standard deviation.

The catch from fisher's specific pots and the pot locations were kept strictly confidential. All data was archived on an Oracle database.

6.1.2.2. Sampling Design – Adjusted

After early results appeared promising (see Chapter 6.1.3), the size of the collection area was increased in an attempt to improve participation rate, expand the regions being evaluated and to test the extent to which sampling restrictions could be relaxed.

Fishers who participated in the initial surveys raised several issues that they believed were restricting the number of fishers who were interested in sampling. This included the concern of several fishers that they could not guarantee that they would go back to the same location in the March and July/August sampling times. If lobster catch rates were better elsewhere then they would be fishing in these locations rather than designated sampling sites. Several fishers were also concerned over the confidentiality of sampling locations.

As a result, we relaxed the sampling restrictions in 1998/99 fishing season. Fishers were not required to resample the same areas visited at the start of the season. It was hoped that with increased participation, different fisher's data could be matched between sampling periods. We did not find any major difference in the exploitation rates of individual fishers, when results were combined or when we used a different fisher for each sampling period for the CIR method (Figure 34). Differences in the IR method indicated that different fishers had differing abilities at catching legal-sized lobsters. As the CIR estimate is based on a ratio, the exploitation rate estimate would not be affected by different fisher's abilities unless their abilities affected the ratio of undersized to legal-sized lobsters they caught. The latter was considered unlikely.

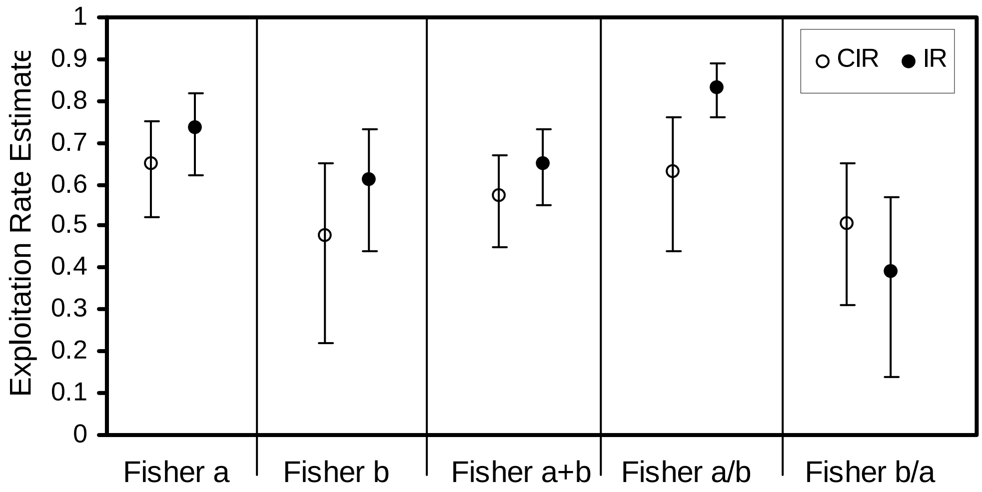


Figure 34. A comparison of fishery dependant derived exploitation rate estimates using data from two fishers (Fisher a and Fisher b). Estimates are for the partial 1997/98 fishing season (November – March). Fisher a (Nov and Mar samples), Fisher b (Nov and Mar), Fisher a+b (Nov and Mar – Fisher a+b combined), Fisher a/b (Nov – Fisher a and Mar – Fisher b) and Fisher b/a (Nov – Fisher b and Mar – Fisher a). Error bars are 95% confidence limits.

Even though confidentiality was stressed, we allowed fishers to report their results in a more general region (e.g. Port Davey).

Data sheets were modified to allow information on sized/undersized female lobsters to be included for east coast and shallow waters sites.

For the 1998/99 fishing season, fishers were asked to collect data from fishing grounds along the coast from Strahan, south around SW Cape, SE Cape and up the east coast as far north as Bicheno, or from within Stock Assessment Areas 1, 2, 7 or 8 (Figure 35).

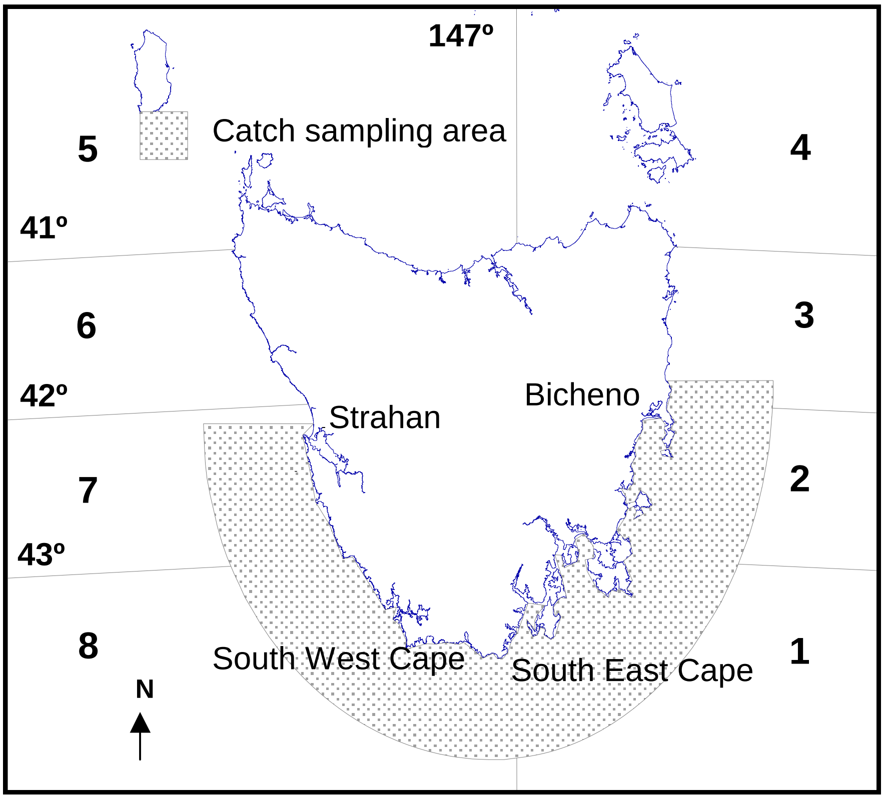


Figure 35. Extended survey region for dependent (commercial fishers) catch sampling for the 1998/99 season onwards. The eight numbered regions are the stock assessment areas.

6.1.2.3. Exploitation Rate Techniques

Exploitation rates were derived from the Change-in Ratio (CIR) and Index Removal (IR) techniques (see Chapter 5.1.1.3 and 5.1.1.4). For the CIR technique, lobsters were divided into two categories; undersized and legal size lobsters. All legal sized lobsters caught were used in the IR technique. As fishers only recorded the number of legal and undersized lobsters, the diagnostic tests (see Chapter 5.1.2), which are based on size distributions, could not be applied to this data.

6.1.2.4. Confidence Intervals

As for the independent catch sampling data a bootstrap procedure was used to determine the 95% percentile confidence limits around the exploitation rate estimates obtained from the CIR and IR techniques (see Chapter 5.1.1.5).

6.1.3. Results and Discussion

During this project, fishery dependent catch sampling was conducted for three and a half fishing seasons (November 1997 until March 2001). After encouraging participation rates and results in the first fishing season, sampling restrictions were relaxed so that fishers could sample all southern waters. The aim being to provide us with exploitation rate estimates for Stock Assessment Areas 1, 2, 7 and 8 from fishery dependent catch sampling data. However, due to a reduction in participation and decreased sample sizes during the remaining seasons these estimates were not obtained. Exploitation rate estimates were only available for the south coast of Tasmania (Stock Assessment Area 8).

When fishery dependent exploitation rate estimates for all depths (Stock Assessment Area 8) are compared to those derived from independent catch sampling, several inconsistencies are apparent (Figure 36). The initial partial season estimates (March) for 1997/98 seemed positive, with a high level of agreement between fishers and research estimates, especially for the IR technique. It was also encouraging that the early moult that was shown to affect the end of season fishery independent survey in August 1998 (see Chapter 5.1.3.3) had a similar effect on the fishery dependent estimates.

However, the 1998/99 fishing season saw a significant reduction in the fisher participation rate. In 1998/99 no fishers provided data for the March sampling period as a result, no partial season estimate could be determined. Due to low sample sizes in 1998/99 and 1999/00 exploitation rate estimates cannot be deemed reliable and therefore have not been included.

To improve fisher involvement after the low participation rate in 1998/99 season, we arranged several port meetings with the Tasmanian Rock Lobster Fisherman's Association (TRLFA) executive officer. At these meetings, there was a positive verbal response. In addition, awareness was increased through articles in the fishing industry magazine '*Fishing Today*', a letter attached to rock lobster licence renewals explaining the project and regular personal contact.

The initial response prior to the 1999/00 season requesting data sheets suggested a potential increase in fisher involvement; however, this did not translate into data for the start of season sample (November 1999). When participating fishers were contacted, it was found that a number of them were not fishing in this period at the start of the new fishing season. This represents a change in fishing practice due to the introduction of quota and an associated shift from a summer to a winter fishery.

Prior to quota, the entire fishing fleet would set out to fish on the first day of the season. The majority of this effort was in southern and south-western regions where the 'run of new-shellers' resulted in high catches of recently moulted lobsters. After the introduction of quota, many fishers were prepared to wait for the beach price to increase before going to sea. An aim of the quota system was to enable fishers to maximise their profits by being able to fish from March to August when the price was high. As catch rates are low during this period, the quota year was set to commence in March and finish in February of the following year[2]. Thus, fishers would be able to virtually guarantee catching the remainder of their quota from November to February when catch rates were high although prices were low. Since the introduction of quota

[2] Note that a fishing year is from November to August (September after the introduction of quota in March 1998) and a quota year is from March to February of the following year with a closed season during September and October. The actual closing date in September has varied as managers and industry evaluate the benefits of keeping this month open (see Cheshuk, 2001 and Cheshuk and Phillips, 2001).

in March 1998, fishers were balancing up the amount of quota they had left against beach price to determine when they would fish.

Prior to the 2000/01 fishing season we contacted fishers who had previously participated in the survey and highlighted the need to increase participation and the amount of data, to determine if this method would be viable. Participation in 2000/01 remained as for the previous season, however the data supplied by this small group of fishers increased and enabled calculation of exploitation rates of this season (Figure 36). There is a high level of agreement, both between the CIR and IR methods and between fishers and research data for the partial season exploitation rate estimates for this year.

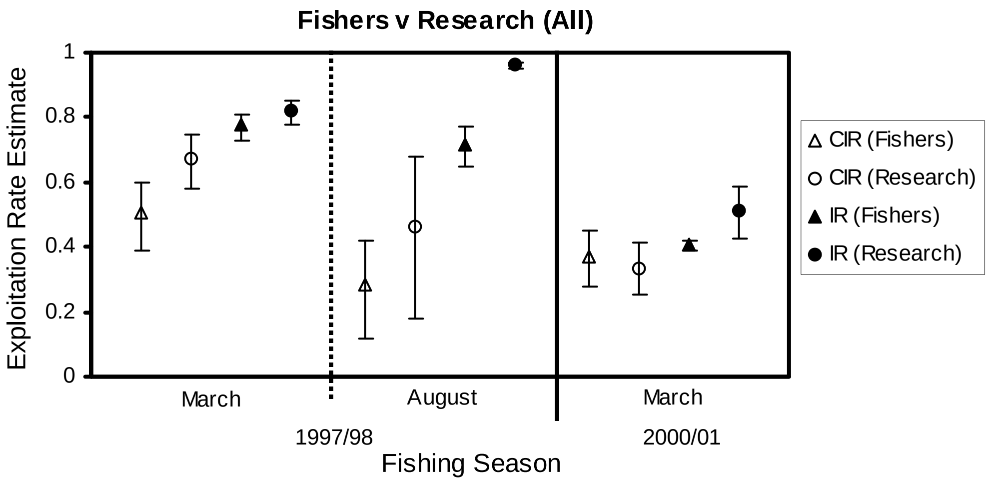


Figure 36. Comparison of exploitation rate estimates for male rock lobsters from southwest Tasmania (Stock Assessment Area 8) calculated using the change-in-ratio (CIR) and index removal (IR) methods for fishery dependent (fishers) and independent (research) data. Estimates are for all depths for the 1997/98 (March and August) and 2000/01 (March) fishing seasons. Error bars are 95% confidence limits.

As fishery independent derived exploitation rate estimates were shown to vary with depth in Area 8 (see Chapter 5.1.3.3), fisher's estimates for various depths were compared. To enable comparison with fishery independent estimates, fisher's data was pooled into two depth classes; deep water (>40m) and shallow water (<35m). When fisher's exploitation rate estimates were compared, inconsistencies were apparent. For deep-water areas of the fishery, the similarities of fishery dependent and independent estimates were encouraging for the 1997/98 season. The early moult that was shown to affect the end of season research survey in August 1998 (see Chapter 5.1.3.3) had a similar effect on the fisher's estimates. This resulted in the higher than expected IR estimate and the low CIR estimate from both fishers and research derived data.

The low research estimates for the partial 2000/01 season were not apparent for the fishery derived estimates for deep water fishing areas (Figure 37). The removal of newly moulted recruits from deep water in September (Cheshuk, 2001) appeared to have biased the research pre-season sample resulting in lower exploitation rate estimates for both the CIR and IR methods (see Chapter 5.1.3.3).

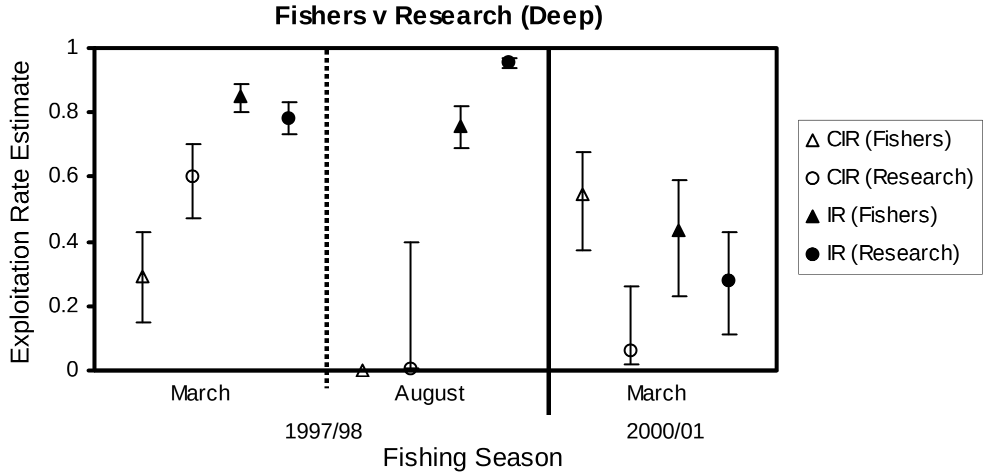


Figure 37. Comparison of exploitation rate estimates for male rock lobsters from southwest Tasmania (Stock Assessment Area 8) calculated using the change-in-ratio (CIR) and index removal (IR) methods for fishery dependent (fishers) and independent (research) data. Estimates are for deep water (>40m) for the 1997/98 (March and August) and 2000/01 (March) fishing seasons. Error bars are 95% confidence limits.

In previous years when September was closed to fishing, the November research sample represented the pre-exploitation sample because the annual moult occurred during the closed season (September to October). Full recruitment to the fishery for the forthcoming fishing year was assumed to have occurred prior to the November survey. Fishing of the new recruits by extending the fishing season into September resulted in partial exploitation of these recruits prior to the re-opening of the fishing season in November. In areas where September fishing occurred (Cheshuk, 2001), there was considerable scope for a major impact as the fishery is primarily based on new recruits each fishing year (Frusher, 1997).

In contrast, fishers would be aware of the areas where lobsters had moulted and either fished in other areas or ‘tested’ these areas. If catch rates were low, they would then move to regions of higher catch rates. In September, the majority of newly moulted lobsters were caught in deeper waters in the south-southwest (Figure 38). Unlike research surveys, fishers would move to regions where catch rates were highest. Normally this would cause fisher’s estimates to be lower than research estimates (see results for shallow water areas). Pre-season surveys would be expected to be equivalent in all areas (i.e. if recruits were not available to the fishery at the end of the previous fishing year). However, the middle or end of year surveys would have higher catch rates as fishers concentrated their efforts in regions which yielded the highest catch rates rather than fixed survey sites.

Exploitation rate estimates for shallow water areas of the fishery indicate estimates from fishery dependent derived data are comparable between the CIR and IR methods for the years when sufficient data was supplied (1997/98 and 2000/01 partial) (Figure 39). These shallow water exploitation rates are expected to provide more robust results as elevated catch rates associated with targeting new recruits only occurred in deeper water in September 2000 (Figure 40). Fishers estimates are consistently lower than research estimates, which suggests that fishers are maintaining higher catch rates as they move to more productive grounds (see paragraph above).

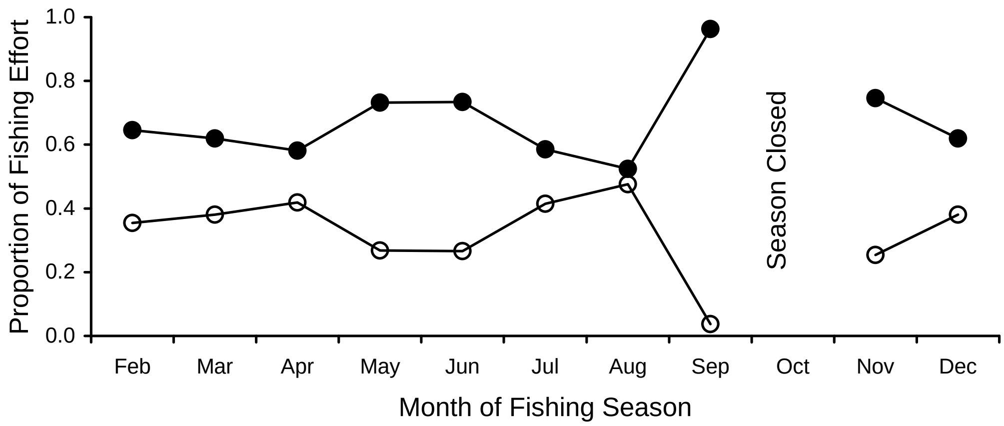


Figure 38. Proportion of fishing effort expended in shallow (open circles) and deep (closed circles) water for Stock Assessment Area 8 between February - December 2000.

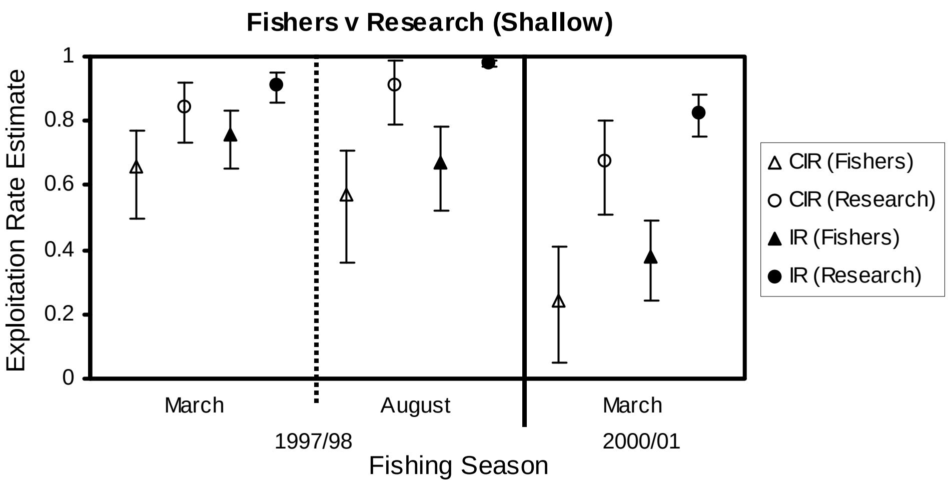


Figure 39. Comparison of exploitation rate estimates for male rock lobsters from southwest Tasmania (Stock Assessment Area 8) calculated using the change-in-ratio (CIR) and index removal (IR) methods for fishery dependent (fishers) and independent (research) data. Estimates are for shallow water (<35m) for the 1997/98 (March and August) and 2000/01 (March) fishing seasons. Error bars are 95% confidence limits.

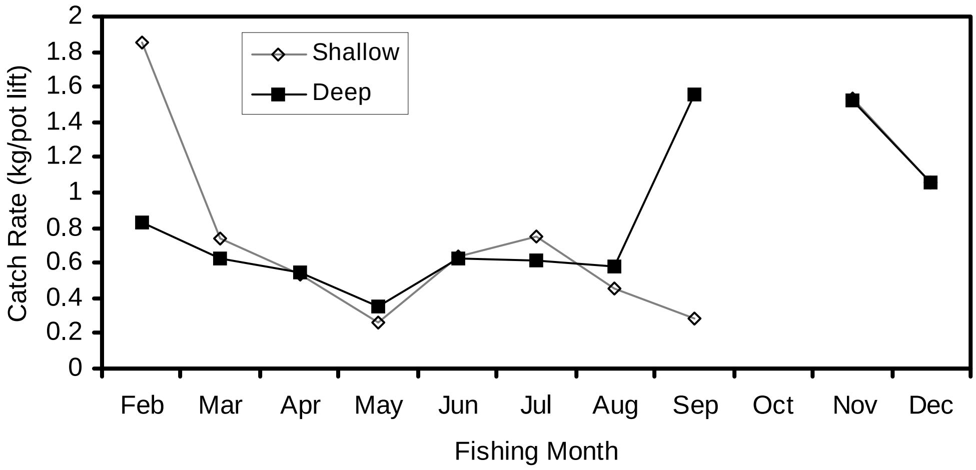


Figure 40. Comparison of monthly commercial catch rates (kg/pot lift) for shallow and deep water for the fishing year 2000. Note that shallow and deep water estimates for November and December overlap.

6.1.4. Conclusion

After a promising early start, fisheries dependent exploitation rate estimates proved problematic. Participation by fishers fluctuated dramatically throughout the project. With a restricted sampling regime and reasonable participation, the first season provided good agreement between fishery independent and fishery dependent estimates of exploitation rate. After the first season, sampling restrictions were relaxed but, unexpectedly, participation dropped. This, combined with changes in fishing practices due to the introduction of quota, resulted in lower sample sizes in the periods required and thus unreliable estimates. Although a lot of effort was put into increasing participation this did not result in a significant increase in data.

A form of serial depletion leading to hyper-stable catch rates appears to have caused under-estimates of fisher derived catch rates as fisher's change fishing locations throughout the fishing season. In comparison, research estimates are derived from sampling in set locations, rather than differing locations, at several different periods throughout the season. These set locations are prone to being affected by localised fishing activity. This has been the case since quota was introduced and the September month opened to fishing. September fishing activity has been focused in deeper water regions where the survey sites are located. Another problem with fishery dependent derived estimates is that they cannot be validated using the simple diagnostic techniques described in Chapter 5.1.2. It was hoped that estimates determined by fishers could be compared to estimates that passed the diagnostic tests and therefore met the assumptions set for the both methods. This was not possible due to the lack of viable estimates from fishery dependent sampling and the lack of the corresponding independent estimates that did not violate the assumptions.

The development of techniques that involve industry participation and lowering of the cost of data collection for research and management were key aims of this project. However, because of biases in the data collected, the use of fishery dependent data to determine exploitation rates and therefore biomass was not viable in its present format. To obtain accurate estimates, fishers may have to fish in regions that have lower catch rates than they could achieve elsewhere. Despite reassurances from industry and their best intentions, this project demonstrated that few fishers were prepared to participate in research surveys if they had to sacrifice higher catch rates. To have greater control over the time and sites of surveys when using commercial fishing vessels, fisher's would need to be compensated for operational costs or the loss of income caused by lower catch rates. In addition to reduced costs, the other major benefit of using the fishing industry is that there are sufficient vessels to cover all eight regions used in the fishery assessment.

A recent review of the Tasmanian rock lobster fishery catch sampling project recognised three major issues:

1) That estimates of exploitation rate and biomass independent of the assessment model are an important ongoing assessment need.

2) All eight stock assessment regions need to be surveyed. As pre-season sampling is restricted to approximately four weeks each year, multiple vessels are required.

3) Fisher's vessels would need to be chartered to at least cover operational costs.

To facilitate the inclusion of the fishing industry in sampling and to meet the above requirements, the Crustacean Fishery Advisory Committee set aside 1% of the annual quota for research. One of the uses of this allocation is to compensate fishers undertaking research surveys. It is anticipated that this will result in more structured catch sampling from fisher vessels and reduce research costs.

7. Conclusions

Catchability changes between surveys were found to be common in the Tasmanian rock lobster fishery. These changes resulted in the index-removal method being inappropriate to estimate exploitation rate (see Table 16). In comparison, the change-in-ratio method is robust against catchability change providing it affects both components used to estimate exploitation rate equally. To minimise the probability of an unequal change in the catchability of the undersized and legal-sized components of the fishery, we used a narrow size bin either side of the minimum legal size. Despite this precaution, there were occasions when there were unequal changes in the catchability of the undersized and legal-size classes between surveys. This mostly occurred between the pre-season and end of season surveys. As lobsters were preparing to moult after the end of season survey, it is most likely that different size classes of lobsters were behaving differently. Frusher *et al*. (1998) found moulting to be staggered by size class during the moulting period and thus the catchability of different size classes of lobsters would change depending on which size class was preparing, undertaking or recovering from moulting. Estimates of exploitation rate from the November to March period proved to be the most reliable and could be estimated from five of the six fishing seasons.

The extension of the fishing season into September when new recruits to the fishery are harvested has resulted in variable catch rates of legal-sized lobsters in the following October/November sampling survey. These variable catch rates result in biases in estimates of exploitation rate using both the IR and CIR methods. If September is to remain open and new recruited lobsters harvested during this period (as seems likely), then we recommend that the CIR and IR methods not be used. An exception to this could be shallower water regions of the fishery where moulting occurs later in the year and thus there is no impact on new recruits to the fishery.

Given the restricted future use of the CIR and IR methods and the unreliable outcomes, we investigated the use of multi-year tagging models. These tagging models have two main advantages when compared to the CIR and IR techniques (see Table 16). Firstly, moulting or the extension of the fishing season into September does not bias estimates. Exploitation rate is estimated by the decline in tagged lobsters. Recruitment to the population by moulting does not affect the estimate, as undersized lobsters that moult to legal-size would not have tags. Unlike the CIR and IR methods, multi-year tagging models are not restricted to southern regions of the fishery and are suitable for all regions of the fishery. Secondly, catchability can be incorporated into the model design and estimated as an additional parameter (Frusher and Hoenig, in review).

To test these models in southern regions of the fishery, increased numbers of legal-sized lobsters were tagged towards the end of this project. Unfortunately, tag recapture rates were too low to be able to trial multi-year tagging models during this project. Estimates of exploitation rate independent of the assessment model are still a high priority of the fishery, especially after the introduction of the individual transferable quota management system. Further trials with tagging models will be undertaken. As part of these trials, we plan to review tagging methodology and fisher participation/awareness in an attempt to improve tag-reporting rate.

Fishery dependent data was problematic due to inconsistent and inadequate participation. Unlike fisheries independent sampling where sampling is restricted to specific sites, fishers are able to move to differing regions within the broad stock assessment regions to maximise their seasonal catch rates. This resulted in differences between fishery independent and fishery dependent results. For periods when the fishery independent data was not affected by the extended seasonal opening in September, fishery dependent data had consistently lower exploitation rates and thus higher biomass estimates compared to fishery independent estimates. This resulted from higher catch rates from fishers at the end of the season as they were able to move to sites of improved catch rates rather than focus on pre-defined sites as used in fishery independent sampling. During periods when pre-season fishery independent catch rates were low due to the impact of the September opening, fishery dependent exploitation rates were higher. This resulted from fishers being able to target regions of higher catch rates (i.e. areas that had minimal fishing in September) at the start of the season.

The fishery dependent estimates of exploitation rate using the CIR and IR methods are also affected by catchability changes as for the independent estimates. Furthermore, exploitation rate estimates are also compromised by fishers changing their fishing regions during the season to maintain optimal catch rates.

The introduction of the individual transferable quota management system resulted in fewer fishers operating in November after the male moult. To compensate for the lack of a pre-season sample, we planned to use research pots with escape gaps and compare these to fisher’s samples obtained later in the season. Unfortunately, the extended opening of the fishing season into September compromised the pre-season research surveys and thus invalidated this comparison.

In a review of the Tasmanian rock lobster fishery catch sampling project, the need for accurate estimates of biomass independent of the assessment model was identified as the foremost priority by Industry and Management. Results from this project demonstrated that the CIR and IR methods would not consistently provide the accurate estimates required (see Table 17). Multi-year tagging models appeared an alternative option as they addressed the catchability and recruitment (moulting) issues that were found to bias estimates obtained using the CIR and IR methods. The outcome of the review was a recommendation that multi-year tagging models be more fully evaluated. To enable regional estimates to be achieved, Government and Industry agreed that research quota would be allocated to fishers to compensate for costs associated with use of their vessels. Thus, several boats will be able to concurrently sample pre-determined sites at pre-determined times in a cost-effective manner. To improve tag reporting rates, Industry and scientists will review existing tag return arrangements, including tagging position (dorsal rather than ventral), tag return methods and more frequent visits to fishers vessels.

Table 16. Comparison of methods available to determine exploitation rates.

Method	Sampling frequency	Data required	Recruitment within fishing season	Catchability change between sampling periods.	Size-specific catchability change during the fishing season	Parameters estimated
Index-removal	Requires pre-season and a second sample preferably towards the end of the fishing season.	Count of the number of legal sized lobsters caught. Size frequency required for diagnostic tests	Compromises method	Compromises method	Compromises method. Has minimal impact if exploitation high.	-Total mortality
Change-in-ratio	Requires pre-season and a second sample preferably towards the end of the fishing season.	Count of numbers of legal and sub-legal lobster caught. Size frequency required for diagnostic tests	Compromises method	No impact	Compromises method. Can minimise size categories to minimise impact.	-Fishing mortality
Multi-year tagging	Requires pre-and post-season tagging. For natural mortality requires a reasonable portion of the year when the fishery is closed (4-6 months).	Number of tagged legal sized lobsters	No impact	Can be accounted for in the model	Compromises method. Has minimal impact if exploitation high.	-Fishing mortality -Natural mortality -Tag reporting rate -Catchability

Table 17. The implications for assessing the Tasmanian rock lobster fishery using the methods available to determine exploitation.

Method	Implications for assessing the Tasmanian rock lobster fishery
Index-removal	Suitable for southern regions of the fishery where moulting occurs outside the fishing season. Recent catchability studies have indicated that it is unlikely that sampling would be conducted when catchability is similar.
Change-in-ratio	Suitable for southern regions of the fishery where moulting occurs outside the fishing season. Size-specific catchability changes imply that only small size classes either side of the size limit can be used. Performs poorly when new recruits are harvested in September prior to the opening of the season in November.
Multi-year tagging	Suitable for all regions of the fishery. Dependent on fishing industry for return of tagged lobsters. Require tag-reporting rate to remain constant over at least three fishing seasons.

8. Client consultation, outcomes and future developments

This project demonstrated that both the Change-in-Ratio (CIR) and Index Removal (IR) methods were unreliable for providing consistent estimates of exploitation rate. It also demonstrated that fisher's behaviour with respect to where and when they set their fishing pots biases data, which in turn leads to an underestimation of exploitation rate in the fishery.

Exploitation rate is a crucial fishery performance indicator in the Tasmanian rock lobster fishery. At a review of future catch sampling research held in May 2002, both Industry and Government identified that further development and trials of new methods for estimating exploitation rate is the highest priority for research in this fishery. This was endorsed at the Crustacean Research Advisory group meeting in June 2002.

This project identified changes in catchability and recruitment that occur during the fishing season to be key factors that violated assumptions associated with the use of the CIR and IR methods. Importantly, changes in catchability are size-specific and can alter over small size class groupings. Based on this result we identified that multi-year tagging models may be a suitable alternative method of estimating these parameters worthy of further investigation and development. As these models only follow the fate of tagged lobsters, recruitment is not of concern (recruits would be non-tagged lobsters and would not influence tagging models). Frusher and Hoenig (in press) developed a tagging model that accounted for variation in catchability. This model was based on rock lobsters tagged in northwestern Tasmania and provided improved estimates of fishing mortality (exploitation rate), natural mortality, tag reporting rate and catchability.

Too few tags were returned by fishers to trial the tagging models in southern Tasmanian. Investigating methods of improving tag reporting rate was endorsed by both Government and Industry as the appropriate strategy in pursing the high priority area of exploitation rate estimation (Catch Sampling Review, May 2002; Crustacean Research Advisory Group, June 2002, Crustacean Fishery Advisory Committee Meeting No. 12, July 2002). The initial focus on future developments will be exploring ways to improve tag reporting rate, including investigation of fisher independent reporting mechanisms and absolute tag reporting rates. This next step is the focus of a new research proposal.

Finally, this project demonstrated that, despite the best intentions of industry members, it was difficult for fishers to target pre-determined sampling sites when the economics of fishing these sites was low. At a meeting of the Crustacean Fishery Advisory Committee (Meeting No. 6), Industry and Government agreed that a better option was for a portion of the Total Allowable Commercial Catch to be allocated to research and that this be used to compensate fishers for operating costs when using their vessels.

Compensating fishers for operating costs is a significant advancement in pursuing tagging models, as both pre-season and mid-season surveys require all legal-sized lobsters to be tagged and returned to the water. During these surveys, fishers would not obtain an income from harvesting lobsters.

The Tasmanian rock lobster fishery exhibits the largest variation in biological parameters of any lobster fishery in the world. Growth rates and the size at onset of sexual maturity in females are substantially different between northern and southern Tasmanian waters (Frusher, 1997). There is also a large variation in the dynamics of the fishery with fishing operations being different between eastern and western regions of the fishery (Frusher *et al.* FRDC final report for project 1999/140). To appropriately assess the fishery, the fishery is divided into eight assessment regions. This project demonstrated the difference in exploitation rates in shallow and deep-water regions in one of these assessment regions. In addition to exploitation rates, biological information such as size structure and growth rate needs to be routinely obtained from different depths in each of these assessment regions.

Industry and Management support the need to obtain estimates regionally and from different depths within each region. Without a mechanism for compensating fishers, costs for chartering vessels would be prohibitive. The allocation of research “quota” will allow cost effective sampling of these regions on a regular basis and address Industry and Government’s need for annual comprehensive assessments.

Meetings:

Crustacean Fishery Advisory Committee Meeting No.6. 9th November 2000, Marine Board Building, Hobart.

Crustacean Fishery Advisory Committee Meeting No.12. 3rd July 2002, Marine Research Laboratories, TAFI, Taroona.

Crustacean Research Advisory Group Meeting, 27th June 2002, Marine Research Laboratories, TAFI, Taroona.

Rock Lobster Catch Sampling Review, 3rd May 2002, Marine Research Laboratories, TAFI, Taroona.

9. Acknowledgments

Special thanks to the crew of *FRV Challenger* (Matthew Francis, Tim Debnam and Jac Gibson) who made sampling possible is some trying conditions. Thanks go to those who have assisted with sampling at sea, including Andrew Cawthorn, Jo Beukers-Stewart, Graeme Ewing and many others. We would like to thank Colin Buxton and Malcolm Haddon for their constructive comments in review.

10. References

Anon (1993). Restructuring of the Tasmanian rock lobster fishery, Interim report. Hobart, Rock Lobster Working Group, Division of Sea Fisheries, DPIF. 43p.

Brownie, C., Anderson, D. R., Burnham, K. P. and Robson, D. S. (1985). 'Statistical Inference from Band Recovery Data—A Handbook.' 2nd Edn. U.S. Fish and Wildlife Service Resource Publication. No. 156. (United States Fish and Wildlife Service: Washington, D.C., USA.) 305 pp.

Burnham, K. P. and Anderson, D. R. (1998). Model selection and inference. A practical information-theoretic approach. Springer-Verlag, New York.

Chapman, D. G. (1961). Statistical problems in dynamics of exploited fisheries populations. Proc. 4th Berkeley Symp. Math. Stat. And Probability, Contr. Biol. And Probl. Med. Univ. Calif. Press. 4: 153 - 168.

Chen, C., Hoenig, J.M., Dawe, E. G., Brownie, C. and Pollock, K.H. (1998). New developments in change in ration and index removal methods, with application to snow crab (Chinoecetes opilio). In Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. Edited by G. S. Jamieson and A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 125. Pp. 49 – 61.

Cheshuk, B. (2001). Impact of the September 2000 opening on the rock lobster resource and industry. Hobart, Tasmanian Aquaculture and Fisheries Institute. 38 pp.

Cheshuk, B. and Philips, A. (2001). September 2001 Rock Lobster Fishery. Hobart, Tasmanian Aquaculture and Fisheries Institute. 37 pp.

Dawe, E. G., Hoenig, J. M., and Xu, X. (1993). Change-in-ratio and index-removal methods for population assessment and their application to snow crab (Chinoecetes opilio). Can. J. Fish. Aquat. Sci. 50: 1467-1476.

Eberhart, L. L. (1982). Calibrating an index using removal data. J. Wildl. Manage. 46: 734-740.

Efron, B. and Tibshirani, R. (1986). Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Stat. Sci. 1: 54-77.

Frusher, S. (1996). The 1995/1996 Rock Lobster season: A temporary reprieve or signs of recovery. Fishing today. 9: 27-29.

Frusher, S. D. (1997). Update to the July 1997 Rock Lobster Stock Assessment Report. Hobart, Marine Resources Division, Department of Primary Industry and Fisheries. 25p

Frusher, S.D. and Gardner, C. (1999). Fishery assessment report: rock lobster. Tasmanian Aquaculture and Fisheries Institute, Hobart, Tasmania, Australia.. 43p.

Frusher, S. D. and Hoenig, J. M. (2001). Estimating natural and fishing mortality and tag reporting rate from up to three tagging events within a multi-year tagging model. Can. J. Fish. Aquat. Sci. 58:2490-2501

Frusher, S. D. and Hoenig, J. M. (in prep). Recent developments in estimating fishing and natural mortality and tag reporting rate of lobsters using multi-year tagging models. Fisheries Research.

Frusher, S. D., Kennedy, R. B. and Gibson, I. D. (1997). Precision of exploitation rate estimates in the Tasmanian rock lobster fishery based on change-in-ratio techniques. Mar. Freshwater. Res. 48: 1069-1074.

Frusher, S. D., Kennedy, R. B. and Gibson, I. D. (1998). Preliminary estimates of exploitation rates in the Tasmanian rock lobster (Jasus edwardsii) fishery using the change-in-ratio and index removal techniques with tag-recapture data. In Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. Edited by G. S. Jamieson and A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 125: 63 – 71.

Gardner, C. (1999). The Tasmanian Rock Lobster stock assessment model. Fishing Today. 12: 20-22.

Gardner, C. (2001). Rock Lobster Tagging Project. Fishing Today 14(4): 17-19.

Gardner, C. and Frusher, S. (2000). Will the removal of closed seasons from the management system of the Tasmanian rock lobster fishery harm the resource? Hobart, Tasmanian Aquaculture and Fisheries Institute. 18p.

Gardner, C., Frusher, S. D. and Eaton, L. (2001). Tasmanian rock lobster fishery 1999/2000. Hobart, Tasmanian Aquaculture and Fisheries Institute. 90p.

Gardner, C., Frusher, S., Eaton, L., Haddon, M. and Mackinnon, C. (2002). Tasmanian rock lobster fishery 2000/2001. Hobart, Tasmanian Aquaculture and Fisheries Institute. 117p.

Gardner, C., Frusher, S., Haddon, M. and Buxton, C. (in prep). Movements of the southern rock lobster *Jasus edwardsii* in Tasmania, Australia. Bulletin of Marine Science.

Haddon, M. (2001). Modelling and quantitative methods in fisheries. Chapman and Hall/CRC. 406p.

Hearn, W. S., Pollock, K. H. and Brooks, E. N. (1998). Pre- and post-season tagging models: estimation of reporting rate and fishing and natural mortality rates. Can. J. Fish. Aquat. Sci. 55: 199-205.

Hoenig, J.M. and K.H. Pollock. (1998). Index-removal methods. invited article for the Encyclopedia of Statistical Sciences Update Volume 2 pp. 342-346 (S. Kotz, C.B. Read and D.L. Banks, editors). John Wiley and Sons, Inc., New York.

Hoenig, J. M., Barrowman, N. J., Hearn, W. S., and Pollock, K. H. (1998). Multiyear tagging studies incorporating fishing effort data. Can. J. Fish. Aquat. Sci. 55: 1466-1465.

Kelker, G. H. (1940). Estimating deer populations by differential hunting loss in the sexes. Proceedings of the Utah Academy of Science, Arts and Letters 17, 6-69.

Kennedy, R. B. (1992). The biology and fishery for the southern rock lobster Jasus edwardsii in Tasmania: A confidential working document summarizing Tasmanian fishery and the fishery related information which is available within Tasmania. Tasmanian Dept. of Prim. Ind. and Fisheries, Taroona. 50p.

Kennedy, R.B. and Tarbath, D.B. (1992). Rock lobster tag update. Fishing Today 5(6), 24-25.

Latour, R. J., Pollock, K. H., Wenner, C. A. and Hoenig, J. M. (2001). Estimates of fishing and natural mortality for subadult red drum in South Carolina waters. N. Am. J. Fish. Manage. 21, 733-744.

Paulik, G. J., and Robson, D. S. (1969). Statistical calculations for change-in-ratio estimators of population parameters. Journal of Wildlife Management 33, 1-27.

Pearn, R. (1994). Rock Lobster tagging shows movement occurs. Fishing Today. 7(5): 27 – 29.

Pollock, K.H., and Hoenig, J. M. (1998). Change-in-ratio estimators. invited article for the Encyclopedia of Statistical Sciences Update Volume 2 pp. 109-112 (S. Kotz, C.B. Read and D.L. Banks, editors). John Wiley and Sons, Inc., New York.

Prescott, J. and Lewis, R. (1992). Summary of the South Australian Southern Rock Lobster Fisheries, South Australian Department of Fisheries. 3p

Punt, A. E. and Kennedy, R. B. (1997). Population modelling of Tasmanian rock lobster, Jasus edwardsii, resources. Marine and Freshwater Research 48(8): 967-980.

Punt, A. E., Kennedy, R. B., and Frusher, S. D. (1997). Estimating the size-transition matrix for Tasmanian rock lobster Jasus edwardsii. Mar. Freshwater Res. 48: 981 – 992.

Ricker, W.E. (1975). Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin No. 191. 382 pp.

Seber, G. A. F. (1982). The estimation of animal abundance and related parameters. 2nd edition. Griffin, London.

Starr, P. J. and M. Vignaux (1997). Comparison of data from voluntary logbook and research catch-sampling programmes in the New Zealand lobster fishery. 5. Int. Conf. and Workshop on Lobster Biology and Management, Queenstown (New Zealand), 10-14 Feb 1997, Marine and Freshwater Research: 1075-1080.

Treble, R. J. (1996). The southern rock lobster (Jasus edwardsii): fisheries biology and abundance estimation. PhD dissertation. University of Melbourne, Melbourne, 435p.

Ziegler, P. E., Haddon, M., Frusher, S. D. and Johnson, C. (in prep). Seasonal catchability of the southern rock lobster *Jasus edwardsii* linked to water temperature, moulting and mating. Can. J. Fish. Aquat. Sci.

11. Appendix 1 – Intellectual Property

No intellectual property was generated through the project that requires protecting.

12. Appendix 2 – Staff

Staff that have participated in this project are:

Dr Stewart Frusher (Senior Research Fellow) (Oct 1997 – current)
Dr Jo Beukers-Stewart (Research Fellow) (Oct 1997 – Oct 1999)
Mr Craig Mackinnon (Junior Research Fellow) (Apr 1999 – current)
Mr Jac Gibson (Senior Technical Officer / *FRV Challenger*) (Oct 1997 – current)
Mr Andrew Cawthorn (Senior Technical Officer) (Oct 1997 – Nov 2001)
Ms Alison Phillips (Research Assistant) (Oct 1999 – Oct 2001)
Mr Matthew Francis (Skipper – *FRV Challenger*) (Oct 1997 – current)
Mr Tim Debnam (1st Mate – *FRV Challenger*) (Oct 1997 – Jul 2000)
Ms Tristan Richards (Technical Officer) (Oct 1997 – Jan 2001)
Mr Graeme Ewing (Technical Officer) (Oct 1997 – Dec 1998)
Prof. John Hoenig (Consultant – Virginia Institute of Marine Science)

13. Appendix 3 - Effect of differential catchability among classes and over time on CIR estimates of exploitation rate

The CIR method for estimating population size is based on the assumption that the two components of the population have the same catchability in any survey. However, when only one component of the population is exploited, the method provides unbiased estimates of the size of the exploited component provided the ratio of catchability of the two components stays constant from survey to survey (Seber, 1982). A similar analysis of the CIR estimator of exploitation rate has not been reported.

Here we investigate the CIR estimator of exploitation rate to see the effect of unequal catchability of the two components. The case where only X-type animals are harvested is considered. Initially, we assume that the ratio of catchability remains constant over time. We then consider the case where the ratio of catchability changes over time.

Suppose the population is composed of X animals of type **X** and Y animals of type **Y**, and let Π_i denote the proportion of animals that is of type **X** in survey i for i = 1,2. If the population is closed except for the removal of **X** type animals, then Π_2 is $(X-R_x)/(Y+X-R_x)$ where R_x is the number of **X** type animals removed. Data from pre- and post-season surveys are used to obtain estimates, p_i of the Π_i. We concern ourselves here with the case where the **X** and **Y** type animals have different catchability such that

$$E(p_i) = X_i/(X_i + \delta Y_i)$$

where E(.) denotes expected value and δ is a parameter expressing the degree to which **X** and **Y** type animals differ in catchability.

The CIR estimator of exploitation rate U_x of commercial-sized (type **X**) animals is

(1) $$\hat{U}_x = \frac{p_1 - p_2}{p_1(1-p_2)}$$

where the ^ denotes an estimate. Substituting expected values for the p_i into (1) gives the (asymptotic) expected value of the estimator:

(2) $$E(\hat{U}_x) \approx \frac{\dfrac{X_1}{X_1+\delta Y_1} - \dfrac{X_1 - R_x}{X_1 - R_x + \delta Y_1}}{\dfrac{X_1}{X_1+\delta Y_1}\left(1 - \dfrac{X_1 - R_x}{X_1 - R_x + \delta Y_1}\right)}$$

$$= \frac{X_1^2 - R_X X_1 + X_1\delta Y_1 - X_1^2 + R_X X_1 - X_1\delta Y_1 + R_X \delta Y_1}{(X_1+\delta Y_1)(X_1 - R_X + \delta Y_1)} \cdot \frac{(X_1+\delta Y_1)(X_1 - R_X + \delta Y_1)}{X_1 \delta Y_1}$$

$$= \frac{R_X \delta Y_1}{X_1 \delta Y_1} \qquad = \frac{R_X}{X_1} \qquad = U_X$$

Thus, catchability can be different for the **X** and **Y** components provided the ratio of catchabilities doesn't change between surveys.

To test the effect of a change in relative catchability of the two components between surveys we replace the catchability parameter δ with a survey specific value, δ_i, for i =1,2. Then (2) becomes

$$E(\hat{U}_x) \approx \frac{\dfrac{X_1}{X_1 + \delta_1 Y_1} - \dfrac{X_1 - R_x}{X_1 - R_x + \delta_2 Y_1}}{\dfrac{X_1}{X_1 + \delta_1 Y_1}\left(1 - \dfrac{X_1 - R_x}{X_1 - R_x + \delta_2 Y_1}\right)}$$

$$= \frac{X_1^2 - R_X X_1 + X_1 \delta_2 Y_1 - X_1^2 + R_X X_1 - X_1 \delta_1 Y_1 + R_X \delta_1 Y_1}{(X_1 + \delta_1 Y_1)(X_1 - R_X + \delta_2 Y_1)} \, X \, \frac{(X_1 + \delta_1 Y_1)(X_1 - R_X + \delta_2 Y_1)}{X_1 \delta_2 Y_1}$$

$$= \frac{X_1 \delta_2 Y_1 - X_1 \delta_1 Y_1 + R_X \delta_1 Y_1}{X_1 \delta_2 Y_1}$$

$$= 1 - \frac{\delta_1}{\delta_2} + \frac{\delta_1 R_X}{\delta_2 X_1} \qquad = 1 - \frac{\delta_1}{\delta_2} + \frac{\delta_1}{\delta_2} U_X$$

Thus, the expected value of the exploitation rate obtained by the CIR method when the ratio of selectivities changes between surveys is a linear function of the true exploitation rate. When the exploitation rate is zero the expected value of the estimator is $1 - \delta_1 / \delta_2$. As the exploitation rate approaches 1.0 the expected value of the estimator also approaches 1.0 (Figure 41).

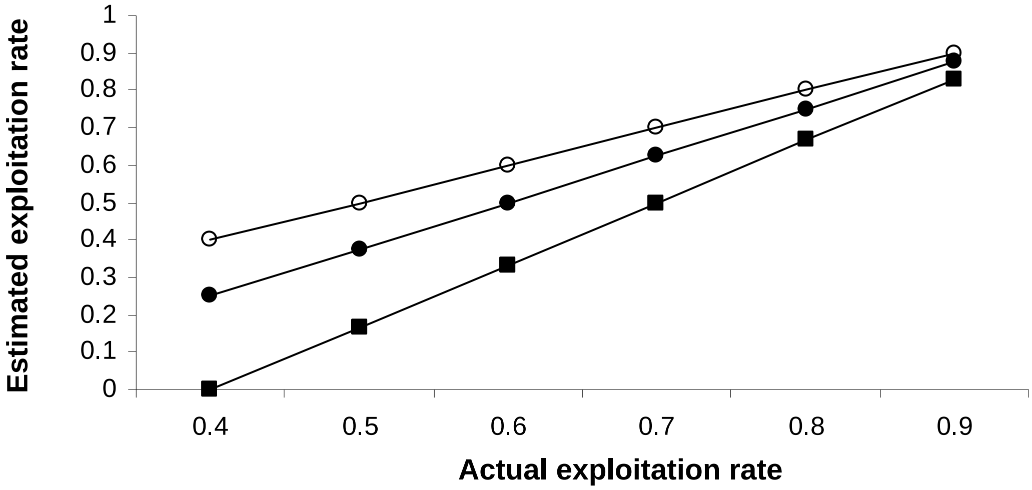


Figure 41. Effect on exploitation rate estimates of a change in relative catchability (δ_1 / δ_2) between survey 1 and survey 2. Open circles represent no change in relative catchability (δ_1 / δ_2 =1) and the closed symbols represent a change in relative catchability of 1.25 (circles) and 1.67 (squares). The lower the exploitation rate the greater the bias in estimated exploitation rate

14. Appendix 4. – Summary of catch sampling surveys

Table 18. Summary of catch details for fisheries independent catch sampling surveys conducted during the project (October 1997 – March 2001).

SEASON	SAMPLING PERIOD	NO. POTS SET	NO. LOBSTERS CAUGHT						NO. LOBSTERS TAGGED						NO. LOBSTERS RECAPTURED					
			MALES		FEMALES		TOTAL		MALES		FEMALES		TOTAL		MALES		FEMALES		TOTAL	
			U/S	S	U/S	S	U/S	S	U/S	S	U/S	S	U/S	S	U/S	S	U/S	S	U/S	S
97/98	Preseason (28/10 - 7/11/97)	680	4093	787	8039	301	12132	1088	1380	423	654	170	2034	593	419	131	371	30	790	161
	Midseason (9/2 - 3/3/98)	748	3455	255	5179	102	8634	357	1127	121	679	54	1806	175	524	56	221	15	745	71
	Postseason (28/7 - 19/8/98)	765	3063	101	4594	220	7657	321	1137	61	802	137	1939	198	161	16	200	17	361	33
98/99	Preseason (19/10 - 10/11/98)	830	4587	1119	8677	379	13264	1498	1698	490	1543	247	3241	737	314	182	308	51	622	233
	Midseason (22/2 - 19/3/99)	728	4287	505	6453	104	10740	609	1503	252	744	62	2247	314	375	111	351	28	726	139
	Postseason (13/7 - 13/8/99)	800	2884	203	4556	159	7440	362	1290	130	501	90	1791	220	262	50	233	33	495	83
99/00	Preseason (25/10 - 17/11/99)	800	5331	1058	7902	436	13233	1494	2180	906	1371	394	3551	1300	287	135	259	37	546	172
	Midseason (28/2 - 23/3/00)	800	3843	423	3984	130	7827	553	1997	351	889	105	2886	456	313	58	137	21	450	79
	Postseason (11/7/00 -4/8/00)	797	3784	228	2958	148	6742	376	1646	171	544	109	2190	280	305	53	132	36	437	89
00/01	Preseason (16/10 - 8/11/00)	800	3370	1182	1643	331	5013	1513	2146	999	788	297	2934	1296	287	166	128	30	415	196
	Midseason (19/2 - 16/3/01)	799	2953	616	1437	116	4390	732	1473	456	526	82	1999	538	471	156	145	32	616	188
TOTAL		**8547**	**41650**	**6477**	**55422**	**2426**	**97072**	**8903**	**17577**	**4360**	**9041**	**1747**	**26618**	**6107**	**3718**	**1114**	**2485**	**330**	**6203**	**1444**

15. Appendix 5 - South Coast diagnostic graphs

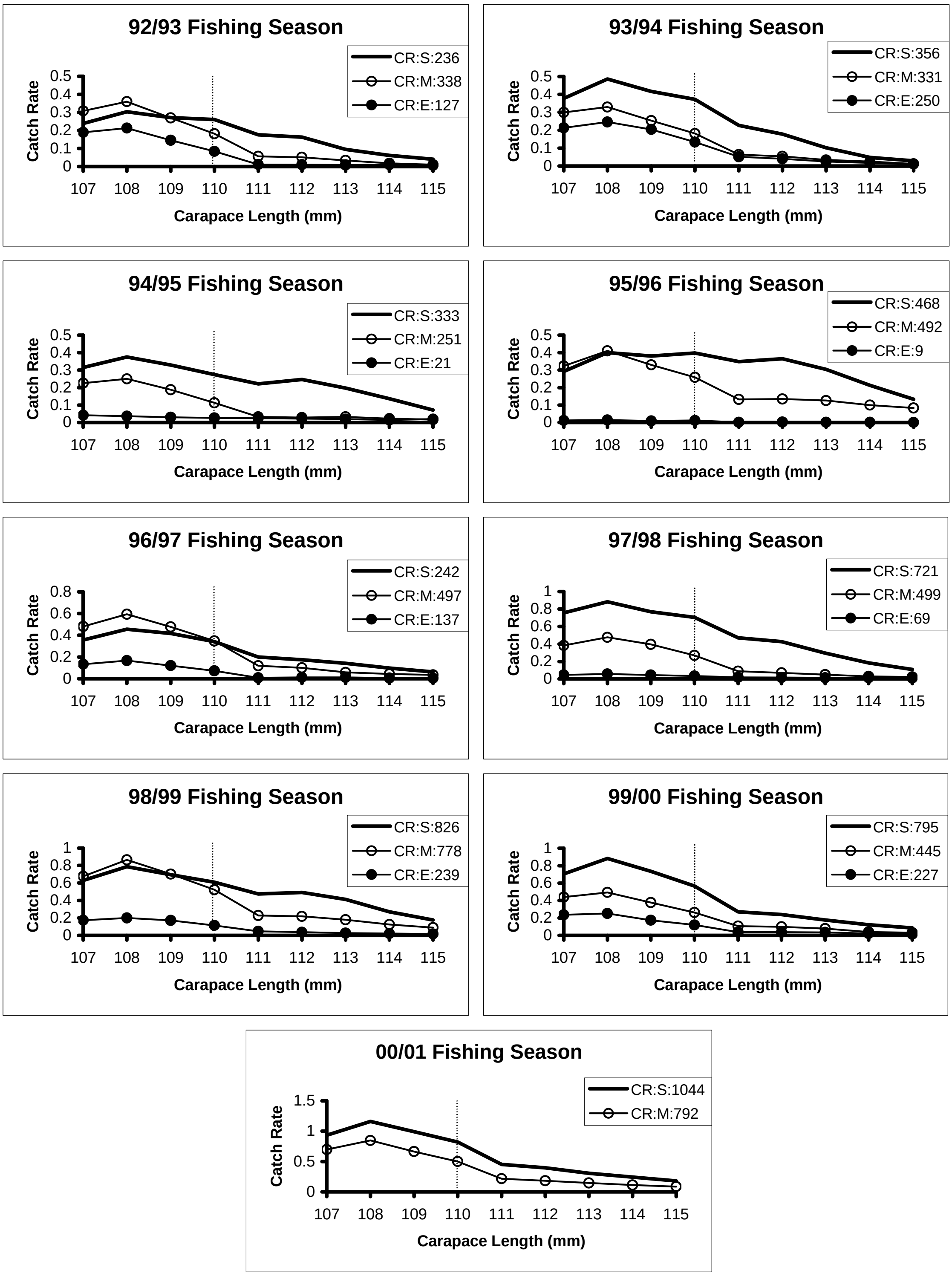


Figure 42. Comparison of catch rates (numbers/pot lift) of male lobsters caught from all southern Tasmania sampling sites during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

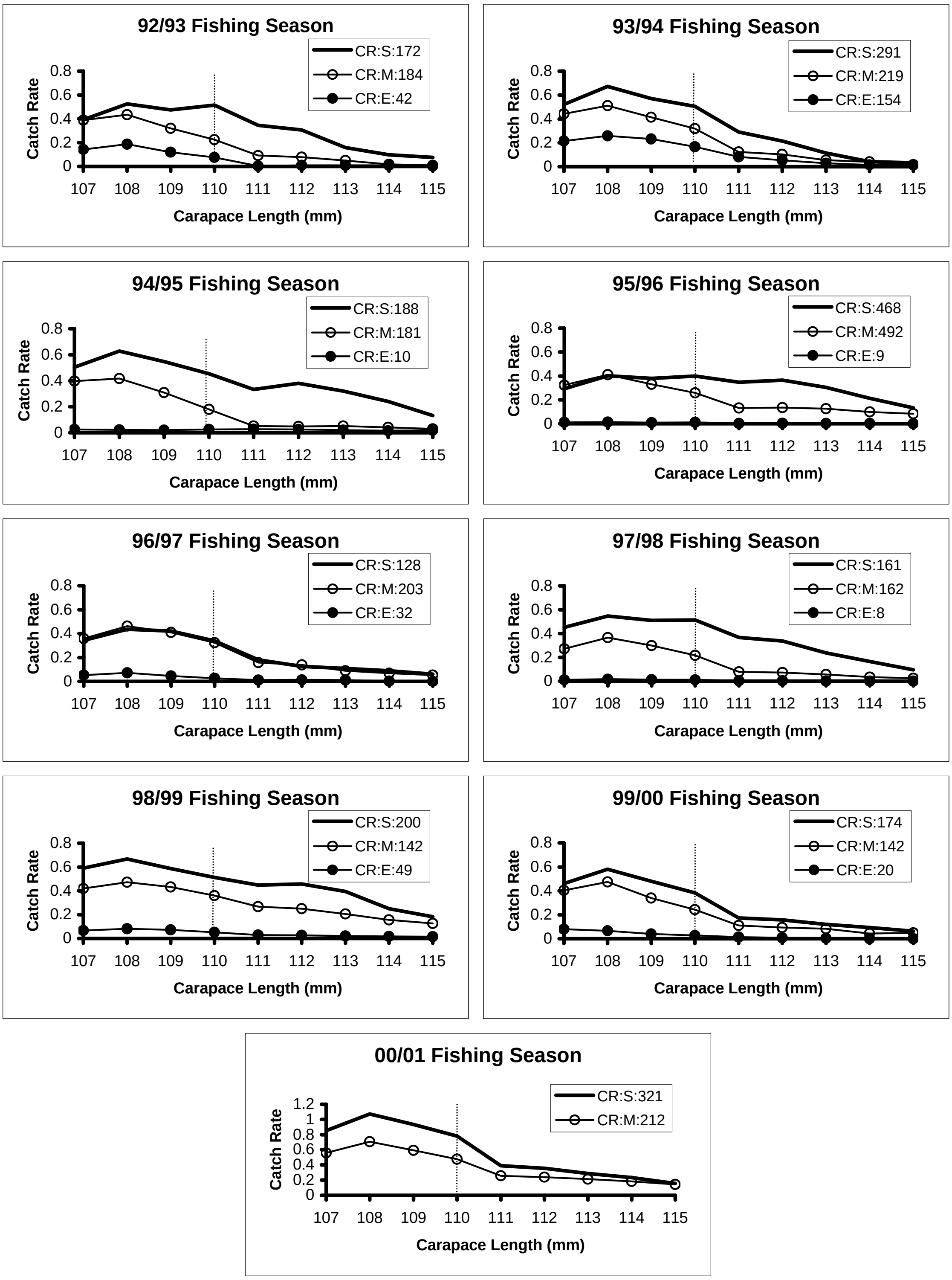


Figure 43. Comparison of catch rates (numbers/pot lift) of male lobsters caught from Maatsuyker Island (deep water), southern Tasmania during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

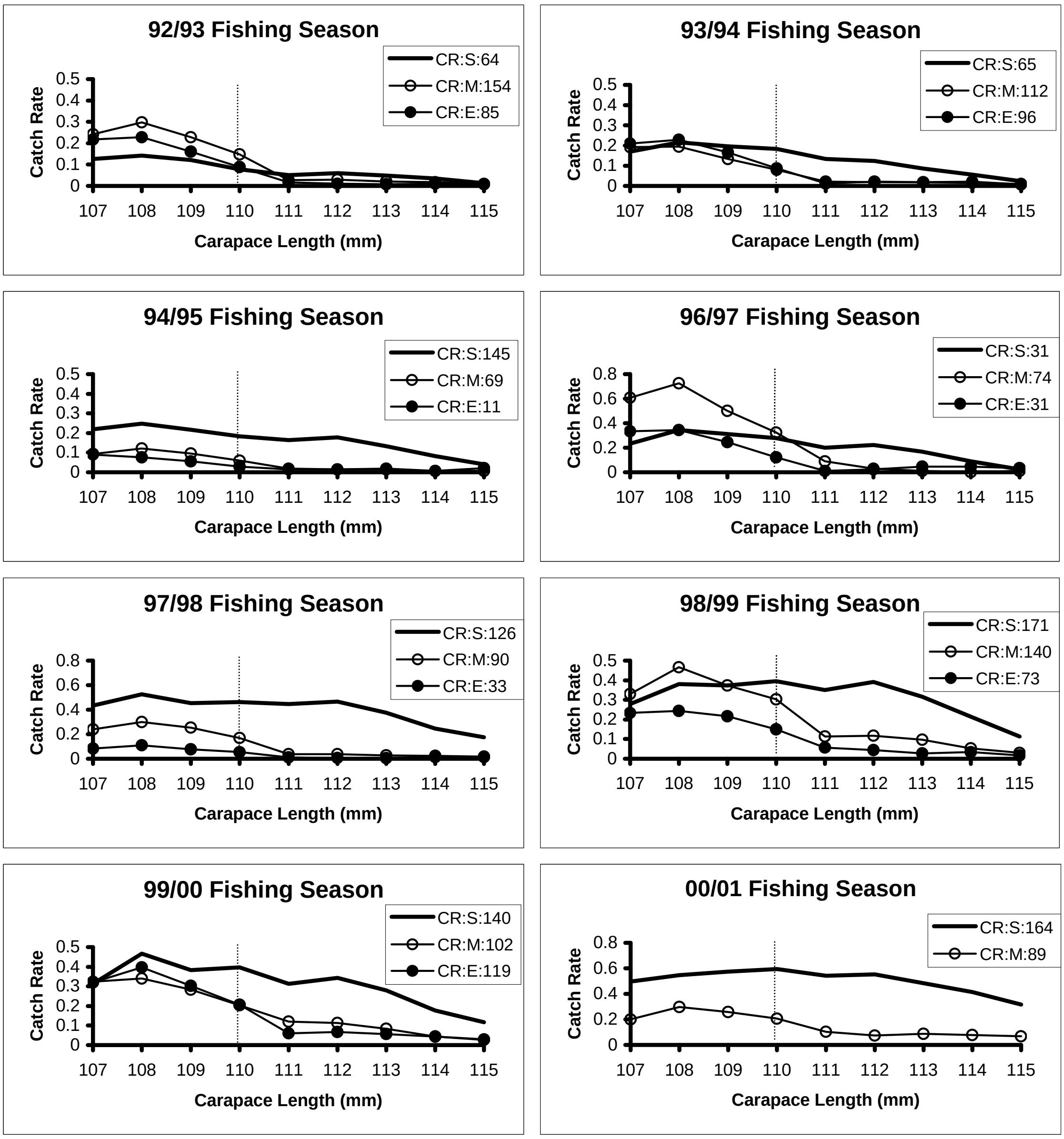


Figure 44. Comparison of catch rates (numbers/pot lift) of male lobsters caught from shallow water sites in southern Tasmania during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/93 to 1994/95 and 1996/97 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

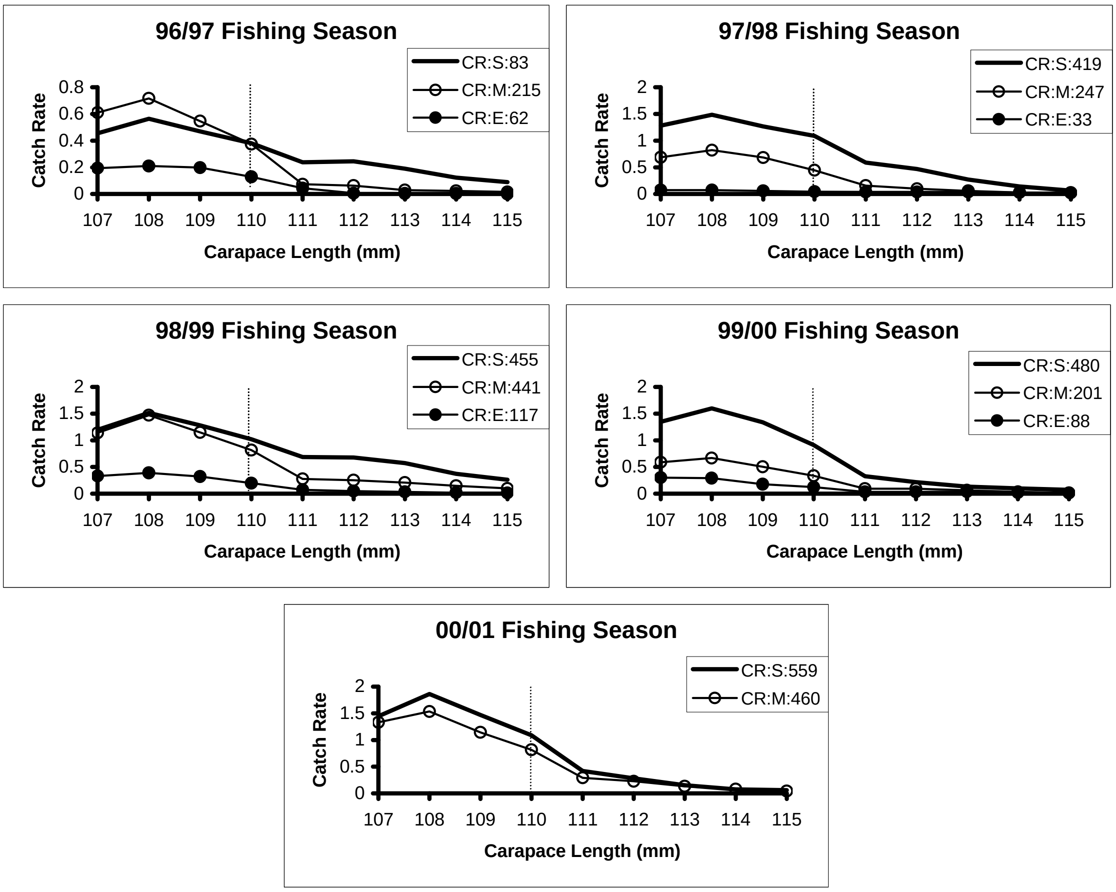


Figure 45. Comparison of catch rates (numbers/pot lift) of male lobsters caught from Port Davey (deep water), southern Tasmania during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1996/97 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

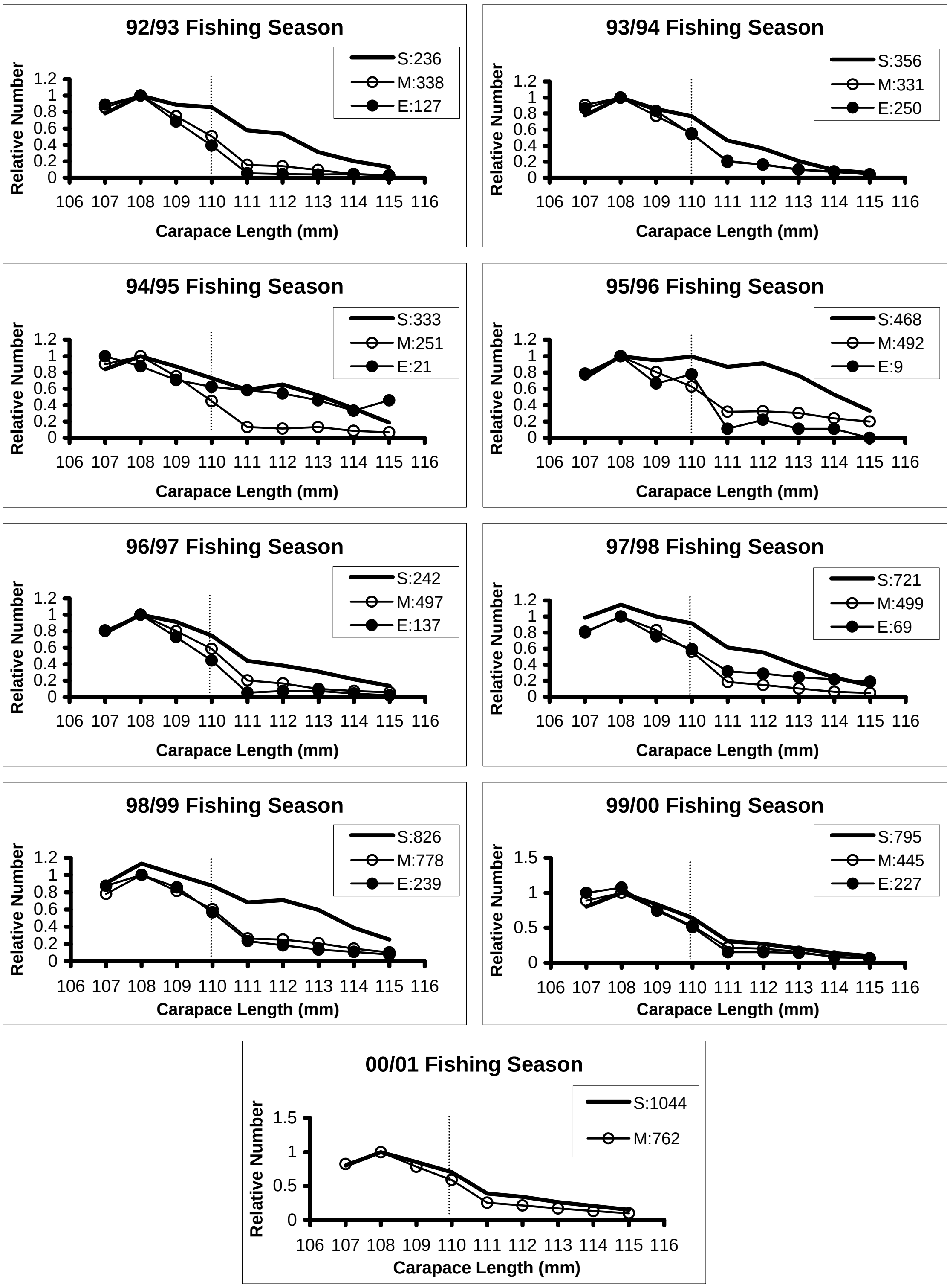


Figure 46. Standardised size frequency distribution of male rock lobsters caught from all southern Tasmanian sampling sites for 107mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

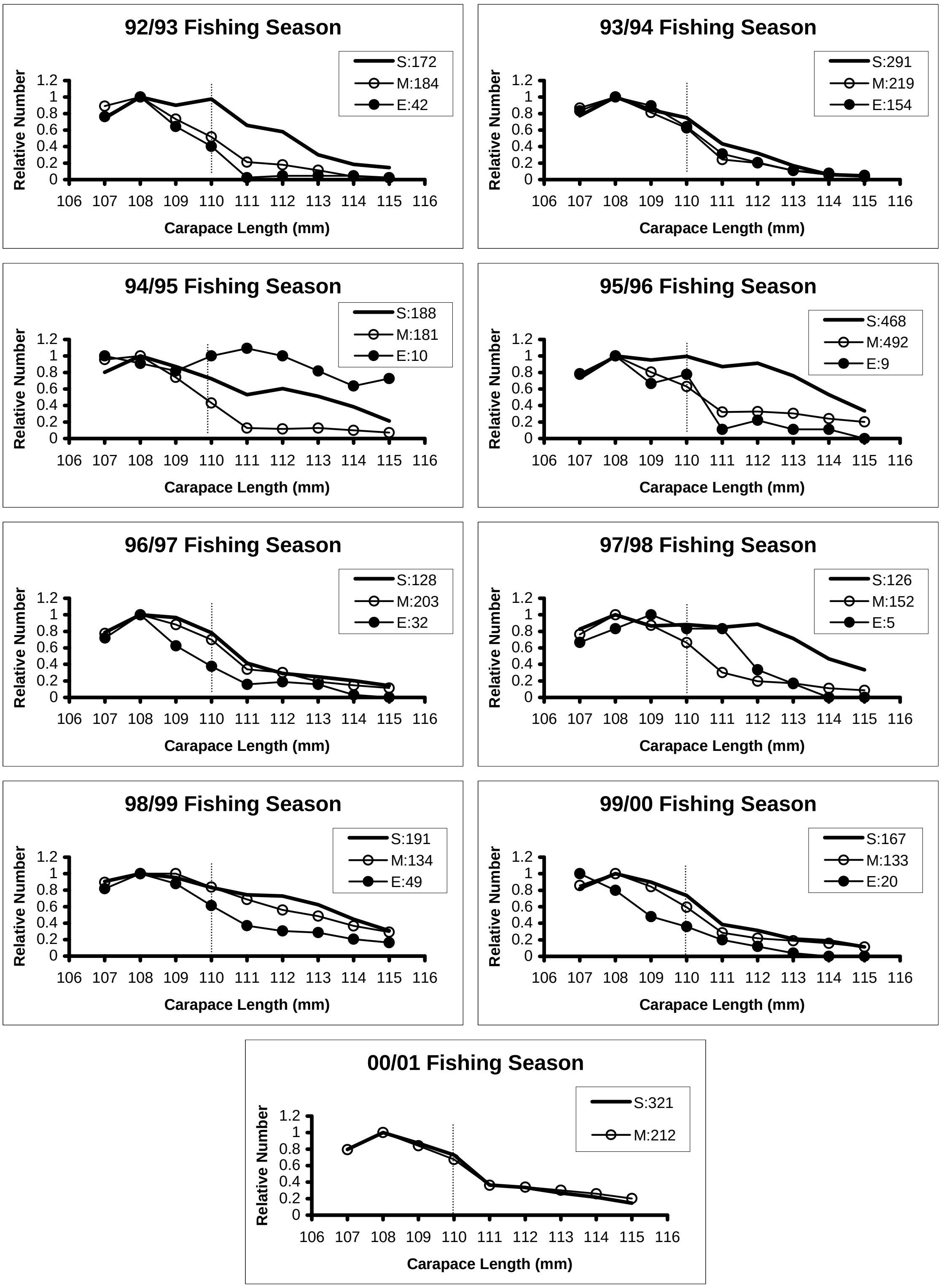


Figure 47. Standardised size frequency distribution of male rock lobsters caught from Maatsuyker Island, southern Tasmania for 107mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

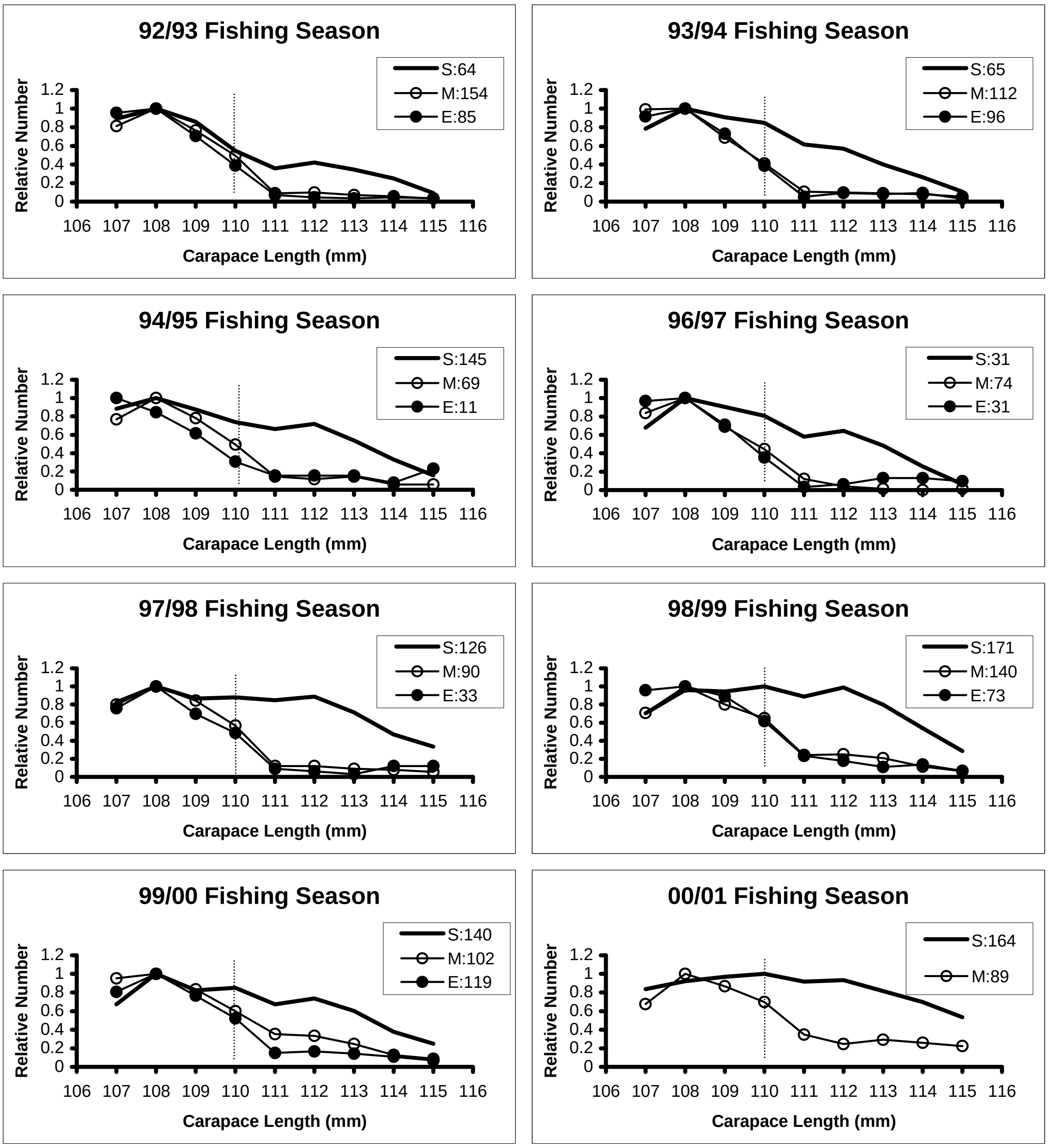


Figure 48. Standardised size frequency distribution of male rock lobsters caught from shallow water sites in southern Tasmania for 107mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1992/93 to 1994/95 and 1996/97 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

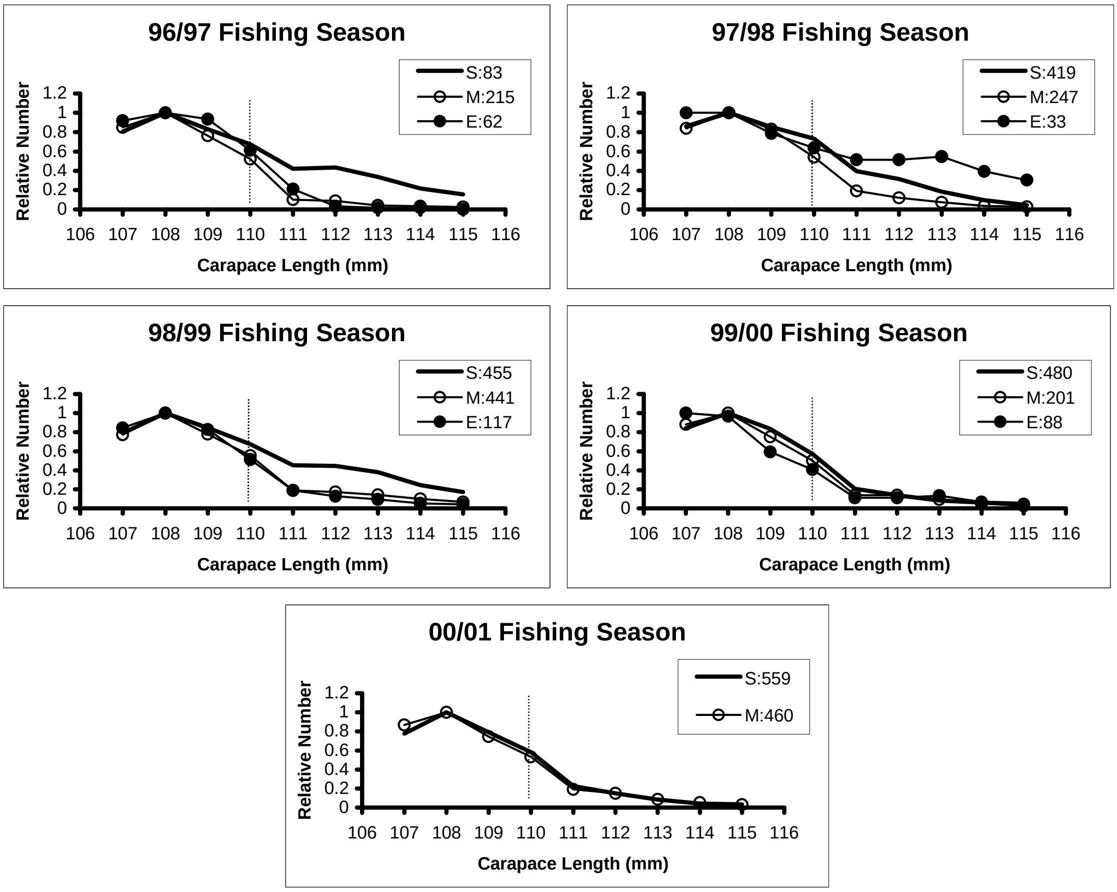


Figure 49. Standardised size frequency distribution of male rock lobsters caught from Port Davey, southern Tasmania for 107mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1996/97 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

16. Appendix 6 – East Coast diagnostic graphs

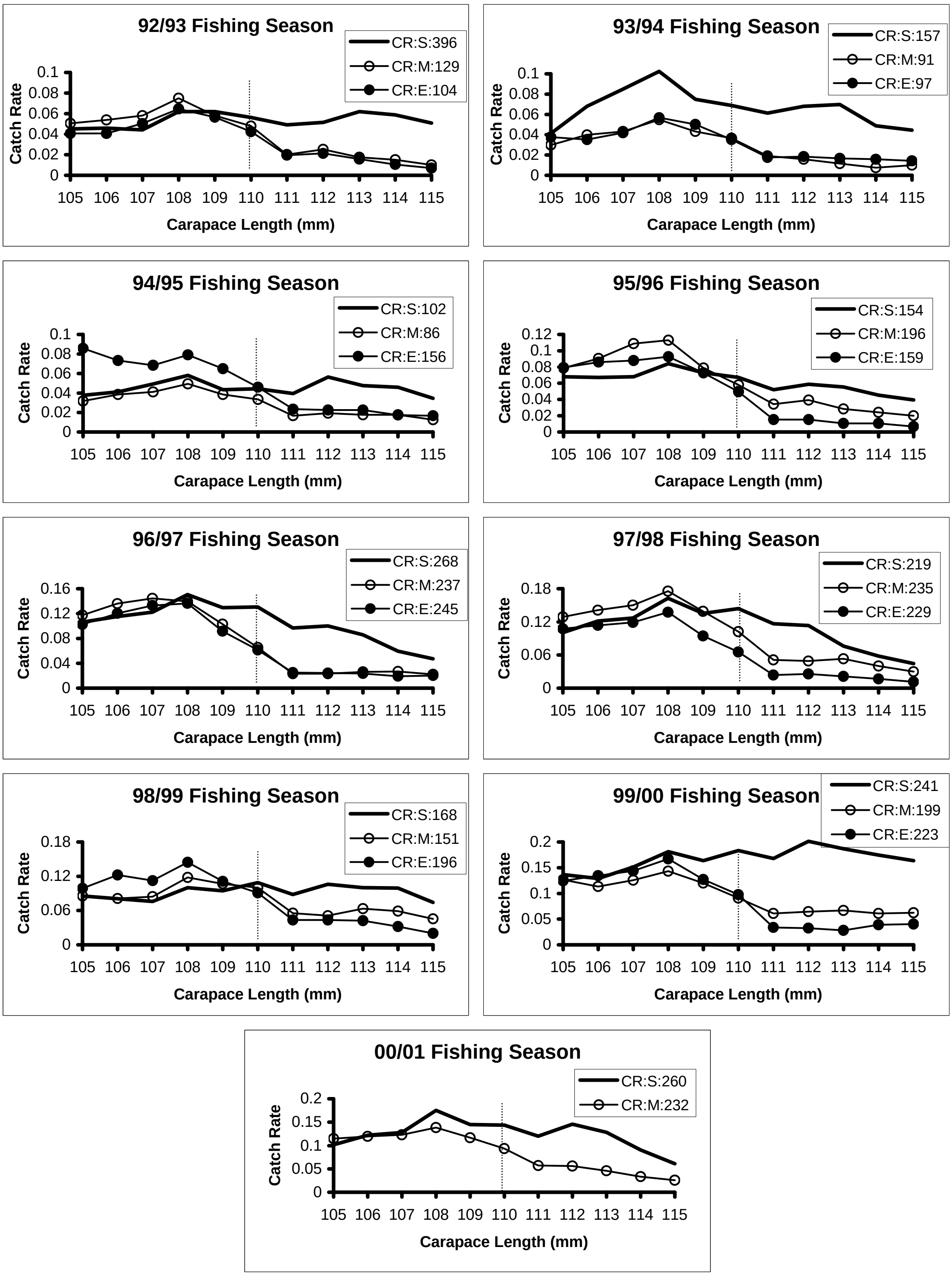


Figure 50. Comparison of catch rates (numbers/pot lift) of male lobsters caught from all eastern Tasmanian sampling sites during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 105mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

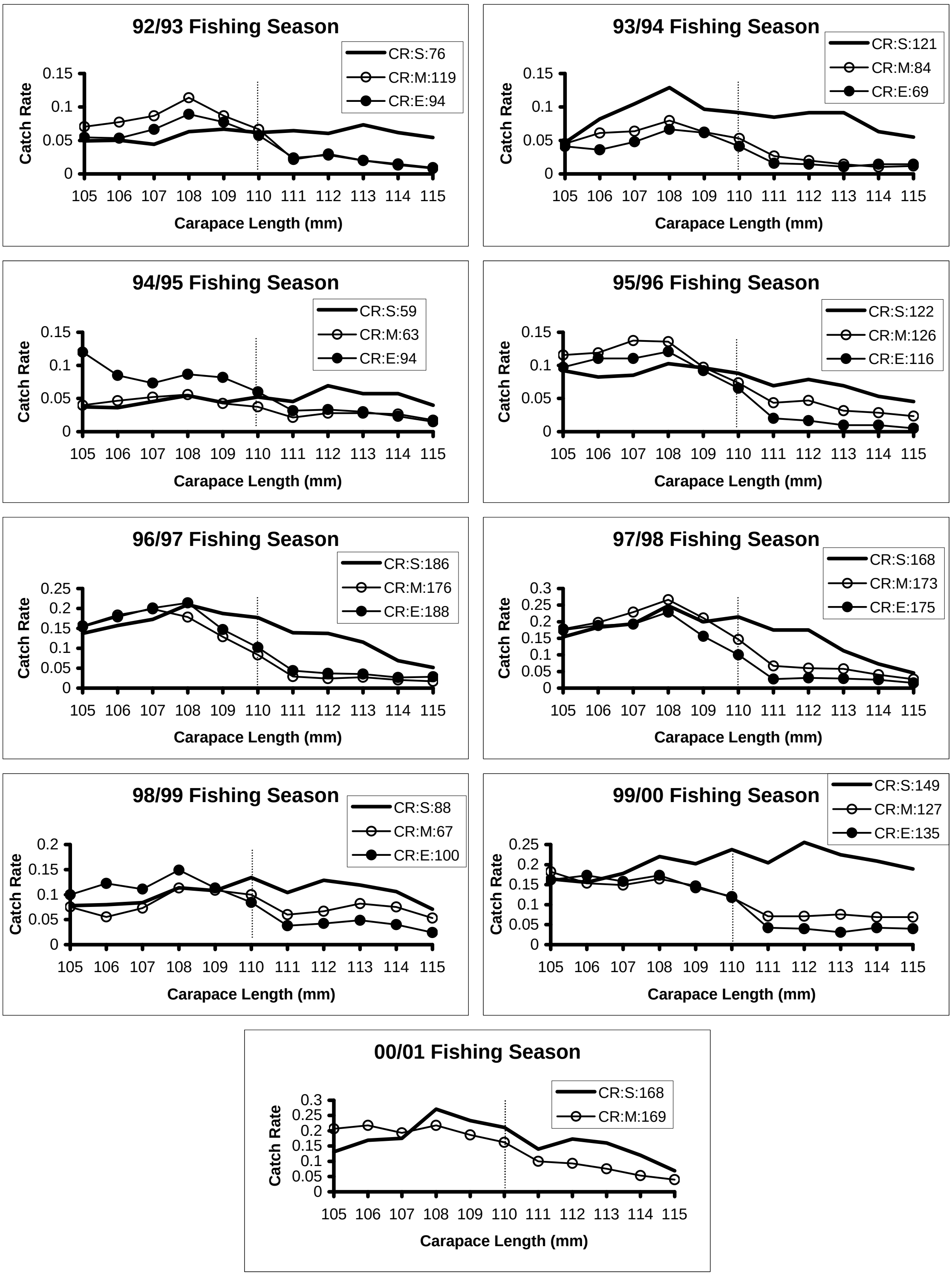


Figure 51. Comparison of catch rates (numbers/pot lift) of male lobsters caught from Sandstone Bluff, eastern Tasmania during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 105mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

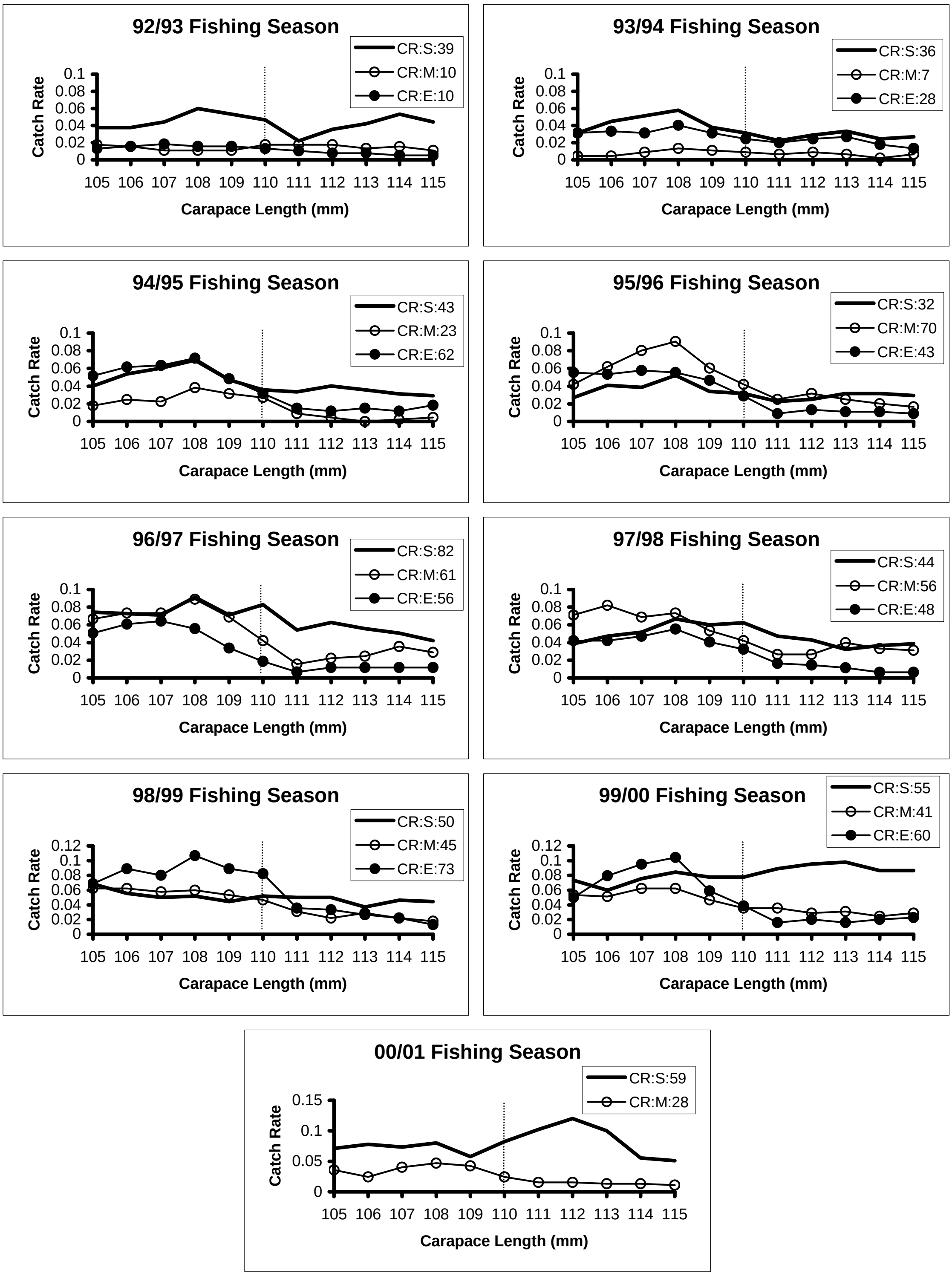


Figure 52. Comparison of catch rates (numbers/pot lift) of male lobsters caught from all shallow water eastern Tasmanian sampling sites during surveys undertaken at the start (thick line, no symbol), middle (open circle) and end (closed circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 105mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

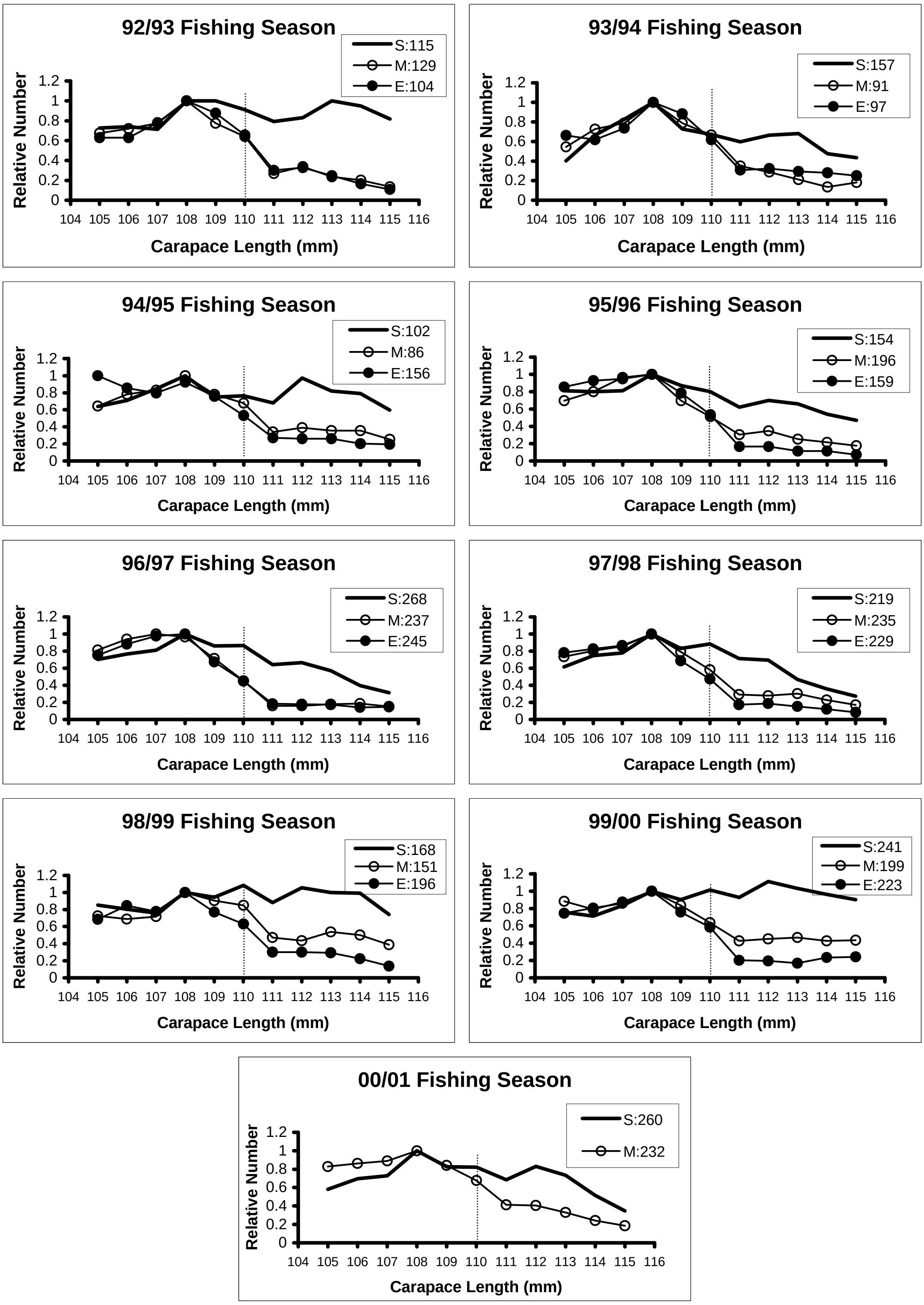


Figure 53. Standardised size frequency distribution of male rock lobsters caught from all eastern Tasmanian sampling sites for 105mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 105mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

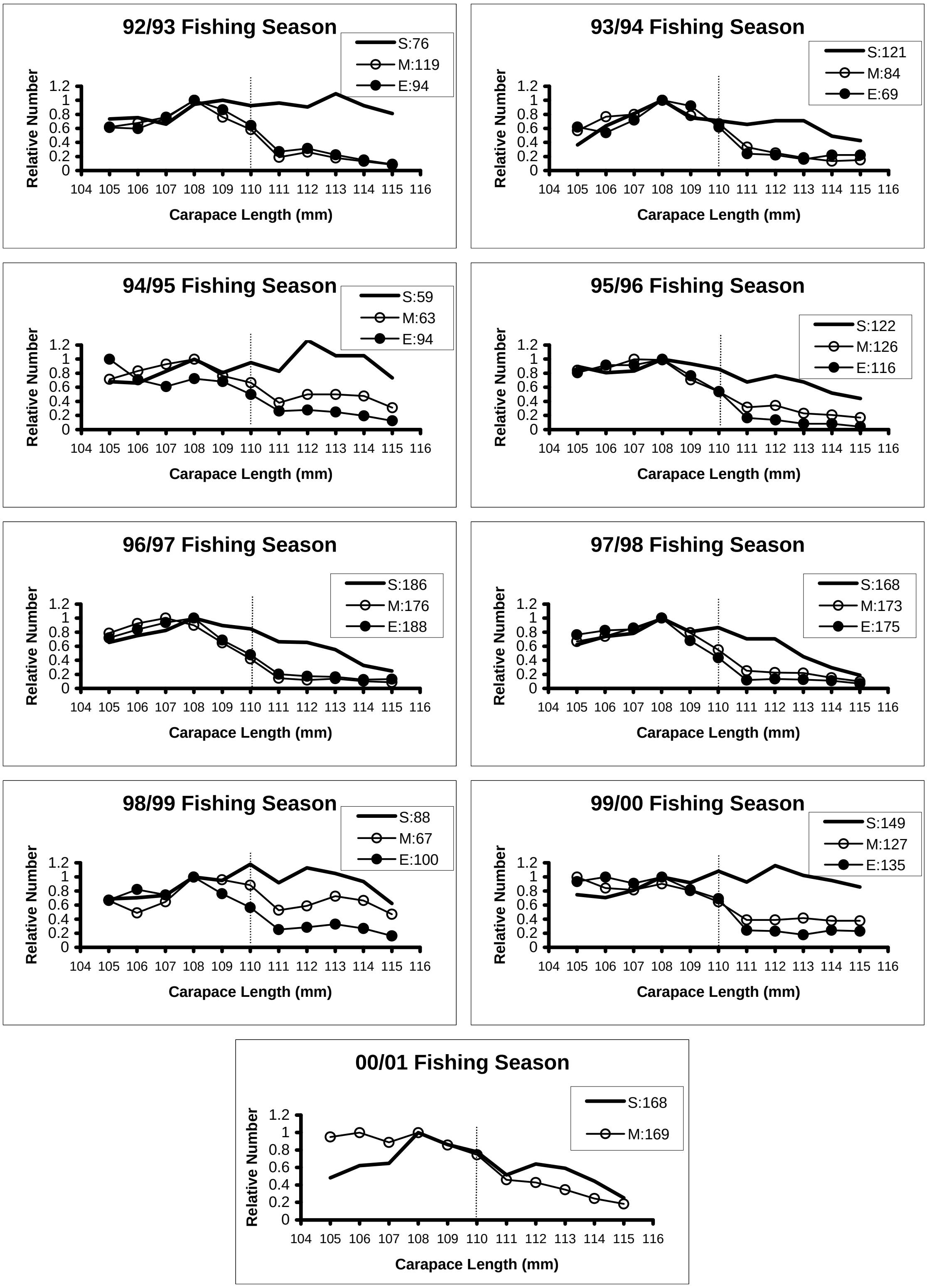


Figure 54. Standardised size frequency distribution of male rock lobsters caught from Sandstone Bluff, southern Tasmania for 107mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 107mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

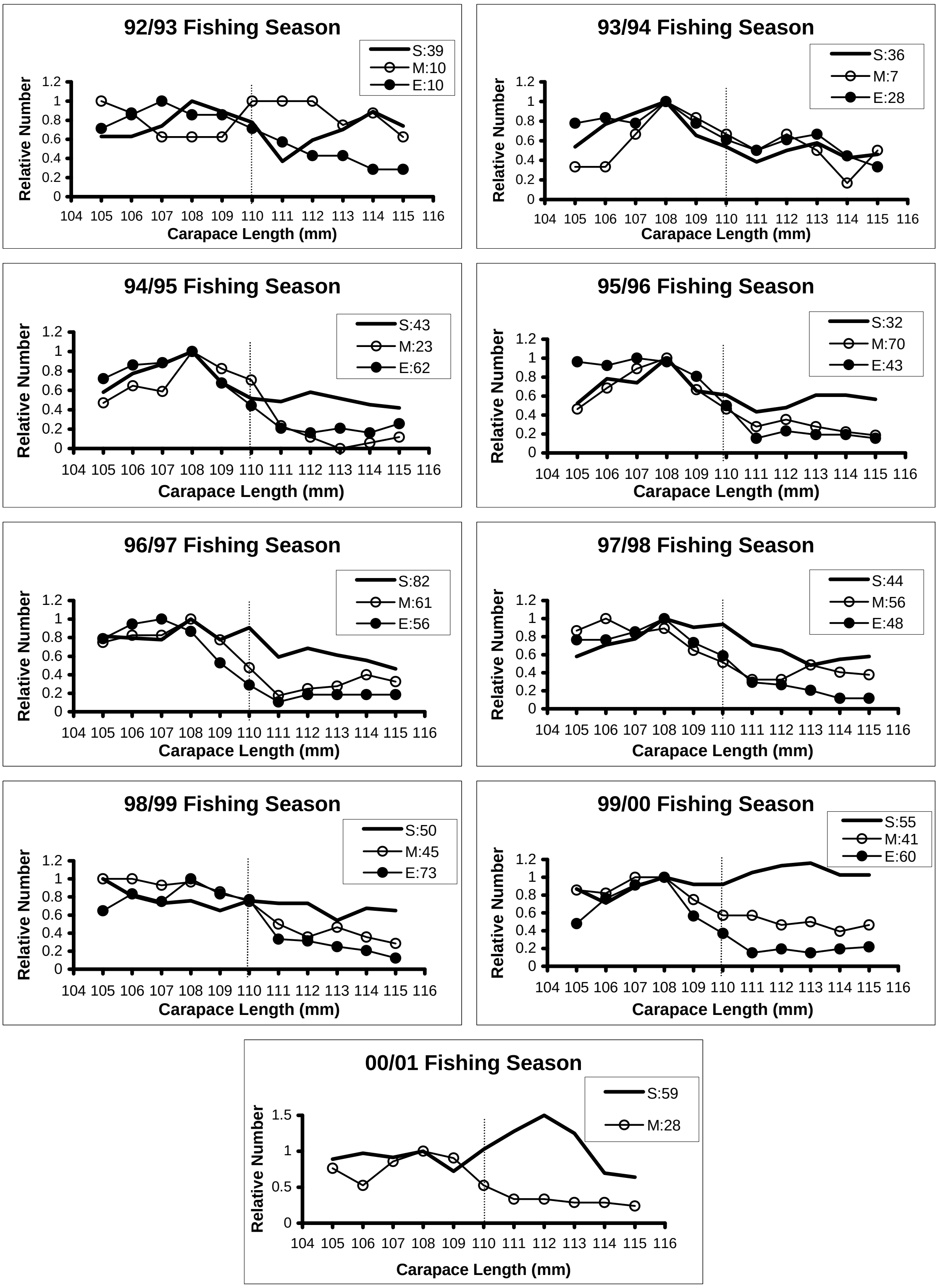


Figure 55. Standardised size frequency distribution of male rock lobsters caught from all shallow water eastern Tasmanian sampling sites for 105mmCL to 115mmCL during surveys at the start (S), middle (M) and end (E) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 105mmCL to 115mmCL size classes. Vertical dashed lines show the minimum legal size limit.

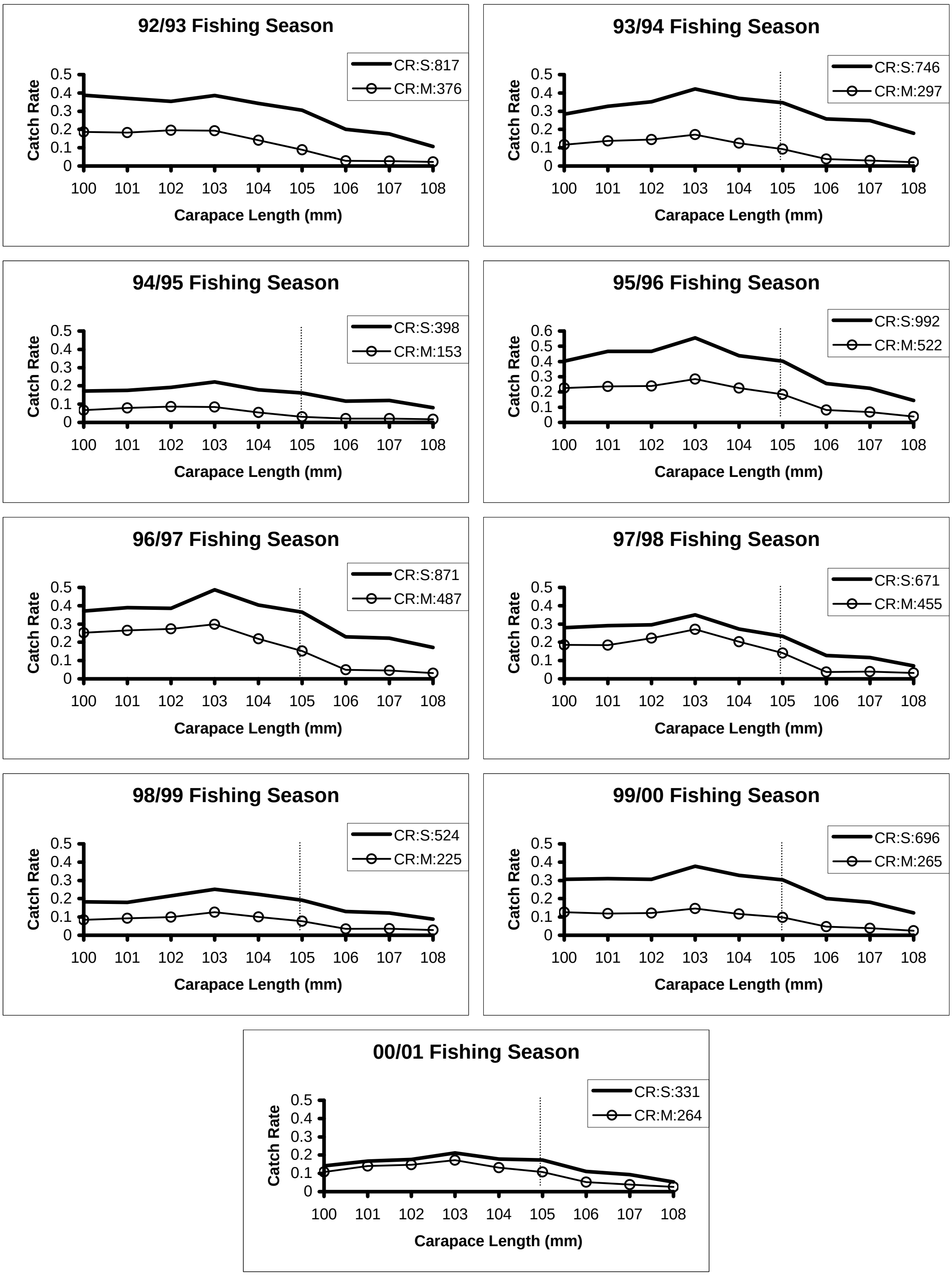


Figure 56. Comparison of catch rates (numbers/pot lift) of female lobsters caught from all eastern Tasmanian sampling sites during surveys undertaken at the start (thick line, no symbol) and middle (open circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 100mmCL to 108mmCL size classes. Vertical dashed lines show the minimum legal size limit.

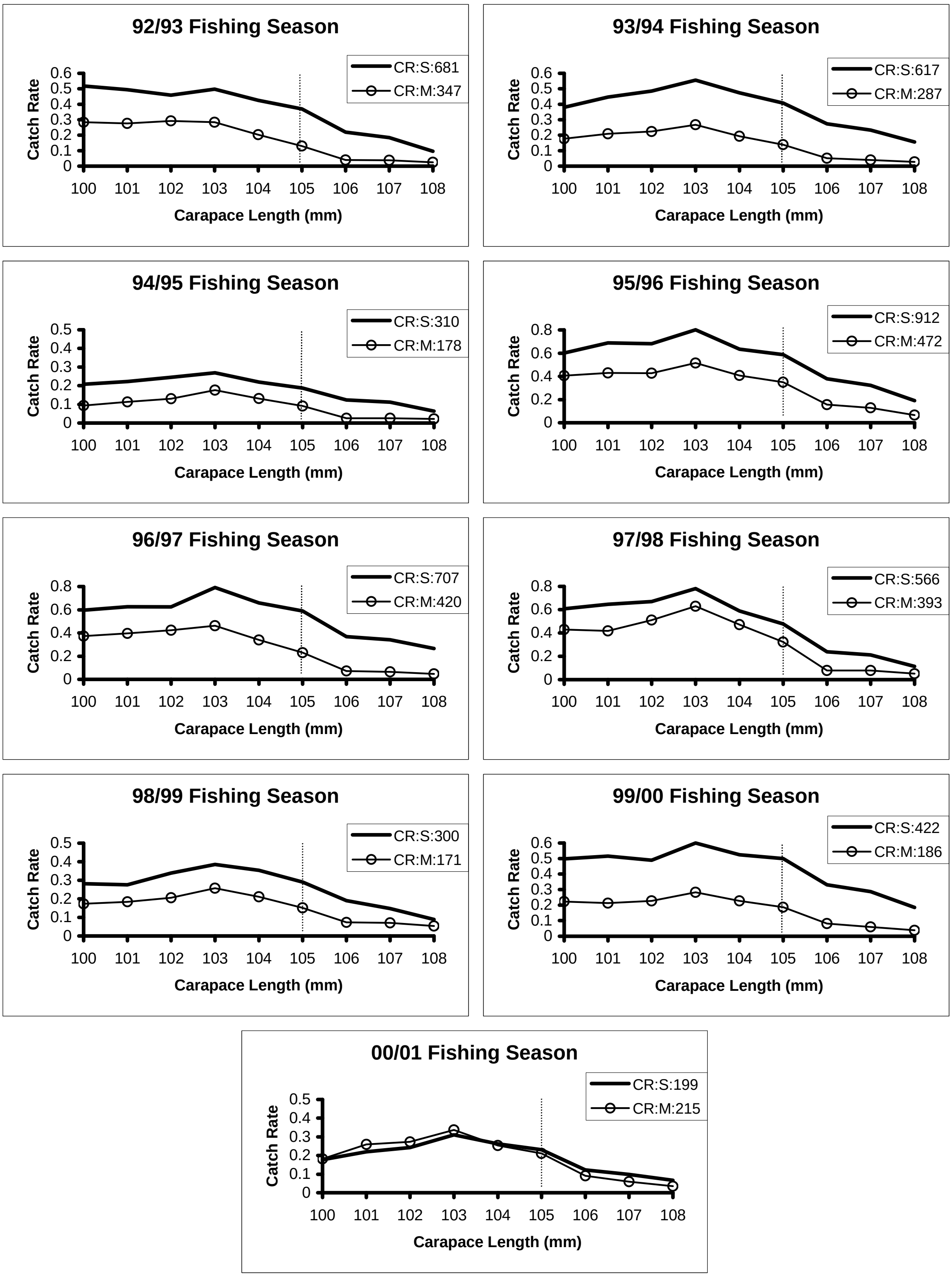


Figure 57. Comparison of catch rates (numbers/pot lift) of female lobsters caught from Sandstone Bluff, eastern Tasmania during surveys undertaken at the start (thick line, no symbol) and middle (open circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 100mmCL to 108mmCL size classes. Vertical dashed lines show the minimum legal size limit.

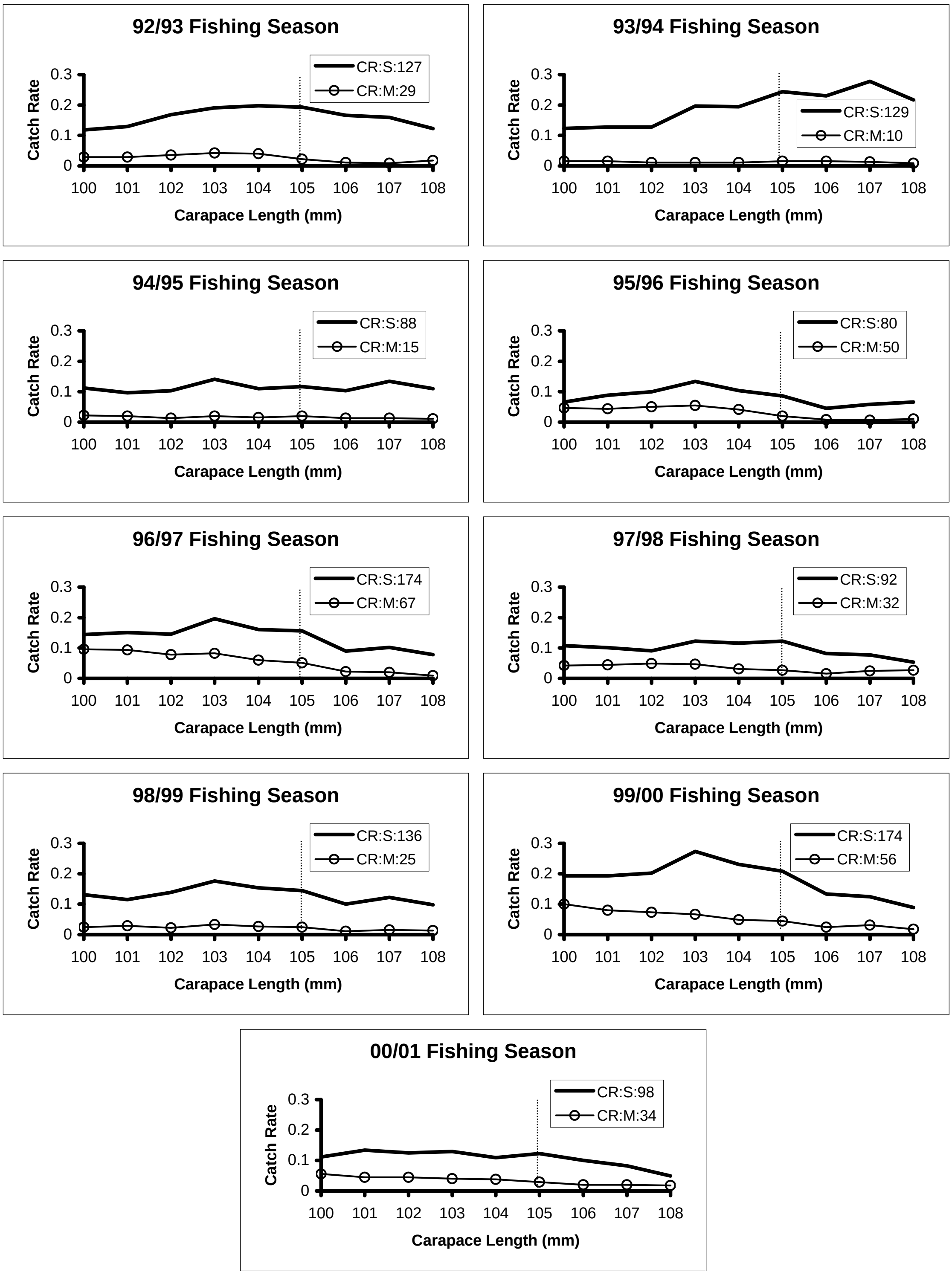


Figure 58. Comparison of catch rates (numbers/pot lift) of female lobsters caught from all shallow water eastern Tasmanian sampling sites during surveys undertaken at the start (thick line, no symbol) and middle (open circle) of the fishing years from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 100mmCL to 108mmCL size classes. Vertical dashed lines show the minimum legal size limit.

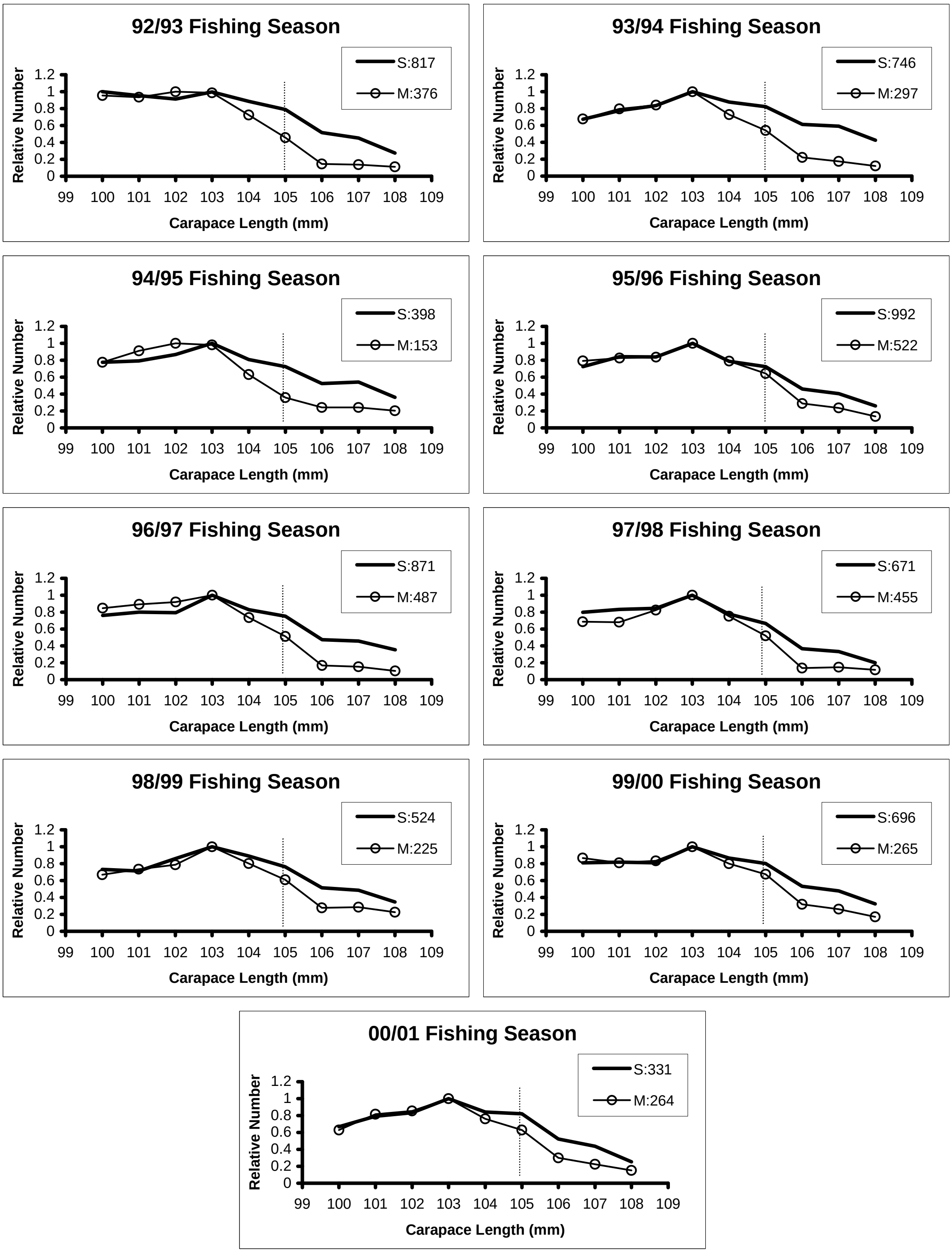


Figure 59. Standardised size frequency distribution of female rock lobsters caught from all eastern Tasmanian sampling sites for 100mmCL to 108mmCL during surveys at the start (S) and middle (M) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 100mmCL to 108mmCL size classes. Vertical dashed lines show the minimum legal size limit.

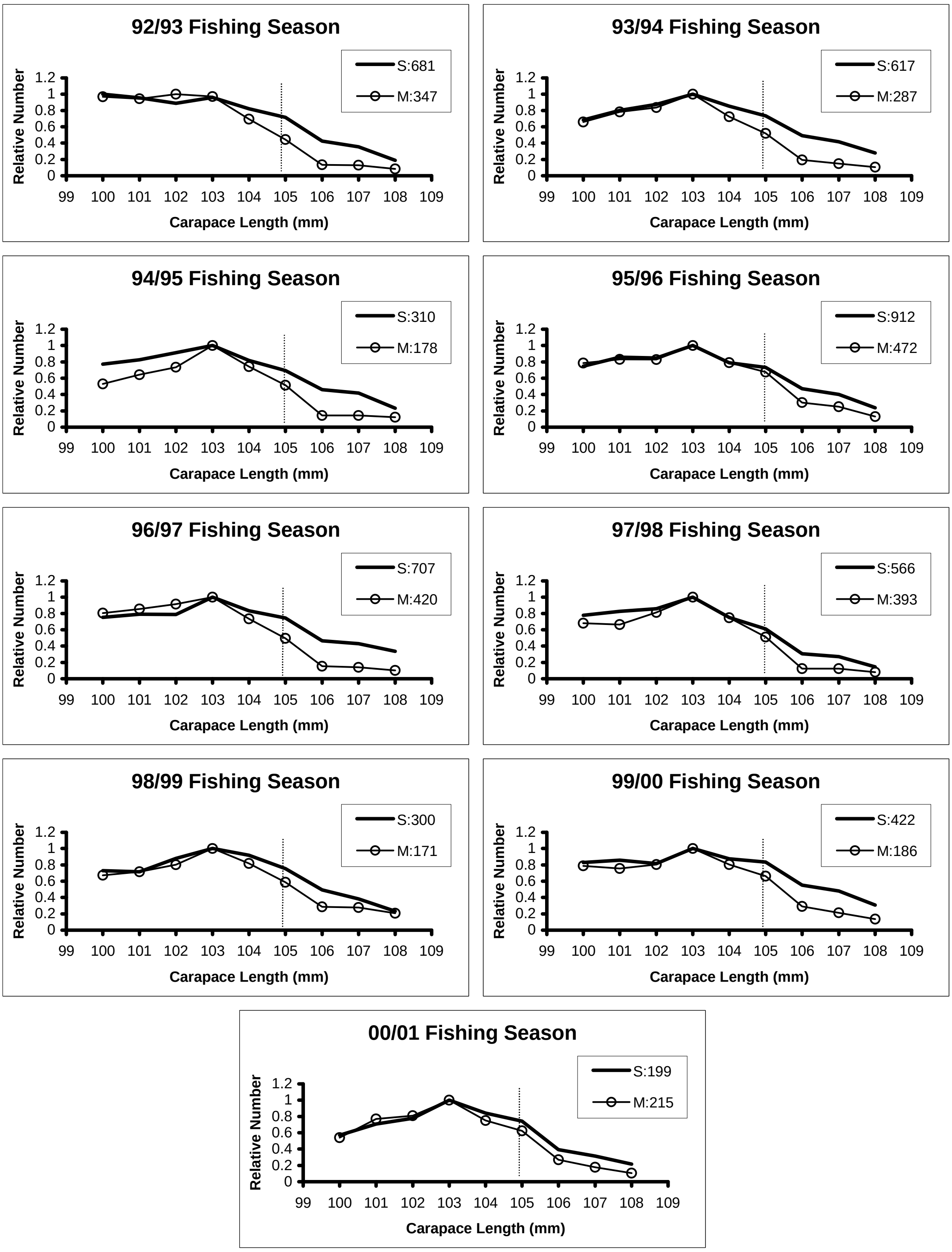


Figure 60. Standardised size frequency distribution of female rock lobsters caught from Sandstone Bluff, eastern Tasmania for 100mmCL to 108mmCL during surveys at the start (S) and middle (M) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 100mmCL to 108mmCL size classes. Vertical dashed lines show the minimum legal size limit.

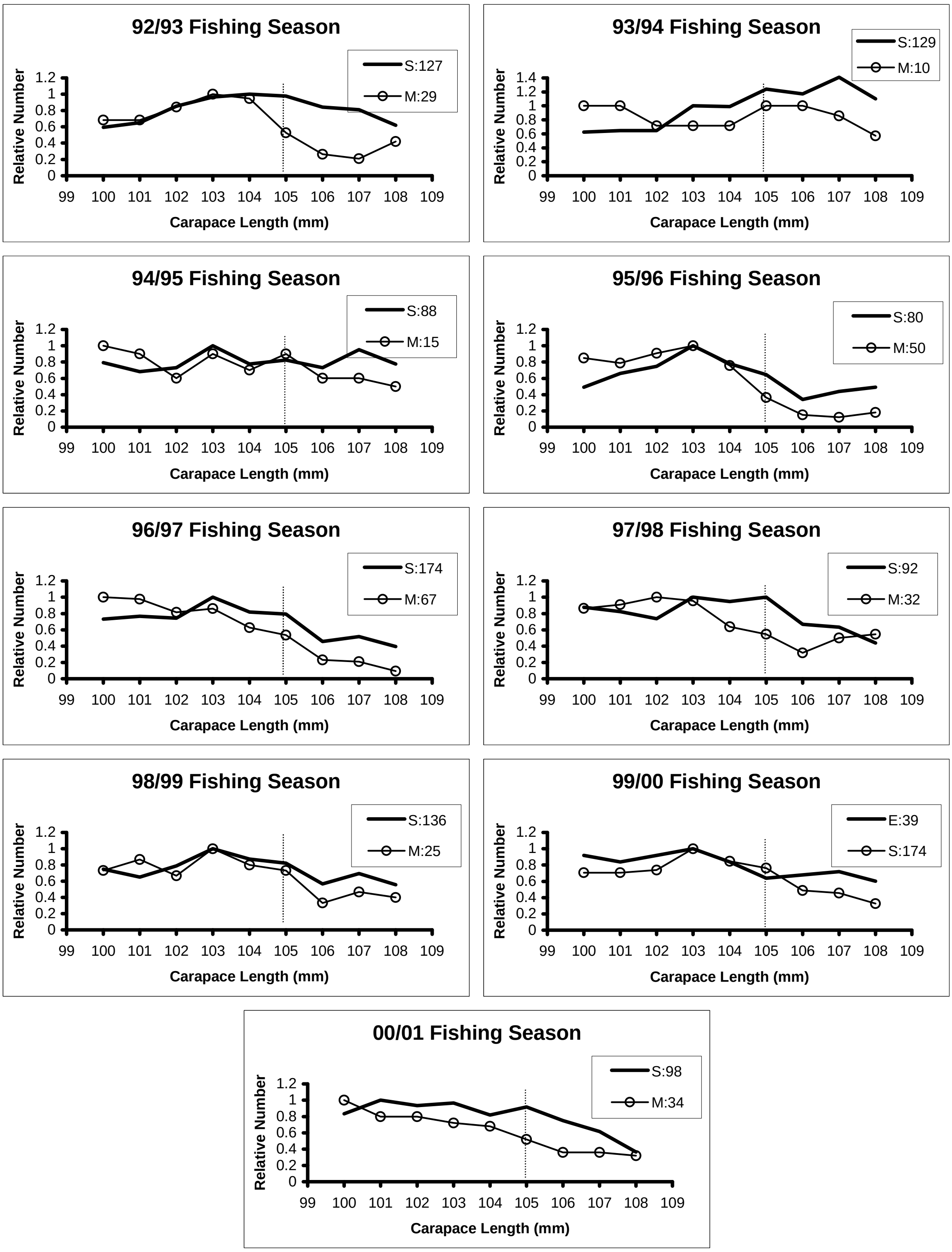


Figure 61. Standardised size frequency distribution of female rock lobsters caught from all shallow water eastern Tasmanian sampling sites for 100mmCL to 108mmCL during surveys at the start (S) and middle (M) of the fishing year from 1992/93 to 2000/01. Numbers in the legend refer to total number of lobsters caught in the survey for the 100mmCL to 108mmCL size classes. Vertical dashed lines show the minimum legal size limit.

17. Appendix 7 – South Coast diagnostic tables

Table 19. Differences in the catch rates of male lobsters caught on the south coast (all sites) from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	0.293	-0.205	-0.385	-0.206	-0.435	-0.289	-0.287	-0.869	-0.816	0.103	-0.962	-0.966	0.349	-0.625	-0.722	-0.493	-0.938	-0.878	0.073	-0.724	-0.743	-0.379	-0.667	-0.464	-0.252
108	0.185	-0.300	-0.409	-0.323	-0.493	-0.251	-0.336	-0.904	-0.855	0.028	-0.964	-0.965	0.303	-0.636	-0.720	-0.459	-0.935	-0.879	0.099	-0.747	-0.770	-0.440	-0.714	-0.488	-0.270
109	-0.003	-0.461	-0.459	-0.391	-0.508	-0.192	-0.428	-0.911	-0.844	-0.130	-0.975	-0.971	0.145	-0.709	-0.746	-0.485	-0.943	-0.890	0.011	-0.754	-0.757	-0.489	-0.762	-0.534	-0.329
Sum of undersized	0.475	-0.965	-1.253	-0.920	-1.436	-0.732	-1.051	-2.683	-2.514	0.000	-2.902	-2.903	0.798	-1.970	-2.188	-1.437	-2.816	-2.647	0.184	-2.225	-2.269	-1.308	-2.142	-1.486	-0.851
Sum of undersized/ no. size classes	0.158	-0.322	-0.418	-0.307	-0.479	-0.244	-0.350	-0.894	-0.838	**0.000**	-0.967	-0.968	0.266	-0.657	-0.729	-0.479	-0.939	-0.882	**0.061**	-0.742	-0.756	-0.436	-0.714	-0.495	-0.284
110	-0.303	-0.679	-0.540	-0.512	-0.640	-0.263	-0.591	-0.906	-0.770	-0.350	-0.972	-0.957	0.023	-0.783	-0.788	-0.618	-0.951	-0.872	-0.141	-0.813	-0.783	-0.538	-0.789	-0.543	-0.389
111	-0.678	-0.933	-0.792	-0.715	-0.770	-0.192	-0.852	-0.891	-0.264	-0.621	-0.995	-0.988	-0.402	-0.957	-0.929	-0.811	-0.961	-0.793	-0.517	-0.902	-0.796	-0.602	-0.868	-0.669	-0.517
112	-0.687	-0.939	-0.803	-0.692	-0.772	-0.261	-0.883	-0.909	-0.222	-0.631	-0.991	-0.977	-0.434	-0.931	-0.878	-0.836	-0.961	-0.760	-0.557	-0.925	-0.832	-0.583	-0.851	-0.643	-0.543
113	-0.642	-0.912	-0.754	-0.670	-0.759	-0.271	-0.833	-0.903	-0.421	-0.588	-0.995	-0.987	-0.586	-0.914	-0.793	-0.834	-0.952	-0.709	-0.566	-0.935	-0.851	-0.569	-0.812	-0.564	-0.531
114	-0.724	-0.837	-0.410	-0.459	-0.629	-0.314	-0.839	-0.898	-0.369	-0.531	-0.993	-0.984	-0.549	-0.926	-0.835	-0.838	-0.932	-0.577	-0.533	-0.919	-0.827	-0.673	-0.827	-0.470	-0.530
115	-0.760	-0.832	-0.301	-0.549	-0.622	-0.161	-0.762	-0.733	0.123	-0.380	-1.000	-1.000	-0.442	-0.941	-0.895	-0.796	-0.899	-0.506	-0.493	-0.910	-0.822	-0.618	-0.842	-0.585	-0.519

Table 20. Differences in the catch rates of male lobsters caught on the south coast (all sites) from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. No sampling occurred in shallow water in 1995/96. Bold figures represent accepted values

	1992/1993			1993/1994			1994/1995			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	0.912	0.719	-0.101	0.134	0.232	0.087	-0.575	-0.587	-0.029	1.605	0.429	-0.452	-0.446	-0.808	-0.653	0.188	-0.160	-0.293	0.032	0.021	-0.010	-0.597
108	1.098	0.607	-0.234	-0.103	0.055	0.176	-0.512	-0.692	-0.369	1.106	0.000	-0.525	-0.429	-0.790	-0.633	0.228	-0.360	-0.479	-0.271	-0.150	0.167	-0.457
109	0.871	0.320	-0.295	-0.320	-0.153	0.247	-0.564	-0.744	-0.414	0.607	-0.214	-0.511	-0.442	-0.831	-0.697	0.000	-0.420	-0.420	-0.261	-0.209	0.071	-0.552
Sum of undersized	2.882	1.645	-0.630	-0.289	0.135	0.510	-1.650	-2.023	-0.812	3.318	0.214	-1.488	-1.317	-2.429	-1.983	0.416	-0.939	-1.191	-0.500	-0.337	0.227	-1.607
Sum of undersized/ no. size classes	0.961	0.548	-0.210	**-0.096**	**0.045**	0.170	-0.550	-0.674	-0.271	1.106	**0.071**	-0.496	-0.439	-0.810	-0.661	0.139	-0.313	-0.397	-0.167	-0.112	0.076	-0.536
110	0.894	0.141	-0.398	-0.564	-0.519	0.103	-0.674	-0.848	-0.534	0.165	-0.560	-0.622	-0.632	-0.885	-0.686	-0.233	-0.621	-0.505	-0.487	-0.479	0.016	-0.652
111	-0.469	-0.684	-0.406	-0.844	-0.911	-0.429	-0.893	-0.915	-0.208	-0.559	-0.944	-0.874	-0.918	-0.978	-0.727	-0.677	-0.839	-0.500	-0.617	-0.809	-0.500	-0.810
112	-0.516	-0.821	-0.630	-0.845	-0.826	0.122	-0.921	-0.922	-0.010	-0.868	-0.900	-0.244	-0.921	-0.986	-0.818	-0.702	-0.889	-0.629	-0.670	-0.806	-0.412	-0.867
113	-0.564	-0.835	-0.622	-0.800	-0.780	0.097	-0.868	-0.896	-0.208	-0.941	-0.733	3.533	-0.929	-0.991	-0.875	-0.694	-0.915	-0.724	-0.702	-0.798	-0.320	-0.821
114	-0.509	-0.698	-0.384	-0.724	-0.622	0.371	-0.914	-0.915	-0.010	-1.000	-0.500	-	-0.905	-0.946	-0.429	-0.750	-0.844	-0.375	-0.755	-0.755	0.000	-0.815
115	-0.273	-0.395	-0.168	-0.554	-0.694	-0.314	-0.822	-0.470	1.969	-0.559	0.500	2.400	-0.905	-0.924	-0.200	-0.735	-0.853	-0.444	-0.743	-0.771	-0.111	-0.789

Table 21. Differences in the catch rates of male lobsters caught at Maatsuyker Island on the south coast from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	-0.010	-0.637	-0.633	-0.150	-0.586	-0.513	-0.210	-0.950	-0.936	0.103	-0.962	-0.966	0.043	-0.848	-0.854	-0.398	-0.975	-0.959	-0.288	-0.887	-0.841	-0.123	-0.826	-0.802	-0.344
108	-0.173	-0.645	-0.571	-0.242	-0.615	-0.492	-0.336	-0.963	-0.945	0.028	-0.964	-0.965	0.065	-0.833	-0.843	-0.334	-0.967	-0.951	-0.290	-0.878	-0.827	-0.184	-0.885	-0.859	-0.340
109	-0.327	-0.747	-0.624	-0.271	-0.592	-0.440	-0.437	-0.962	-0.933	-0.130	-0.975	-0.971	-0.031	-0.892	-0.889	-0.413	-0.974	-0.955	-0.261	-0.878	-0.835	-0.292	-0.917	-0.882	-0.364
Sum of undersized	-0.509	-2.029	-1.828	-0.663	-1.793	-1.446	-0.982	-2.875	-2.814	0.000	-2.902	-2.903	0.077	-2.574	-2.587	-1.144	-2.916	-2.864	-0.839	-2.642	-2.503	-0.599	-2.628	-2.543	-1.048
Sum of undersized/ no. size classes	-0.170	-0.676	-0.609	-0.221	-0.598	-0.482	-0.327	-0.958	-0.938	**0.000**	-0.967	-0.968	**0.026**	-0.858	-0.862	-0.381	-0.972	-0.955	-0.280	-0.881	-0.834	-0.200	-0.876	-0.848	-0.349
110	-0.563	-0.853	-0.664	-0.367	-0.670	-0.478	-0.604	-0.944	-0.859	-0.350	-0.972	-0.957	-0.047	-0.920	-0.916	-0.579	-0.978	-0.948	-0.299	-0.899	-0.856	-0.365	-0.930	-0.890	-0.389
111	-0.733	-0.987	-0.952	-0.576	-0.723	-0.346	-0.841	-0.917	-0.478	-0.621	-0.995	-0.988	-0.126	-0.937	-0.928	-0.785	-0.988	-0.943	-0.403	-0.937	-0.894	-0.365	-0.923	-0.879	-0.342
112	-0.745	-0.971	-0.886	-0.524	-0.750	-0.475	-0.873	-0.933	-0.476	-0.631	-0.991	-0.977	0.107	-0.892	-0.902	-0.786	-0.987	-0.938	-0.453	-0.942	-0.893	-0.404	-0.957	-0.929	-0.327
113	-0.688	-0.944	-0.821	-0.507	-0.748	-0.488	-0.835	-0.935	-0.609	-0.588	-0.995	-0.987	-0.182	-0.896	-0.873	-0.764	-1.000	-1.000	-0.475	-0.945	-0.895	-0.306	-0.972	-0.960	-0.256
114	-0.831	-0.909	-0.463	-0.049	-0.636	-0.618	-0.828	-0.933	-0.611	-0.531	-0.993	-0.984	-0.226	-0.974	-0.967	-0.797	-1.000	-1.000	-0.373	-0.933	-0.894	-0.536	-1.000	-1.000	-0.214
115	-0.876	-0.942	-0.530	-0.497	-0.584	-0.175	-0.776	-0.862	-0.385	-0.380	-1.000	-1.000	-0.142	-1.000	-1.000	-0.740	-1.000	-1.000	-0.309	-0.918	-0.882	-0.211	-1.000	-1.000	-0.085

Table 22. Differences in the catch rates of male lobsters caught at Port Davey on the south coast from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1996/1997 to March 2000/01. Bold figures represent accepted values.

	1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	0.338	-0.575	-0.682	-0.461	-0.943	-0.894	-0.053	-0.725	-0.710	-0.562	-0.775	-0.486	-0.079
108	0.269	-0.627	-0.706	-0.446	-0.951	-0.911	-0.031	-0.743	-0.735	-0.581	-0.817	-0.562	-0.177
109	0.165	-0.580	-0.639	-0.460	-0.954	-0.915	-0.106	-0.748	-0.718	-0.623	-0.865	-0.642	-0.222
Sum of undersized	0.772	-1.781	-2.027	-1.367	-2.848	-2.720	-0.190	-2.216	-2.162	-1.767	-2.457	-1.690	-0.478
Sum of undersized/ no. size classes	0.257	-0.594	-0.676	-0.456	-0.949	-0.907	**-0.063**	-0.739	-0.721	-0.589	-0.819	-0.563	-0.159
110	-0.020	-0.661	-0.654	-0.590	-0.957	-0.896	-0.199	-0.804	-0.755	-0.631	-0.865	-0.634	-0.248
111	-0.692	-0.814	-0.397	-0.734	-0.936	-0.759	-0.597	-0.893	-0.735	-0.714	-0.898	-0.643	-0.302
112	-0.741	-0.972	-0.893	-0.786	-0.919	-0.622	-0.626	-0.926	-0.803	-0.576	-0.848	-0.643	-0.179
113	-0.843	-0.982	-0.887	-0.780	-0.854	-0.333	-0.642	-0.936	-0.823	-0.525	-0.700	-0.368	-0.130
114	-0.809	-0.972	-0.854	-0.789	-0.796	-0.037	-0.604	-0.946	-0.864	-0.655	-0.793	-0.400	0.043
115	-0.812	-1.000	-1.000	-0.634	-0.652	-0.048	-0.628	-0.936	-0.828	-0.773	-0.818	-0.200	-0.222

Table 23. Difference between standardised catches of male lobsters caught on the south coast (all sites) from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	0.071	0.106	0.035	0.134	0.089	-0.045	0.063	0.162	0.100	0.054	0.045	-0.009	0.028	0.022	-0.006	-0.181	-0.171	0.010	-0.125	-0.034	0.092	0.088	0.200	0.112	0.020
108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.125	-0.125	0.000	0.000	0.000	0.000	0.000	0.000	-0.148	-0.148	0.000	-0.133	-0.133	0.000	0.000	0.076	0.076	0.000
109	-0.141	-0.205	-0.063	-0.086	-0.025	0.062	-0.121	-0.166	-0.045	-0.146	-0.284	-0.138	-0.110	-0.183	-0.073	-0.170	-0.246	-0.076	-0.188	-0.142	0.045	-0.072	-0.087	-0.015	-0.069
Sum of undersized	-0.070	-0.099	-0.029	0.048	0.064	0.016	-0.058	-0.128	-0.070	-0.092	-0.239	-0.147	-0.083	-0.161	-0.079	-0.499	-0.565	-0.066	-0.446	-0.309	0.137	0.016	0.188	0.173	-0.049
Sum of undersized/ no. size classes	**-0.023**	**-0.033**	-0.010	**0.016**	**0.021**	0.005	**-0.019**	-0.043	-0.023	**-0.031**	-0.080	-0.049	**-0.028**	-0.054	-0.026	-0.166	-0.188	-0.022	-0.149	-0.103	0.046	**0.005**	0.063	0.058	**-0.016**
110	-0.354	-0.466	-0.112	-0.214	0.223	0.009	0.280	0.105	-0.175	0.366	0.218	-0.148	0.160	0.303	0.142	0.352	0.321	-0.031	0.271	0.306	0.035	0.112	0.112	0.021	-0.115
111	-0.419	-0.521	-0.102	-0.270	0.254	-0.016	0.457	0.005	-0.452	0.549	0.759	0.210	0.237	0.387	0.150	0.427	0.294	-0.132	0.418	0.449	0.030	0.089	0.089	0.066	-0.132
112	-0.396	-0.491	-0.095	-0.199	0.201	0.002	0.539	0.113	-0.426	0.585	0.690	0.105	0.217	0.311	0.094	0.408	0.264	-0.144	0.456	0.524	0.068	0.069	0.069	0.051	-0.128
113	-0.219	-0.274	-0.055	-0.108	0.111	0.003	0.391	0.064	-0.327	0.456	0.650	0.194	0.211	0.237	0.026	0.280	0.136	-0.144	0.387	0.460	0.073	0.046	0.046	0.013	-0.095
114	-0.156	-0.156	0.000	-0.020	0.026	0.007	0.273	0.027	-0.246	0.288	0.419	0.131	0.140	0.171	0.031	0.177	0.021	-0.155	0.242	0.278	0.036	0.057	0.057	-0.009	-0.074
115	-0.105	-0.100	0.005	-0.020	0.015	-0.005	0.121	-0.269	-0.391	0.132	0.333	0.201	0.078	0.114	0.036	0.094	-0.048	-0.142	0.150	0.173	0.023	0.030	0.030	0.008	-0.052

Table 24. Difference between standardised catches of male lobsters caught in shallow water on the south coast from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. No sampling occurred in shallow water in 1995/96. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	-0.079	0.062	0.141	0.206	0.132	-0.074	-0.115	0.117	0.232	0.160	0.290	0.130	-0.025	-0.068	-0.042	0.005	0.257	0.252	0.280	0.135	-0.144	-0.163
108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.154	-0.154	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.039	0.000	0.000	0.000	0.000	0.079
109	-0.093	-0.153	-0.060	-0.220	-0.179	0.042	-0.093	-0.260	-0.167	-0.214	-0.194	0.020	-0.021	-0.168	-0.147	-0.144	-0.053	0.090	0.012	-0.057	-0.069	-0.101
Sum of undersized	-0.172	-0.091	0.081	-0.014	-0.046	-0.033	-0.208	-0.297	-0.089	-0.054	0.097	0.150	-0.046	-0.236	-0.190	-0.100	0.243	0.342	0.291	0.079	-0.213	-0.185
Sum of undersized/ no.size classes	-0.057	**-0.030**	0.027	**-0.005**	**-0.015**	-0.011	-0.069	-0.099	-0.030	**-0.018**	0.032	0.050	**-0.015**	-0.079	-0.063	**-0.033**	0.081	0.114	0.097	**0.026**	-0.071	-0.062
110	-0.053	-0.159	-0.105	-0.435	-0.461	-0.025	-0.245	-0.430	-0.185	-0.361	0.452	0.091	0.314	0.396	0.082	0.350	0.384	0.034	0.252	0.329	0.077	-0.303
111	0.268	-0.289	-0.020	-0.508	-0.563	-0.055	-0.517	-0.508	0.009	-0.459	0.548	0.089	0.727	0.758	0.031	0.645	0.655	0.010	0.318	0.520	0.202	-0.567
112	0.324	-0.375	-0.050	-0.471	-0.475	-0.004	-0.601	-0.563	0.038	-0.605	0.581	-0.024	0.767	0.828	0.062	0.739	0.811	0.072	0.402	0.568	0.165	-0.685
113	0.272	-0.308	-0.036	-0.311	-0.317	-0.006	-0.393	-0.384	0.009	-0.470	0.355	-0.116	0.625	0.684	0.059	0.591	0.688	0.098	0.355	0.457	0.102	-0.522
114	0.192	-0.203	-0.011	-0.181	-0.168	0.013	-0.273	-0.254	0.019	-0.258	0.129	-0.129	0.390	0.347	-0.043	0.425	0.402	-0.023	0.251	0.269	0.018	-0.438
115	0.061	-0.058	0.003	-0.054	-0.076	-0.022	-0.101	0.072	0.173	-0.051	-0.032	-0.083	0.278	0.212	-0.066	0.222	0.218	-0.004	0.162	0.183	0.021	-0.309

Table 25. Difference between standardised catches of male lobsters caught at Maatsuyker Island on the south coast from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	0.147	0.018	-0.129	0.094	0.058	-0.036	0.153	0.197	0.044	0.054	0.045	-0.009	-0.016	-0.070	-0.055	-0.062	-0.159	-0.096	-0.010	-0.089	-0.079	0.037	0.180	0.143	-0.005
108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.091	-0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.167	-0.167	0.000	0.000	0.000	0.000	-0.200	-0.200	0.000
109	-0.167	-0.258	-0.091	-0.033	0.051	0.083	-0.132	-0.054	0.078	-0.146	-0.284	-0.138	-0.087	-0.344	-0.257	0.010	0.135	0.125	0.047	-0.075	-0.122	-0.056	-0.418	-0.362	-0.033
Sum of undersized	-0.020	-0.241	-0.220	0.062	0.109	0.047	0.021	0.052	0.031	-0.092	-0.239	-0.147	-0.103	-0.414	-0.311	-0.052	-0.190	-0.138	0.037	-0.165	-0.202	-0.019	-0.439	-0.419	-0.038
Sum of undersized/ no. size classes	**-0.007**	-0.080	-0.073	**0.021**	0.036	0.016	**0.007**	0.017	0.010	**-0.031**	-0.080	-0.049	**-0.034**	-0.138	-0.104	**-0.017**	-0.063	-0.046	**0.012**	-0.055	-0.067	**-0.006**	-0.146	-0.140	-0.013
110	-0.460	-0.572	-0.112	-0.124	0.106	-0.017	0.292	-0.277	-0.569	0.366	0.218	-0.148	0.082	0.406	0.325	0.216	0.048	-0.169	-0.003	0.220	0.224	0.143	0.143	0.234	-0.054
111	-0.445	-0.633	-0.188	-0.191	0.121	-0.070	0.405	-0.559	-0.964	0.549	0.759	0.210	0.074	0.258	0.184	0.547	0.016	-0.531	0.057	0.376	0.319	0.098	0.098	0.086	-0.001
112	-0.402	-0.534	-0.132	-0.119	0.112	-0.007	0.490	-0.394	-0.884	0.585	0.690	0.105	-0.011	0.102	0.113	0.692	0.556	-0.136	0.168	0.422	0.254	0.093	0.093	0.098	0.006
113	-0.188	-0.255	-0.067	-0.059	0.058	-0.001	0.384	-0.308	-0.691	0.456	0.650	0.194	0.058	0.094	0.036	0.543	0.548	0.004	0.138	0.337	0.199	0.022	0.022	0.148	0.034
114	-0.148	-0.138	0.010	0.016	0.003	0.019	0.284	-0.253	-0.537	0.288	0.419	0.131	0.055	0.172	0.117	0.356	0.468	0.112	0.079	0.241	0.162	0.028	0.028	0.158	0.041
115	-0.124	-0.122	0.002	-0.016	-0.004	-0.020	0.141	-0.515	-0.655	0.132	0.333	0.201	0.027	0.141	0.113	0.248	0.333	0.086	0.018	0.146	0.128	0.001	0.001	0.113	0.056

Table 26. Difference between standardised catches of male lobsters caught at Port Davey on the south coast from 107mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1996/1997 to March 2000/01. Bold figures represent accepted values.

	1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
107	0.044	0.112	0.068	-0.024	0.138	0.162	-0.018	0.055	0.073	0.039	0.158	0.119	0.093
108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.033	-0.033	0.000
109	-0.069	0.104	0.173	-0.022	-0.064	-0.042	-0.066	-0.017	0.049	-0.084	-0.242	-0.158	-0.043
Sum of undersized	-0.025	0.216	0.241	-0.046	0.074	0.120	-0.084	0.038	0.122	-0.045	-0.117	-0.071	0.050
Sum of undersized/ no. size classes	**-0.008**	0.072	0.080	**-0.015**	0.025	0.040	**-0.028**	**0.013**	0.041	**-0.015**	-0.039	-0.024	0.017
110	-0.154	-0.062	0.092	-0.190	-0.096	0.094	-0.117	-0.160	-0.043	-0.068	-0.164	-0.096	-0.051
111	-0.319	-0.212	0.107	-0.206	0.119	0.325	-0.265	-0.265	0.000	-0.065	-0.094	-0.029	-0.034
112	-0.345	-0.401	-0.056	-0.194	0.200	0.394	-0.274	-0.318	-0.044	0.002	-0.028	-0.029	0.000
113	-0.295	-0.321	-0.026	-0.111	0.362	0.473	-0.240	-0.286	-0.047	0.011	0.049	0.037	0.005
114	-0.184	-0.201	-0.016	-0.059	0.298	0.358	-0.144	-0.193	-0.048	-0.011	0.006	0.016	0.011
115	-0.133	-0.157	-0.023	-0.015	0.260	0.275	-0.106	-0.129	-0.023	-0.021	-0.002	0.019	-0.002

18. Appendix 8 – East Coast diagnostic tables

Table 27. Differences in the catch rates of male lobsters caught on the east coast (all sites) from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
105	0.120	-0.098	-0.195	-0.273	-0.086	0.256	-0.152	1.288	1.697	0.158	0.166	0.007	0.108	-0.032	-0.126	0.282	0.070	-0.165	0.002	0.158	0.156	-0.073	-0.088	-0.016	0.125
106	0.174	-0.114	-0.245	-0.413	-0.484	-0.121	-0.062	0.786	0.903	0.347	0.280	-0.050	0.178	0.044	-0.114	0.160	-0.065	-0.194	0.004	0.513	0.507	-0.121	0.045	0.188	-0.021
107	0.312	0.138	-0.132	-0.490	-0.507	-0.034	-0.164	0.391	0.665	0.601	0.292	-0.193	0.184	0.090	-0.080	0.181	-0.063	-0.206	0.109	0.474	0.329	-0.169	-0.049	0.144	-0.035
108	0.208	0.041	-0.138	-0.464	-0.445	0.035	-0.148	0.366	0.602	0.347	0.103	-0.181	-0.073	-0.095	-0.024	0.077	-0.156	-0.216	0.175	0.440	0.226	-0.209	-0.077	0.167	-0.210
109	-0.063	-0.087	-0.026	-0.422	-0.329	0.160	-0.114	0.495	0.687	0.078	-0.006	-0.078	-0.205	-0.292	-0.110	0.025	-0.303	-0.321	0.126	0.173	0.042	-0.265	-0.224	0.057	-0.195
Sum of undersized	0.751	-0.120	-0.736	-2.062	-1.852	0.297	-0.640	3.325	4.555	1.529	0.834	-0.494	0.192	-0.285	-0.454	0.726	-0.517	-1.103	0.416	1.758	1.260	-0.837	-0.393	0.072	-0.335
Sum of undersized/ no. size classes	0.150	**-0.024**	-0.147	-0.412	-0.370	0.059	-0.128	0.665	0.911	0.306	0.167	-0.099	**0.038**	**-0.057**	-0.091	0.145	-0.103	-0.221	**0.083**	0.352	0.252	-0.167	**-0.079**	0.014	**-0.067**
110	-0.149	-0.247	-0.115	-0.469	-0.490	-0.041	-0.243	0.035	0.368	-0.140	-0.261	-0.141	-0.498	-0.529	-0.062	-0.290	-0.547	-0.362	-0.079	-0.161	-0.089	-0.503	-0.467	0.072	-0.349
111	-0.589	-0.604	-0.037	-0.688	-0.714	-0.082	-0.575	-0.409	0.393	-0.340	-0.706	-0.555	-0.761	-0.739	0.092	-0.561	-0.795	-0.534	-0.370	-0.509	-0.220	-0.636	-0.799	-0.449	-0.522
112	-0.510	-0.588	-0.160	-0.768	-0.730	0.164	-0.658	-0.601	0.168	-0.330	-0.740	-0.612	-0.769	-0.756	0.056	-0.568	-0.774	-0.477	-0.517	-0.591	-0.152	-0.680	-0.838	-0.495	-0.613
113	-0.715	-0.743	-0.100	-0.833	-0.760	0.436	-0.630	-0.526	0.279	-0.486	-0.810	-0.631	-0.697	-0.725	-0.094	-0.300	-0.722	-0.603	-0.368	-0.579	-0.333	-0.643	-0.850	-0.579	-0.643
114	-0.742	-0.819	-0.300	-0.846	-0.674	1.122	-0.617	-0.619	-0.005	-0.464	-0.768	-0.567	-0.549	-0.676	-0.282	-0.313	-0.712	-0.581	-0.407	-0.676	-0.453	-0.650	-0.775	-0.357	-0.631
115	-0.801	-0.861	-0.300	-0.776	-0.681	0.424	-0.637	-0.519	0.327	-0.491	-0.831	-0.667	-0.530	-0.571	-0.088	-0.325	-0.742	-0.618	-0.387	-0.731	-0.561	-0.619	-0.753	-0.351	-0.577

Table 28. Differences in the catch rates of male lobsters caught at Sandstone Bluff on the east coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
105	0.431	0.110	-0.224	-0.040	-0.121	-0.085	0.071	2.214	2.000	0.256	0.056	-0.159	0.139	0.122	-0.015	0.153	0.137	-0.014	-0.034	0.279	0.324	0.108	-0.014	-0.110	0.576
106	0.529	0.056	-0.309	-0.255	-0.561	-0.411	0.296	1.361	0.821	0.439	0.337	-0.070	0.167	0.138	-0.024	0.079	0.030	-0.045	-0.306	0.526	1.200	-0.014	0.114	0.130	0.289
107	0.962	0.509	-0.231	-0.392	-0.542	-0.247	0.147	0.618	0.410	0.610	0.296	-0.195	0.153	0.165	0.010	0.181	-0.006	-0.158	-0.125	0.326	0.515	-0.163	-0.113	0.060	0.101
108	0.803	0.415	-0.215	-0.382	-0.483	-0.163	0.024	0.585	0.548	0.322	0.175	-0.111	-0.147	0.024	0.201	0.076	-0.075	-0.140	-0.002	0.311	0.314	-0.253	-0.212	0.054	-0.197
109	0.296	0.156	-0.108	-0.355	-0.366	-0.017	-0.030	0.856	0.914	0.012	-0.040	-0.052	-0.311	-0.214	0.140	0.056	-0.220	-0.261	0.008	0.049	0.041	-0.275	-0.297	-0.030	-0.200
Sum of undersized	3.021	1.245	-1.088	-1.425	-2.074	-0.923	0.509	5.634	4.693	1.638	0.823	-0.588	0.001	0.235	0.312	0.544	-0.133	-0.618	-0.459	1.491	2.393	-0.596	-0.521	0.019	0.570
Sum of undersized/ no. size classes	0.604	0.249	-0.218	-0.285	-0.415	-0.185	0.102	1.127	0.939	0.328	0.165	-0.118	**0.000**	0.047	0.062	0.109	**-0.027**	-0.124	**-0.092**	0.298	0.479	-0.119	-0.104	0.004	0.114
110	0.073	-0.073	-0.136	-0.419	-0.548	-0.222	-0.282	0.154	0.607	-0.162	-0.258	-0.114	-0.531	-0.425	0.226	-0.317	-0.533	-0.317	-0.254	-0.370	-0.156	-0.505	-0.495	0.019	-0.232
111	-0.663	-0.627	0.107	-0.686	-0.811	-0.398	-0.529	-0.301	0.484	-0.372	-0.710	-0.538	-0.792	-0.687	0.506	-0.619	-0.846	-0.595	-0.425	-0.638	-0.370	-0.652	-0.793	-0.406	-0.286
112	-0.508	-0.538	-0.061	-0.782	-0.840	-0.264	-0.596	-0.519	0.190	-0.404	-0.787	-0.643	-0.827	-0.732	0.548	-0.657	-0.824	-0.486	-0.481	-0.671	-0.367	-0.722	-0.843	-0.438	-0.462
113	-0.722	-0.727	-0.016	-0.840	-0.883	-0.270	-0.512	-0.477	0.071	-0.541	-0.855	-0.684	-0.765	-0.696	0.293	-0.486	-0.743	-0.500	-0.310	-0.590	-0.405	-0.663	-0.861	-0.588	-0.528
114	-0.759	-0.784	-0.105	-0.832	-0.768	0.381	-0.535	-0.593	-0.125	-0.466	-0.812	-0.647	-0.703	-0.610	0.313	-0.451	-0.656	-0.374	-0.288	-0.623	-0.471	-0.670	-0.798	-0.387	-0.556
115	-0.825	-0.853	-0.157	-0.783	-0.734	0.227	-0.567	-0.625	-0.135	-0.483	-0.889	-0.786	-0.672	-0.452	0.674	-0.418	-0.664	-0.422	-0.246	-0.655	-0.542	-0.635	-0.788	-0.419	-0.419

Table 29. Differences in the catch rates of male lobsters caught in shallow waters on the east coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
105	-0.529	-0.653	-0.262	-0.858	0.000	6.047	-0.553	0.283	1.868	0.539	1.042	0.327	-0.105	-0.318	-0.239	0.837	0.092	-0.405	-0.092	0.005	0.107	-0.273	-0.320	-0.065	-0.497
106	-0.588	-0.583	0.012	-0.901	-0.250	6.550	-0.539	0.149	1.489	0.518	0.307	-0.139	0.008	-0.163	-0.169	0.738	-0.106	-0.486	0.120	0.600	0.429	-0.148	0.323	0.553	-0.684
107	-0.750	-0.587	0.654	-0.827	-0.391	2.523	-0.627	0.049	1.812	1.086	0.499	-0.281	0.032	-0.095	-0.123	0.335	-0.086	-0.315	0.156	0.600	0.385	-0.176	0.261	0.531	-0.451
108	-0.815	-0.738	0.417	-0.771	-0.308	2.020	-0.448	0.033	0.872	0.734	0.065	-0.386	-0.027	-0.389	-0.372	0.100	-0.171	-0.246	0.157	1.057	0.778	-0.263	0.235	0.676	-0.413
109	-0.792	-0.705	0.417	-0.708	-0.176	1.819	-0.329	0.029	0.533	0.773	0.372	-0.226	-0.031	-0.524	-0.509	-0.114	-0.325	-0.238	0.200	1.000	0.667	-0.400	-0.242	0.263	-0.264
Sum of undersized	-3.474	-3.265	1.239	-4.065	-1.125	18.960	-2.495	0.542	6.573	3.650	2.284	-0.706	-0.123	-1.489	-1.412	1.895	-0.596	-1.691	0.541	3.263	2.365	-1.261	0.257	0.084	-2.308
Sum of undersized/ no. size classes	-0.695	-0.653	0.248	-0.813	-0.225	3.792	-0.499	0.108	1.315	0.730	0.457	-0.141	**-0.025**	-0.298	-0.282	0.379	-0.119	-0.338	0.108	0.653	0.473	-0.252	**0.051**	0.017	-0.462
110	-0.619	-0.719	-0.262	-0.716	-0.214	1.768	-0.245	-0.115	0.172	0.319	-0.090	-0.310	-0.491	-0.776	-0.559	-0.323	-0.479	-0.230	-0.100	0.586	0.762	-0.543	-0.504	0.084	-0.701
111	-0.200	-0.528	-0.409	-0.702	-0.100	2.020	-0.732	-0.553	0.665	0.108	-0.608	-0.646	-0.713	-0.875	-0.565	-0.436	-0.656	-0.390	-0.378	-0.289	0.143	-0.600	-0.821	-0.554	-0.847
112	-0.500	-0.779	-0.557	-0.694	-0.154	1.768	-0.888	-0.710	1.590	0.276	-0.465	-0.581	-0.645	-0.811	-0.467	-0.380	-0.660	-0.451	-0.556	-0.333	0.500	-0.698	-0.786	-0.294	-0.870
113	-0.684	-0.814	-0.409	-0.801	-0.200	3.027	-1.000	-0.581	-	-0.209	-0.650	-0.558	-0.562	-0.788	-0.515	0.240	-0.647	-0.715	-0.220	-0.280	-0.077	-0.682	-0.838	-0.490	-0.866
114	-0.708	-0.902	-0.663	-0.910	-0.273	7.054	-0.928	-0.628	4.180	-0.367	-0.650	-0.447	-0.300	-0.767	-0.667	-0.088	-0.822	-0.805	-0.520	-0.520	0.000	-0.718	-0.765	-0.165	-0.758
115	-0.750	-0.882	-0.528	-0.752	-0.500	1.013	-0.845	-0.370	3.070	-0.432	-0.698	-0.469	-0.317	-0.720	-0.590	-0.196	-0.832	-0.791	-0.600	-0.700	-0.250	-0.667	-0.738	-0.215	-0.781

Table 30. Difference between standardised catches of male lobsters caught on the east coast (all sites) from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
105	-0.053	-0.097	-0.044	0.144	0.260	0.116	0.005	0.361	0.356	-0.114	0.046	0.159	0.109	0.049	-0.060	0.117	0.165	0.048	-0.125	-0.167	-0.042	0.129	-0.010	-0.139	0.246
106	-0.021	-0.110	-0.089	0.063	-0.046	-0.110	0.071	0.146	0.075	0.000	0.128	0.128	0.175	0.117	-0.057	0.057	0.080	0.023	-0.117	0.041	0.157	0.079	0.094	0.015	0.166
107	0.061	0.067	0.006	-0.040	-0.093	-0.053	-0.017	-0.051	-0.034	0.153	0.138	-0.015	0.190	0.165	-0.025	0.075	0.086	0.011	-0.042	0.018	0.060	0.042	0.025	-0.017	0.161
108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.078	-0.078	0.000	0.000	0.000	-0.033	0.000	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
109	-0.225	-0.123	0.101	0.058	0.153	0.094	0.030	0.007	-0.022	-0.174	-0.086	0.087	-0.147	-0.187	-0.040	-0.040	-0.145	-0.105	-0.039	-0.175	-0.136	-0.065	-0.143	-0.079	0.015
Sum of undersized	-0.238	-0.264	-0.026	0.226	0.274	0.049	0.089	0.386	0.296	-0.134	0.225	0.360	0.294	0.144	-0.149	0.210	0.186	-0.023	-0.323	-0.284	0.039	0.185	-0.035	-0.220	0.589
Sum of undersized/ no. size classes	**-0.048**	-0.053	-0.005	**0.045**	0.055	0.010	**0.018**	0.077	0.059	**-0.027**	**0.045**	0.072	0.059	**0.029**	-0.030	**0.042**	**0.037**	-0.005	-0.065	-0.057	0.008	**0.037**	**-0.007**	-0.044	0.118
110	-0.269	-0.252	0.017	-0.005	-0.054	-0.049	-0.086	-0.230	-0.144	-0.289	-0.264	0.025	-0.413	-0.415	-0.003	-0.301	-0.409	-0.108	-0.234	-0.453	-0.218	-0.377	-0.377	-0.052	-0.145
111	-0.523	-0.491	0.032	-0.250	-0.290	-0.040	-0.342	-0.409	-0.067	-0.316	-0.455	-0.139	-0.482	-0.457	0.025	-0.423	-0.541	-0.118	-0.408	-0.580	-0.172	-0.500	-0.500	-0.225	-0.271
112	-0.494	-0.502	-0.008	-0.376	-0.340	0.036	-0.582	-0.710	-0.128	-0.352	-0.535	-0.183	-0.505	-0.486	0.019	-0.416	-0.509	-0.093	-0.622	-0.756	-0.134	-0.661	-0.661	-0.255	-0.425
113	-0.764	-0.753	0.011	-0.468	-0.386	0.082	-0.464	-0.557	-0.094	-0.408	-0.547	-0.138	-0.390	-0.397	-0.007	-0.164	-0.314	-0.150	-0.462	-0.708	-0.245	-0.566	-0.566	-0.297	-0.403
114	-0.746	-0.784	-0.038	-0.339	-0.196	0.143	-0.436	-0.588	-0.152	-0.325	-0.427	-0.101	-0.210	-0.255	-0.045	-0.129	-0.235	-0.106	-0.491	-0.768	-0.277	-0.537	-0.537	-0.191	-0.275
115	-0.683	-0.709	-0.025	-0.253	-0.184	0.068	-0.343	-0.403	-0.060	-0.292	-0.398	-0.106	-0.160	-0.165	-0.005	-0.102	-0.189	-0.088	-0.354	-0.602	-0.248	-0.468	-0.468	-0.192	-0.162

Table 31. Difference between standardised catches of male lobsters caught at Sandstone Bluff on the east coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
105	-0.117	-0.124	-0.007	0.202	0.255	0.053	0.031	0.317	0.286	-0.055	-0.091	-0.036	0.130	0.063	-0.068	0.045	0.143	0.098	-0.022	-0.017	0.005	0.253	0.188	-0.064	0.465
106	-0.076	-0.158	-0.082	0.131	-0.095	-0.227	0.175	0.050	-0.125	0.061	0.111	0.051	0.171	0.084	-0.087	0.002	0.084	0.082	-0.215	0.116	0.331	0.134	0.293	0.159	0.377
107	0.102	0.086	-0.016	-0.013	-0.093	-0.080	0.099	-0.218	-0.317	0.169	0.085	-0.083	0.176	0.114	-0.063	0.077	0.059	-0.018	-0.091	0.009	0.099	0.009	0.102	0.093	0.240
108	0.057	0.057	0.000	0.000	0.000	0.000	0.000	-0.278	-0.278	-0.012	0.000	0.012	-0.103	0.000	0.103	0.000	0.000	0.000	0.000	0.000	0.000	-0.098	0.000	0.098	0.000
109	-0.238	-0.134	0.104	0.033	0.170	0.137	-0.043	-0.124	-0.081	-0.228	-0.171	0.057	-0.246	-0.209	0.038	-0.015	-0.126	-0.111	0.010	-0.190	-0.200	-0.114	-0.099	0.016	-0.004
Sum of undersized	-0.273	-0.273	-0.001	0.354	0.238	-0.117	0.262	-0.253	-0.516	-0.065	-0.065	0.000	0.128	0.052	-0.077	0.109	0.160	0.051	-0.317	-0.082	0.235	0.184	0.485	0.301	1.079
Sum of undersized/ no. size classes	-0.055	-0.055	0.000	0.071	0.048	-0.023	0.052	-0.051	-0.103	**-0.013**	**-0.013**	0.000	**0.026**	0.010	-0.015	**0.022**	**0.032**	0.010	-0.063	**-0.016**	0.047	**0.037**	0.097	0.060	0.216
110	-0.341	-0.283	0.058	-0.042	-0.088	-0.047	-0.285	-0.451	-0.167	-0.321	-0.315	0.005	-0.429	-0.371	0.058	-0.316	-0.429	-0.113	-0.298	-0.613	-0.315	-0.434	-0.434	0.046	-0.034
111	-0.772	-0.694	0.078	-0.323	-0.416	-0.093	-0.448	-0.565	-0.117	-0.358	-0.509	-0.150	-0.519	-0.461	0.058	-0.456	-0.588	-0.132	-0.389	-0.664	-0.276	-0.539	-0.539	-0.147	-0.057
112	-0.644	-0.592	0.052	-0.458	-0.488	-0.030	-0.768	-0.991	-0.222	-0.425	-0.627	-0.203	-0.536	-0.484	0.052	-0.481	-0.571	-0.091	-0.543	-0.848	-0.305	-0.771	-0.771	-0.159	-0.211
113	-0.916	-0.870	0.045	-0.525	-0.548	-0.023	-0.549	-0.799	-0.250	-0.444	-0.592	-0.148	-0.415	-0.388	0.027	-0.237	-0.328	-0.091	-0.324	-0.721	-0.397	-0.606	-0.606	-0.235	-0.243
114	-0.794	-0.775	0.018	-0.356	-0.270	0.087	-0.573	-0.854	-0.282	-0.312	-0.436	-0.124	-0.225	-0.203	0.022	-0.144	-0.185	-0.041	-0.268	-0.666	-0.398	-0.571	-0.571	-0.134	-0.198
115	-0.728	-0.722	0.006	-0.277	-0.207	0.070	-0.422	-0.607	-0.185	-0.271	-0.400	-0.129	-0.163	-0.115	0.047	-0.085	-0.118	-0.033	-0.152	-0.459	-0.306	-0.481	-0.481	-0.147	-0.070

Table 32. Difference between standardised catches of male lobsters caught in shallow water on the east coast from 105mmCL to 115mmCL between the start and middle (SM), start and end (SE) and middle and end (ME) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/1993			1993/1994			1994/1995			1995/1996			1996/1997			1997/1998			1998/1999			1999/2000			2000/01
Size Class	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM	SE	ME	SM
105	0.370	0.085	-0.286	-0.205	0.239	0.444	-0.110	0.140	0.250	-0.059	0.440	0.499	-0.065	-0.025	0.039	0.284	0.184	-0.100	0.000	-0.354	-0.354	-0.011	-0.390	-0.379	-0.127
106	0.245	0.228	-0.018	-0.436	0.064	0.500	-0.127	0.086	0.213	-0.097	0.140	0.238	0.029	0.151	0.122	0.290	0.055	-0.235	0.189	0.023	-0.167	0.111	0.050	-0.061	-0.448
107	-0.116	0.259	0.375	-0.218	-0.107	0.111	-0.283	0.013	0.295	0.150	0.261	0.111	0.047	0.222	0.175	0.064	0.079	0.015	0.199	0.020	-0.179	0.105	0.018	-0.087	-0.060
108	-0.375	-0.143	0.232	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.038	-0.038	0.000	-0.132	-0.132	-0.108	0.000	0.108	0.208	0.243	0.036	0.000	0.000	0.000	0.000
109	-0.264	-0.032	0.232	0.179	0.124	-0.056	0.146	-0.003	-0.149	0.014	0.156	0.141	-0.003	-0.251	-0.249	-0.255	-0.168	0.087	0.208	0.185	-0.024	-0.171	-0.356	-0.185	0.183
Sum of undersized	-0.139	0.397	0.536	-0.679	0.321	1.000	-0.374	0.236	0.610	0.008	0.958	0.950	0.008	-0.035	-0.043	0.276	0.150	-0.126	0.804	0.117	-0.688	0.034	-0.677	-0.711	-0.452
Sum of undersized/ no. size classes	-0.028	0.079	0.107	-0.136	0.064	0.200	-0.075	0.047	0.122	**0.002**	0.192	0.190	**0.002**	**-0.007**	-0.009	0.055	**0.030**	-0.025	0.161	**0.023**	-0.138	**0.007**	-0.135	-0.142	-0.090
110	0.222	-0.063	-0.286	0.128	0.073	-0.056	0.190	-0.074	-0.264	-0.146	-0.109	0.037	-0.432	-0.618	-0.186	-0.422	-0.347	0.075	-0.007	0.014	0.021	-0.350	-0.350	-0.202	-0.504
111	0.630	0.201	-0.429	0.115	0.115	0.000	-0.249	-0.275	-0.026	-0.157	-0.281	-0.124	-0.418	-0.487	-0.070	-0.385	-0.416	-0.030	-0.230	-0.396	-0.167	-0.481	-0.481	-0.419	-0.944
112	0.407	-0.164	-0.571	0.167	0.111	-0.056	-0.463	-0.418	0.045	-0.126	-0.247	-0.121	-0.435	-0.501	-0.066	-0.321	-0.380	-0.060	-0.373	-0.417	-0.045	-0.667	-0.667	-0.269	-1.167
113	0.046	-0.275	-0.321	-0.077	0.090	0.167	-0.516	-0.307	0.209	-0.331	-0.416	-0.085	-0.336	-0.427	-0.091	0.003	-0.278	-0.281	-0.076	-0.291	-0.214	-0.658	-0.658	-0.348	-0.964
114	-0.014	-0.603	-0.589	-0.256	0.021	0.278	-0.393	-0.289	0.104	-0.386	-0.416	-0.030	-0.156	-0.371	-0.216	-0.143	-0.431	-0.288	-0.319	-0.467	-0.149	-0.633	-0.633	-0.197	-0.409
115	-0.116	-0.455	-0.339	0.038	-0.128	-0.167	-0.302	-0.164	0.138	-0.380	-0.411	-0.031	-0.138	-0.279	-0.141	-0.202	-0.463	-0.261	-0.363	-0.524	-0.161	-0.562	-0.562	-0.247	-0.401

Table 33. Differences in the catch rates of female lobsters caught on the east coast (all sites) from 100mmCL to 108mmCL between the start and middle (SM) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
Size Class	SM	SM	SM	SM	SM	SM	SM	SM	SM
100	-0.517	-0.590	-0.611	-0.438	-0.320	-0.334	-0.542	-0.586	-0.234
101	-0.506	-0.580	-0.551	-0.494	-0.320	-0.367	-0.485	-0.617	-0.162
102	-0.449	-0.589	-0.551	-0.488	-0.292	-0.245	-0.540	-0.602	-0.165
103	-0.501	-0.592	-0.618	-0.485	-0.389	-0.226	-0.499	-0.614	-0.187
104	-0.588	-0.660	-0.695	-0.485	-0.458	-0.253	-0.550	-0.644	-0.265
Sum of undersized	-1.538	-1.841	-1.864	-1.458	-1.139	-0.724	-1.589	-1.860	-0.617
Sum of undersized/ no. size classes	-0.308	-0.368	-0.373	-0.292	-0.228	-0.145	-0.318	-0.372	-0.123
105	-0.708	-0.732	-0.807	-0.542	-0.583	-0.394	-0.601	-0.676	-0.377
106	-0.857	-0.852	-0.820	-0.678	-0.782	-0.707	-0.730	-0.768	-0.533
107	-0.847	-0.880	-0.826	-0.697	-0.796	-0.656	-0.706	-0.788	-0.586
108	-0.794	-0.884	-0.781	-0.733	-0.821	-0.548	-0.677	-0.796	-0.516

Table 34. Differences in the catch rates of female lobsters caught at Sandstone Bluff on the east coast from 100mmCL to 108mmCL between the start and middle (SM) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
Size Class	SM	SM	SM	SM	SM	SM	SM	SM	SM
100	-0.453	-0.536	-0.551	-0.324	-0.375	-0.295	-0.384	-0.554	0.025
101	-0.442	-0.530	-0.491	-0.378	-0.367	-0.353	-0.331	-0.586	0.182
102	-0.363	-0.539	-0.473	-0.373	-0.322	-0.238	-0.390	-0.536	0.128
103	-0.428	-0.518	-0.347	-0.357	-0.416	-0.195	-0.331	-0.530	0.086
104	-0.522	-0.591	-0.406	-0.355	-0.485	-0.198	-0.403	-0.568	-0.034
Sum of undersized	-1.314	-1.648	-1.225	-1.085	-1.223	-0.631	-1.125	-1.634	0.180
Sum of undersized/ no. size classes	-0.263	-0.330	-0.245	-0.217	-0.245	-0.126	-0.225	-0.327	0.036
105	-0.648	-0.659	-0.514	-0.407	-0.611	-0.325	-0.480	-0.627	-0.087
106	-0.821	-0.811	-0.796	-0.589	-0.806	-0.675	-0.614	-0.752	-0.255
107	-0.794	-0.829	-0.774	-0.599	-0.811	-0.634	-0.517	-0.791	-0.386
108	-0.749	-0.821	-0.660	-0.649	-0.821	-0.546	-0.403	-0.795	-0.467

Table 35. Differences in the catch rates of female lobsters caught in shallow waters on the east coast from 100mmCL to 108mmCL between the start and middle (SM) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
Size Class	SM	SM	SM	SM	SM	SM	SM	SM	SM
100	-0.755	-0.874	-0.799	-0.287	-0.336	-0.607	-0.814	-0.483	-0.497
101	-0.776	-0.878	-0.789	-0.508	-0.380	-0.560	-0.748	-0.586	-0.664
102	-0.789	-0.913	-0.869	-0.496	-0.466	-0.459	-0.840	-0.637	-0.640
103	-0.779	-0.944	-0.856	-0.587	-0.581	-0.619	-0.811	-0.756	-0.688
104	-0.798	-0.943	-0.856	-0.599	-0.627	-0.732	-0.827	-0.788	-0.651
Sum of undersized	-2.366	-2.799	-2.581	-1.682	-1.673	-1.810	-2.477	-2.182	-1.979
Sum of undersized/ no. size classes	-0.473	-0.560	-0.516	-0.336	-0.335	-0.362	-0.495	-0.436	-0.396
105	-0.885	-0.936	-0.826	-0.767	-0.672	-0.782	-0.831	-0.787	-0.762
106	-0.933	-0.932	-0.869	-0.815	-0.752	-0.810	-0.889	-0.817	-0.799
107	-0.944	-0.952	-0.899	-0.886	-0.803	-0.684	-0.873	-0.750	-0.755
108	-0.855	-0.959	-0.897	-0.847	-0.886	-0.504	-0.864	-0.800	-0.634

Table 36. Difference between standardised catches of female lobsters caught on the east coast (all sites) from 100mmCL to 108mmCL between the start and middle (SM) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/93	**1993/94**	**1994/95**	**1995/96**	**1996/97**	**1997/98**	**1998/99**	**1999/00**	**2000/01**
Size Class	SM	SM	SM	SM	SM	SM	SM	SM	SM
100	-0.043	0.003	-0.001	0.067	0.086	-0.112	-0.062	0.058	-0.039
101	-0.019	0.022	0.120	-0.014	0.090	-0.152	0.020	-0.008	0.024
102	0.085	0.006	0.132	-0.004	0.126	-0.021	-0.071	0.024	0.022
103	-0.011	0.000	-0.019	0.000	0.000	0.000	0.000	0.000	0.000
104	-0.162	-0.147	-0.176	0.001	-0.093	-0.027	-0.091	-0.068	-0.081
Sum of undersized	-0.087	-0.141	-0.064	-0.003	0.034	-0.047	-0.161	-0.043	-0.059
Sum of undersized/ no.size classes	**-0.017**	**-0.028**	**-0.013**	**-0.001**	**0.007**	**-0.009**	**-0.032**	**-0.009**	**-0.012**
105	-0.333	-0.282	-0.365	-0.079	-0.238	-0.144	-0.155	-0.129	-0.192
106	-0.371	-0.389	-0.282	-0.173	-0.303	-0.227	-0.237	-0.212	-0.223
107	-0.315	-0.418	-0.301	-0.166	-0.304	-0.184	-0.200	-0.216	-0.215
108	-0.162	-0.304	-0.158	-0.125	-0.250	-0.083	-0.124	-0.153	-0.102

Table 37. Difference between standardised catches of female lobsters caught at Sandstone Bluff on the east coast from 100mmCL to 108mmCL between the start and middle (SM) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/93	**1993/94**	**1994/95**	**1995/96**	**1996/97**	**1997/98**	**1998/99**	**1999/00**	**2000/01**
Size Class	SM	SM	SM	SM	SM	SM	SM	SM	SM
100	-0.032	-0.025	-0.242	0.038	0.053	-0.097	-0.057	-0.042	-0.032
101	-0.012	-0.020	-0.183	-0.028	0.066	-0.162	0.001	-0.103	0.063
102	0.076	-0.038	-0.176	-0.021	0.127	-0.046	-0.078	-0.012	0.031
103	-0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
104	-0.161	-0.130	-0.074	0.003	-0.098	-0.003	-0.099	-0.071	-0.093
Sum of undersized	-0.113	-0.168	-0.250	-0.018	0.029	-0.049	-0.176	-0.083	-0.062
Sum of undersized/ no.size classes	**-0.038**	-0.056	-0.083	**-0.006**	**0.010**	**-0.016**	-0.059	**-0.028**	**-0.021**
105	-0.299	-0.214	-0.178	-0.057	-0.248	-0.098	-0.167	-0.172	-0.118
106	-0.307	-0.300	-0.316	-0.170	-0.311	-0.183	-0.208	-0.261	-0.123
107	-0.241	-0.269	-0.272	-0.150	-0.292	-0.148	-0.106	-0.265	-0.137
108	-0.112	-0.176	-0.111	-0.108	-0.233	-0.063	-0.025	-0.174	-0.109

Table 38. Difference between standardised catches of female lobsters caught in shallow water on the east coast from 100mmCL to 108mmCL between the start and middle (SM) surveys for the fishing years from 1992/1993 to March 2000/01. Bold figures represent accepted values.

	1992/93	**1993/94**	**1994/95**	**1995/96**	**1996/97**	**1997/98**	**1998/99**	**1999/00**	**2000/01**
Size Class	SM	SM	SM	SM	SM	SM	SM	SM	SM
100	0.089	0.375	0.206	0.357	0.267	-0.014	-0.014	0.293	0.167
101	0.033	0.352	0.217	0.127	0.210	0.085	0.214	0.093	-0.200
102	-0.012	0.067	-0.130	0.163	0.073	0.263	-0.123	-0.007	-0.133
103	0.034	-0.286	-0.100	0.000	-0.140	-0.045	0.000	-0.333	-0.247
104	-0.053	-0.274	-0.078	-0.022	-0.191	-0.311	-0.074	-0.357	-0.137
Sum of undersized	-0.031	-0.494	-0.308	0.141	-0.258	-0.093	-0.196	-0.696	-0.517
Sum of undersized/ no.size classes	**-0.006**	-0.099	-0.062	**0.028**	-0.052	-0.019	**-0.039**	-0.139	-0.103
105	-0.451	-0.239	0.075	-0.280	-0.258	-0.455	-0.088	-0.320	-0.397
106	-0.580	-0.170	-0.130	-0.187	-0.224	-0.348	-0.235	-0.243	-0.390
107	-0.598	-0.552	-0.352	-0.319	-0.308	-0.132	-0.228	-0.144	-0.257
108	-0.197	-0.531	-0.278	-0.310	-0.304	0.107	-0.158	-0.147	-0.047

19. Appendix 9 – Metadata information

All rock lobster data is stored on CRAYBASE an Oracle relational database. Robert Kennedy initially built this database in 1994. It houses all the rock lobster data including historic research (1960s +) and catch and effort (1947+) data. The main design of the database, which includes all data collected by this project, is attached as appendix A-1. Details of the structure of each of the tables used to store data from this project are attached as appendix A-2.

The accuracy of the data recorded is presented in Table 39. Further information is available from the column names identified in each of the tables.

Table 39. Details of accuracy of fields used to record rock lobster data in CRAYBASE.

Field	Accuracy
Length	Nearest mm
Locations (pots)	Accuracy of GPS (10 - 50m)
Time (setting and hauling of pots)	(+/- 5minutes)

Custodianship and contact information for CRAYBASE is presented in Table 40.

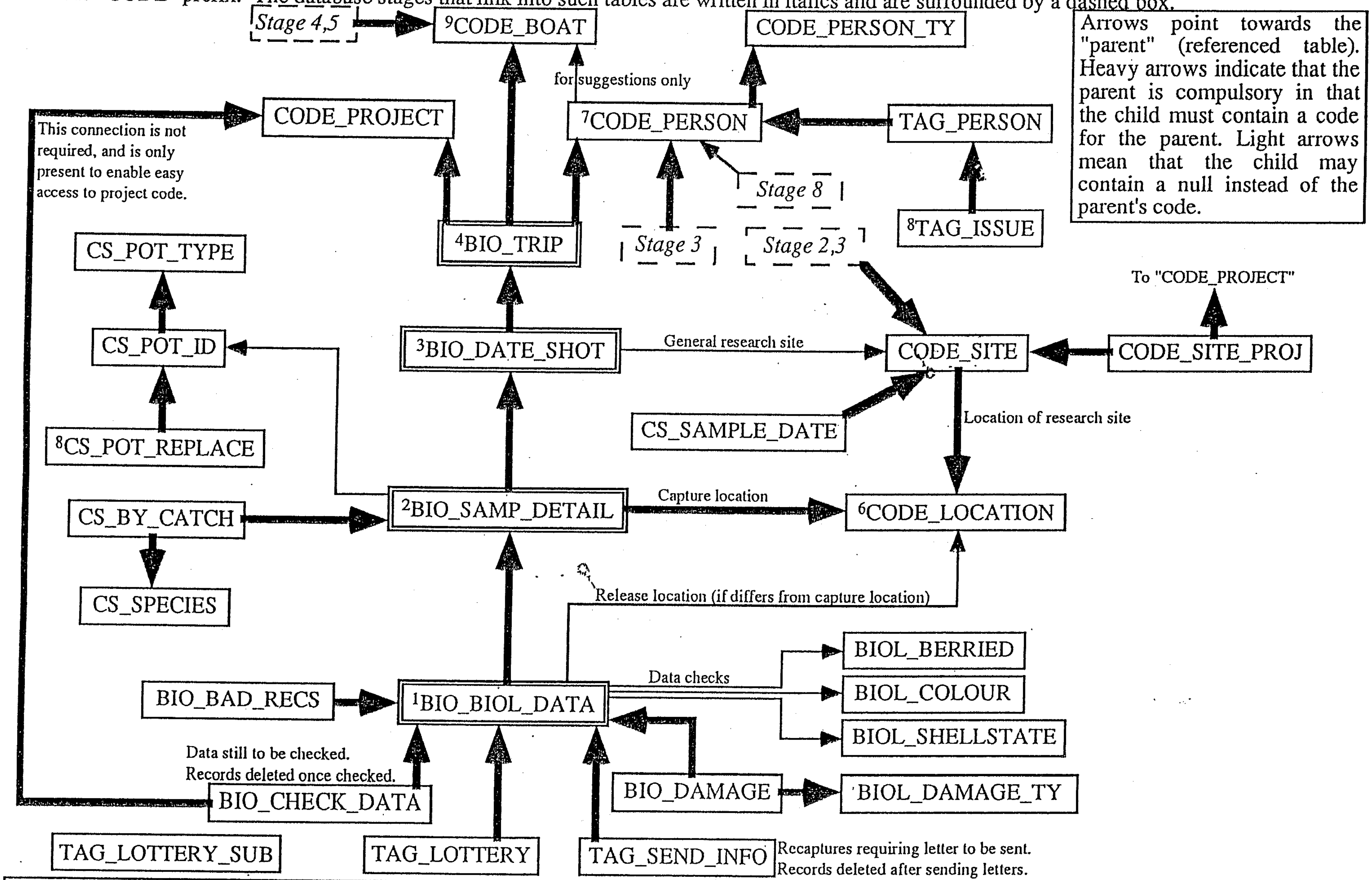
Table 40. Details of custodianship of CRAYBASE.

Custodian	Department of Primary Industries, Water and Environment
Contact Organisation	Department of Primary Industries, Water and Environment
Contact Position:	Manager Licensing and Administration.
Mail Address:	Manager Licensing and Administration, Department of Primary Industries, Water and Environment, GPO Box 44, Hobart, Tasmania, 7001.
Telephone:	03 62336632
Email:	craig.midgley@dpiwe.tas.gov.au
Access constraints:	Rock lobster researchers and technical officers at TAFI and rock lobster fisheries managers at DPIWE.

19.1. Appendix 9.1 – Design of CRAYBASE

See next page.

Rock Lobster Database Design: Stage 1 (primarily for tagging and catch sampling projects). Other stages of the database link into the tables with the "CODE" prefix. The database stages that link into such tables are written in italics and are surrounded by a dashed box.



Superscripts in front of table names indicate that the primary key of such tables are obtained via a sequence generator. The names of the sequence generators for each of these tables are:	1=SEQ_BIO_DATA_RECNUM 2=SEQ_BIO_SAMP_CODE 3=SEQ_BIO_DATESHOT_CODE 4=SEQ_BIO_TRIP_CODE	6=SEQ_LOCATION_CODE 7=SEQ_PERSON_CODE 8=SEQ_TAG_ISSUE_CODE	9=SEQ_BOAT_CODE

19.2. Appendix 9.2 – Description of tables used in CRAYBASE to store rock lobster data

See following pages.

Table Name **BIOL_BERRIED**
Table Owner CRAY_RES
Table Remarks Contains a single record for each type of berried condition.

Primary Key - PRIMARY KEY (BB_BERRIED_STATE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$BB_BERRIED_STATE On (BB_BERRIED_STATE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BB_BERRIED_STATE	VARCHAR2	2		N	User defined primary key. The state must be either "N", or commence with a "Y" (in which case a second letter may be used to define the status of the eggs)
BB_BERRIED_DESCRIPTION	VARCHAR2	255		N	A description of this berried state

Data Checks
Referenced by Tables - BIO_BIOL_DATA, CRAB_BIOL_DATA
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIOL_COLOUR**
Table Owner CRAY_RES
Table Remarks Contains a single record for each type of colour.

Primary Key - PRIMARY KEY (BC_COLOUR_CODE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$BC_COLOUR_CODE On (BC_COLOUR_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BC_COLOUR_CODE	VARCHAR2	2		N	User defined primary key. The first character must be either "R", "P", or "W". A second character may be used to refine the code (eg. "PW" or "P1" etc).
BC_COLOUR_DESCRIPTION	VARCHAR2	255		N	Description of this colour.

Data Checks
Referenced by Tables - BIO_BIOL_DATA
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIOL_DAMAGE_TY**
Table Owner CRAY_RES
Table Remarks Contains a single record for each type of damage to a lobster.

Primary Key - PRIMARY KEY (BDT_DAMAGE_CODE)
Foreign Keys
Unique Columns - UNIQUE (BDT_DAMAGE_TYPE)
Indexed Columns - INDEX=I_$BDT_DAMAGE_CODE On (BDT_DAMAGE_CODE) UNIQUE
- INDEX=I_$BDT_DAMAGE_TYPE On (BDT_DAMAGE_TYPE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BDT_DAMAGE_CODE	NUMBER	16	0	N	Primary key. Obtained via a sequence generator.
BDT_DAMAGE_TYPE	VARCHAR2	60		N	A complex code for this type of damage.
BDT_DAMAGE_DESCRIPTION	VARCHAR2	255		Y	Description for this type of damage

Data Checks
Referenced by Tables - BIO_DAMAGE, BIO_DAMAGE, BIO_DAMAGE, CRAB_DAMAGE, CRAB_DAMAGE, CRAB_DAMAGE
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIOL_SHELLSTATE**
Table Owner CRAY_RES
Table Remarks Contains a single record for each shell state.

Primary Key - PRIMARY KEY (BSS_SHELL_STATE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$BSS_SHELL_STATE On (BSS_SHELL_STATE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BSS_SHELL_STATE	VARCHAR2	2		N	User defined primary key. Holds the alphanumeric code for this type of shell state.
BSS_SHELL_STATE_DESCRIPTION	VARCHAR2	255		N	Description of shell state

Data Checks
Referenced by Tables - CRAB_BIOL_DATA, BIO_BIOL_DATA
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIO_BAD_RECS**
Table Owner CRAY_RES
Table Remarks Contains a record for each record in "BIO_BIOL_DATA" which contains bad data (bad data is NOT missing data).

Primary Key - PRIMARY KEY (BBR_BIOL_RECNUM)
Foreign Keys - FOREIGN KEY (BBR_BIOL_RECNUM) References table: BIO_BIOL_DATA
Unique Columns
Indexed Columns - INDEX=I_$BBR_BIOL_RECNUM On (BBR_BIOL_RECNUM) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BBR_BIOL_RECNUM	NUMBER	16	0	N	Primary key and foreign key to the table of biological data.
BBR_BAD_TAG_NUM	NUMBER	1	0	N	(0 or 1). "1" indicates that the tag number is in doubt.
BBR_BAD_LENGTH	NUMBER	1	0	N	(0 or 1). "1" indicates that the length is in doubt.
BBR_BAD_DATE	NUMBER	1	0	N	(0 or 1). "1" indicates that the date is in doubt.
BBR_SEX_CHANGE	NUMBER	1	0	N	(0 or 1). "1" indicates that the sex has changed (since a previous capture).
BBR_BAD_OTHER	NUMBER	1	0	N	(0 or 1). "1" indicates that some additional aspect of the data (not covered by the previous fields) is in doubt. When this occurs, a description of the problem should be provided.
BBR_DESCRIPTION	VARCHAR2	255		Y	A description of the problem.

Data Checks
Referenced by Tables
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIO_BIOL_DATA**
Table Owner CRAY_RES
Table Remarks Contains general biological data (primarily from catch sampling or tagging projects). Each record contains data for a unique lobster or a unique capture of a non-unique lobster.

Primary Key - PRIMARY KEY (BBD_BIOL_RECNUM)
Foreign Keys - FOREIGN KEY (BBD_BERRIED_STATE) References table: BIOL_BERRIED
- FOREIGN KEY (BBD_COLOUR) References table: BIOL_COLOUR
- FOREIGN KEY (BBD_RELEASE_LOCATION_CODE) References table: CODE_LOCATION
- FOREIGN KEY (BBD_SAMPLE_CODE) References table: BIO_SAMP_DETAIL
- FOREIGN KEY (BBD_SHELL_STATE) References table: BIOL_SHELLSTATE
Unique Columns
Indexed Columns - INDEX=I_$BBD_BIOL_RECNUM On (BBD_BIOL_RECNUM) UNIQUE
- INDEX=I_$BBD_RELEASE_LOCATION_CODE On (BBD_RELEASE_LOCATION_CODE) NONUNIQUE
- INDEX=I_$BBD_SAMPLE_CODE On (BBD_SAMPLE_CODE) NONUNIQUE
- INDEX=I_$BBD_TAG_NUMBER_TR On (BBD_TAG_NUMBER,BBD_TAG_REC) NONUNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BBD_BIOL_RECNUM	NUMBER	16	0	N	Primary key. Obtained from a sequence generator.
BBD_SAMPLE_CODE	NUMBER	16	0	N	Foreign key to link this capture to the sample details
BBD_LENGTH	NUMBER	3	0	Y	Carapace length (mm).
BBD_SEX	VARCHAR2	1		Y	Sex (M/F)
BBD_MATURE	VARCHAR2	1		Y	Maturity: Y(es), N(o), or P(artial). Only applies to females.
BBD_BERRIED_STATE	VARCHAR2	2		Y	Berried. Only for females. Has two levels (Y/N), with "Y" meaning at least some eggs and another character may then indicate the condition. (eg. N,Y,YS,YR). Foreign key to table of berried states.
BBD_COLOUR	VARCHAR2	2		Y	Colour code of lobster: R(ed), P(ale), S(ome white), W(hite) plus an optional second character to refine the colour. Foreign key to the table of colour codes.
BBD_LEGAL	VARCHAR2	1		Y	Legal sized flag. Indicates whether the lobster was of legal size.
BBD_SHELL_STATE	VARCHAR2	2		Y	The state of the shell. Foreign key to the shell states table.
BBD_DAMAGED	VARCHAR2	1		Y	Whether or not this lobster was damaged (Y/N).
BBD_TAG_NUMBER	VARCHAR2	6		Y	The tag number. Must exist if the next field is "T". There may not be two identical tag numbers with a "T" in the Tag_Recap field.
BBD_TAG_REC	VARCHAR2	1		Y	Contains "T" for a tagging record and "R" for a recapture record.
BBD_STATUS	VARCHAR2	1		Y	D(ead), O(out of fishery), R(eleased back), M(oved elsewhere)
BBD_RELEASE_LOCATION_CODE	NUMBER	16	0	Y	Only for moved lobsters. The release location of this lobster (as apposed to the capture location which is stored in the sample details table). Foreign key to the table of location codes.
BBD_RELEASE_DEPTH	NUMBER	3	0	Y	Only for moved lobsters. The release depth of this lobster (as apposed to the capture depth which is stored in the sample details table).
BBD_WEIGHT	NUMBER	4	0	Y	Weight of lobster in grams.
BBD_DATA_IS_BAD	VARCHAR2	1		Y	Either "Y" or Null. If "Y", then this record has problems (other than missing data). If the data has problems, the table "BIO_BAD_RECS" will contain a description of the problem.
BBD_PLEOPOD_CLIPPED_TODAY	VARCHAR2	1		Y	Y/N/null. Whether or not a pleopod was clipped for this lobster on this sampling occasion. Should only occur for tagged/recaptured lobsters. Note: Should be Y if BBD_PLEOPOD_REGENERATED= N.
BBD_PLEOPOD_REGENERATED	VARCHAR2	1		Y	N/C/P/null. The extent of pleopod regeneration. N(one), C(omplete), P(artial). Should normally only be recorded for tagged/recaptured lobsters.

Data Checks
Referenced by Tables - BIO_CHECK_DATA, BIO_FECUNDITY, BIO_DAMAGE, BIO_BAD_RECS, TAG_LOTTERY, TAG_SEND_INFO
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIO_CHECK_DATA**
Table Owner CRAY_RES
Table Remarks Contains a record for each biological record in which data entry has yet to be checked. The record is deleted once data has been checked.

Primary Key - PRIMARY KEY (BCD_BIOL_RECNUM)
Foreign Keys - FOREIGN KEY (BCD_BIOL_RECNUM) References table: BIO_BIOL_DATA
- FOREIGN KEY (BCD_PROJECT_CODE) References table: CODE_PROJECT
Unique Columns
Indexed Columns - INDEX=I_$BCD_BIOL_RECNUM On (BCD_BIOL_RECNUM) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BCD_BIOL_RECNUM	NUMBER	16	0	N	Primary key and Foreign key to the biological record
BCD_PROJECT_CODE	VARCHAR2	8		N	Foreign key to the project code.

Data Checks
Referenced by Tables
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIO_DAMAGE**
Table Owner CRAY_RES
Table Remarks Contains a single record for each lobster in which damage has been recorded.

Primary Key - PRIMARY KEY (BD_BIOL_RECNUM)
Foreign Keys - FOREIGN KEY (BD_BIOL_RECNUM) References table: BIO_BIOL_DATA
- FOREIGN KEY (BD_NEW_DAMAGE_CODE) References table: BIOL_DAMAGE_TY
- FOREIGN KEY (BD_OLD_DAMAGE_CODE) References table: BIOL_DAMAGE_TY
- FOREIGN KEY (BD_UNAGED_DAMAGE_CODE) References table: BIOL_DAMAGE_TY
Unique Columns
Indexed Columns - INDEX=I_$BD_BIOL_RECNUM On (BD_BIOL_RECNUM) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BD_BIOL_RECNUM	NUMBER	16	0	N	Primary key as well as a foreign key to the biological data.
BD_OLD_DAMAGE_CODE	NUMBER	16	0	Y	This field is used for any old damage to the lobster. Is a foreign key to the table of damage codes.
BD_NEW_DAMAGE_CODE	NUMBER	16	0	Y	This field is used for any new (recent) damage to the lobster. Is a foreign key to the table of damage codes.
BD_UNAGED_DAMAGE_CODE	NUMBER	16	0	Y	This field is used for any damage to the lobster which was not been classified as "Old" or "New". Is a foreign key to the table of damage codes.

Data Checks
Referenced by Tables
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name BIO_DATE_SHOT
Table Owner CRAY_RES
Table Remarks Contains a single record for each shot of a day. Actually, a "shot" only applies to catch sampling projects. For other projects, this table serves the purpose of holding the date of a set of samples.

Primary Key - PRIMARY KEY (BDS_DATESHOT_CODE)
Foreign Keys - FOREIGN KEY (BDS_SITE_CODE) References table: CODE_SITE
- FOREIGN KEY (BDS_TRIP_CODE) References table: BIO_TRIP
Unique Columns
Indexed Columns - INDEX=I_$BDS_DATE On (BDS_DATE) NONUNIQUE
- INDEX=I_$BDS_DATESHOT_CODE On (BDS_DATESHOT_CODE) UNIQUE
- INDEX=I_$BDS_SITE_CODE On (BDS_SITE_CODE) NONUNIQUE
- INDEX=I_$BDS_TRIP_CODE On (BDS_TRIP_CODE) NONUNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BDS_DATESHOT_CODE	NUMBER	16	0	N	Primary key obtained from a sequence generator.
BDS_TRIP_CODE	NUMBER	16	0	N	Foreign key to the table of trip codes.
BDS_SITE_CODE	VARCHAR2	6		Y	Foreign key to the table of site codes. Indicates the general research site. Is null if this is not a specific research site.
BDS_DATE	DATE	7		Y	The date of this shot/sample. If null, it is hoped that there are some trip dates which cover this shot/ sample.
BDS_SHOT_NUMBER	NUMBER	2	0	Y	Number of this shot (within the day). Night shots are "1" by definition. The first day shot in an area is "2", the second day shot is "3" and so on.
BDS_TIME_SET_START	DATE	7		Y	Time and date at which the setting of pots commenced.
BDS_TIME_SET_END	DATE	7		Y	Time and date at which the setting of pots was completed.
BDS_TIME_HAUL_START	DATE	7		Y	Time and date at which the hauling of pots commenced.
BDS_TIME_HAUL_END	DATE	7		Y	Time and date at which the hauling of pots was completed.
BDS_ESCAPE_GAPS_TIED	VARCHAR2	1		Y	Flag (Y/N) to indicate whether the escape gaps were tied. However, in some cases, this might refer to the majority of pots, in which case the pot ID details should contain the exceptions.
BDS_NUMBER_OF_POTS	NUMBER	2	0	Y	Number of pots sampled. This is necessary when individual pot records were not kept. It is also a useful check when such records are kept.
BDS_MIN_DEPTH	NUMBER	3	0	Y	The minimum depth (metres) of this shot. Necessary when individual pot records were not kept, and a useful check when they are kept.
BDS_MAX_DEPTH	NUMBER	3	0	Y	The maximum depth (metres) of this shot. Necessary when individual pot records were not kept, and a useful check when they are kept.
BDS_SEA_HEIGHT	NUMBER	2	0	Y	Sea height in metres
BDS_CLOUD_COVER	NUMBER	1	0	Y	Cloud cover (6th:-, 0=no cloud, 6=overcast)
BDS_WIND_SPEED	NUMBER	2	0	Y	Wind speed (knots)
BDS_WIND_DIRECTION	VARCHAR2	3		Y	Direction of the wind (N,NE,E,SE,S,SW,W,NW)
BDS_MATURITY_KNOWN	VARCHAR2	1		Y	"Y" or null. Y=Maturity recorded for females in all pots. Mainly used by catch sampling projects. Other projects may record maturity but not on a random or complete basis (these should be null).

Data Checks
Referenced by Tables - BIO_SAMP_DETAIL
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIO_SAMP_DETAIL**
Table Owner CRAY_RES
Table Remarks Contains a single record for each specific sample. ie. a specific pot for catch sampling projects, or a specific location/depth/vessel in other projects (eg industry tagging).

Primary Key - PRIMARY KEY (BSD_SAMPLE_CODE)
Foreign Keys - FOREIGN KEY (BSD_DATESHOT_CODE) References table: BIO_DATE_SHOT
- FOREIGN KEY (BSD_LOCATION_CODE) References table: CODE_LOCATION
- FOREIGN KEY (BSD_POT_ID) References table: CS_POT_ID
Unique Columns
Indexed Columns - INDEX=I_$BSD_DATESHOT_CODE On (BSD_DATESHOT_CODE) NONUNIQUE
- INDEX=I_$BSD_LOCATION_CODE_DEPTH On (BSD_LOCATION_CODE,BSD_DEPTH) NONUNIQUE
- INDEX=I_$BSD_SAMPLE_CODE On (BSD_SAMPLE_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BSD_SAMPLE_CODE	NUMBER	16	0	N	Primary key. Obtained via a sequence generator.
BSD_DATESHOT_CODE	NUMBER	16	0	N	Foreign key to the table of date/shot details (which holds the date of the sample plus weather conditions etc.
BSD_LOCATION_CODE	NUMBER	16	0	N	Foreign key to the table of locations. Is the specific capture location (eg. location of the pot which caught the lobsters).
BSD_DEPTH	NUMBER	3	0	Y	Depth in metres of the capture location.
BSD_POT_ORDER	NUMBER	2	0	Y	Is the order in which pots were hauled for a particular shot. eg "1" means it was the first hauled, "50" means it was the fiftieth hauled.
BSD_POT_ID	VARCHAR2	4		Y	Is the ID of a pot (which may be a specific unique pot or simply a link through to the type of pot - see CS_POT_ID for more details). Is NULL if no information kept.
BSD_POT_DATA_OK	VARCHAR2	1		Y	Y/N/null. Indicates whether the data from this pot is suitable for size frequency/catch analysis etc. For example, a N might be recorded due to a hole in the pot which caused bias in results.

Data Checks
Referenced by Tables - BIO_BIOL_DATA, CS_BY_CATCH
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **BIO_TRIP**
Table Owner CRAY_RES
Table Remarks A single record for each trip. Primary use is for catch sampling projects. In other projects (eg tagging), the trip serves the purpose of identifying the person and boat (dates being ignored).

Primary Key - PRIMARY KEY (BT_TRIP_CODE)
Foreign Keys - FOREIGN KEY (BT_BOAT_CODE) References table: CODE_BOAT
- FOREIGN KEY (BT_PERSON_CODE) References table: CODE_PERSON
- FOREIGN KEY (BT_PROJECT_CODE) References table: CODE_PROJECT
Unique Columns
Indexed Columns - INDEX=I_$BT_BOAT_CODE On (BT_BOAT_CODE) NONUNIQUE
- INDEX=I_$BT_PERSON_CODE On (BT_PERSON_CODE) NONUNIQUE
- INDEX=I_$BT_PROJECT_CODE On (BT_PROJECT_CODE) NONUNIQUE
- INDEX=I_$BT_TRIP_CODE On (BT_TRIP_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
BT_TRIP_CODE	NUMBER	16	0	N	Primary key, obtained from a sequence generator.
BT_PROJECT_CODE	VARCHAR2	8		N	Identifies the project which obtained this data. Foreign key to the table of project codes.
BT_BOAT_CODE	NUMBER	16	0	N	Identifies the boat which obtained the data. Foreign key to the table of boat codes.
BT_PERSON_CODE	NUMBER	16	0	N	Identifies the person who obtained the data. Foreign key to the table of person codes.
BT_DATE_TRIP_STARTED	DATE	7		Y	Date at which the trip commenced (if relevant).
BT_DATE_TRIP_ENDED	DATE	7		Y	Date at which the trip finished (if relevant).

Data Checks
Referenced by Tables - BIO_DATE_SHOT
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CODE_BOAT**
Table Owner CRAY_RES
Table Remarks Contains a single record for each vessel. Both the distinguishing mark and name are unique, but they have been known to change on occassions, hence a sequence is used as the primary key.

Primary Key - PRIMARY KEY (CB_BOAT_CODE)
Foreign Keys
Unique Columns - UNIQUE (CB_BOAT_DM)
- UNIQUE (CB_BOAT_NAME)
Indexed Columns - INDEX=I_$CB_BOAT_CODE On (CB_BOAT_CODE) UNIQUE
- INDEX=I_$CB_BOAT_DM On (CB_BOAT_DM) UNIQUE
- INDEX=I_$CB_BOAT_NAME On (CB_BOAT_NAME) UNIQUE
- INDEX=I_$CB_BOAT_OLD_DM On (CB_BOAT_OLD_DM) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CB_BOAT_CODE	NUMBER	16	0	N	The primary key. Obtained from a sequence generator.
CB_BOAT_DM	VARCHAR2	8		N	The distinguishing mark of this vessel
CB_BOAT_NAME	VARCHAR2	30		N	The name of this boat
CB_BOAT_REMARKS	LONG			Y	Any remarks concerning this boat
CB_BOAT_OLD_DM	VARCHAR2	8		Y	The old distinguishing mark for this vessel if such a mark exists
CB_BOAT_OLD_NAME	VARCHAR2	30		Y	The old name of this vessel, if such a name exists
CB_BOAT_DM_OLD_DATE	DATE	7		Y	The date at which the old distinguishing mark became invalid

Data Checks
Referenced by Tables - BIO_TRIP, LIC_HISTORY_OVERRIDE_CATCH, CODE_PERSON, RLC_MONTH_DETAIL, LIC_TRANSACTION, CRAB_TRIP
Grants - RLSCI (Select)

Table Name **CODE_LOCATION**
Table Owner CRAY_RES
Table Remarks Contains a single record for each location. In addition to the primary key, each record must have a unique combination of latitude, longitude and accuracy.

Primary Key - PRIMARY KEY (CL_LOCATION_CODE)
Foreign Keys
Unique Columns - UNIQUE (CL_LOCATION_LATITUDE,CL_LOCATION_LONGITUDE,CL_LOCATION_ACURRACY)
Indexed Columns - INDEX=I_$CL_LOCATION_CODE On (CL_LOCATION_CODE) UNIQUE
- INDEX=I_$CL_LOCATION_LAT_LONG_ACC On (CL_LOCATION_LATITUDE,CL_LOCATION_LONGITUDE,CL_LOCATION_ACURRACY) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CL_LOCATION_CODE	NUMBER	16	0	N	Primary key. Generated from a sequence generator
CL_LOCATION_LATITUDE	NUMBER	9	6	N	Latitude of location (decimal degrees)
CL_LOCATION_LONGITUDE	NUMBER	10	6	N	Longitude of location (in decimal degrees)
CL_LOCATION_ACURRACY	NUMBER	6	2	N	Indicates accuracy of location (in nautical miles). The larger the value, the less accurate
CL_LOCATION_SECRET	VARCHAR2	1		N	Flag (Y/N) to indicate whether this is a secret location (ie provided in confidence by a fisher)
CL_LOCATION_DESCRIPTION	VARCHAR2	255		Y	Description of location
CL_LOCATION_MIN_DEPTH	NUMBER	3	0	Y	In some cases, a location will be provided with a depth range. In such cases, this holds the minimum depth of that range
CL_LOCATION_MAX_DEPTH	NUMBER	3	0	Y	In some cases, a location will be provided with a depth range. In such cases, this holds the maximum depth of that range

Data Checks
Referenced by Tables - CRAB_SAMP_DETAIL, CRAB_BIOL_DATA, BIO_BIOL_DATA, BIO_SAMP_DETAIL, CODE_SITE
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CODE_PERSON**
Table Owner CRAY_RES
Table Remarks contains a single record for each individual person. Is unique by both the primary key and a combination of surname and initials

Primary Key - PRIMARY KEY (CP_PERSON_CODE)
Foreign Keys - FOREIGN KEY (CP_BOAT_CODE) References table: CODE_BOAT
- FOREIGN KEY (CP_PERSON_TYPE) References table: CODE_PERSON_TY
Unique Columns - UNIQUE (CP_SURNAME,CP_INITIAL)
Indexed Columns - INDEX=I_$CP_BOAT_CODE On (CP_BOAT_CODE) NONUNIQUE
- INDEX=I_$CP_PERSON_CODE On (CP_PERSON_CODE) UNIQUE
- INDEX=I_$CP_SURNAME_INITIAL On (CP_SURNAME,CP_INITIAL) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CP_PERSON_CODE	NUMBER	16	0	N	Primary key. Obtained from a sequence generator.
CP_PERSON_TYPE	VARCHAR2	3		N	Type of person. Foreign key to the table of person types
CP_SURNAME	VARCHAR2	30		N	Surname of person (this might be a company name or buisness name where appropriate)
CP_INITIAL	VARCHAR2	10		Y	Initials of person
CP_PREF_NAME	VARCHAR2	15		Y	Preferred name of person (the name used in correspondence, it might be the christian name or a nick name)
CP_SPOUSE_NAME	VARCHAR2	15		Y	The name (christian or nick) of the persons spouse
CP_ADDRESS	VARCHAR2	255		Y	Postal address of this person. Embedded carriage returns within this field provide line delimiters.
CP_POST_CODE	VARCHAR2	4		Y	Post code
CP_STD_AREA_CODE	VARCHAR2	3		Y	Telephone STD code
CP_PHONE_NUMBER	VARCHAR2	8		Y	Telephone number
CP_FAX_NUMBER	VARCHAR2	8		Y	Fax number
CP_RELIABILITY	VARCHAR2	1		Y	Reliability of person (Good, Poor, Fair, or Null if unknown)
CP_REMARKS	VARCHAR2	255		Y	Remarks concerning this person. They might contain the persons common fishing area, or an alternative phone number for the person etc.
CP_BOAT_CODE	NUMBER	16	0	Y	The code of the current (or last) boat which this person is using (did use). Is a foreign key to the table of boats

Data Checks
Referenced by Tables - BIO_TRIP, PUER_BIOLOGY, MM_SAMP_DETAIL, TAG_PERSON, PUER_SAMPLERS, PUER_DIVER_LOG, MM_SAMP_DETAIL, CRAB_TRIP
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CODE_PERSON_TY**
Table Owner CRAY_RES
Table Remarks A single record for each type (classification) of person. For example, Research, Fisher, Police, Company, Processor etc.

Primary Key - PRIMARY KEY (CPT_PERSON_TYPE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$CPT_PERSON_TYPE On (CPT_PERSON_TYPE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CPT_PERSON_TYPE	VARCHAR2	3		N	Primary key, user defined code for this type of person
CPT_PERSON_TYPE_DESCRIPTION	VARCHAR2	40		N	Description of this type of person

Data Checks
Referenced by Tables - CODE_PERSON
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CODE_PROJECT**
Table Owner CRAY_RES
Table Remarks Contains a single record for each type of project (eg. puerulus sampling, old catch sampling, new catch sampling, fishermens tagging, old tagging etc etc).

Primary Key - PRIMARY KEY (CP_PROJECT_CODE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$CP_PROJECT_CODE On (CP_PROJECT_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CP_PROJECT_CODE	VARCHAR2	8		N	Primary key. Is a user specified project ID
CP_PROJECT_SHORT_DESC	VARCHAR2	40		N	Short description (title) of the project
CP_PROJECT_DESCRIPTION	LONG			Y	Description of the project

Data Checks
Referenced by Tables - BIO_CHECK_DATA, BIO_TRIP, CODE_SITE_PROJ, CRAB_TRIP, CRAB_CHECK_DATA, CRAB_CS_POT_ENTRY_PREFS
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CODE_SITE**
Table Owner CRAY_RES
Table Remarks Contains a single record for each research site.

Primary Key - PRIMARY KEY (CS_SITE_CODE)
Foreign Keys - FOREIGN KEY (CS_LOCATION_CODE) References table: CODE_LOCATION
Unique Columns - UNIQUE (CS_SITE_NAME)
Indexed Columns - INDEX=I_$CS_LOCATION_CODE On (CS_LOCATION_CODE) NONUNIQUE
- INDEX=I_$CS_SITE_ALTERNATE_CODE On (CS_SITE_ALTERNATE_CODE) UNIQUE
- INDEX=I_$CS_SITE_CODE On (CS_SITE_CODE) UNIQUE
- INDEX=I_$CS_SITE_NAME On (CS_SITE_NAME) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CS_SITE_CODE	VARCHAR2	6		N	Alphanumeric key for a site. For most areas, this is a 3 digit "site" code followed by a 3 digit "station" code.
CS_SITE_NAME	VARCHAR2	30		N	Name of site.
CS_LOCATION_CODE	NUMBER	16	0	N	Foreign key to a table of location codes for the specific location of this site.
CS_SITE_DESCRIPTION	VARCHAR2	255		Y	Description of the site.
CS_SITE_ALTERNATE_CODE	NUMBER	4	0	Y	This is an alternative numeric code to represent the site. For example, with meteorological data, it holds the code used by the weather bureau.
CS_SITE_MET_WANTED	VARCHAR2	1		Y	A flag (Y/N) to indicate whether meteorological data should be imported for this site. It is only required for meteorological sites.

Data Checks
Referenced by Tables - CRAB_DATE_SHOT, BIO_DATE_SHOT, CODE_SITE_PROJ, CS_SAMPLE_DATES, ENV_SEA_SWELL, ENV_LOG_DEPLOY, ENV_SYNOPT_INST, ENV_SYNOPT_24HR, PUER_DATE_SITE, PUER_C_POSITION, PUER_C_HISTORY
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CS_BY_CATCH**
Table Owner CRAY_RES
Table Remarks Holds details the by catch (non lobster catch) in each pot. Contains a single record for each species caught in a pot. Is unique by the combination of Sample code and Species code.

Primary Key - PRIMARY KEY (CBC_SAMPLE_CODE,CBC_SPECIES_CODE)
Foreign Keys - FOREIGN KEY (CBC_SAMPLE_CODE) References table: BIO_SAMP_DETAIL
- FOREIGN KEY (CBC_SPECIES_CODE) References table: CS_SPECIES
Unique Columns
Indexed Columns - INDEX=I_$CBC_SAMPLE_CODE_SPECIES On (CBC_SAMPLE_CODE,CBC_SPECIES_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CBC_SAMPLE_CODE	NUMBER	16	0	N	Part of primary key. Also a foreign key to the table of sample details.
CBC_SPECIES_CODE	VARCHAR2	4		N	Part of primary key. Is also a foreign key to the table of species codes.
CBC_NUMBER_CAUGHT	NUMBER	2	0	N	Number of individuals of this species that were caught. Only two digits long since any number of 99 or more is not counted. Thus "99" means at least 99 individuals were caught.

Data Checks
Referenced by Tables
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name ***CS_POT_ID***
Table Owner CRAY_RES
Table Remarks Contains a single record for each specific pot. However, as pots are occassionaly replaced, a single ID may refer to more than one pot through time. See the table of pot replacement dates.

Primary Key - PRIMARY KEY (CPI_POT_ID)
Foreign Keys - FOREIGN KEY (CPI_POT_TYPE) References table: CS_POT_TYPE
Unique Columns
Indexed Columns - INDEX=I_$CPI_POT_ID On (CPI_POT_ID) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CPI_POT_ID	VARCHAR2	4		N	User defined primary key. Is the ID of a specific pot except where replacement has been made (with identical pot - see pot replacement table), or where CPI_POT_ID=CPI_POT_TYPE (see below).
CPI_POT_TYPE	VARCHAR2	2		N	The type of pot. Refers to the table of pot types. If equal to CPI_POT_ID, then CPI_POT_ID does not refer to a specific pot and is only used as a link from BIO_SAMP_DETAILS to CS_POT_TYPE.
CPI_NUMBER_GAPS	NUMBER	1	0	Y	Number of escape gaps. Zero means no gaps. Is only allowed to be null if CS_POT_ID= CS_POT_TYPE
CPI_POT_DESCRIPTION	VARCHAR2	255		Y	Description of this pot.

Data Checks
Referenced by Tables - BIO_SAMP_DETAIL, CS_POT_REPLACE, CRAB_SAMP_DETAIL
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CS_POT_REPLACE**
Table Owner CRAY_RES
Table Remarks Contains a single record for each replacement of a specific pot.

Primary Key - PRIMARY KEY (CPR_POT_ID,CPR_REPLACEMENT_DATE)
Foreign Keys - FOREIGN KEY (CPR_POT_ID) References table: CS_POT_ID
Unique Columns
Indexed Columns - INDEX=I_$CPR_POT_ID_REPLACE_DATE On (CPR_POT_ID,CPR_REPLACEMENT_DATE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CPR_POT_ID	VARCHAR2	4		N	Part of primary key. Refers to the table of Pot IDs.
CPR_REPLACEMENT_DATE	DATE	7		N	Part of the primary key. The date at which this replacement occurred. Is the starting date of this new pot.
CPR_REPLACEMENT_REMARKS	VARCHAR2	255		Y	Remarks concerning this replacement.

Data Checks
Referenced by Tables
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CS_POT_TYPE**
Table Owner CRAY_RES
Table Remarks Contains a single record for each type of pot.

Primary Key - PRIMARY KEY (CPT_POT_TYPE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$CPT_POT_TYPE On (CPT_POT_TYPE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CPT_POT_TYPE	VARCHAR2	2		N	User defined primary key. Defines the type of pot.
CPT_POT_TYPE_DESCRIPTION	VARCHAR2	255		Y	Description of this type of pot.

Data Checks
Referenced by Tables - CS_POT_ID
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **CS_SAMPLE_DATES**
Table Owner CRAY_RES
Table Remarks The CS90 (and other CS projects) had primary sampling periods (up to 3 per year). This table holds the dates of these periods to simplify the grouping of data for analysis.

Primary Key - PRIMARY KEY (CSD_SITE_CODE,CSD_SAMPLE_PERIOD,CSD_YEAR_SEASON_START)
Foreign Keys - FOREIGN KEY (CSD_SITE_CODE) References table: CODE_SITE
Unique Columns
Indexed Columns - INDEX=I_$CSD_SITE_SAMPLE_SEASON On (CSD_SITE_CODE,CSD_SAMPLE_PERIOD,CSD_YEAR_SEASON_START) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CSD_SITE_CODE	VARCHAR2	6		N	The code of the site for which this sampling period applies.
CSD_SAMPLE_PERIOD	NUMBER	1	0	N	A numeric code (1-3) which holds the number relating to this sampling period.
CSD_YEAR_SEASON_START	NUMBER	4	0	N	The year in which this season started. For example 1992 would be entered for the season which starts October/November 1992 and ends in August/September 1993.
CSD_START_DATE	DATE	7		N	Date at which this sampling period comenced.
CSD_END_DATE	DATE	7		N	Date at which this sampling period finished.

Data Checks
Referenced by Tables
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name ***CS_SPECIES***
Table Owner CRAY_RES
Table Remarks Contains a single record for each species of animal.

Primary Key - PRIMARY KEY (CSP_SPECIES_CODE)
Foreign Keys
Unique Columns
Indexed Columns - INDEX=I_$CSP_COMMON_NAME On (CSP_COMMON_NAME) UNIQUE
- INDEX=I_$CSP_NATIONAL_CODE On (CSP_NATIONAL_CODE) UNIQUE
- INDEX=I_$CSP_SCIENTIFIC_NAME On (CSP_SCIENTIFIC_NAME) UNIQUE
- INDEX=I_$CSP_SPECIES_CODE On (CSP_SPECIES_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
CSP_SPECIES_CODE	VARCHAR2	4		N	Code for this species.
CSP_COMMON_NAME	VARCHAR2	30		N	The common name for this species.
CSP_SCIENTIFIC_NAME	VARCHAR2	30		Y	The scientific name (Genus species) for this species).
CSP_NATIONAL_CODE	VARCHAR2	8		Y	The national code used for this species.

Data Checks
Referenced by Tables - CS_BY_CATCH, CRAB_BY_CATCH
Grants - RLSCI (Select, Insert, Delete, Update)

Table Name **TAG_PERSON**
Table Owner CRAY_RES
Table Remarks Contains a single record for each person who has, or is conducting tagging.

Primary Key - PRIMARY KEY (TP_PERSON_CODE)
Foreign Keys - FOREIGN KEY (TP_PERSON_CODE) References table: CODE_PERSON
Unique Columns
Indexed Columns - INDEX=I_$TP_PERSON_CODE On (TP_PERSON_CODE) UNIQUE

Column Name	Type	Size	Scale	Null	Remarks
TP_PERSON_CODE	NUMBER	16	0	N	Primary key and Foreign key to the table of person codes
TP_STILL_TAGGING	VARCHAR2	1		N	(Y/N), whether the person is still conducting tagging.
TP_DATE_STARTED	DATE	7		Y	If known, is the date at which this person started tagging.
TP_DATE_FINISHED	DATE	7		Y	If known, is the date at which this person finished tagging.
TP_REMARKS	VARCHAR2	255		Y	Remarks concerning this tagger.

Data Checks
Referenced by Tables - TAG_ISSUE
Grants - RLSCI (Select, Insert, Delete, Update)