FISHERY ASSESSMENT REPORT

TASMANIAN ROCK LOBSTER FISHERY 2001/2002

Stewart Frusher, Caleb Gardner, Craig Mackinnon and Malcolm Haddon

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Tasmanian Aquaculture
& Fisheries Institute
University of Tasmania

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TAFI Marine Research Laboratories, Private Bag 49, Hobart, TAS 7001, Australia. E-mail: tafi@utas.edu.au. Ph. (03) 6227 7277, Fax (03) 6227 8035

Rock Lobster Fisheries Assessment: 2001/2002

Executive Summary

The 2001/2002 rock lobster fishery assessment provides information on the status of the fishery and new developments in research at the Tasmanian Aquaculture and Fisheries Institute (TAFI). This assessment of the rock lobster resource is the seventh in the series and the fifth to be produced by the Tasmanian Aquaculture and Fisheries Institute and uses input from the Rock Lobster Fishery Assessment Working Group (RLAWG). The assessment found that no trigger points were breached during the period under review. Catch rates remain substantially higher than the 1990 reference years although small declines over the last 12 months were noted in areas 6 (west) and 8 (south-west). Substantial improvements in catch rates were recorded from the East Coast. This trend was also reflected in estimates of the biomass of legal-sized lobsters and the proportion of lobsters caught.

Declines in catch rates over the last 12 months in two areas on the west coast were partly a result of changing fishing patterns. In Area 6, there was an increase in effort in shallower waters (<50m) where catch rates were typically lower. Inter-annual changes in catch rates in Area 8 appear to be strongly influenced by catches of recently moulted males, just prior to the closing of the fishery in September. In September 2000, a number of vessels targeted these recently moulted males, which led to substantial increases in both the catch and catch rate. By comparison, the September catch rate in 2001 was a third of that in the previous year due to a change in the timing of the moult and thus limited access to the 'new shellers'.

Egg production still remains below 25% of the virgin biomass target in northern areas of the State although, with the exception of Area 6, egg production is increasing. Egg production estimates for Area 6 may also be biased by a change in fishing pattern, which influenced catch rates. Examination of the eight regions used in the assessment showed that all had an increase in the proportion of effort undertaken in shallower waters (<20m) since 1992. With the exception of areas 5 and 6 in the northwest, this trend was apparent prior to the introduction of quota. Currently the assessment model does not account for changes in fishing patterns associated with depth. Options for standardisation of catch rates to incorporate depth are being investigated for incorporation into future assessments.

Puerulus settlement rates at all the collection sites were compared to catch rates in adjacent fishing regions. As juvenile growth rates are variable, the analysis this year also attempted to link puerulus settlement with catches over a two or three year period. As expected the lag time between puerulus settlement and subsequent catches in the fishery increases from north to south in the fishery (as growth rate declines north to south). Although reasonable links could be found for all regions, the number of overlapping data points is too few for puerulus settlement to be used as a robust

indicator of future catches. Nevertheless, the results are encouraging and we expect this method to provide an indicator of catches in the near future.

During 2001/2002 a review was undertaken of the fishery independent catch sampling project and field sampling was reduced during this period. Part of the reason for the review was that undersized catch rates were not being reflected in future legal-sized commercial or research catch rates. Further analysis of the undersized data identified a relationship between smaller lobsters (<87mmCL) and the commercial catch in shallow water. This also holds promise for short term (2 – 3 years) predictions although, like puerulus settlement, further analyses incorporating different growth rates and lag periods needs to be undertaken so that a longer time series of data is available.

The number of recreational pot, dive and ring licences continued to increase in 2002. The recreational catch is estimated to be around 7.5% of the Total Allowable Commercial Catch (TACC) statewide. The majority of this catch occurs in southeastern Tasmania where in shallow water it exceeds the commercial catch.

Harvest strategies based on the current TACC of 1523 tonnes were evaluated against increases to 1550 tonnes and 1576 tonnes as well as decreases to 1500 tonnes and 1471 tonnes. All scenarios showed an increase in biomass over the next two years (2002 and 2003) prior to declines in 2004 (relative to 2003). There is considerable uncertainty associated with the estimates projected three years forward (2004) as they are based largely on simulated recruitment, which is highly variable. In contrast, estimates for 2002 and 2003 are mainly influenced by the simulated growth of the biomass existing at the end of 2001, so greater certainty exists with the predicted increases in biomass over the next 2 years. The certainty of the 2004 estimates will improve in the 2002/2003 assessment. If the predicted downturn reflected in this assessment continues, a re-evaluation of the TACC will be required.

During 2002, two FRDC projects were completed. The first project showed that the change-in-ratio (CIR) and index removal (IR) methods did not provide consistent robust estimates of exploitation rate and biomass. Both methods were compromised by changes in catchability during the fishing season and the harvesting of newly recruited lobsters in September. Surprisingly, catchability was found to vary during the fishing season between size groupings of lobsters just below and above the size limit. This biased the estimates that were based on ratios of these two groups of lobsters. Given the importance of biomass as a performance indicator in the fishery, research is underway to evaluate alternatives such as multi-year tagging models which are not affected by catchability or recruitment. Preliminary trials have shown that tagging methods can be applied to all regions of the fishery. Unlike CIR and IR estimates, recruitment during the fishing season that occurs in northern regions of Tasmania does not appear to bias exploitation rate estimates.

The second project evaluated changes that have occurred in the fishery since the implementation of the Individual Transferable Quota Management System (ITQMS). This project identified a number of changes that were occurring in the fishery. Although several of these were apparent prior to ITQMS, the rate of change has escalated since its introduction. Importantly, changes in fishing patterns can result in changes in catch rates that are not related to changes in abundance of lobsters. As catch rates are the primary indicator of abundance (legal-sized biomass) in pot fisheries, our assessments need to identify how changes in fishing patterns influence abundance estimates. Standardisation of the data to incorporate changes in fishing patterns and improvement in the fleet dynamics model are being investigated and implemented to improve assessment model outcomes. This project also included an extensive socio-economic study that developed a list of performance indicators that may assist ongoing assessment of socio-economic aspects of the fishery.

Four permits were issued in 2002 to harvest puerulus and early stage juveniles for ongrowing under aquaculture conditions. Under Government policy, the removal of these lobsters from the wild needs to be compensated to ensure no impact on the resource (biological neutrality). As the survival of puerulus and early stage juveniles is considered to be low in the wild and high in aquaculture, an option for achieving biological neutrality is to release older and larger juveniles after a period in captivity. These lobsters would be expected to have higher survival and the number released is considered to be equivalent to the number of lobsters that would have survived if the unharvested puerulus had remained in the wild. Projects determining the appropriate number to release and the fate of lobsters that have been held in captivity prior to release are currently underway.

In keeping with the national agenda on environmentally based management, this assessment includes information on the sustainability of the fishery. This information has been used to accredit the fishery under the Environment Protection and Biodiversity Conservation Act 1999.

By-catch and by-product from lobster fishing operations are minimal reflecting the specific nature of the gear. Of the 17 species recorded as by-product only octopus has been retained in quantities greater than one tonne since the introduction of quota in 1998. Although escape gaps are mandatory in the fishery, research surveys use pots without escape gaps to evaluate the catch of pre-recruit lobsters. These surveys caught 12 species of crustaceans, 42 species of finfish, 9 species of molluscs and 10 other invertebrate species. The majority of this by-catch normally exits through the escape gaps. A study investigating the impact of by-catch from these research pots on the catchability of lobsters found that as by-catch increases the number of lobsters caught decreases. In addition to the total amount of by-catch in the pot, predatory and aggressive species such as the draughtboard shark, octopus and wrasse were found to have a slightly greater negative affect on lobster catchability.

The majority of interactions with protected species involved birds that used vessels to roost during the evenings or fed on discarded bait. One leatherback turtle drowned due to entanglement in a buoy line off northeastern Tasmania. Although sighting of whales, dolphins and seals regularly occur, there were no reported cases of interactions with marine mammals.

Recently we have commenced projects on octopus and draughtboard sharks, two predators of lobsters. Although the number of octopus caught in lobster pots varied during the lunar period, the number of lobster mortalities in the pots was surprisingly constant at approximately two per pot. It is currently unknown what is the cause of this apparent saturation level. Preliminary results suggest that in northern regions of Tasmania, where larger lobsters are found, that the largest lobster in the pot is killed first. Underwater video footage has confirmed that octopus are also attracted to the bait and will enter a pot when no lobsters are present. Octopus were also observed to enter a pot, attack the bait and leave the pot even when lobsters are present in the pot. Estimates of octopus abundance is likely to be underestimated based on the number of octopus caught in pots. Draughtboard sharks are a common by-catch species in lobster pots. These sharks are considered a major upper trophic level predator on southern temperate reefs. Sharks are normally removed from pots and returned alive to the sea. In 2000, we commenced tagging sharks during research surveys. The majority of recaptures recorded to date are from the location of tagging, suggesting that a portion of the shark population is residential. However, one shark had moved from eastern Tasmania to southern Bass Strait indicating that there is also the potential for considerable intermixing between large regions.

Comparisons of lobster populations between fished and unfished regions indicated that there has been a substantial increase in both the number and the size range of legal-sized lobsters in the unfished region.

Preliminary results from a project evaluating the use of marine protected areas (MPAs) as a management tool for rock lobsters (and other species) has shown that MPAs are of low value for management of the Tasmanian rock lobster fishery, with the exception of smaller areas that contribute to research. In scenarios where catch was constrained by a TACC, the implementation of MPAs increased the risk of a decline in biomass and egg production levels. It appears that current practices that manage the stock as a whole (e.g. size limits, gear, catch and effort restrictions) are more likely to lead to the continuation of stock rebuilding, and possible associated ecological benefits. Closure of fishing regions using MPAs would require a reduction in the TACC by the equivalent loss in catch to ensure sustainability of the stock and to meet management objectives (eg rebuilding of biomass).

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1. Introduction

Tasmania's rock lobster fishery is distributed around the entire coastline of Tasmania from sub-tidal reefs to deeper reefs on the continental slope. From humble beginnings of approximately 70,000 lobsters valued at $1,456 recorded from the Hobart fish market in 1888, the rock lobster industry today lands around 1.75 million lobsters annually with a landed value of approximately $AU50 million.

The rock lobster fishing industry is the backbone of Tasmania's fishing fleet with the majority of vessels working out of Tasmania's coastal rural towns. Over 80% of the licenses are held by Tasmanians, with the majority being owner-operators. The industry spends between 24 to 36% of the $50 million landed value of the catch on materials and approximately 41% on labour, thus being a valuable contributor to regional employment and economic activity. The processing sector is dependent on live holding facilities as approximately 74% of the catch is marketed live. The rock lobster processing sector is highly specialised adding to the socio-economic benefits that the rock lobster industry contributes to Tasmania.

The commercial fishing fleet comprises approximately 220 vessels, which are licensed to use between 15 and 50 pots. Additionally, the rock lobster resource supports an active recreational fishery with over 16,000 licenses issued in 2001.

Historically, the commercial fishery developed around the established towns on the weather protected East Coast in the late 1800's and early 1900's. As catch declined in these regions and technology improved, vessels moved to deeper and less protected waters off the West Coast. Today, the majority of the catch comes from the West Coast.

Markets have adapted to technology change with local markets dominating until after the Second World War when refrigeration enabled a rapid expansion into the American frozen tail market. With the advent of live transport, this market has been replaced by markets for live lobsters in Asia. The southern rock lobster is considered the premium lobster species and commands a high price on both the domestic and international market.

Although rock lobsters are harvested from coastal waters right around the state, the patterns of commercial fishing vary dramatically from region to region. Biological parameters such as growth and maturity of lobsters also vary dramatically around the state. For this reason the information presented in this report is often split into the eight assessment areas shown in Figure 1.

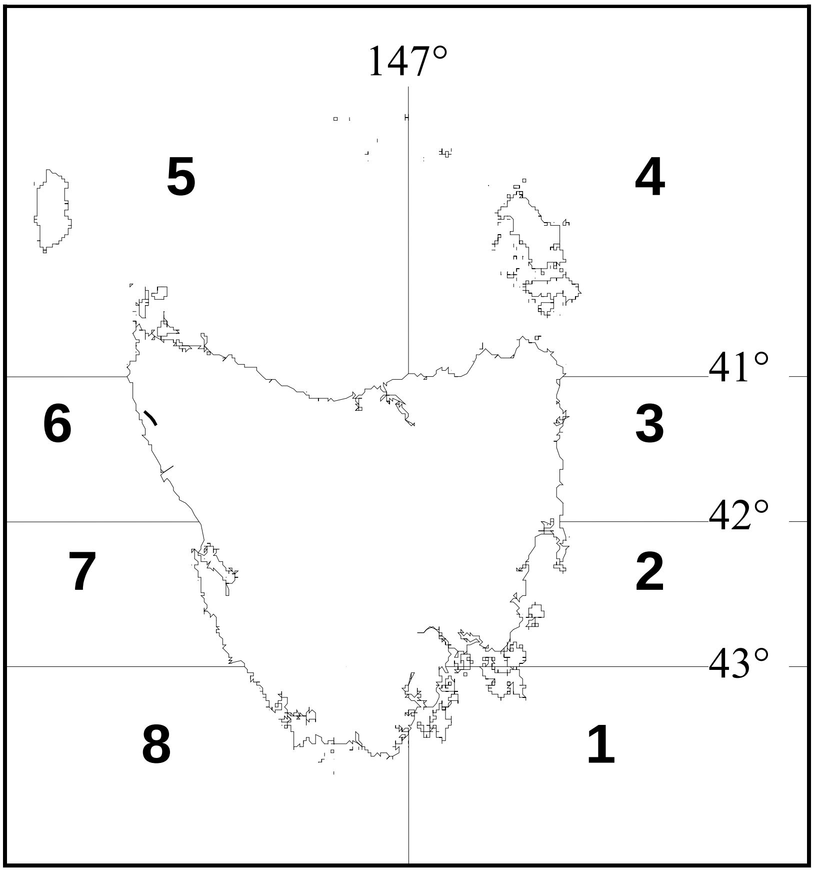


Figure 1. Divisions used for stock assessment areas.

1.1 Management

Rock lobsters were an important source of food for coastal aboriginal tribes and this was also the case for the first European settlers, which arrived in Hobart in 1804. In 1882, a Royal Commission into the fisheries of Tasmania produced what was effectively the first Tasmanian rock lobster stock assessment report. This report led to the introduction of regulations in 1889, which included a minimum legal size, and a prohibition on taking soft shelled (recently moulted) lobsters or berried female lobsters. These input controls still play a role in management of the resource although soft shelled lobsters are now protected by a seasonal closure.

Since the inception of catch records in the 1880's, catch steadily increased in the rock lobster fishery to a high in 1984 of over 2,250 tonnes. During this time, concerns about overfishing were expressed by industry, and resulted in government intervention. The most important changes were the legislation of pots in 1926, the restriction of the number of licenses in 1966 and a ceiling on the number of pots in the fishery at 10,993 in 1972.

Since 1984, the catch has declined to a low of 1,440 tonnes in 1994. Recognising the declining trend in biomass, industry adopted an individual transferable quota (ITQ) management system in March 1998.

Management has remained relatively stable since the introduction of quota. Quota was initially set at 1500 tonnes for the 1998/1999 fishing season. After three years of successive improvements in biomass, the quota was increased to 1523 tonnes for the 2001/2002 fishing season. In addition to increasing the quota, the length of the fishing season has increased. The entire month of September was open in 2000 and the first 18 days were open in 2001. This was intended to provide fishers with flexibility to take hard old-shell lobsters that command a high price at this time of the year or fish for the lower priced soft new-shell lobsters that have a higher catchability after their moult.

2. Previous Assessments

This report is the seventh assessment report and uses data available up until 1st March 2002. It includes data for the first four years since ITQ implementation.

Assessment Report No.	Last month of data used	Reference
1	December 1995	Frusher, 1997a
2	December 1996	Frusher, 1997b
3	February 1998	Frusher and Gardner, 1999
4	February 1999	Gardner, 1999
5	February 2000	Gardner, Frusher and Eaton, 2001
6	February 2001	Gardner, Frusher, Eaton, Haddon and Mackinnon, 2002

3. Recent Developments

3.1 The Fishery

On the 1st March 1998, management of the Tasmanian fishery changed from input controls based primarily on licence limitations and closed seasons, to an output controlled fishery based on individual transferable quotas (ITQs). In adopting the ITQ system, several of the input controls have been maintained, including the limitation of the maximum number of pots allowed in the fishery and seasonal closures which had been implemented to protect moulting lobsters.

This change has had the effect of increasing focus on the value of the finite number of animals landed each season. The change in the dynamics of the fleet was discussed extensively in the last assessment Gardner *et al.* (2001), but a key observation was a shift in effort towards winter when prices are highest. Associated changes include an increase in night fishing using lights, and trial extensions to the open season for males so that September remained open in 2000 and partially open in 2001.

3.2 Developments in stock assessment analyses

3.2.1 Correction of database errors

During the last year, changes were made to the data stored in both Craybase (historical and research data) and ICE (commercial data since 1999). These have resulted in changes to the stored data that may result in some differences between information presented in this report to that presented previously. Data were checked by looking for outliers, or by matching comparable sources of data (eg. do catch records collected through the quota audit system match those collected through the logbooks?).

3.2.2 Data collection

No catch sampling was conducted from October/November 2001 to July/August 2002. A review of the catch sampling project was held on the 2nd May 2002. This review proposed a shift away from a survey designed to estimate exploitation rates using CIR and IR methods to trialing multi-year tagging models. The review also highlighted the need to obtain size structure and depth stratified biological information in northern and western regions of the fishery. A new catch sampling program will be instigated in October/November 2003. To obtain size structure and maximise longer-term tag returns, all sites where tagging was undertaken from 1992 to 2001 will be revisited in October/November 2002 and March 2003.

3.2.3 Estimation and incorporation of recreational catch

With the production of the latest survey report for the Tasmanian recreational rock lobster fishery (Forward & Lyle, 2002) it was possible to update the manner in which the effects of recreational fishing have been incorporated into the model. Recreational catches are included in the model by estimating what proportion they constitute of the commercial catch. In this way, the total catch is accounted for and the assessment continues as normal. The recreational catches are incorporated into the model as a set of proportions for each of the eight assessment regions; i.e. if the recreational catch in the southeast in 97/98 is estimates to have been 28.14% of the commercial catch in that area, then 0.2814 is entered for that year and assessment region.

Previously, the 1995/1996 estimate (Lyle & Smith, 1998) and the 97/98 estimates (Lyle 2000) were the only reliable estimate of state wide recreational catch of rock lobsters. These provided for two point estimates of recreational catch, which were included in the model as an increment to the commercial catch. With the latest, increased (at least in some regions) estimate of recreational take (Forward & Lyle, 2002) it was necessary to devise a means of including all estimates into the model's summary of catch. Because the estimates differ as a trend across years, it was also necessary to include a means of predicting the recreational catch in the intervening years and allowing for different regimes of recreational catch to occur in the projections.

During the 2001/2002, the recreational catch input file in the assessment model was altered to permit the years of recreational catch estimates by region to be accommodated. In addition, the proportion of the recreational catch was generated backwards to year one in the model. This back projection was assumed to be at the level estimated in the 1995/1996 survey. The various recreational catch estimates are connected by a linear interpolation of the values (this being the simplest and most reasonable approach).

To accommodate changes in recreational catch in the forward projections of the model, the input files allow for projections to simply extend the latest estimates forward unchanged, or to extend the latest estimates under some given schedule of change.

These changes will allow for future estimates of recreational catch to be directly added to the data inputs of the model, which should improve the performance and precision of the modelled outputs. In those areas of the assessment where the recreational catch is significant i.e. the East and South-East coasts, these estimates of recreational catch are critical to providing an adequate assessment of the state of the stock in those regions.

3.2.4 FRDC Projects

Descriptions of two recently completed FRDC projects aimed at improving the rock lobster stock assessment are provided below.

FRDC 1997/ 101 - *Assessment of broad scale exploitation rates and biomass estimates for the Tasmanian southern rock lobster fishery*

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.
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 relies on its *de facto* relationship with 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 outputs 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 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 very poor tag return rates.

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 consistently lower than research estimates. Research surveys sampled in exactly the same location in the March and July/August surveys as pre-season (October/November) survey was undertaken. In contrast, fishers would operate in areas where they considered their catches would be maximised. A change in site to slightly shallower or deeper water could occur for a number of reasons. A fisher may be aware of improved catches coming from an adjacent region, or a fisher may be aware that the set locations fished in the November trip had been recently fished and were therefore unlikely to yield good catches. A fisher's acquired knowledge could lead him to operate in a region where he knew good catches could be obtained for that time of the year from past experience. 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 (equivalent to fishery independent pre-season sample) 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 surveys. 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.

FRDC 1999/140 - *Impact of management change to an ITQ system in the Tasmanian rock lobster fishery*

Objectives:

1) To assess the response (fleet dynamics) of rock lobster fishers to changes in management, including any change in the rules, which fishers used to influence their fishing decisions prior to and after quota implementation.

2) To evaluate the impacts (catch and effort) of rock lobster fishers on other fisheries prior to and post quota implementation.

3) To determine socio-economic changes associated with implementation of quota management and establish performance indicators relevant to managing the fishery.

Outcomes Achieved:

- Future rock lobster fishery assessments in Tasmania will account for CPUE changes independent of changes in lobster abundances. This will enable valid comparisons of pre-and post- quota implementation data and provide managers and industry with greater certainty when recommending Total Allowable Commercial Catch (TACC) amounts.

- Routine assessments of the lobster fishery are now able to account for changes in fisher behaviour that have occurred since 1995. This project has demonstrated that changes are occurring in the fleet dynamics of the fishery after implementation of quota and that the sub-model will need to be regularly up-dated. A fleet dynamics sub-model based on post-quota data will need at least 5 years of data and a review will be undertaken in 2004. The rock lobster model has been amended appropriately.

- Despite there being no evidence of increased effort into other fisheries there is the possibility of gradual effort creep, and data extraction routines developed in this project will be used to monitor effort redirection in the future.

- Industry and Government are currently in the process of developing a strategic plan and vision for the commercial rock lobster fishery. The results of this study have provided a stimulus for the inclusion of socio-economic performance indicators in the document so that industry will be better positioned to address ESD requirements under the EPBC Act (1999).

Non-Technical Summary:

In any fishery, a change in the management system is expected to result in a change in fishing activity. In the Tasmanian commercial rock lobster fishery an individual transferable quota management system (ITQMS) was introduced in 1998. This change in management system, which allocated fishers a set portion of the total allowable catch, was expected to encourage individual fishers to maximise profits by improving their return per unit of fish caught rather than by increasing effort to catch more lobsters. This change to a profit maximisation strategy had the potential to alter the meaning of catch and effort data, the linchpin of routine assessments of the resource.

Catch rates are used in most lobster fishery assessments as a proxy for lobster abundance – as abundance declines, so too does catch rate. Prior to implementation of the ITQMS, when catch rates reflected maximising the number of fish caught, this assumption was considered appropriate. However, post-ITQMS, fishers could target premium fish at periods of high prices and low catchability, which in turn could result in lower catch rates that were unrelated to abundance. Further alterations to catch rates that are unrelated to abundance could also have occurred with a change in the efficiency of existing fishers. A rapid reduction in the lobster fishing fleet from 315 to 240 vessels in the years after quota presented such an opportunity. Analysis of the catch efficiency of pre-and post-quota vessels found that there were small gains in the efficiency of the remaining vessels, although these were insufficient to account for the increases in biomass noted since implementation of quota. Changes in fisher's behaviour that was likely to impact on catch rates were also identified in interviews with fishers. These changes were primarily related to: 1. Fishing more in winter when prices were higher and catch rates were lower; 2. Fishing inshore to maximise the number of premium quality large red lobsters caught; and 3. Fishing less from homeports.

Analysis of fisher's catch returns confirmed an increase in effort during winter although it was noted that this trend was apparent prior to the introduction of quota. Since the introduction of quota the trend has been amplified. Catch and effort data suggested that fishers might have increased effort in shallower waters, although with the limited amount of data available this trend is inconclusive. Data from interviews may be more sensitive to this, with 25% of those interviewed stating that they had changed their fishing patterns. Analysis of the number of statistical reporting blocks fished by vessels did not support the 33% of fishers who considered that fishing was becoming more localised since quota. These results suggest that spatial catch and effort data obtained since the introduction of quota is continuous with pre-quota data. Comparisons may thus be made between pre- and post-quota datasets for the initial period after introduction of quota, although it should be remembered that change is often not instantaneous. Statements by fishers regarding likely changes in their own fishing patterns need to be constantly evaluated and do not necessarily relate to the whole fleet.

Evaluation of differing harvests (changes in quota) is a powerful tool used by the Tasmanian Crustacean Fisheries Advisory Committee (CFAC) to recommend future quotas to the Minister. The impact of an increase or decrease in quota on biomass and egg production is aggregated over eight regions of the fishery in Tasmania. These different regions are modelled independently as biological characteristics such as growth and size of maturity vary regionally around Tasmania. However, the fishing fleet is not constrained in where it fishes and is highly mobile in Tasmanian waters. Movement of the fleet between the eight stock assessment areas is considered in the assessment to take account of changes in catch rate in any one region. For instance, if catch rates increase in one region due to a recruitment pulse, it is likely that more of the fishing fleet will move to this region to take advantage of the improved catch rates. A fleet dynamics sub-model is therefore used to describe the expected movement of the fleet in future projections of different harvest levels (quotas).

The existing fleet dynamics sub-model is based on the fishing patterns of fishers from 1990 to 1995, which was when the primary rock lobster fishery assessment model was constructed. This sub-model was compared with both a sub-model that only used data since quota implementation (3 years of data) and with one that used all of the data. In addition to these, sub-models that incorporated parameters not used in the initial sub-model were also compared. Although changes since the introduction of quota management have been noted, the dataset was still too small to create a post-quota fleet dynamics sub-model. The best fit to the data was achieved by incorporating additional parameters (an area by month interaction term) and using the largest (10 year) dataset.

Fishers stated that the main impact of the introduction of quota in the rock lobster fishery was minor with a few boats shifting interstate. Several large fishers moved to Queensland to operate in the tuna fishery and others moved to lobster fisheries in Victoria and South Australia. The main Tasmanian fishery to receive “lobster effort” was the giant crab fishery, which has subsequently changed to an ITQ management system. Some lobster fishers have access to the scallop fishery and operate in this fishery when it is open although, as with giant crab, the fishery is managed on a weight based ITQMS. Fishers did not report redirecting effort into other Tasmanian fisheries, although an analysis of finfish catch and effort data suggests that there was a small expansion into Tasmanian line fishing. This expansion was primarily in the striped trumpeter fishery, which has seen a gradual increase in effort by rock lobster fishers since the mid-1990s. The recent decline in catch and catch rates in this fishery is considered to be associated with recent scalefish management changes. On the other hand, the decline in the number of vessels now operating in the rock lobster fishery has resulted in less effort being directed into most scalefish fisheries. Changes in the management plans of the giant crab, scallops, and some of the scalefish fisheries appears to have limited the capacity for rock lobster fishers to substantially shift effort into any of these fisheries.

A comprehensive socio-economic survey of the majority of participants in the lobster industry identified a number of positive and negative responses by fishers relating to the introduction of quota management. Positive responses related primarily to the improvement in lobster stocks, reduction in boat numbers and an end to the ‘race for fish’. It is worthwhile noting that reduction in boat numbers would have been required under any restructuring of the fishery to reduce effort, although the group of fishers affected may have been different under different management regimes or quota allocation mechanisms. Negative responses to quota management related primarily to the increase in the price of quota units (pots). Although prices are currently comparable to other lobster fisheries operating either under input or output controls in Australia, a substantial escalation in prices occurred after the introduction of quota management. Fishers needing to lease quota to make up catch equivalent to pre-quota catches and leasee’s have both found profit margins restrictive, while fishers attempting to buy into the fishery have found the costs prohibitive. Fishers are concerned that there is limited opportunity for persons associated with the fishery (e.g. deckhands, skippers currently leasing) to buy into the fishery and that the fishery is gradually moving into the hands of investors. Concerns were also aired regarding decreasing employment associated with decline in the number of boats. Decline in economic activity was also noted in several ports, disproportionate to the expected loss due solely to the reduction in boat numbers.

Zoning was the most frequently raised unsolicited issue, with the industry split evenly for and against this management tool.

A series of performance indicators was developed to monitor the main issues raised in this report. This report represents the baseline for these indicators, recognising however, that monitoring of any trends is of little value unless a direction for the industry is determined.

In summary, this study has shown that fishers, their behaviour, their capital investments and their regional distribution are all essential components of Tasmania's valuable rock lobster resource. As such, the sustainability of these socio-economic components of the fishery is considered to be as important as any biological components in the evaluation of the rock lobster fishery.

4. Fishery Assessment

4.1 Evaluation of Trigger Points

4.1.1 Commercial catch rates

Commercial catch rates for 2001 were shown to have improved for the majority of assessment areas when compared to the previous year (Table 1). The largest improvements occurred on the East Coast, particularly in Areas 2 and 3. This may reflect delayed recruitment from 1995 puerulus settlement peak (see Section 6). The improvement is encouraging as 2000 showed minor declines (Gardner *et al*, 2002). Only Area 6 has showed a decline for each year over the last two years, although it still shows a 23% improvement in catch rate since the reference year. This decline may be associated with an increase in effort being directed to inshore fishing grounds. These inshore shallow water grounds have a lower catch rate than the deeper offshore grounds (see Section 8).

Table 1. Change in annual commercial catch rates. Negative values indicate a decline in the change. The reference year is defined as the year with lowest CPUE among 1993, 1994 and 1995. Included also are commercial catch statistics for 2001.

Region	Reference Year	Commercial catch rates (kg/potlift)			% change in 2001		Commercial catch stats 2001 (Jan-Dec)	
		Ref. Year	2000	2001	vs Ref. Year	vs 2000	Catch (t)	Effort (1000 potlifts)
Statewide	1994	0.82	1.02	**1.04**	+27%	+2%	1513	1461
1	1994	0.52	0.75	**0.81**	+56%	+8%	123	152
2	1994	0.54	0.72	**0.84**	+56%	+17%	107	128
3	1994	0.44	0.55	**0.68**	+55%	+24%	85	125
4	1994	0.63	1.03	**1.08**	+71%	+5%	245	226
5	1995	0.90	1.14	**1.19**	+32%	+4%	335	283
6	1995	1.21	1.55	**1.49**	+23%	-4%	198	133
7	1994	1.11	1.27	**1.31**	+18%	+3%	124	95
8	1993	0.77	1.00	**0.93**	+21%	-7%	296	319

Monthly commercial catch rates within each area continue to remain higher or equal to the representative catch rates of the reference year (Figure 2). Catch rates in September are only available for the current year, as this month has been recently opened to allow fishers to target the higher prices available for fish in winter. The September catch rates may explain the decline shown in Area 8. As this area accounts for approximately 20% of the annual catch, a decline in catch rates in this region is of concern. When September catch rates are compared from the last two years (Figure 3), the exceptionally high value of 2000 that was the result of an early moult (Gardner *et al*, 2002) was not repeated in 2001. Despite the slightly lower catch rates for Areas 6 and 8, they are still above the reference year and have not triggered the performance indicator.

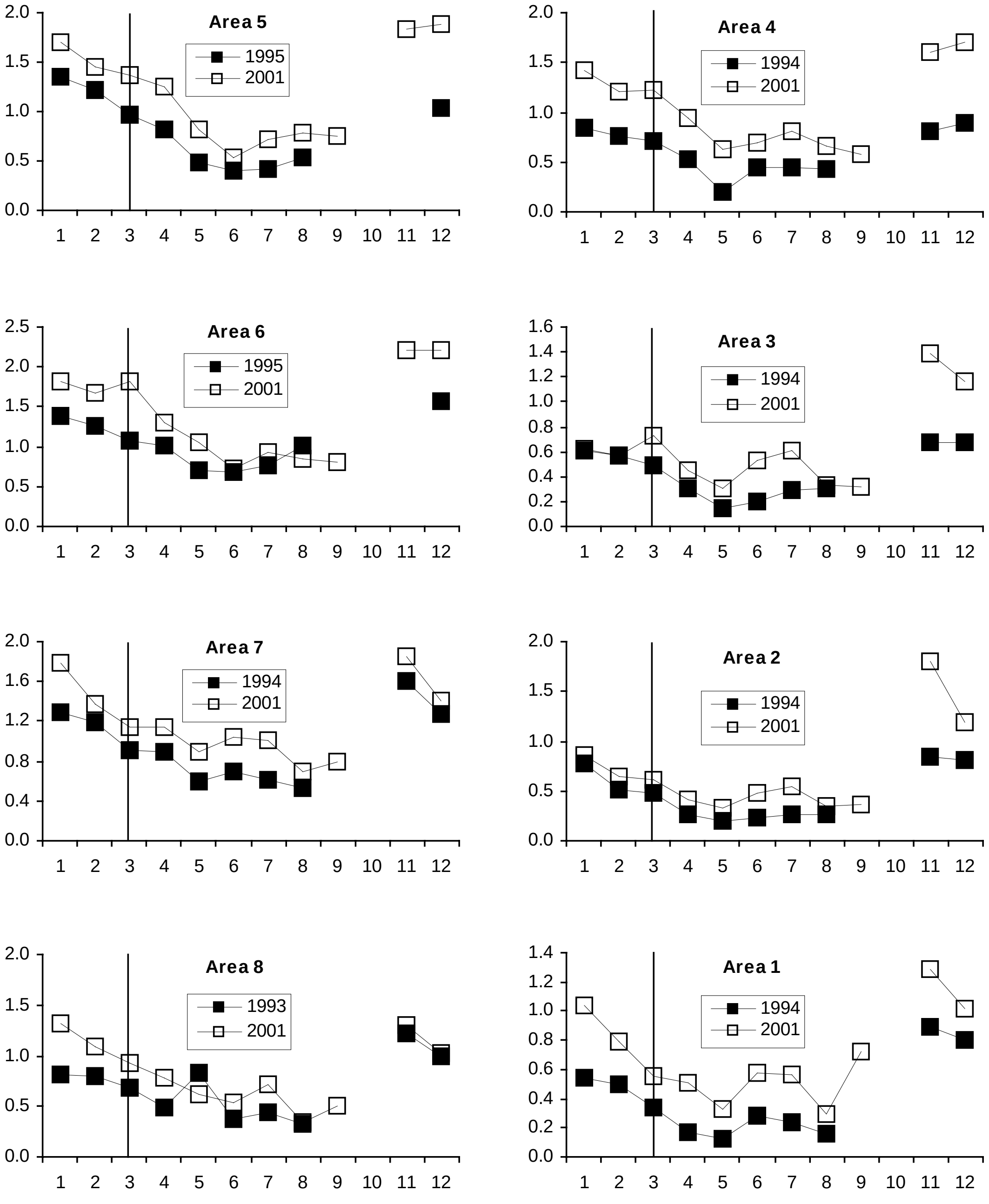


Figure 2. Change in catch-rate (CPUE, kg/pot lift) between months for 2001 and for reference year. Vertical line in each plot indicates the start of the quota season.

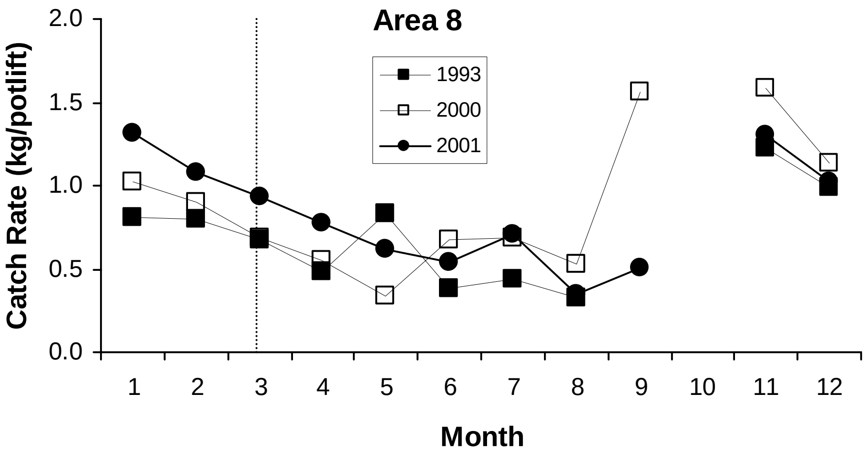


Figure 3. Comparsion of monthly catch rates for the reference year 1993, 2000 and 2001 for Area 8.

The improvement in East Coast catch rates appears to be associated with an increase in the months of November and December and to a lesser degree in winter. The improved winter catch rates are encouraging as a management objective of commencing the ‘quota fishing year’ in March was to enable fishers to catch more of their quota during winter when prices are higher.

4.1.2 Research catch rates

A comparison of research and commercial catch rates for the start of the 2001/2002 season (Oct/Nov) was not available, as research sampling was not conducted for this period. Sampling was paused while a review of the catch sampling project was undertaken.

4.1.3 Legal - sized biomass

Table 2. Change in legal-sized biomass in October. Negative values indicate a decline in the percentage change. Shaded lines are regions with greater uncertainty in biomass estimates. “State (adj)” is statewide data excluding regions 1, 4, and 8 where biomass is estimated poorly for recent years (i.e. includes only areas 2,3,5,6 and 7).

Region	Reference	Sized biomass estimate (tonnes)			% change in 2001	
	Year	Ref. Year	2000	2001	vs Ref. year	vs 2000
Statewide	1993	2525	3597	3823	+51%	+6%
State (adj)	1993	1438	1895	2018	+40%	+6%
1	1993	250	443	516	+106%	+17%
2	1993	134	193	242	+81%	+26%
3	1994	74	107	137	+86%	+28%
4	1994	431	755	753	+75%	+0%
5	1993	682	912	959	+41%	+5%
6	1995	254	339	323	+27%	-5%
7	1994	294	344	357	+21%	+4%
8	1993	389	505	537	+38%	+6%

During 2001, the rock lobster assessment model indicates that there has been continued stock rebuilding (Table 2). The legal-sized biomass reflects the changes seen in commercial catch rates with the greatest improvements being on the East Coast, particularly Areas 2 and 3. This is encouraging, as this region of the fishery has historically been the most heavily exploited.

Area 6 is the only area that has shown a decline in biomass over the last year. This may be associated with the decreased catch rate resulting from a shift into inshore fishing than actual changes in biomass. In 2001, there was a substantial increase in fishing effort in shallow water (<50m) (Figure 4). As the catch rates are lower in shallower waters (Figure 5), the overall decline in catch rates and biomass in Area 6 may result from a change in distribution of effort rather than a change in abundance of lobsters. Although biomass has increased in all areas since the reference years of ’93, ’94 and ’95, biomass is still below the estimates for the early 1980s (Figure 6). This is most noticeable in the productive northern regions (Area’s 4 and 5).

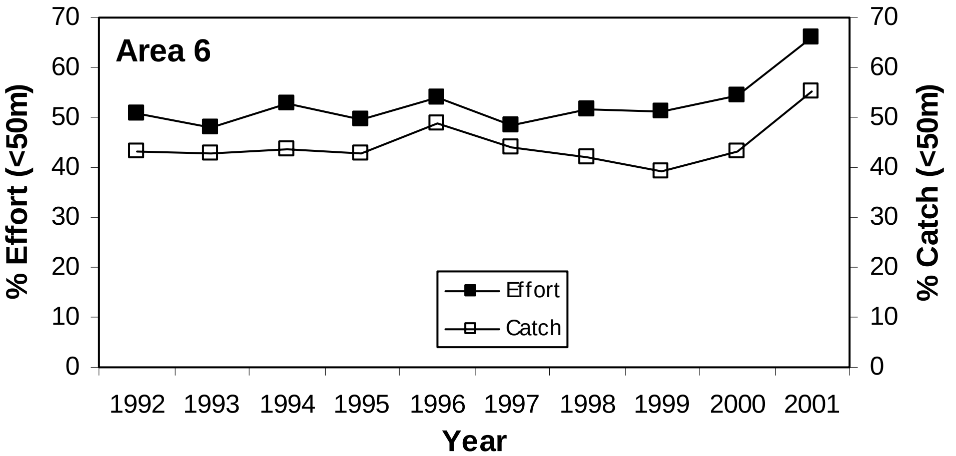


Figure 4. The percentage of effort and catch from shallow water grounds (<50m) from Area 6 for the last ten years.

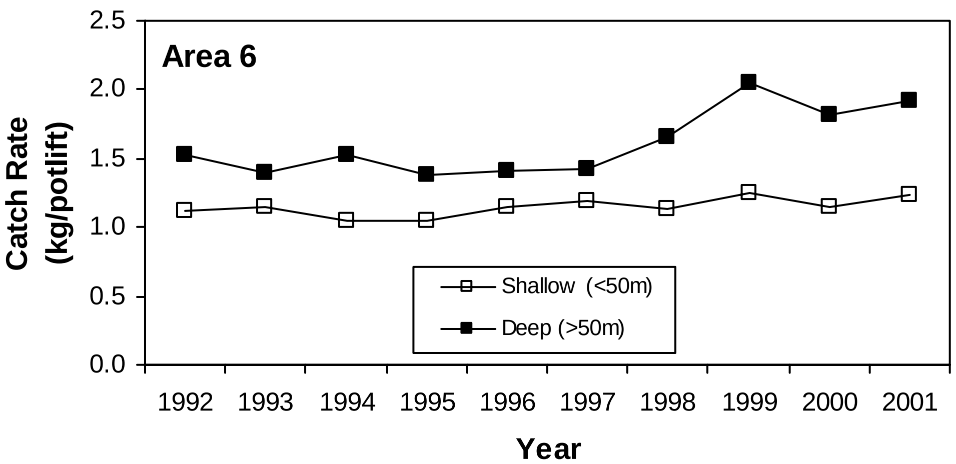


Figure 5. Comparison of catch rates from shallow (<50m) and deep (>50m) water from Area 6 for the last ten years.

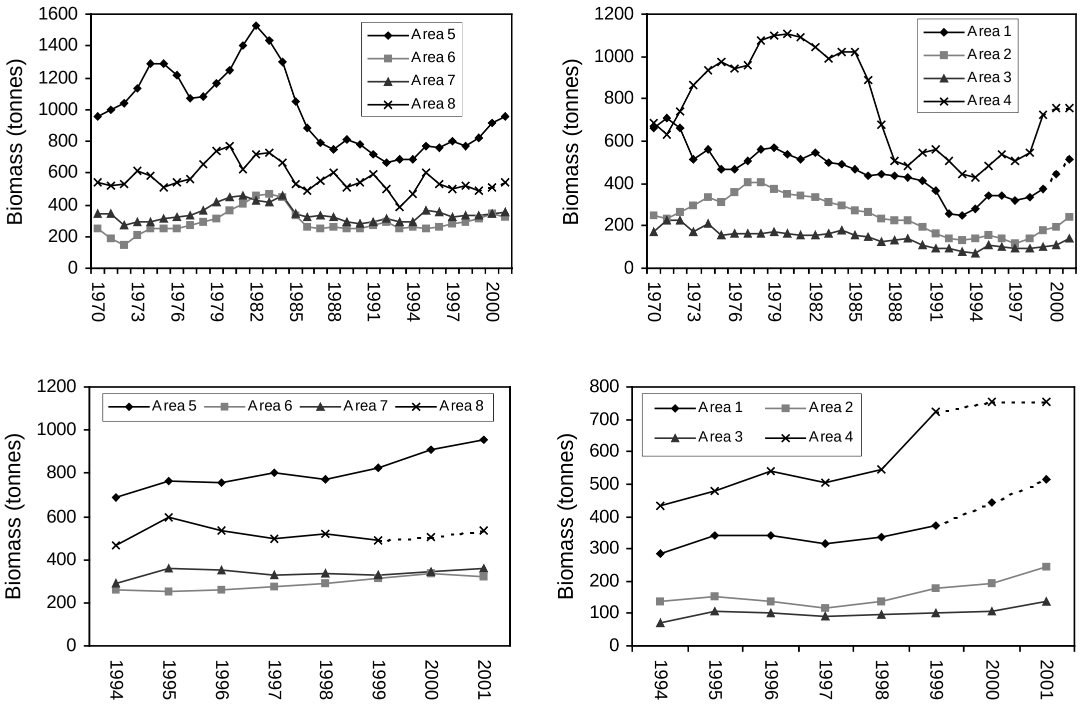


Figure 6. Regional legal-sized biomass estimates for the Tasmanian rock lobster fishery from (upper) 1970 to 2001 and (lower) from 1994 to 2001. All estimates are for October. Interannual changes, which are likely to be less accurate, are dashed.

4.1.4 Egg production

As expected from the increase in legal-sized biomass, egg production has increased in regions 3, 4 and 5 (Table 3, Figure 7 and Figure 8). Despite these increases, egg production is still below the management target of 25% of virgin production and further improvement is required. Area 6 has shown declines in egg production over the last two years. This is the only area that is currently below the recommended management value that is declining in egg production. Again, caution needs to be used in interpreting this results as changes independent of biomass are occurring in this region of the fishery and would be biasing model estimates. This bias in fleet dynamics is additional to the biases associated with model runs as highlighted by Gardner (2000). Because of these concerns, it is recommended that this be a high priority region for future catch sampling surveys.

Table 3. Change in relative egg production from the reference year to 2001, and the level of egg production in 2001 as a percentage of virgin egg production. Virgin egg production is the estimated egg production prior to commercial exploitation, assuming average recruitment is the same as that from 1970 to the present. Relative egg production is a numerical (linear) index of egg production so that a relative egg production of 200 implies twice as many eggs are being produced compared to a relative egg production of 100. Shaded lines are regions with greater uncertainty in egg production estimates. "State (adj)" is statewide data excluding region 6, where egg production is estimated poorly for recent years. Note: different reference years from previous assessments, due to change in size at onset of maturity parameters (see section 2.3.2).

Region	Reference Year	Relative Egg Production			% change in 2001		% Virgin prodn. in 2001
		Ref. Year	2000	2001	vs Ref. year	vs 2000	
Statewide	1993	936	1116	1133	+21%	+2%	30%
State (adj)	1993	868	1028	1055	+22%	+3%	30%
1	1995	158	148	147	-7%	-1%	60%
2	1992	69	93	100	+45%	+4%	36%
3	1993	27	43	55	+104%	+26%	14%
4	1993	78	141	144	+84%	+2%	16%
5	1992	78	131	141	+81%	+8%	13%
6	1986	51	88	78	+53%	-12%	19%
7	1989	134	138	134	+0%	-3%	45%
8	1994	300	331	335	+11%	+1%	114%

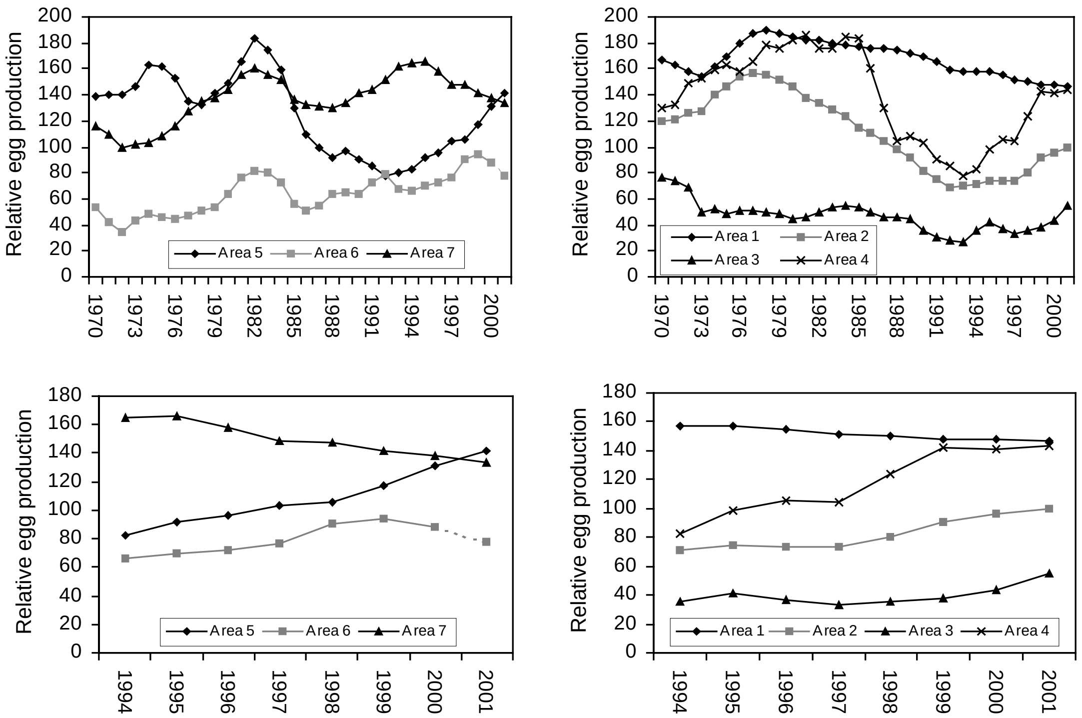


Figure 7. Relative egg production from 7 Areas around Tasmania, western regions to the left, eastern regions to the right. Area 8 is not included due to problems mentioned in the text. Interannual changes, which are likely to be less accurate, are dashed.

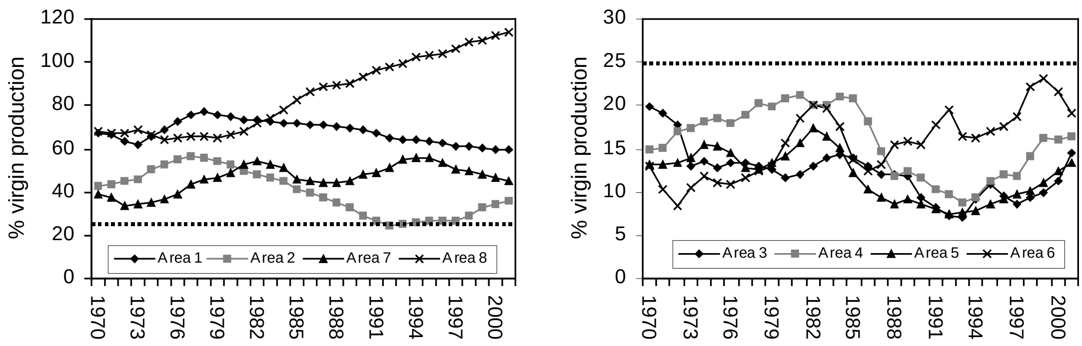


Figure 8. Percentage of virgin egg production from eight Areas around Tasmania, southern Areas to the left, northern Areas to the right. The horizontal bar in each plot represents the management target of 25%. The last year of the plot for Area 6 should be accepted cautiously.

4.1.5 Relative abundance of undersized lobster

Research estimates

East Coast

Fishery independent potting surveys have been conducted around Maria Island on the East coast from 1992 to 2000. During this period there has also been a series of dive surveys inside and outside the Maria Island Marine Reserve (see Chapter 17). The dive surveys aggregated lobsters of both sexes into two smaller size groupings: 35-87mmCL and 88-112mmCL. The latter grouping includes a small number of legal sized males and females.

Both survey methods show considerable variation in the abundance of undersized lobsters during the last nine years (Figure 9). For the smallest size groupings both survey methods found peaks in abundance in 1993 and/or 1994 and in 1997 and/or 1998 and 1999. While the diving data suggest progression of the peaks between the different size groupings this is not the case for the potting data. This is not surprising, as the selectivity of the research fishing pots would result in the majority of the 35-87mmCL size groupings being just under the 87mmCL size. This would also explain why there was a start to the 1997-1999 peak in 1997 in the diving data. The 1997 lobsters would be the smaller lobsters that are unavailable to pots. By 1998 these lobster would have grown to approximately 70mmCL where they would be reflected in the potting data. The 1997-1999 peak in abundance of juveniles is considered to have resulted from the peak puerulus index recorded at Bicheno in 1995 (see Section 6.1.2).

Surprisingly the potting data from the smaller size class provides the best fit to the commercial catch data from the same region. The 1993/1994 peak in the 35-87mmCL data appears as an improvement in the catch in 1995/1996 suggesting a two year delay. Similarly the improvement in the number of small lobsters from 1996 to 1999 is reflected in the improved catches from 1998 to 2001.

Previous assessment reports compared lobsters that were approximately one growth increment undersized and found no relationship between these pre-recruits and either recruited lobsters or the commercial catch rate on the East Coast. As such, no performance indicator for undersized lobster had been established for this region. The relationship between the smaller size class holds promise for establishing a performance indicator as well as a predictive tool. However, a longer time index is required. More work is planned in modelling this data over the next year.

South Coast

As no catch sampling was undertaken in November 2001, comparisons with reference years in November for the South Coast could not be achieved. Sampling was undertaken in March of 2001, so this month has been evaluated as an alternative. Catch rates of legal sized lobsters derived from research and commercial pots for March are similar until the introduction of quota in 1998 (Figure 10). The difference in the magnitude of the improvement in catch rates between commercial and research pots for March 1999 and 2001 is uncertain. March research catch rates for pre-recruits and legal sized lobsters mirror each other suggesting that these changes reflect changes in catchability, rather than changes in recruitment to the fishery (Figure 11).

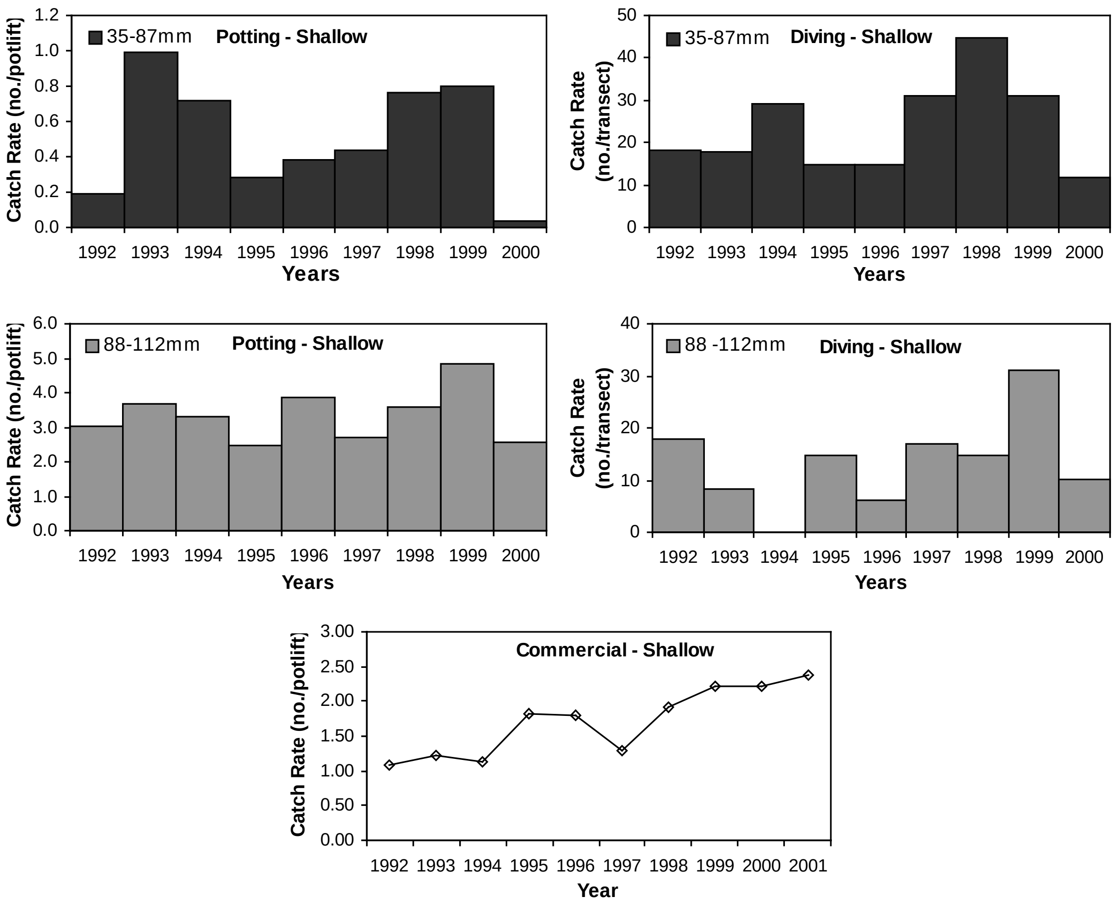


Figure 9. The undersized component broken into two size classes (35-87mm and 88-112mm) determined separately by potting and diving. Also included is the commercial catch rate. All are for shallow water (<20m) from Block 6G4 (inside of Maria Island – East Coast).

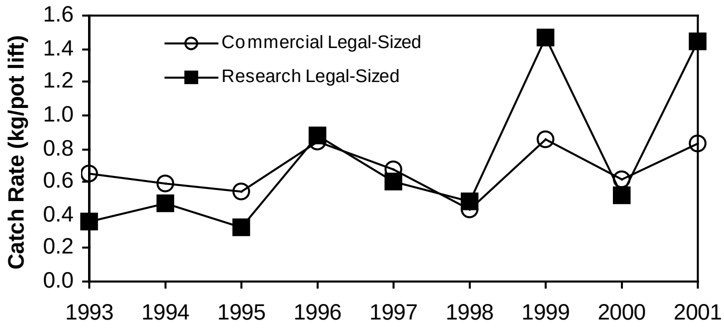


Figure 10. Catch rates of legal sized lobsters caught from research surveys and commercial fishing during March for medium to deep water (45-100m) on the south coast of Tasmania.

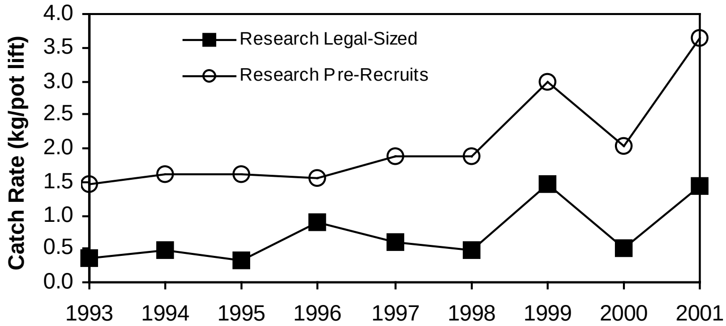


Figure 11. Catch rates of legal sized lobsters and pre-recruit lobsters (males between 106 and 110mm CL) caught from research surveys during March for medium to deep water (45-100m) on the south coast of Tasmania.

4.1.6 The total annual catch

The total annual commercial catch (TACC) is constrained by output controls on the fishery. A TACC of 1500 tonnes was introduced for the first time in March 1998. This was increased to 1523 tonnes in March 2002. A management trigger is set at a catch of 95% or less of this amount (2001/2002=1425 tonnes). The total catch for the period March 2001 to February 2002 (inclusive) was 1498 tonnes, which is greater than the trigger. Several fishers have reported that they retained a small amount of quota unfished, as it was not economically viable to return to sea for this small catch. This implies the TACC shortfall is not a function of lobster abundance.

4.1.7 The size of the rock lobster fleet

As noted in previous assessment reports, the introduction of quota resulted in an immediate decrease in the number of active vessels and licences, as several licences were aggregated on to a single vessel (Table 4). Since this redistribution, changes have been minimal with the same number of active vessels participating in 2002 as there were in 2001.

Table 4. Changes in the number of licences and vessels in the Tasmanian rock lobster fishery in calendar years from 1993 to 2002. Licenses cannot be created so the 2001 value cannot change although it is based on partial year data. Active licenses are those that recorded catch. It is possible that the number of active licenses in 2002 is an underestimate as it is based on partial year data.

Year	Number of licences	% change	Number of active licenses	% change	Number of active Vessels	% change
1993	337	-	330	-	353	-
1994	334	-0.9	329	-0.3	342	-3
1995	331	-0.9	326	-0.9	348	2
1996	321	-3.0	315	-3.4	332	-5
1997	316	-1.5	309	-1.9	330	-1
1998	314	-0.6	304	-1.6	314	-5
1999	314	0	269	-11.5	270	-14
2000	314	0	259	-3.7	254	-6
2001	314	0	253	-2.4	246	-3
2002	314	0	250	-1.2	246	0

4.1.8 The recreational catch

During the 2000/01 recreational rock lobster fishing season, a telephone/diary survey of recreational rock lobster licence-holders was undertaken (Forward and Lyle, 2002). This survey was conducted partly in response to the steady increase in recreational licences issued over the last seven fishing seasons (Figure 12).

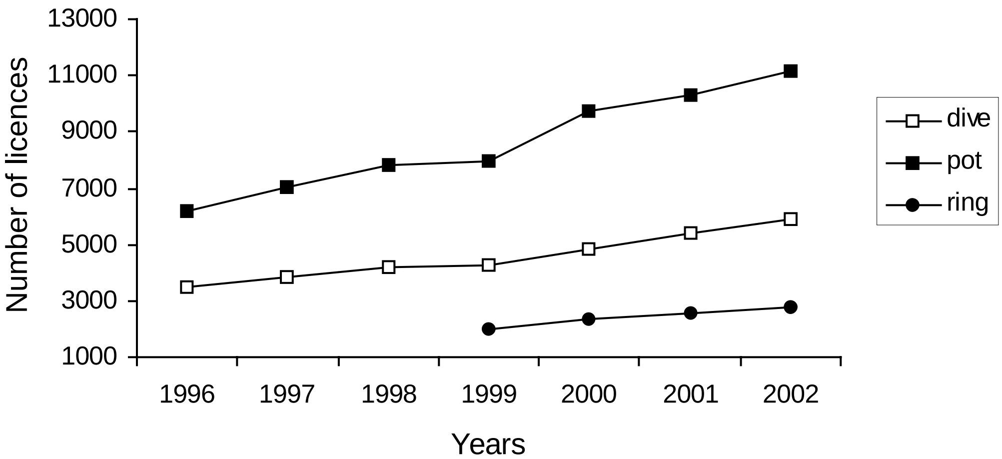


Figure 12. Number of recreational pot, dive and ring licences issued from 1996 to 2002.

Since the introduction of the present licensing system in 1995, there has been a 67% increase in the number of rock lobster licence-holders (Figure 13). Fishers are able to hold up to three rock lobster licences, i.e. rock lobster pot, rock lobster dive and rock lobster ring (introduced in 1999), with the total number of licences issued increasing by 108% since 1995 (Figure 13).

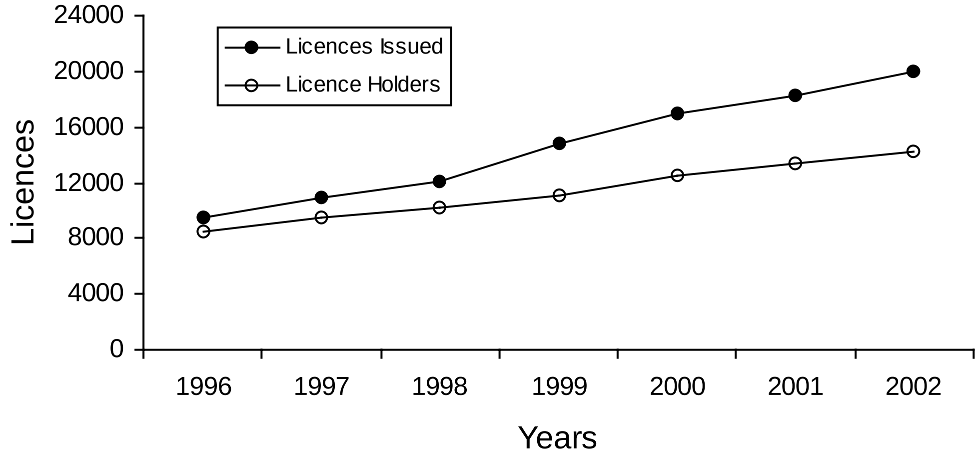


Figure 13. Comparison between the total number of recreational rock lobster licences issued (pots, dive and rings; solid circles) and the number of licence holders (open circles) from 1996 to 2002.

The escalation in licences has caused concern for both recreational and commercial fishers. Although biomass and catch rates are increasing in each stock assessment area, there is concern that this maybe restricted to the offshore fishing regions and that the combined commercial and recreational effort in inshore water maybe resulting in declines in this region. Fishery independent appraisals of inshore fishing waters are planned to commence in 2004. These surveys will target Area 1 where the recreational catch for the 2000/01 season was only slightly lower than the commercial, accounting for 45% of the total inshore catch (Forward and Lyle, 2002).

4.2 Trends in Commercial Catch Rate Data

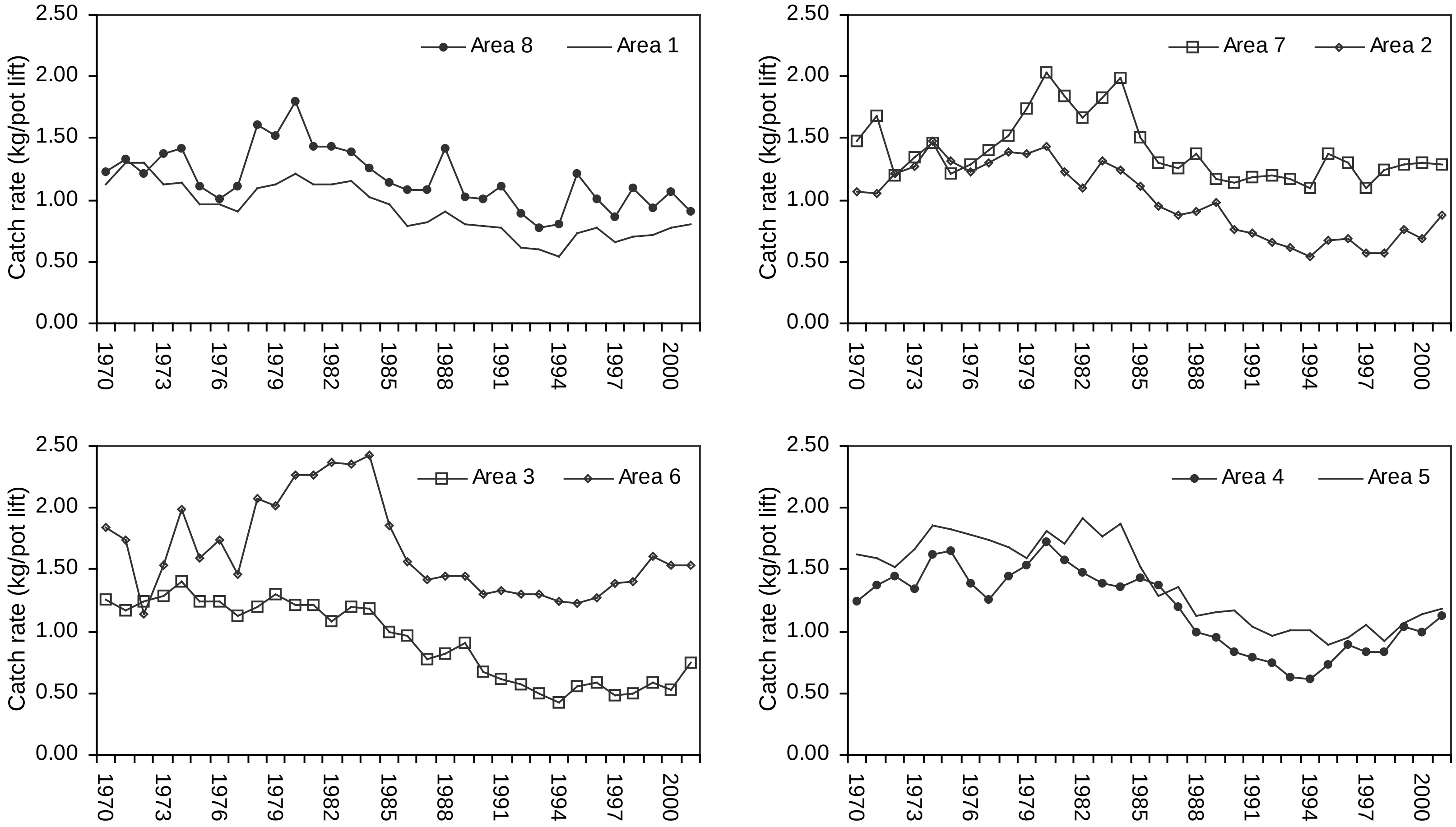


Figure 14. Regional catch rates from southern and northern Tasmania since 1970. Data is presented on a quota year basis (i.e. March to February) so the last data point is for March 2001 to February 2002 inclusive.

Table 5. Comparison of highest and lowest commercial catch rates (kg/pot lift) regionally around Tasmania from 1970. Comparisons are between years on a quota year basis (i.e. March to February). Included is the regional catch (kg) for the 2001/02 season.

Area	Highest Catch Rate		Lowest Catch Rate		% Difference in Catch Rate	2001/02 Catch Rate	% Difference 2000/01 to 2001/02	Catch 2001/02 (t)
	Year	Catch Rate	Year	Catch Rate				
All	1981/82	1.66	1995/96	0.82	+51%	1.05	+2%	1498
1	1971/72	1.30	1994/95	0.54	+58%	0.81	+4%	125
2	1974/75	1.47	1994/95	0.54	+63%	0.87	+26%	110
3	1974/75	1.40	1994/95	0.43	+69%	0.74	+42%	87
4	1980/81	1.72	1994/95	0.61	+65%	1.13	+13%	256
5	1982/83	1.92	1995/96	0.89	+54%	1.18	+4%	328
6	1984/85	2.43	1972/73	1.14	+53%	1.54	0%	193
7	1980/81	2.03	1997/98	1.09	+46%	1.29	-1%	119
8	1980/81	1.80	1993/94	0.77	+57%	0.90	-15%	281

The commercial catch rates presented in Figure 14 and Table 5 are based on a quota year (i.e. March to February), where as the catch rates presented in Table 1 as based on a calendar year (i.e. January to December). This 3-month shift in the catch rate analysis has resulted in larger percentage increases in catch rates in eastern regions of the fishery (Area's 2,3 and 4) and larger decreases in southern regions (Area's 1 and 8). This would suggest that the improved catches in eastern regions noted in Section 4.1.1, are likely to continue into 2002. The decline in southern regions suggests that catch rates in southern regions are expected to continue to decline. This is of particular concern in Area 8 as this area contributes substantially to the overall Tasmanian catch (see Figure 58, Section 23.3). Further investigations of the fishery dynamics in this Area is warranted to determine the impact of the September opening and the distribution of fishing effort (eg. summer to winter and deep to shallow).

4.3 Trends in fisheries independent abundance indices

South Coast

As noted in previous Stock Assessment reports the pre-season research (November) catch rates followed similar trends to the commercial catch rates in November of the same year from 1992 to 1996. From 1996, the trend is weaker with an opposing trend seen in 1997, a weaker trend in the research catch rates in 1998 and stronger trends in the research catch rates in 1999 and 2000 (Figure 15). The exploitation rate estimates obtained since the introduction of quota (see Section 3.2.4 – FRDC Report) indicate that the opening of the September fishery is impacting on the November catch rates of the following season. In contrast, the trends in catch rates in March appear to reflect trends in the commercial catch rates. The lack of a relationship between the trends on commercial and research catch rates in July is not surprising. A recent study (see Section 3.2.4) found fishers exploitation rates to be lower than fishery independent estimates. Fishery independent estimates undertake their July surveys in regions identical to the pre-season and March surveys where as fishers shift to other regions to improve catch rates.

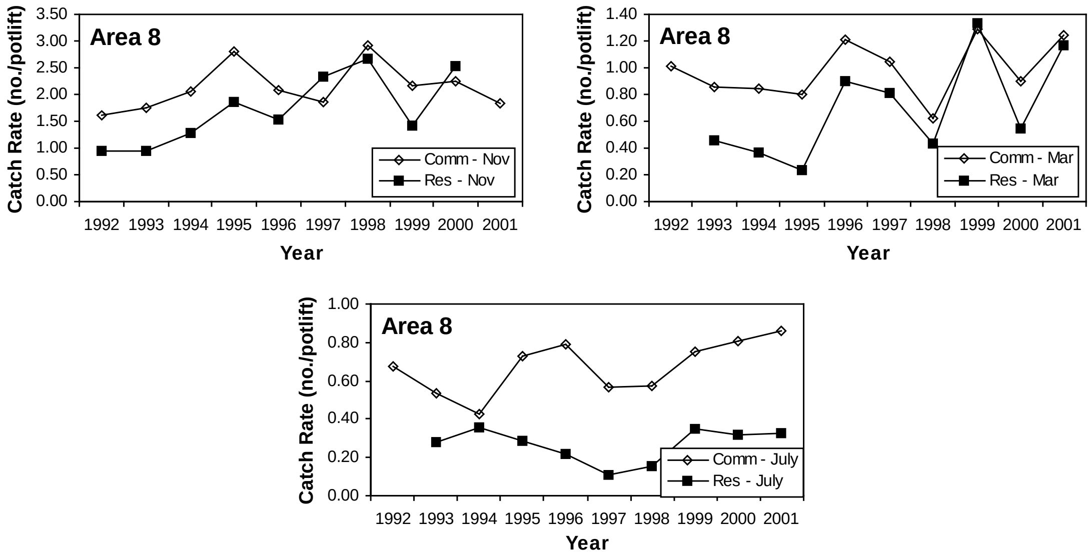


Figure 15. Comparison of commercial and research catch rates (number/potlifts) derived from Stock Assessment Area 8 for November, March and July for the last ten years. Note research catch rates for March and July 1992 and November 2001 where not available as no sampling occurred.

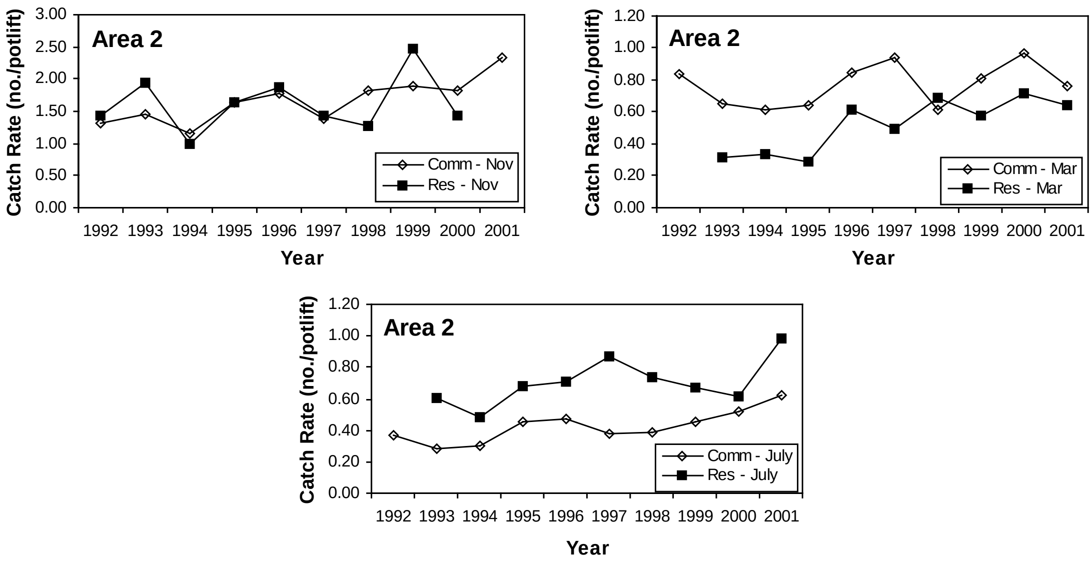


Figure 16. Comparison of commercial and research catch rates (number/potlifts) derived from Stock Assessment Area 2 for November, March and July for the last ten years. Note research catch rates for March and July 1992 and November 2001 where not available as no sampling occurred.

East Coast

There was a relatively close relationship between commercial and research catch rates on the East Coast in November until 1998, the first year of the introduction of ITQMS (Figure 16). Since 1998, trends in research catch rates do not reflect commercial catch rates. The reason for this is currently unknown. Commercial catch rate trends for

March and July do not reflect the trend in research catch rates. In March, the long-term trend appears relatively flat whereas the research catch rates demonstrate an increasing trend since 1995. Since 1997, the commercial catch rates in July have steadily increased where as the research catch rates have declined with the exception of last year in 2001.

4.4 Other analyses including risk assessments

Projections of future biomass and virgin egg production were conducted using one hundred simulations with averages of these simulations shown here. Estimates of error around these averages are estimated by the variation in these different simulations.

Various projection scenarios were tested, to explore the effects of increasing the TACC while still maintaining reasonable probability of stock rebuilding. Scenarios were based on round number increases to the per-pot quota holding (with a total of 10507 pots in Tasmania).

The scenarios tested were:

- TACC of 1471 tonnes (140kg/pot);
- TACC of 1500 tonnes (142.7kg/pot);
- the status-quo of 1523 tonnes (145 kg/pot);
- TACC of 1550 tonnes (147.5 kg/pot);
- TACC of 1576 tonnes (150 kg/pot)

The effects of each scenario on both egg production and legal sized biomass are presented. Note that egg production and legal sized biomass can vary independently of each other as a large proportion of egg production is contributed by undersize females. Furthermore, in some regions females never reach legal size.

4.4.1 Biomass

Legal-sized biomass projections for the next four years show an initial increase in TACC for all scenarios to 2003 prior to a small decline in all scenarios for 2004 and 2005. The variance around the 2004 and 2005 figures is large indicating that there is greater uncertainty in these predictions. Although predicted biomass estimates have declined in 2005, the estimates for the status quo simulation of 1523 tonnes is above the current 2002 estimate. The degree of uncertainty in the 2005 estimates indicates that there is limited value in projections this far ahead. Only projections to 2004 are considered in the following analyses.

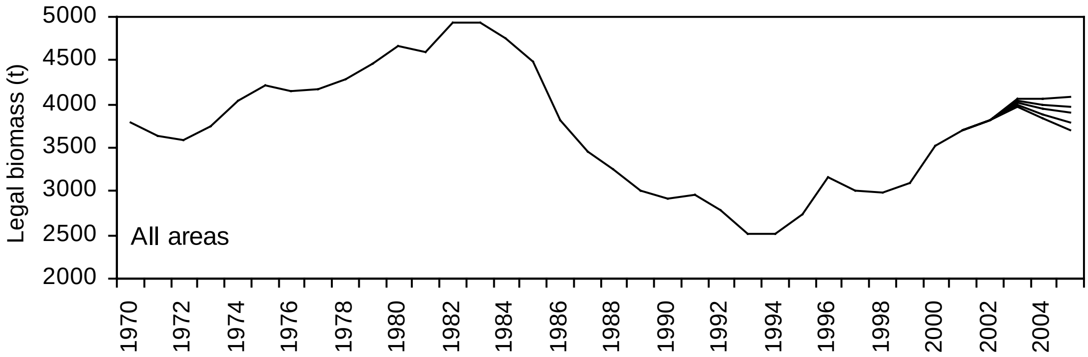


Figure 17. Statewide legal-sized biomass estimates from November 1970 to November 2001 with averaged trajectories to 2005 of biomass for TACCs of 1471 (upper line), 1500 (second upper line), 1523 (middle line), 1550 (second lower line) and 1576 (lower line). Biomass estimates are for the month of March.

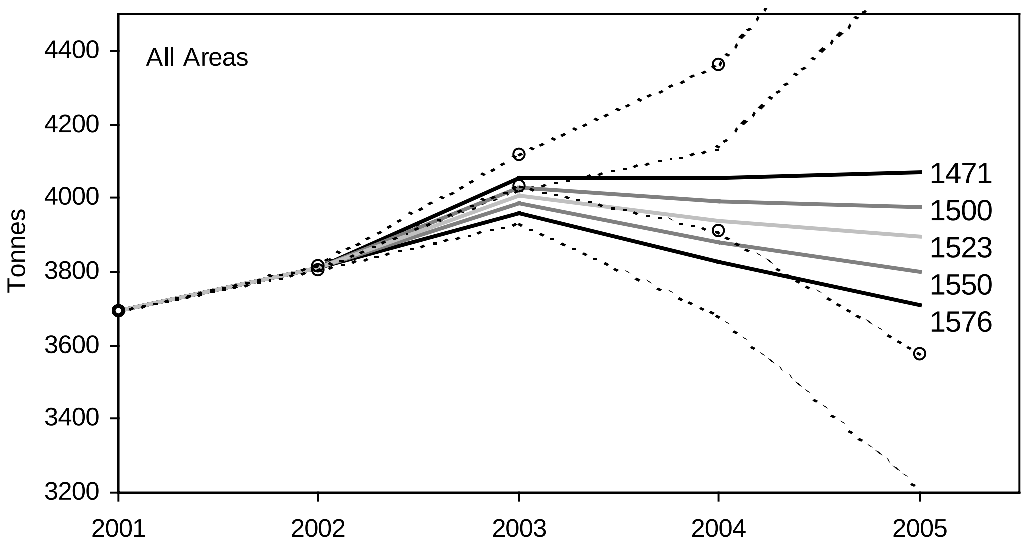


Figure 18. Statewide legal sized biomass projections showing the same data presented in the previous graph (Figure 17) but focused on projections for the next 4 years. Biomass estimates are for March. Maximum and minimum ranges of the 100 simulations are shown for the 1471 and 1576 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

Gardner (2000) found model estimates to have a greater bias in southern regions. Excluding these regions (Figure 19 and Figure 20), the trends appear similar, although the decline in biomass in 2004 is greater. The status quo estimate of biomass for the TACC of 1523 is approximately the same as the 2002 estimate. In contrast, the increase in biomass for the northern regions (Areas 4 and 5) (Figure 21 and Figure 22) is substantially greater than for all regions combined or for region 2-7 combined. The status quo estimate is greater than the 2002 estimate.

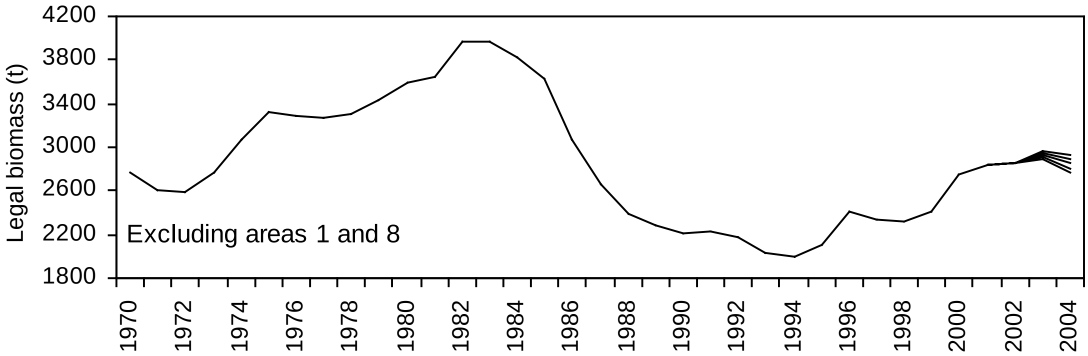


Figure 19. Legal-sized biomass estimates from November 1970 to November 2001 with averaged trajectories to 2004 of biomass for TACCs of 1471 (upper line), 1500 (second upper line), 1523 (middle line), 1550 (second lower line) and 1576 (lower line) for areas 2 to 7 (that is, with areas 1 and 8 excluded). Biomass estimates are for the month of March. Biomass projections from Areas 1 and 8 are typically most positively biased.

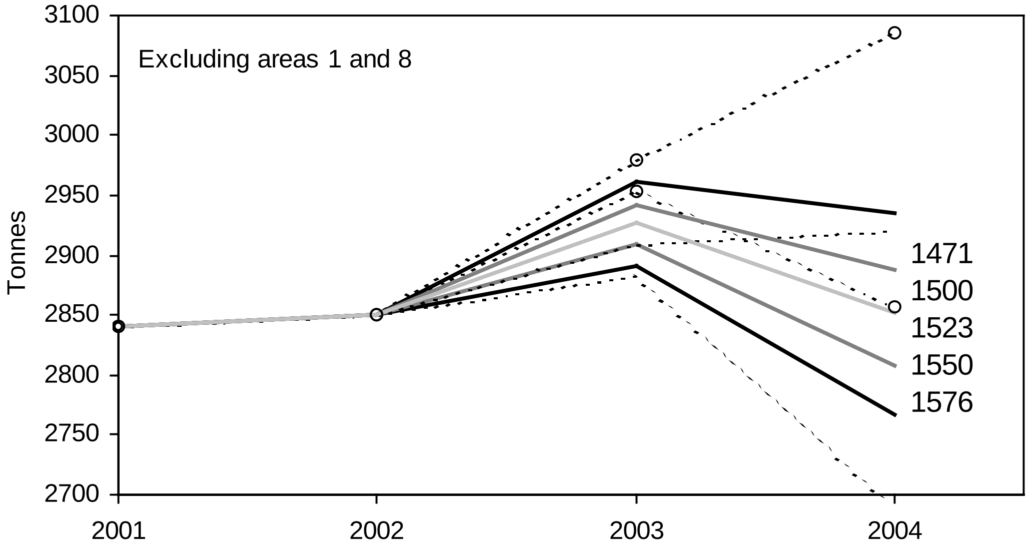


Figure 20. Legal sized biomass projections with areas 1 and 8 excluded showing the same data presented in the previous graph (Figure 19) but focused on projections for the next 3 years. Biomass estimates are for March. Maximum and minimum ranges of the 100 simulations are shown for the 1471 and 1576 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

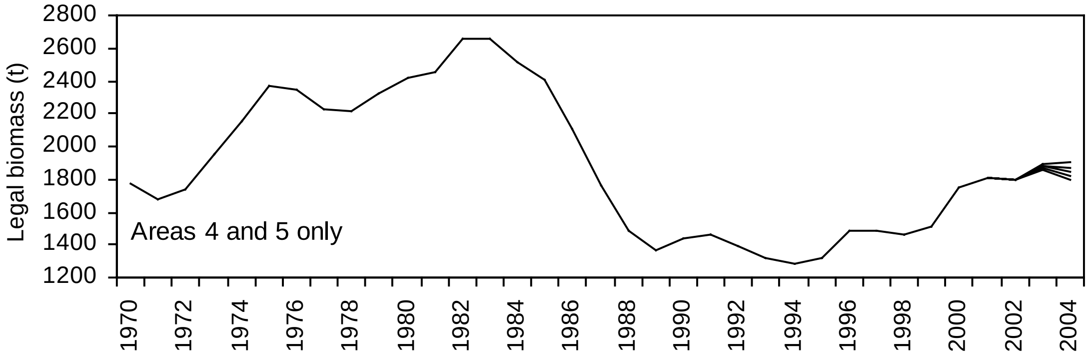


Figure 21. Legal-sized biomass estimates from November 1970 to November 2001 with averaged trajectories to 2004 of biomass for TACCs of 1471 (upper line), 1500 (second upper line), 1523 (middle line), 1550 (second lower line) and 1576 (lower line) for Areas 4 and 5 only (Northern areas). Biomass estimates are for the month of March. Biomass projections from Areas 4 and 5 are typically least biased.

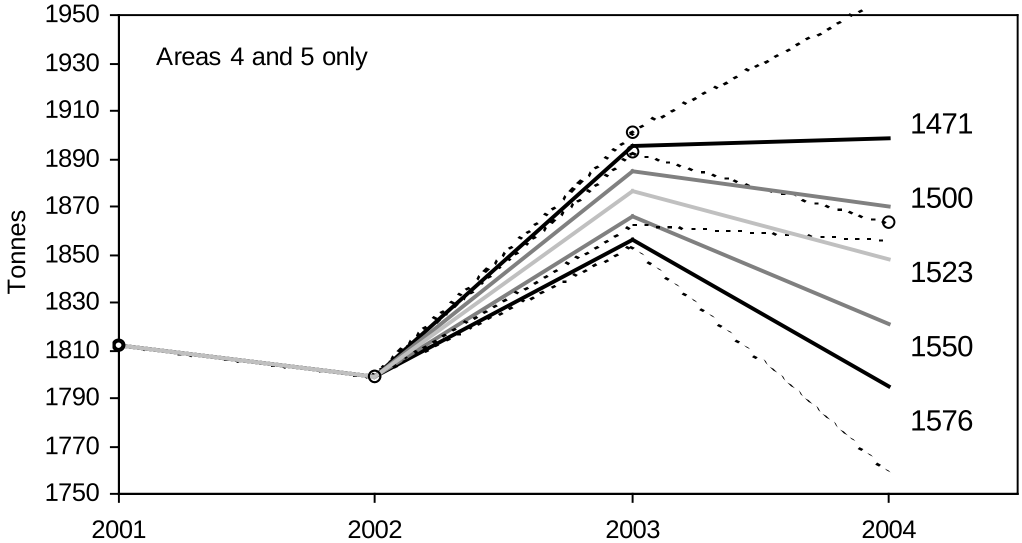


Figure 22. Legal sized biomass projections for areas 4 and 5 only showing the same data presented in the previous graph (Figure 21) but focused on projections for the next 3 years. Biomass estimates are for March. Maximum and minimum ranges of the 100 simulations are shown for the 1471 and 1576 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

Regional predictions of biomass (Figure 23) suggest an increasing biomass in Areas 1,2,3,4,5 and 8 for 2003 and a decline in biomass in Areas 6 and 7. In the following year biomass is still expected to increase in Areas 1 and 3, remain steady in 2 ad 4 and decline in 5-8. Caution is required for the 2004 estimates as they rely on average recruitment to the fishery and have wide confidence limits. Although the catch and effort data do not suggest that there has been a large shift in effort inshore, fishers state that this is happening (see Section 3.2.4 – ITQ Report). Fishers also state that this trend is most apparent on the West Coast and thus more likely to affect Areas 6 and 7. In Figure 4 we noted a shift in effort to shallow water and last years stock assessment report (Gardner *et al*., 2002) noted an increase in winter fishing. Both these trends would result in lower catch rates independent of biomass. The assessment model uses catch rates as a 'defacto' measure of biomass and thus the decline in Areas 6 and 7 may reflect fisher behaviour rather than biomass decline. Fishery independent sampling will commence in Area 6 in 2003 to elucidate these trends.

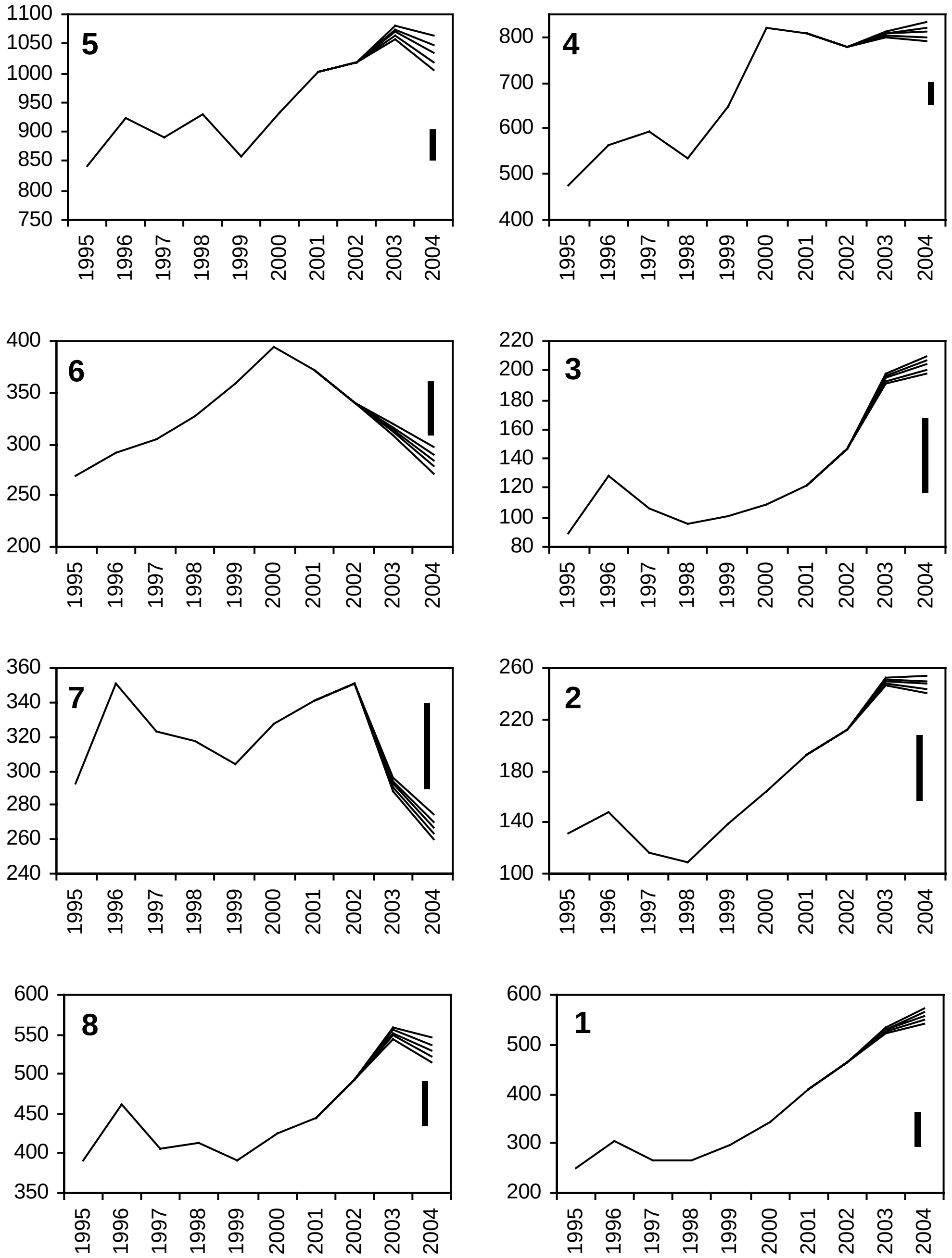


Figure 23 Mean legal-sized biomass projections for TACCs of 1471 (upper line), 1500 (second top line), 1523 (middle line), 1550 (second lower line) and 1576 (lower line) for each stock assessment area. Each plot is scaled differently to enable the different projection scenarios to be distinguished. A scale bar is included in each figure equivalent to 50 tonnes to facilitate comparison between areas.

4.4.2 Egg Production

Statewide egg production is predicted to be relatively stable with a possible decline of between 1 & 2% (Figure 24 and Figure 25). The uncertainty around these average estimates implies that there is no predictable increase or decrease in egg production. Similarly, the northern areas, where there is greater certainty with the model outputs, demonstrate no predictable trend (Figure 26 and Figure 27). Uncertainties associated with fisher behaviour that were mentioned for regional biomass trends are also expected to bias regional egg production estimates (Figure 28).

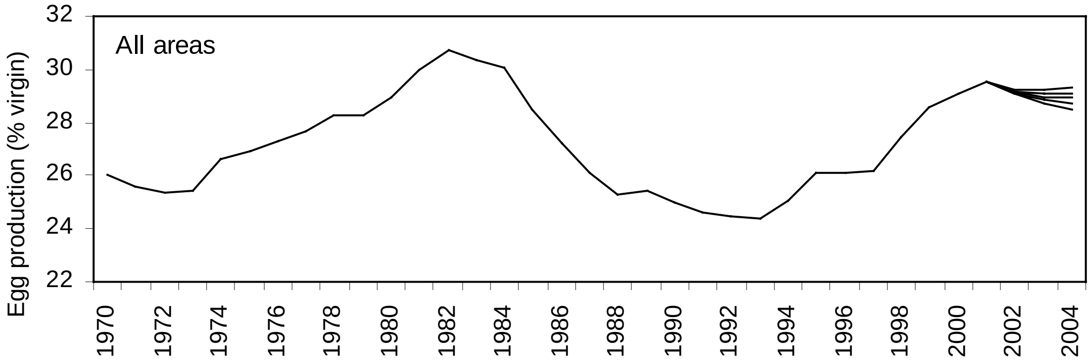


Figure 24. Averaged statewide egg production relative to virgin under 5 TACC scenarios: 1471 (upper line), 1500 (second upper line), 1523 (middle line), 1550 (second lower line) and 1576 (lower line). All trajectories are the average of 100 simulations.

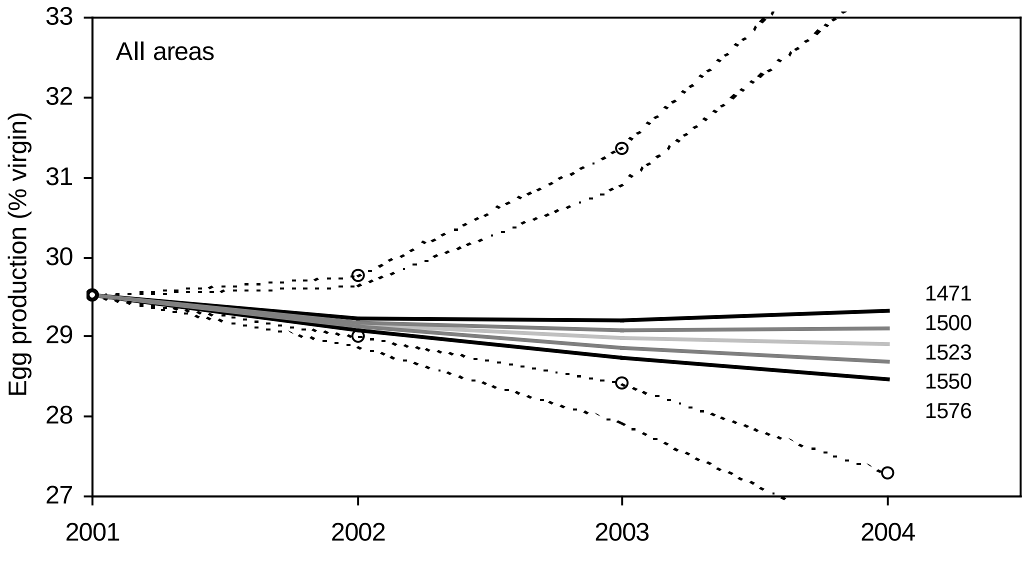


Figure 25. Statewide egg production projections (as % of virgin) showing the same data presented in the previous graph (Figure 24) but focused on projections for the next 3 years. Maximum and minimum ranges of the 100 simulations are shown for the 1471 and 1576 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

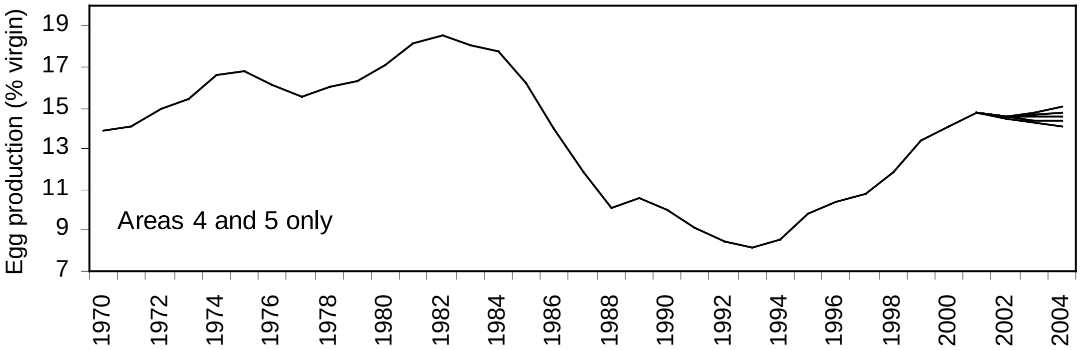


Figure 26. Mean relative egg production in the north of the state (Areas 4 and 5) under 5 TACC scenarios: 1471 (upper line), 1500 (second upper line), 1523 (middle line), 1550 (second lower line) and 1576 (lower line). Means are drawn from 100 simulations.

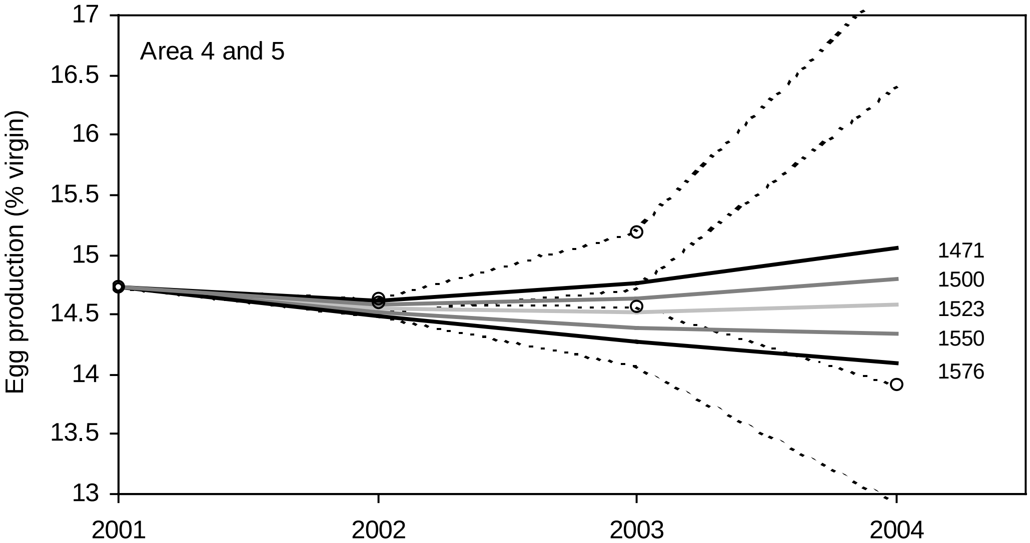


Figure 27. Egg production projections (as % of virgin) from areas 4 and 5 combined showing the same data presented in the previous graph (Figure 26) but focused on projections for the next 3 years. Maximum and minimum ranges of the 100 simulations are shown for the 1471 and 1576 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

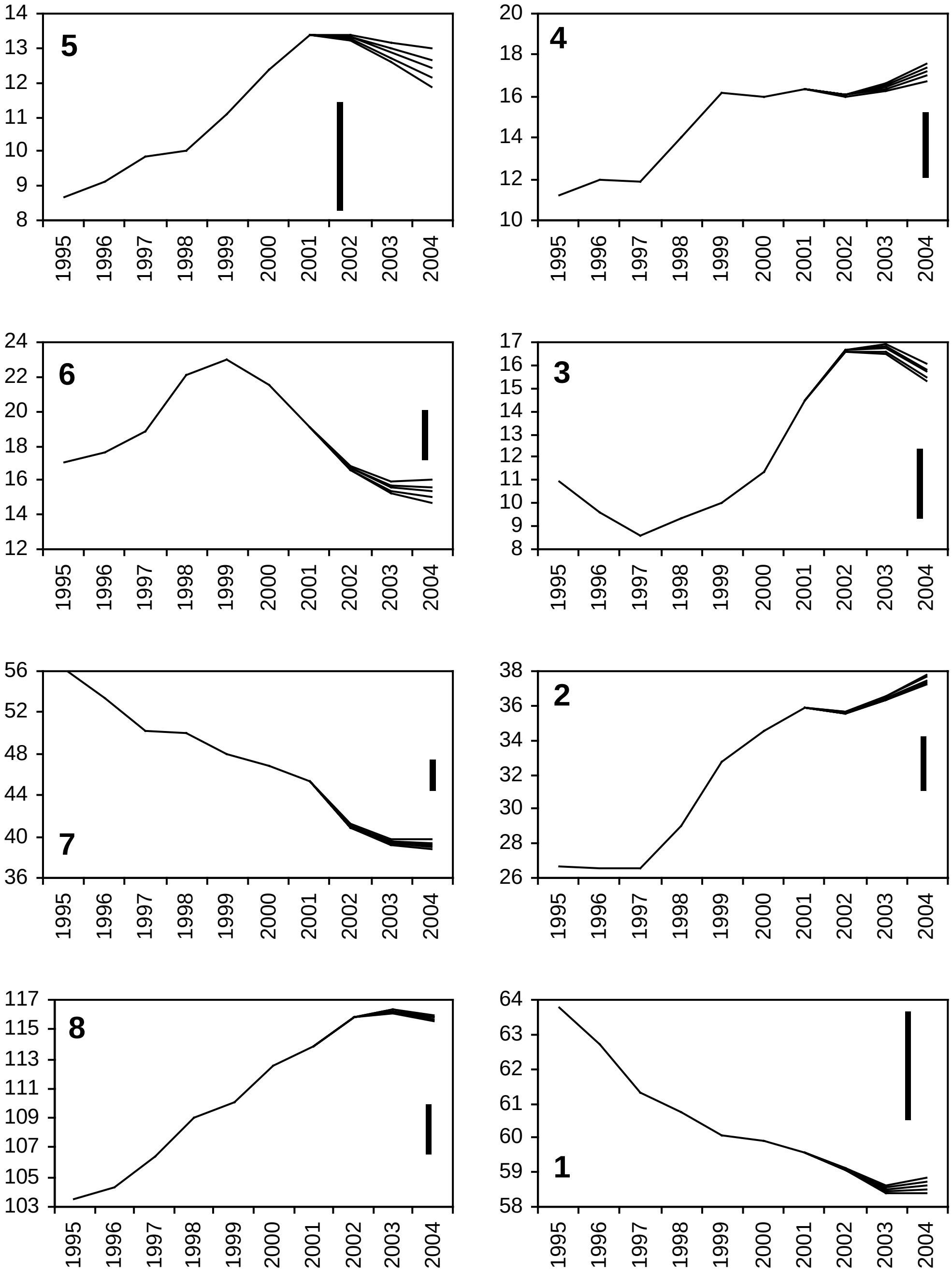


Figure 28. Mean virgin egg production in each of the stock assessment areas under 5 TACC scenarios: 1471 (upper line), 1500 (second upper line), 1523 (medium line), 1550 (second lower line), and 1576 (lower line). Means are drawn from 100 simulations. Note that each plot is on a different scale. A scale bar equivalent to 3% change in egg production relative to virgin is included in each plot to facilitate comparison.

5. Recreation Fishery

Obtained from Forward and Lyle, 2002.

5.1 Effort, harvest and harvest rates

Monthly estimates of recreational pot and dive effort (number of days fished), harvest and harvest rates for the 2000/01 season are presented in Figure 29. Pot effort was concentrated between November and January, with greatest activity during January, and then fell sharply in February. Dive effort was also highest in January, though showed only a moderate decline in February. Effort for both methods remained relatively stable between February and April, declined in May and was maintained at relatively low levels through to the end of the season.

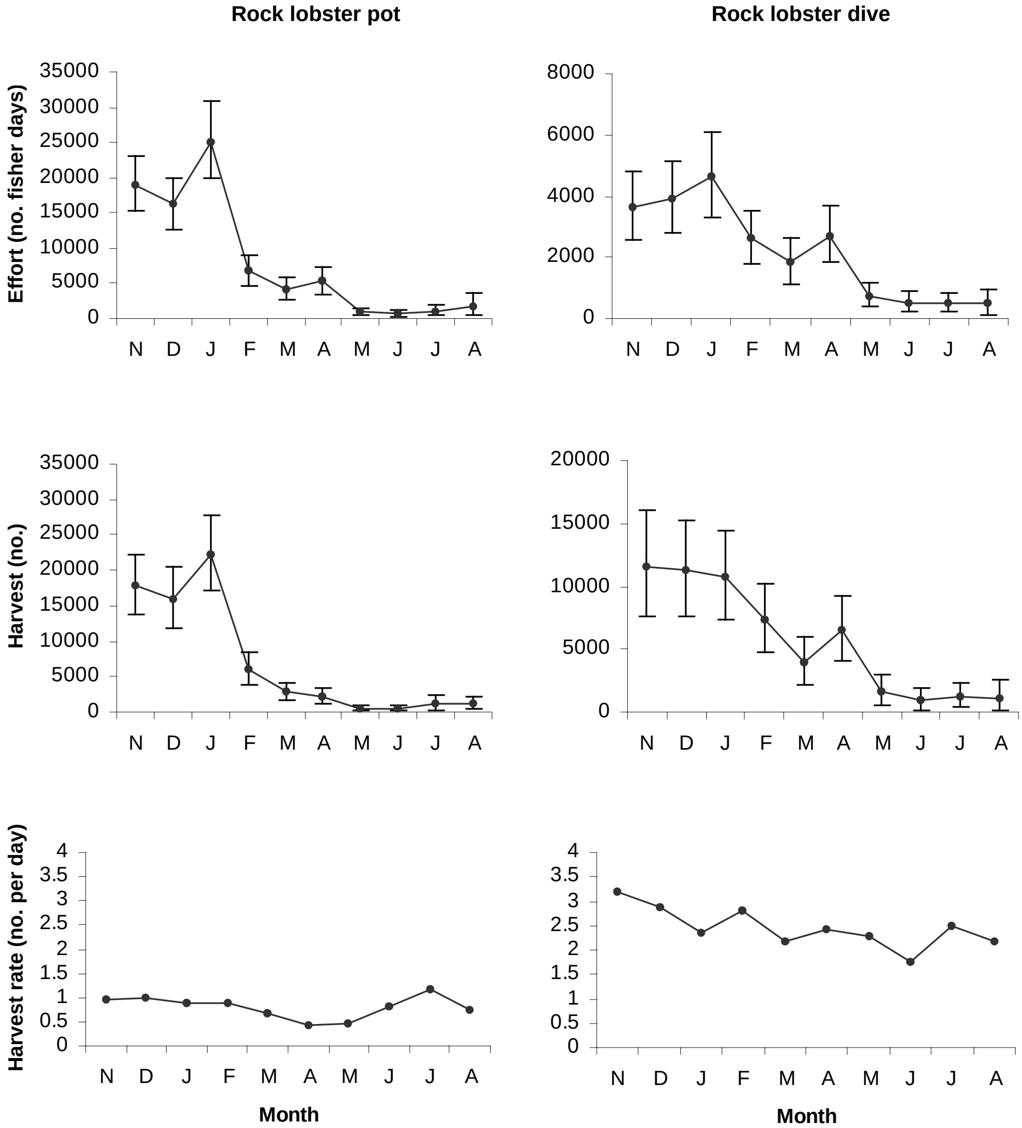


Figure 29. Monthly estimates (with 95% confidence limits) of rock lobster effort (days fished) and harvest (numbers), and mean harvest rates (lobsters per day) for pot and dive methods for the 2000/01 recreational rock lobster season. (Note, the Y-axis differs between the two fishing methods for effort and harvest).

Almost 80% of the total rock lobster pot harvest (about 55,900 rock lobster) and 60% of the dive harvest (about 33,600 lobster) was accounted for during the first three months of the season. By the end of April, 95% of the pot and 91% of the dive harvest was taken.

Harvest rates for pots were relatively stable between November and January, at around 0.9 rock lobster per pot day whereas dive harvest rates declined from about 3.1 to 2.3 lobster per day. Between February and April pot harvest rates then declined to just 0.5 but rose slightly in subsequent months, though this apparent 'recovery' was based on very limited data. Dive harvest rates generally declined as the season progressed but remained consistently 2 to 3 times higher than harvest rates for pots.

5.2 Effort and harvest per fisher

On average, diary respondents targeted rock lobster using pots for 10.2 days during 2000/01 and harvested a total of 8.9 lobster for the season (Table 6). The average daily harvest rate for pots was 0.9 rock lobster. By contrast, respondents using dive methods averaged fewer fishing days (5.8 days), but harvested nearly twice as many rock lobster for the season (15.3 lobster). The average daily harvest rate for dive methods was 2.6 lobster.

A number of dive collection methods were reported by diary respondents, namely, snorkel, scuba and surface air supply (hookah). Scuba diving was the most frequently used method (45% of reported dive events), followed by surface air (41%) and snorkel (14%). About 30% of respondents who reported dive activity used more than one dive method during the season.

Table 6. Mean effort, harvest and harvest rates for rock lobster pot and diving methods by diarists during the 2000/01 season.

	Rock lobster pot	Rock lobster dive
No. reported events	2145	565
No. fishers	211	97
Mean days fished	10.2	5.8
Mean harvest	8.9	15.3
Mean harvest per day	0.9	2.6

5.3 Daily harvest

The distribution of daily harvests during the 2000/01 season differed substantially between rock lobster pot and dive methods (Figure 30). Just 50% of pot days fished resulted in a retained catch of at least one rock lobster, compared to 80% for dive. The daily bag limit of five rock lobster was attained or exceeded in only a very small proportion (1.6%) of days fished with pots and contrasted the situation for dive capture, where at least five lobster were retained in over one quarter (27%) of the days dived for rock lobster.

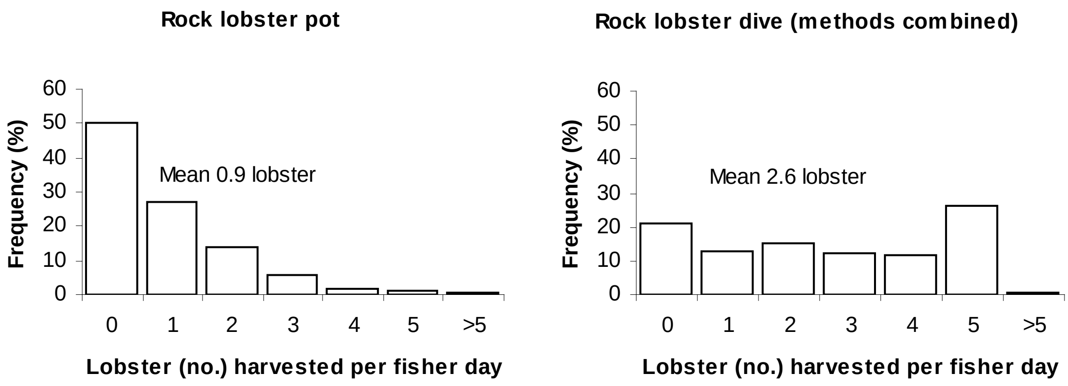


Figure 30. Distribution of rock lobster pot and dive harvest per fisher day by 2000/01 recreational rock lobster licence holders.

Amongst the dive methods, surface air was the most effective method, with one or more rock lobster harvested on 87% of dive days, compared with 77% for snorkel and 72% for scuba (Figure 31). The proportion of days on which the daily bag limit was achieved (or exceeded) was also higher for surface air (38% of days fished), than for either scuba (20%) or snorkel (18%) methods. Overall, mean harvest rates for divers using surface air were 3.3 lobster per day and compared to 2.2 for scuba and snorkel methods.

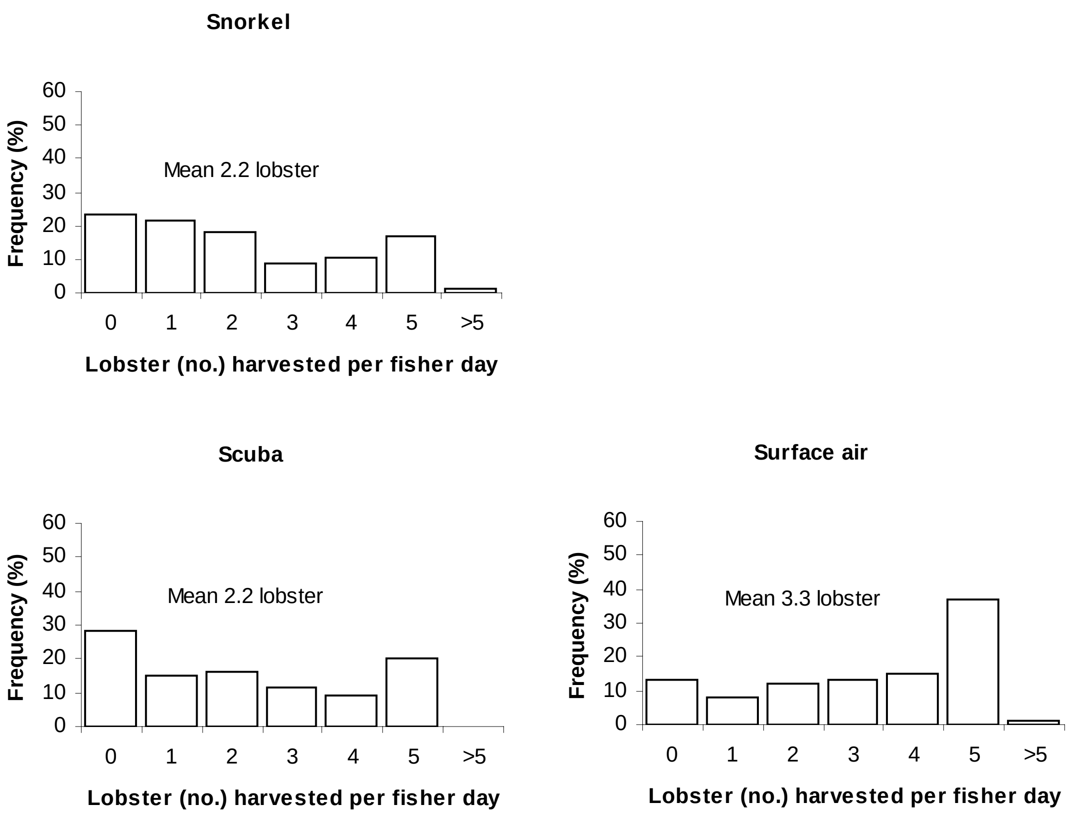


Figure 31. Distribution by method of rock lobster dive harvest per fisher day by 2000/01 recreational rock lobster licence holders.

6. Recruitment

A pre-recruit monitoring program has been run since 1990 to provide information on changes in the abundance of rock lobsters prior to recruiting to legal size. Data is mainly collected through monitoring the catches of puerulus on artificial collectors, which simulate natural reef (Figure 32). These collectors are deployed in groups at several sites around the coast and are serviced monthly to provide an index of the number of settling puerulus. Additional information on the abundance of lobsters prior to recruiting to legal-size is collected through diver surveys and surveys of undersize abundance in traps.

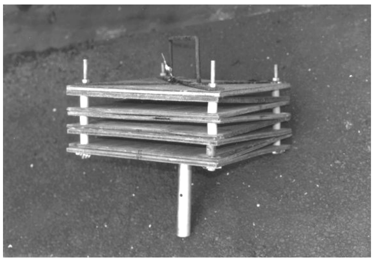


Figure 32. Crevice collector used for catching puerulus. These are deployed in groups ranging from 8 to 16. Monthly catches are assumed to provide a relative index of settlement along nearby coastal areas.

6.1 Puerulus catch records

Individual puerulus settling onto natural reef grow at different rates, so we would expect that any peak of settling puerulus to recruit into the fishery over a period of more than 1 year. In comparisons between commercial catch rate and puerulus settlement data presented previously, relatively little data were available so recruitment of a single cohort spread over more than one year was ignored (Gardner *et al.*, 2001). More data has been collected since that time so results below are based on model fits that allow recruitment to occur over more than one year.

These models are a positive step forwards in the use of puerulus monitoring data although they remain very preliminary. This is because the time series of data is still quite short, and because several other aspects have been kept simple by necessity. For instance, commercial catch rate is used as the measure of adult abundance, yet this is a function of a range of factors other than recruitment, such as stock rebuilding through quota management. As additional data is collected, it will become possible to test and refine these models more thoroughly.

The recruitment models shown below compare catch rate as kg/potlift for single stock assessment areas for the months December to April - against puerulus catch per collector, lagged by time periods ranging from 3 to 8 years (depending on area – longer lag for areas with slower growth). The models were simple linear models fitted by standard least squares regression.

6.1.1 South East Coast (Area 1)

Two puerulus collecting sites are located in Area 1, one in the north of the area, at South Arm (Iron Pot) and the other at Recherche Bay in the south. Growth is expected to be slower at the more southerly site. Reasonable fits of puerulus catch data to future catch rates were obtained with lags of between 5 and 8 years (Figure 33 and Figure 34).

Closer correlation between predicted catch rates and observed catch rates for models based on puerulus settlement lagged over 3 years (6, 7 and 8) than over 2 years at Recherche Bay (Table 7). However, this improvement is not surprising as more parameters are involved. The results shown here are based on very few years of overlap between puerulus catch data and fishery catch rate data, so the models presented are unlikely to provide accurate predictions of future catch rates. The main implication of information shown in Figure 33 and Figure 34 is that it appears possible to link puerulus catches to future catch – and that this suggests the possibility of forecasting in the future once more years of puerulus catch data are available.

Table 7. Correlation coefficients for fits of puerulus catch data to observed commercial lobster catch rates in area 1, with different lag times of growth through to the fishery. Values closer to 1 indicate improved fits. The time taken to grow from a settling puerulus through to legal size is unknown so this process helps establish appropriate lag times for the model.

Model	South Arm	Recherche Bay
5 and 6 year lag	0.75	0.70
6 and 7 year lag	0.80	0.01
7 and 8 year lag	Insufficient data	0.86
5, 6 and 7 year lag	0.99	
6, 7 and 8 year lag		0.93

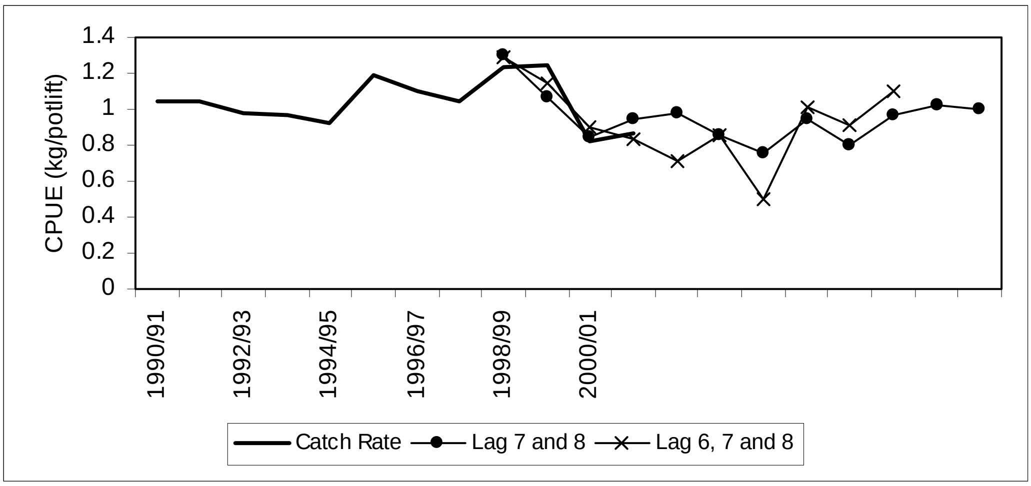


Figure 33. Recherche Bay: Comparison of commercial catch rates in area 1 with predicted catch rates from puerulus data from Recherche Bay assuming (a) puerulus settlement recruits to the fishery 7 and 8 years later; or (b) puerulus settlement recruits to the fishery 6, 7 and 8 years later.

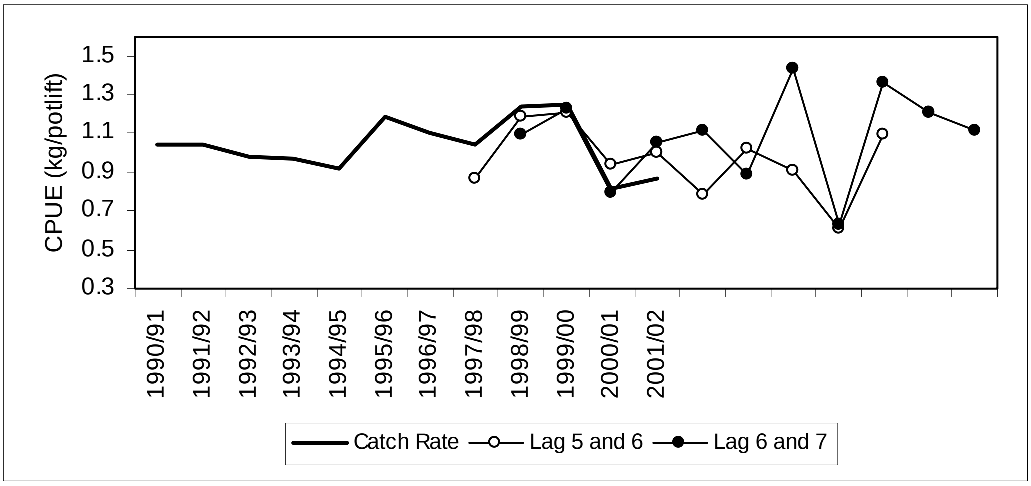


Figure 34. South Arm: Comparison of commercial catch rates from area 1 with predicted catch rates from puerulus data from South Arm assuming (a) puerulus settlement recruits to the fishery 5 and 6 years later; or (b) puerulus settlement recruits to the fishery 6 and 7 years later.

6.1.2 East Coast (Areas 2 and 3)

The Bicheno puerulus collecting site is located near the boundary between Areas 2 and 3 on the East Coast. This site consistently achieves higher catches than other sites in the State and has high power for analyses with 2 sites, each of 12 collectors. Growth is expected to be faster than sites in area 1 (Section 6.1.1). Reasonable fits of puerulus catch data to future catch rates were obtained with lags of 5 and 6 years (Figure 35 and Figure 36).

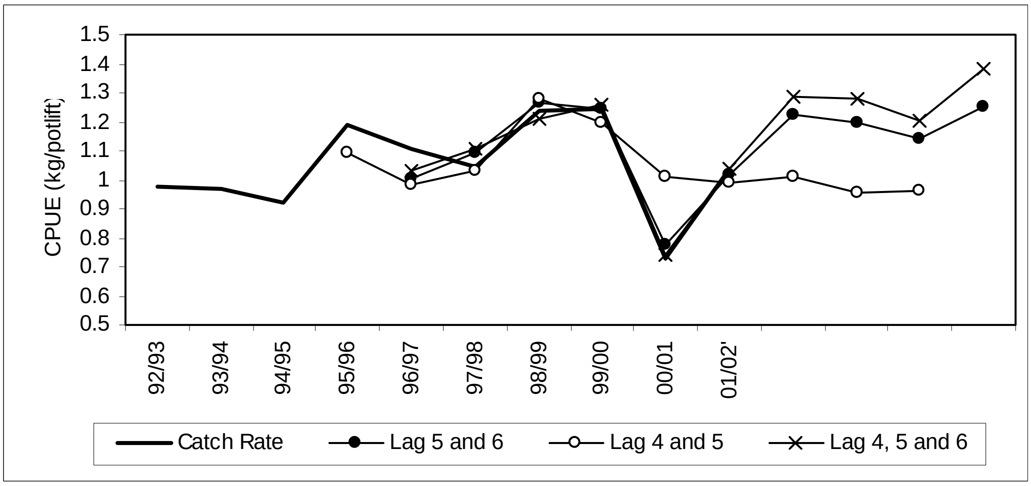


Figure 35. Area 2: Comparison of commercial catch rates from area 2 with predicted catch rates from puerulus data from Bicheno assuming (a) puerulus settlement recruits to the fishery 4 and 5 years later; (b) puerulus settlement recruits to the fishery 5 and 6 years later; or (c) puerulus settlement recruits to the fishery 4, 5 and 6 years later.

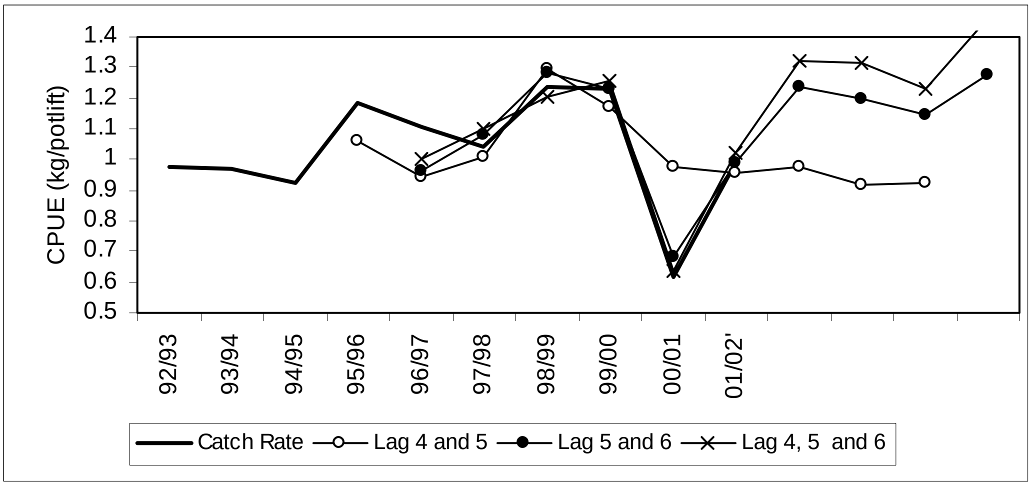


Figure 36. Area 3: Comparison of commercial catch rates from area 3 with predicted catch rates from puerulus data from Bicheno assuming (a) puerulus settlement recruits to the fishery 4 and 5 years later; (b) puerulus settlement recruits to the fishery 5 and 6 years later; or (c) puerulus settlement recruits to the fishery 4, 5 and 6 years later.

Closer correlations were found between the predicted catch rates and observed catch rates for models based on puerulus settlement lagged over 3 years (4,5 and 6) than over 2 years at both area 2 and 3 (Table 8). However, this improvement is not surprising as more parameters are involved. The main implication of information shown in Figure 35 and Figure 36 is that it appears possible to link puerulus catches to future catch with the six years of data. Again a longer time series of information is required although these multi-year correlations show considerable promise.

Table 8. Correlation coefficients for fits of puerulus catch data to observed commercial lobster catch rates in Areas 2 and 3, with different lag times of growth through to the fishery. Values closer to 1 indicate improved fits. The time taken to grow from a settling puerulus through to legal size is unknown so this process helps establish appropriate lag times for the model.

Model	Area 2	Area 3
5 year lag	0.30	0.25
4 and 5 year lag	0.64	0.60
5 and 6 year lag	0.95	0.94
4,5 and 6 year lag	0.97	0.97

6.1.3 North East Coast (Area 4)

Catch rates of puerulus from the Flinders Island site in the north east are typically much lower than further south, which is consistent with our understanding of oceanographic dispersal of phyllosoma larvae (Bruce *et al.*, 2000). This has been running for a shorter period than others on the east coast and thus there are fewer years of overlap with commercial catch rate data. A poor fit to commercial catch rate data is obtained when puerulus data is lagged only 3 years (Table 9). Fits using puerulus data lagged 4 years, or 4 years and 3 years combined are better, but these fits are based on very few years of overlap (Figure 37). Again, the main conclusion to be drawn from these results are that there appears to be potential for the use of the puerulus data for predicting catch, but additional years of puerulus settlement data are required.

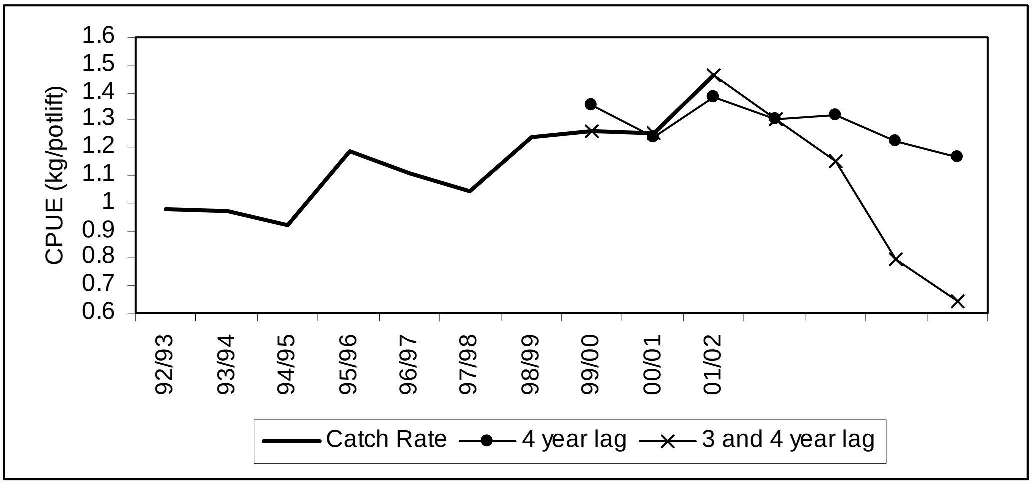


Figure 37. Area 4: Comparison of commercial catch rates from Area 4 with predicted catch rates from puerulus data from Flinders Island assuming (a) puerulus settlement recruits to the fishery 4 years later; or (b) puerulus settlement recruits to the fishery 3 and 4 years later.

Table 9. Correlation coefficients for fits of puerulus catch data to observed commercial lobster catch rates in Area 4, with different lag times of growth through to the fishery. Values closer to 1 indicate improved fits. The time taken to grow from a settling puerulus through to legal size is unknown so this process helps establish appropriate lag times for the model.

Model	Area 4
3 year lag	0.08
4 year lag	0.65
3 and 4 year lag	0.99

6.1.4 North West Coast (Area 5)

Puerulus monitoring at King Island has been underway since 1992. As growth is also expected to relatively fast in this area (based on tag recaptures of larger animals), we expect there to be several years of overlap between lagged puerulus data and commercial catch rates.

Several of the models tested provide reasonable fits of the puerulus data to the commercial catch, with none of the options predicting a sharp decline in catch over the next three years (Figure 38 and Table 10). Unfortunately, puerulus monitoring at this site has been sporadic with months missed in most years - thus predicted catch rates shown here are highly tentative.

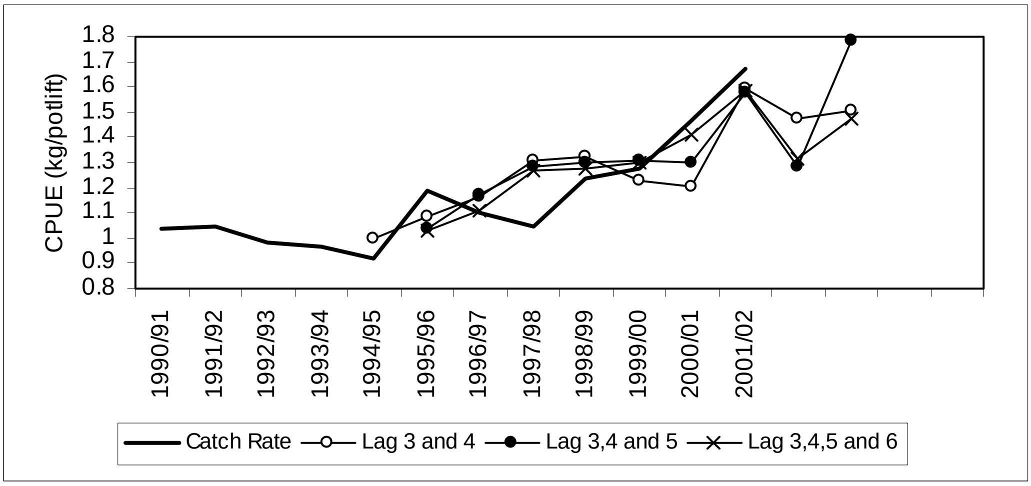


Figure 38. Area 5: Comparison of commercial catch rates from area 5 with predicted catch rates from puerulus data from King Island assuming (a) puerulus settlement recruits to the fishery 3 and 4 years later; (b) puerulus settlement recruits to the fishery 3, 4 and 5 years later; or (c) puerulus settlement recruits to the fishery 3,4 and 5 years later.

Table 10. Correlation coefficients for fits of puerulus catch data to observed commercial lobster catch rates in area 5, with different lag times of growth through to the fishery. Values closer to 1 indicate improved fits. The time taken to grow from a settling puerulus through to legal size is unknown so this process helps establish appropriate lag times for the model.

Model	Area 4
3 and 4 year lag	0.75
4 and 5 year lag	0.43
3,4 and 5 year lag	0.75
3,4,5 and 6 year lag	0.83

6.1.5 West Coast (Areas 6-8)

Several sites have been tested for puerulus monitoring on the west coast over the last decade, but none have proved successful with catch rates typically too low to be of value. Trials are currently underway at two sites near Cape Grim.

7. September Opening

The Tasmanian rock lobster fishery was traditionally closed during the male moulting season from September - November to prevent the capture of lobsters soon after the moult while they are in a vulnerable, soft-shelled state. This ‘soft-shelled’ condition is mostly found in southern regions of the fishery. A portion of the industry has requested removing this closure to provide greater flexibility in the capture of quota. However, concerns remain over the potential harm to the resource in the southern region where soft shelled sized and undersized lobsters are being caught. To identify areas where recently moulted lobsters occur and their proportion of the total catch, the fishery was opened for two weeks in September 2001. Special research permits were issued, conditional on fishers collecting data for scientific and resource management purposes.

Fishing effort in September was concentrated in NW (Area 5, 42%) and SW (Area 1 and 8, 28%) waters. There was no indication of effort increasing in northern areas during September, which has been a concern of northern fishers, scientists and fishery management regarding a September fishery.

Recently moulted lobsters were caught in all state waters, although very few in the west (Areas 6 and 7). Over 90% of all recently moulted lobsters (newshellers) came from the SW (Areas 1 and 8); newshellers comprised over 80% of the legal sized catch from these waters.

Newshellers had the effect of lowering prices for lobsters caught in southern areas. In August, lobsters received in excess of $50 per kilogram. In September, approximately 87% of lobsters from Area 1 and 78% from Area 8 received minimum prices of $28-$30 per kilogram. In all other areas, lobsters continued to receive over $50 per kilogram.

An estimated 45,000 undersized newshellers were caught and discarded during September. The fate of discarded lobsters is of interest to determine differential mortality rates of pre-moult and post-moult lobsters and to assess the potential effects of the September fishery on the resource. Insufficient tag returns had been received at the time of preparation of this report to assess these aspects of the September opening.

7.1 Further Research

Future research into the September opening will be focused on two issues. The first is the evaluation of the survival of released soft-shelled lobsters from tag-recapture data. This will only be possible if sufficient tag-returns are received by industry. The second issue is the quantification of “shell hardness” with durometers.

Although a potentially valuable source of biological information, “shell-hardness” is difficult to quantify. Currently, “shell-hardness” is crudely categorised into “soft” or “hard” shell. These are subjective measures and classifications inevitably vary between individual observers. Observers placed on vessels to record landings of “soft-shelled” lobsters have difficulty in standardising observations.

The need to ascertain a shell hardness standard has prompted a collaborative research project, undertaken by TAFI and SARDI, with support from the Rock Lobster Post Harvest Subprogram of the Australian Fisheries Research and Development Corporation (FRDC 2002/238 - Rock lobster post-harvest subprogram: quantification of shell hardness in southern rock lobster). The main objectives of the study are to establish a method by which hardness can be accurately measured and identify the most appropriate position on the carapace to take this measure.

Shell hardness is being measured with durometers. These devices were designed for measuring the hardness of plastic sheeting but appear also suited to quantifying the hardness of lobster shells. Different types of durometer are being tested, with the aim of providing researchers, fishers and processors with a tool that is practical, cost effective, durable, reliable and objective.

8. Fleet Dynamics

Since the introduction of the ITQMS in 1998, there has been a small improvement in catch rates in all regions and most depth categories (Figure 39). Exceptions to this include the substantial increase in catch rate in deeper water over the last year in Area 4, the improvement in catch rates over the last three years in deeper water in Area 6 and the decline in deeper water catch rates in Areas 7 and 8.

Changes in catch rates are attributable to changes in the dynamics of the fleet. This was highlighted in Section 4 where an increase in effort in shallow water had resulted in a decline in the overall catch rate for the Assessment Area. In the previous assessment it was noted that there was insufficient data since quota to construct a post-quota fleet dynamics model and that a 10 year model provided the best fit to the data. If trends in the fleet dynamics since quota become substantial it is likely that future predictions will be less representative of actual fishing practices. Review of the fleet dynamics model is planned for 2004 when 5 years of post-quota data will be available. Until this review, monitoring of changes in the dynamics of fishing effort will be represented graphically. The rock lobster assessment model uses monthly time steps and spatial coverage is based on the 8 assessment areas. Thus changes in fishing behaviour that occur at the assessment area spatial scale and the monthly temporal scale are incorporated in the model design. Changes that occur within an assessment area that are unrelated to time are currently not factored into the model. Through both the socio-economic survey of the Tasmanian rock lobster fishery (FRDC Final Report “Impact of management change to an ITQ system in the Tasmanian rock lobster fishery”) and meetings of the rock lobster fishery assessment working group, fishers report that there has been an increase in fishing in shallower water since the introduction of the ITQMS. As catch rates vary with depth fished, a change in fishing depth could result in biomass and egg production biases. Changes in catch rates would reflect fisher behaviour rather than changes in abundance.

To investigate this further, trends in the proportion of fishing effort in shallow (0-20m), medium (21-50m) and deep (51m+) water for the eight assessment regions were compared (Figures 40 to 42). The most substantial changes are seen in Areas 4 and 6 for shallow water where proportionally there was a declining trend prior to quota and this has been reversed since the introduction of quota (Figure 40). In medium depths only Area 4 shows a major change with a relatively constant proportion of effort prior to quota changing to a decline in effort after quota implementation (Figure 41). Deeper water plots showed considerable variability and this is due to the limited amount of fishing that occurs in these depths, particularly on the East Coast with Areas 2, 3 and 4 having less than 12% of effort expended in deeper water (Figure 42). The largest assessment area where there is a substantial amount of effort expended in deep water is Area 6. This area has shown a substantial reduction in the proportion of effort expended since quota. In summary, the major differences in the distribution of effort are an increase in proportion of effort being directed to shallow water fishing in Areas 4 and 6 (Figure 43). As noted in Section 4, this has resulted in changes in CPUE in Area 6 that are a result of changing fishing practices.

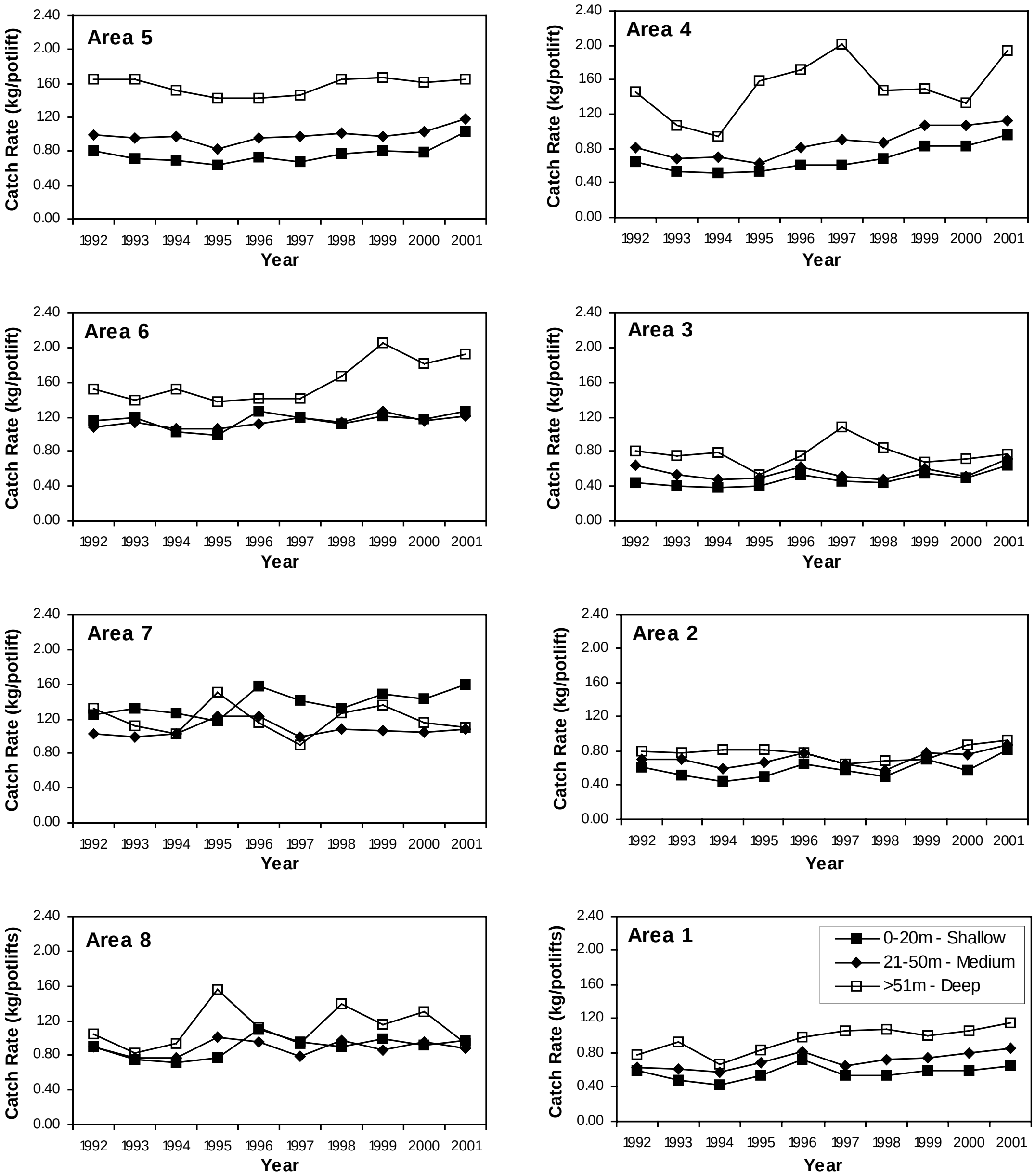


Figure 39. Comparison of catch rates from shallow (0-20m – enclosed squares), medium (21-50m – enclosed diamonds) and deep water (>51m – open squares) for each of the eight stock assessment areas for the last ten years.

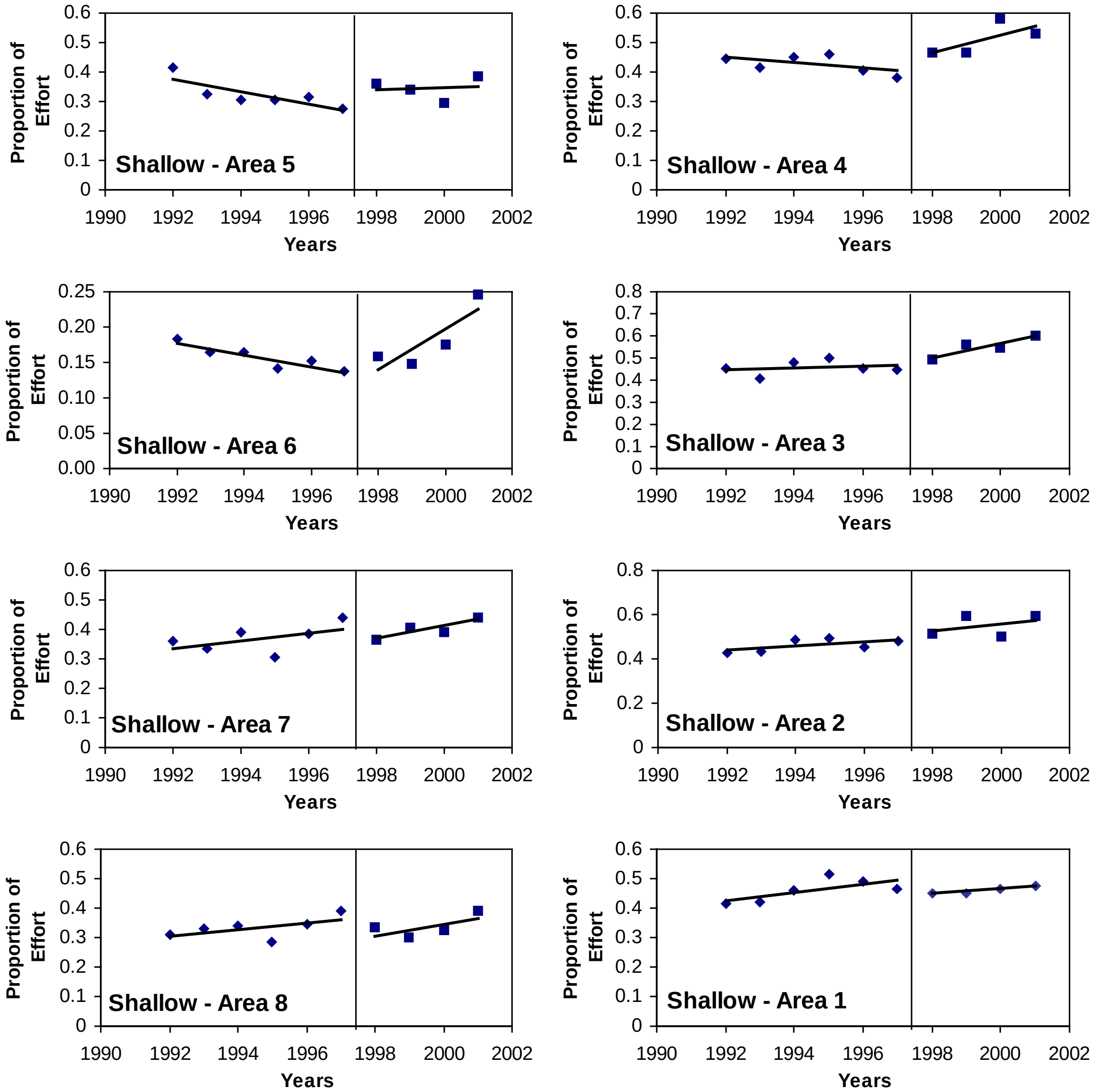


Figure 40. The proportion of effort exerted in each Stock Assessment Area for shallow water (0-20m) for the last ten years. A linear trend line has been fitted to the data to demonstrate the trend prior to (diamonds – 1992-1997) and after (squares 1998+) the implementation of ITQ. Please note differences in Y-axis.

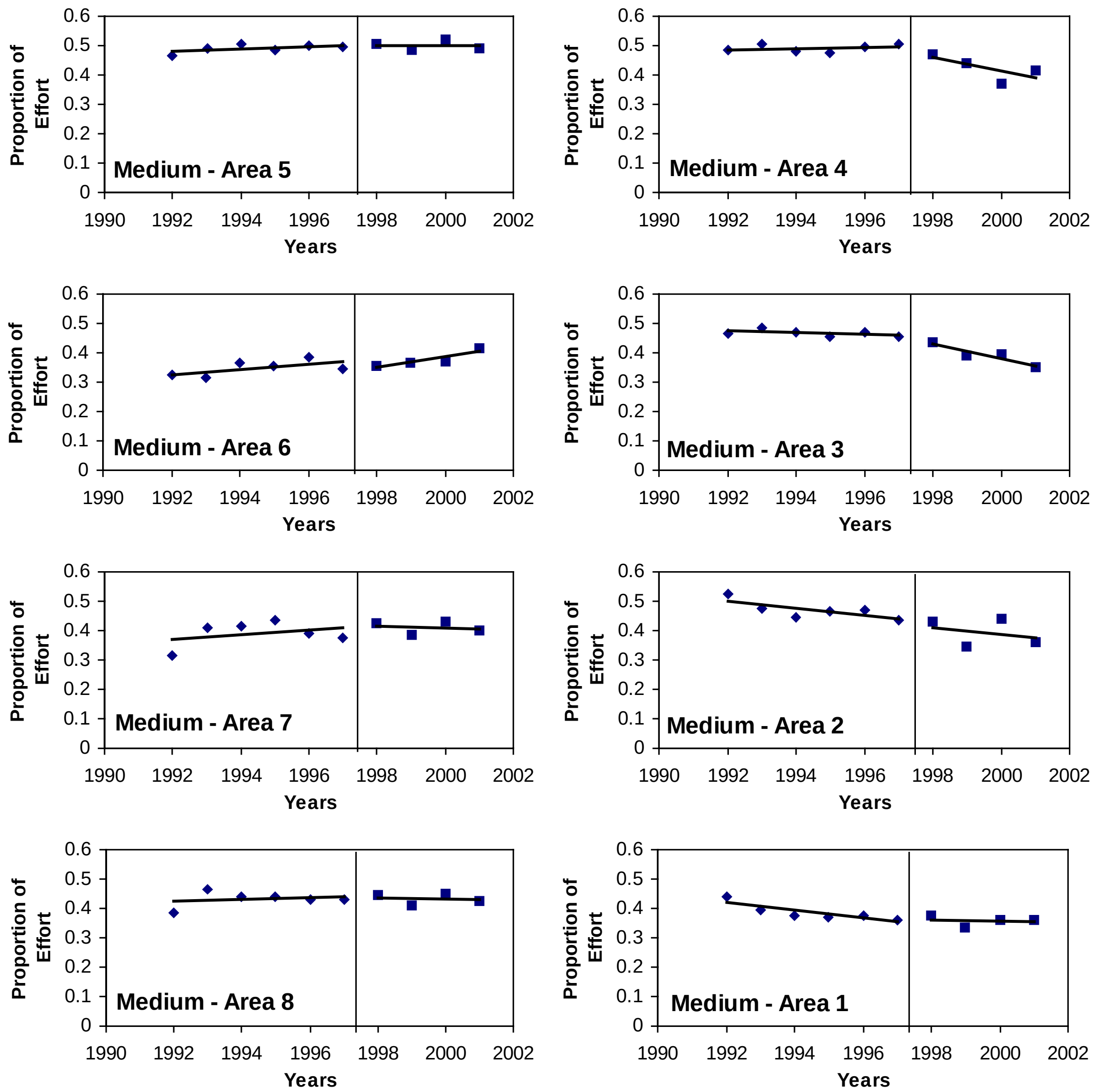


Figure 41. The proportion of effort exerted in each Stock Assessment Area for medium depths (21-50m) for the last ten years. A linear trend line has been fitted to the data to demonstrate the trend prior to (diamonds – 1992-1997) and after (squares 1998+) the implementation of ITQ. Please note differences in Y-axis.

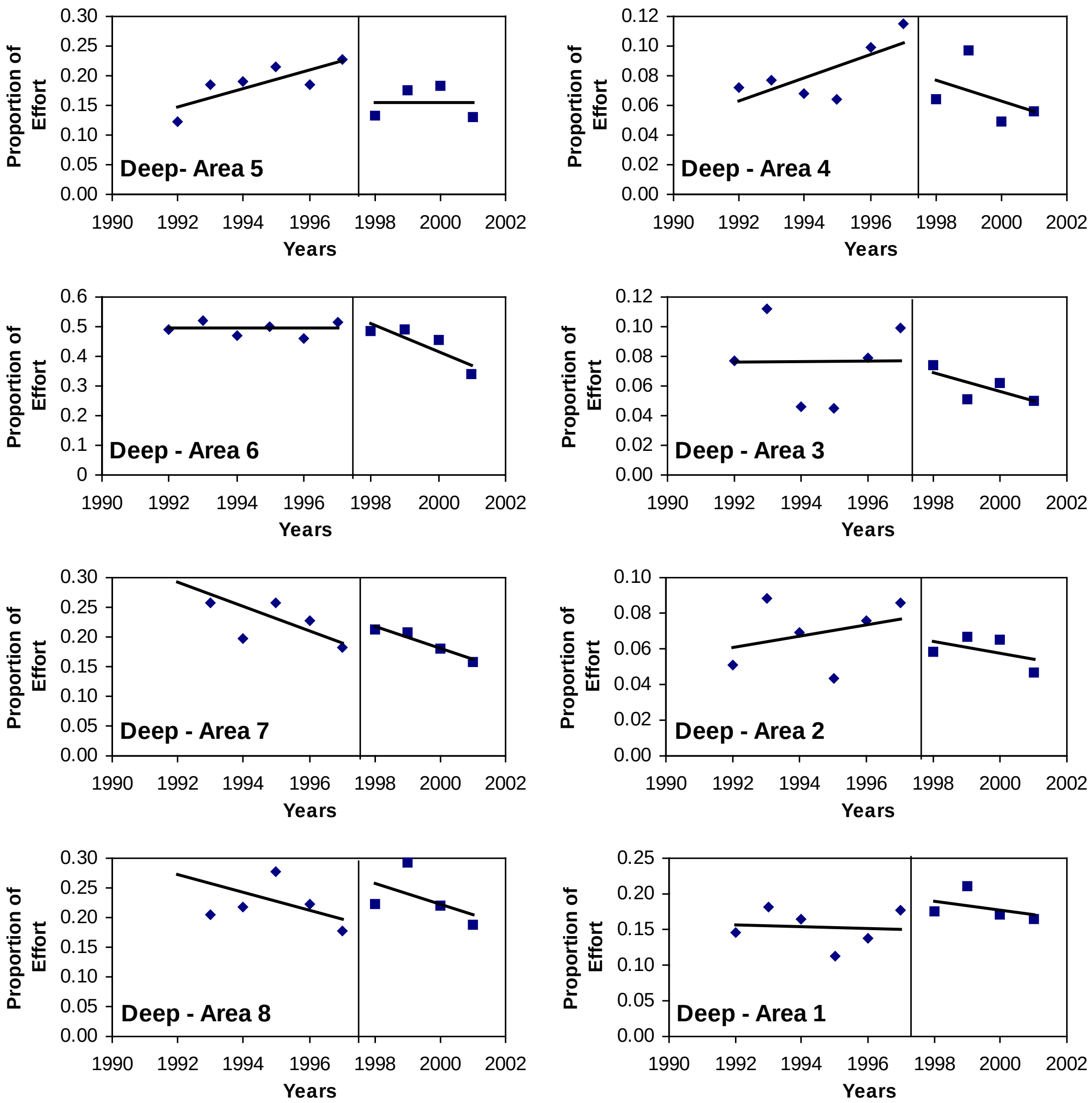


Figure 42. The proportion of effort exerted in each Stock Assessment Area for deep water (>50m) for the last ten years. A linear trend line has been fitted to the data to demonstrate the trend prior to (diamonds – 1992-1997) and after (squares 1998+) the implementation of ITQ. Please note differences in Y-axis.

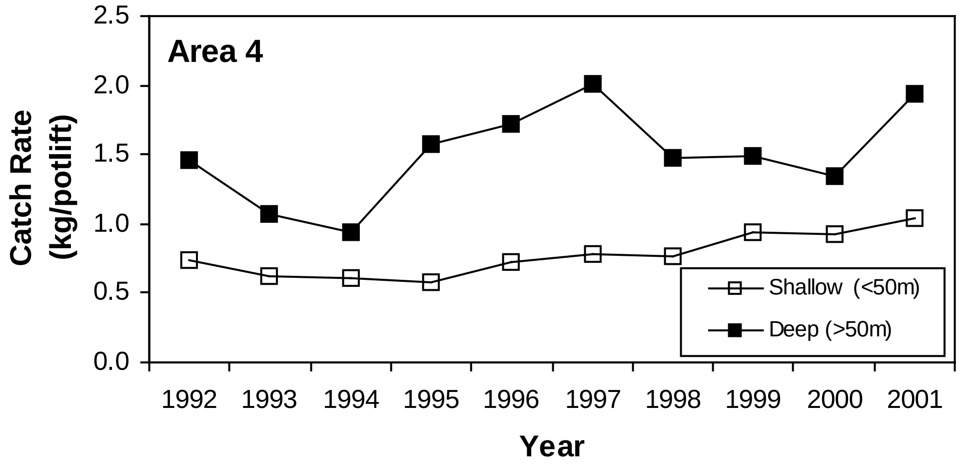


Figure 43. Comparison of catch rates from shallow (<50m) and deep (>50m) water from Area 4 for the last ten years.

9. Socio-economics

An objective of the FRDC project "Impact of management change to an individual transferable quota system in the Tasmanian rock lobster fishery" was to develop a number of socio-economic performance indicators that could be applied to the fishery.

A series of performance indicators has been developed to monitor the main issues raised in this project (Table 11). These performance indicators are being discussed by the Government's Rock Lobster Fishery Advisory Committee. This committee, which includes fishers, fishery managers and fishery scientists, has yet to decide on which performance indicators are appropriate for the fishery.

The report of the FRDC project represents a comprehensive baseline and understanding of the social position of the fishery around the commencement of quota management. It is from this baseline that future trends can be monitored. Such monitoring, however, is of little value unless a position regarding the future direction of the fishery is developed. It would be against this future direction that trends would be seen as either positive or negative.

Both Government and the Tasmanian commercial rock lobster industry are yet to develop a vision for the future of the fishery so that future directions are transparent. Performance indicators are of little more than interest value unless there is a clear and accepted understanding as to where certain trends are taking the industry or Government, whether this direction is desirable as well as where the industry and Government want to be. There needs to be a Government and industry view on the favourability of any destination if points *en route* are to be identified at which the direction might be influenced. In short, the rationale underlying performance indicators and trigger points is crucial to their identification and setting, as well as to any response to them.

During 2001, the Tasmanian Rock Lobster Fisherman's Association began to develop a vision for the industry. At the time of writing, this development is still in progress and support for this vision is being sought from the Tasmanian Government. For the community of Tasmania, it needs to be recognised that the value of the rock lobster fishery extends beyond the annual beach price of AU$60 million. Fishers, their boats and their regional distribution are essential components of Tasmania's socioeconomic and cultural profile and their sustainability is equally as important as the biological sustainability of the resource.

Table 11. Present and possible performance indicators regarding the Tasmanian commercial rock lobster fishery.

	Rationale	Data source	How often
No. of boats (real capital)	Work platforms of the industry; fleet of various length boats necessary to maximising yield from all parts of the fishery; onshore unloading, reprovisioning, maintenance, repair and replacement activity; employment; and career opportunities	Catch returns (DPIWE)	Update every fishing year
Percentage of boats owner-operated	Fleet traditionally owner-operated; regulatory compliance arguably greater, co-management arguably facilitated and sustainable fishing practices arguably more likely by owner-operator stakeholders; greater retention of value in Tasmania	Licensing data and catch returns (DPIWE)	Update every fishing year
Geography of licence holders (concentrating in Hobart)	Indicative of centralisation of ownership; indicative of increased proportion of licence ownership by non-operators; and indicative of declining 'rural' 'home' fleets	Licensing data and catch returns (DPIWE)	Update every fishing year
Boats-through-ports (by landing)	Indicative of 'home' and visiting boat activity by port; geography of boat-related activity; long-term monitoring of use of ports possible; possible (de)centralisation measure re activity; average kilograms unloaded per landing and per boat also useful re local activity level	Catch returns (DPIWE)	Update every fishing year
No. of processors	The greater the number of processors purchasing more than ten tonnes of rock lobster per fishing year, the less likely oligopoly	Licensing data and receipts (DPIWE)	Update every fishing year
Boats by length and geography of catch	Size-class distribution of boats according to where fished is indicative of trends in types of boats as well as in fleet dynamics; various types of boat and areas fished may be important to maximising yield from the fishery	Catch returns (DPIWE)	Update every fishing year
Age distribution of 'skippers' (human capital)	Monitor number of leavers, size of pre-retirement cohort, and number of new entrants to the fishery; may assist planning for future human capital requirements of the fishery	Licensing data (DPIWE)	Update every fishing year
Percentage of quota units (sub)leased	Indication of extent of lease economies, both onshore and on the water; monitoring of subleasing regarding possibly anti-competitive behaviour	Licensing data (DPIWE)	Update every fishing year
Social impact assessment	Provide background detail regarding performance indicators and issues in the industry	Social research	Every five years, coincide with new management plan

10. Disease Monitoring.

A project is currently underway to monitor the disease status of wild juvenile southern rock lobsters: Health Assurance of Southern Rock Lobsters. This project is run through the TAFI Fish Health Unit by Dr Judith Handlinger and is funded through the FRDC Rock Lobster Enhancement and Aquaculture Sub-Program. An objective of the study is to provide baseline information on the disease status of wild stocks to facilitate monitoring of aquacultured animals. This information will also be of value in the event of any observed increase in incidence of disease in wild stocks.

Juveniles are being collected from each of the 6 Tasmanian bioregions and examined by standard pathology techniques of histology and microbiology. Sampling has been completed for 4 of the 6 regions. Several organisms have been identified including metazoan parasites and bacteria, although none appear to be associated with serious disease risk.

11. Aquaculture

Aquaculture of rock lobsters in Tasmania is proceeding by the harvest and ongrowing of wild caught juveniles, although the State Government has indicated that this will only occur for a limited period.

Permits for the collection of puerulus and early stage juveniles for the purpose of ongrowing for aquaculture were issued for the first time in 2001. Seven permits were initially issued, each for the collection of 50,000 puerulus and early stage juveniles (<15mm CL equivalent to puerulus and the first 2 or 3 instars post settlement). The number of permits was reduced by the State Government in 2002 to 4. Puerulus are to be collected using artificial collectors deployed over sand in Areas 1, 2, 7 or 8 only.

Approximately 1000 puerulus and early juveniles were captured by holders of these permits in 2001 and approximately 2500 have been captured in 2002, although this collecting season is not yet complete.

Although the harvest of puerulus appears to represent additional removals from the resource, the exercise is intended to be either biologically neutral or positive for stock abundance. The outcome of enhancement or biological neutrality is achieved by the release of juveniles after one year in culture. Natural mortality during this period would normally be high so it is theoretically possible to compensate or enhance the natural stocks while also providing animals for commercial culture.

Although this exercise can lead to the outcomes of both provision of animals for aquaculture (which is not possible through hatchery production) and enhancement of the wild fishery, there are several issues critical to the exercise that require further research. These issues are:

1) Assessment of the survival of those animals released after 1 year in captivity. This research is underway in the FRDC funded project "Rock lobster enhancement and aquaculture subprogram: evaluating the release and survival of juvenile lobsters released for enhancement purposes". It involves collaboration with scientists in New Zealand (NIWA).

2) Estimation of the natural survival of juveniles during their first year. This research is underway through the FRDC funded project "Can production in the southern rock lobster fishery be improved? Linking juvenile growth, survival and density dependence to sustainable yield." It involves collaboration with scientists in South Australia (SARDI) and Victoria (MAFRI).

3) Assurance that diseases will not be transmitted from aquaculture operations. This issue requires the development of the tools for monitoring the health of cultured animals and will be addressed in the FRDC funded project "Rock lobster enhancement and aquaculture subprogram: health assurance for southern rock lobsters".

12. Larval Dispersal

The planktonic larval phase of southern rock lobsters is extremely protracted (13-24 months) which implies considerable potential for long distance transport. Thus, recruitment within a management area may be influenced by what happens in adjacent or distant zones (Bruce *et al.*, 2000). Bruce *et al.* (2000) examined the oceanographic processes that were likely to influence the dispersal of rock lobster larvae around Tasmania. They concluded that mechanisms exist to allow the retention of larvae within the region of release, rather than being lost to a generalised west-east flow. They also noted that the East Australian Current appears to influence settlement strength and that settlement in the North East of Tasmania (Flinders Island) is likely to remain generally low and highly variable.

A new project supervised by Barry Bruce (CSIRO) commenced in 2002 and is directed to the issue of rock lobster larval dispersal. This project is funded by FRDC and aims to:

i) Examine the relationship between spawning region and settlement success (identify where puerulus come from);

ii) Model the effects of changing spawning output on recruitment;

iii) Develop model outputs into a form that provide ongoing information for assessments.

13. By-Product

Byproduct of species captured in lobster traps has been reported through the general fish logbook system since 1995. Seventeen types of byproduct have been reported although these groupings may have overlap with others (eg "morwong other" with "jackass" and "banded morwong"), or include several species (eg "shark", "octopus", "flathead", "mullet", "whiting", "leatherjacket" and "gurnard/latchet"). Some records appear spurious, such as a reported 20 kg catch of tuna, but are included here for completeness. These records that appear spurious represent very small catches and are insiginificant to the assessment of overall byproduct catches. Total reported byproduct of most fish types was small; only two types of fish had reported annual catches for the fleet of greater than 1 tonne - cod and octopus (Figure 44). Catches of cod have declined since 1996/97 while no clear pattern is apparent in octopus catches.

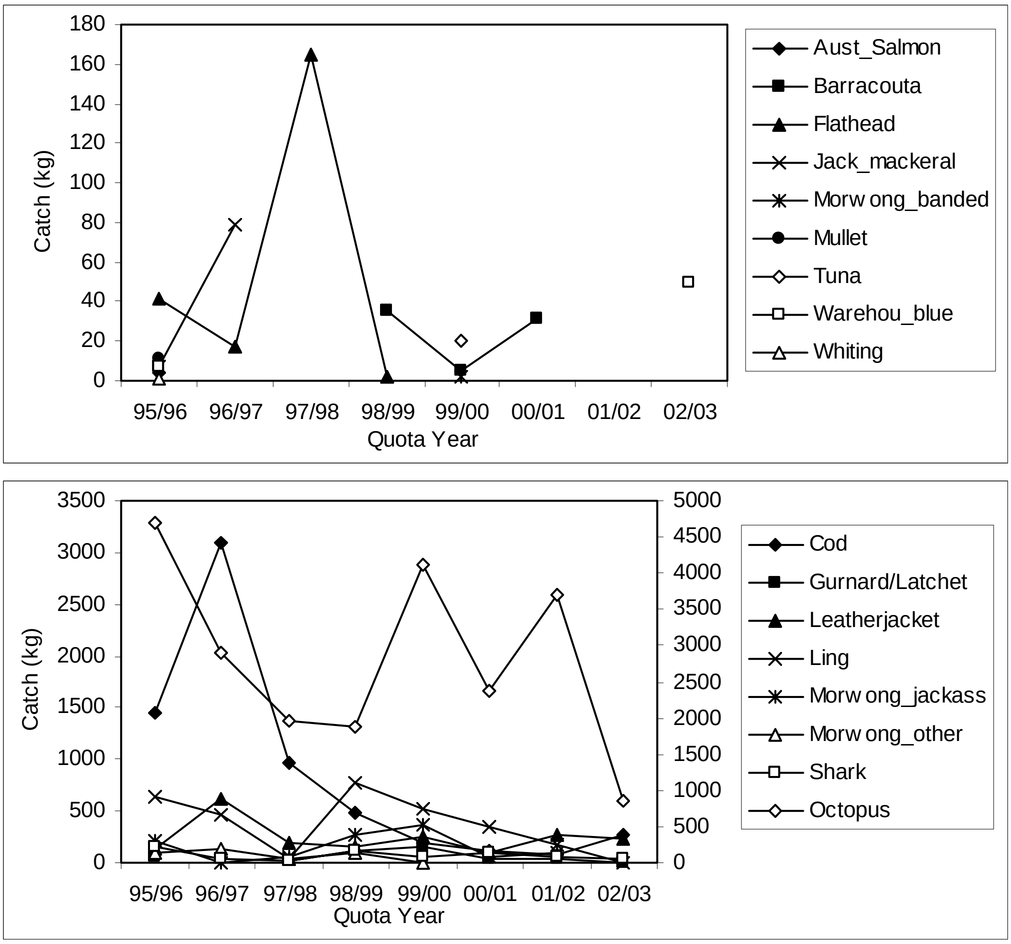


Figure 44. Reported by-product from rock lobster pots, January 1995 to August 2002. Data is grouped into quota years (March to February) so annual catches are incomplete for the 1995/96 and the 2002/03 quota years. Catches of minor species are shown in upper plot, those with greater catch are shown in the lower. Values for catches of octopus are shown on the right-hand axis of the lower plot.

14. By-Catch

Traps used in the Tasmanian fishery for the southern rock lobster (*Jasus edwardsii*) also catch individuals of other species that are discarded (bycatch). In 2001, an honours project analysed the bycatch in 26110 research trap lifts undertaken between 1992 and 2000. Detailed results from that work are in press (Marine and Freshwater Research). A summary is provided below.

The bycatch was dominated by decapod crustacean and bony finfish species (accounting for 143,385 (87.3%) and 18,395 (11.2%) of all bycatch respectively) (Table 12). The most abundant crustaceans were the hermit crab (*Strigopagurus strigimans*), red swimmer crab (*Nectocarcinus tuberculosus*) and red bait crab (*Plagusia chabrus*), while the most abundant finfish were the rosy wrasse (*Pseudolabrus psittaculus*), Degen's leatherjacket (*Thamnoconus degeni*) and barber perch (*Pseudophycis barbata*).

The distribution of 164,270 bycatch individuals from 26,110 research trap lifts in Tasmanian waters were examined in relation to their effect on lobster catchability at the species and functional group levels. These trap lifts were undertaken as part of fishery independent surveys and all traps had escape gaps closed. The distribution of bycatch species varied significantly among depth ranges within regions, but not on a seasonal or inter-annual basis because most species are non-migratory site-attached reef residents. The relationship between total lobster catch and total bycatch within distinct bycatch assemblages identified in this study was best described by triangular factor-ceiling distributions. These distributions suggest that bycatch imposes an upper limit on lobster numbers and as by-catch increases lobster catch decreases. However, when by-catch is low it is clear that other mechanisms may operate to limit lobster catches.

Similar triangular factor-ceiling relationships hold between lobster catch and the catch of the most numerous individual bycatch species. Multiple regression analyses of the upper edges of these relationships enabled the identification of bycatch species most important in contributing to the relationship. Overall, these analyses indicated that the importance of a species in the regressions corresponded closely with its abundance, suggesting that the amount of bycatch entering a trap is more important than its identity.

While the species or group that entered a trap in greatest numbers had the greatest negative effect on lobster catchability, some possibly predatory and aggressive species (e.g. *Octopus maorum*, *Cephaloscyllium laticeps*, *Pseudolabrus spp*.) have negative effects on lobster catches disproportionate to their abundance, but these species comprise a small fraction of the bycatch when escape gaps are closed. However, due to their size, Frusher and Gibson (1999) found that these species are retained in traps with escape gaps and are likely to impact on lobster catchability in commercial traps. The effect of bycatch is evident both in periods of elevated and reduced (i.e. during moulting and mating) lobster activity. The suite of important species/groups affecting lobster catch does not change between these periods. The influence of bycatch on catchability of rock lobsters as indicated in this study may be incorporated into the catchability components of stock assessment models, provided that the underlying data are independent of the fishery.

Future catch sampling surveys are planned using Industry traps with escape gaps open.

Table 12 Abundance of bycatch species caught in 26,110 rock lobster trap lifts between 1992 and 2000.

CRUSTACEANS: 12 species	Scientific name	Number	% of total
Stridulating Hermit Crab	*Strigopagurus strigimanus*	125,554	76.43
Red Velvet Crab	*Nectocarcinus tuberculosus*	16,444	10.01
Red Bait Crab	*Plagusia chabrus*	1,193	0.73
Spider Crab (*Leptomithrax*, *Naxia*, and *Notomithrax* species)		88	0.05
Giant Crab	*Pseudocarcinus gigas*	56	0.03
Pie Crust Crab	*Cancer novaezealandiae*	67	0.04
Other Crustaceans	5 species	24	0.01
FINFISH: 42 species			
Rosy Wrasse	*Pseudolabrus psittaculus*	3,222	1.96
Degen's Leatherjacket	*Thamnoconus degeni*	2,943	1.79
Barber Perch	*Caesioperca rasor*	2,713	1.65
Blue Throat Wrasse	*Notolabrus tetricus*	2,022	1.23
Purple Wrasse	*Notolabrus fucicola*	1,952	1.19
Southern Conger Eel	*Conger verreauxi*	1,652	1.01
Draughtboard Shark	*Cephaloscyllium laticeps*	1,216	0.74
Red Gurnard Perch	*Helicolenus percoides*	809	0.49
Brown-Striped Leatherjacket	*Meuschenia australis*	798	0.49
Bearded Rock Cod	*Pseudophycis barbata*	606	0.37
Velvet Leatherjacket	*Meuschenia scaber*	499	0.30
Jackass Morwong	*Nemadactylus macropterus*	279	0.17
Toothbrush Leatherjacket	*Acanthaluteres vittiger*	185	0.11
Butterfly Perch	*Caesioperca lepidoptera*	180	0.11
Senator Wrasse	*Pictilabris laticlavius*	140	0.09
Scorpaenid (Unidentified)		111	0.07
Southern Rock Cod	*Scorpaena papillosa*	73	0.04
Perch (Unidentified)		47	0.03
Red Rock Cod	*Pseudophycis bachus*	36	0.02
Leatherjacket (Unidentified)		35	0.02
Catshark (Unidentified)		27	0.02
Rock Cod (Unidentified)		25	0.02
Other	20 Species	98	0.06
MOLLUSCS: 9 species			
Octopus	*Octopus maorum*	879	0.54
Gastropod (Unidentified)		36	0.02
Triton Shell	*Cabestana spengleri*	34	0.02
Giant Cuttle	*Sepia apama*	28	0.02
Other	5 Species	9	0.01
ECHINODERMS: 6 species			
Slate Urchin	*Goniocidaris tubaria*	59	0.04
Other	5 Species	48	0.03
OTHER INVERTEBRATES: 4 species			
Ascidian	*Ascidia challengeri*	42	0.03
Salp	*Pegea confoederata*	32	0.02
Other salps	2 Species ?	9	0.01

15. Protected Species Interactions

During the period of this assessment report, changes were made to the commercial logbook to facilitate reporting of interactions with protected and threatened species. As these changes are in the process of introduction, no data are available for analysis in this report. Interactions during the 2001/02 season were collected less formally with fishers encouraged to report interactions. All fishers contacted reported numerous interactions with protected bird species, primarily with silver and pacific gulls, cormorant species, prion species, shearwater species, albatross species, and other waterbirds. These interactions were generally non-damaging such as birds roosting on vessels or eating discarded bait. Fishers working in the Bass Strait also reported interaction with migrating silvereyes, which were observed to rest on the vessel. One fisher reported the drowning of a pied cormorant in a lobster trap.

No interaction with protected or threatened fish (eg great white shark and spotted handfish) or invertebrate species (three seastar species) were reported and these would seem unlikely given the habitats where lobster fishing occurs.

One interaction with a protected reptile was reported. In January 2002, a leatherback turtle *Dermochelys coriacea* weighing approximately 250 kg was entangled in a lobster buoy line off Flinders Island and subsequently drowned. The animal was recovered by the fisher and supplied to the Tasmanian Museum. Bone (1998) undertook a preliminary investigation into the abundance and occurrences of the leatherback turtle in waters around Tasmania. This investigation concluded that the presence of turtles in Tasmanian waters may be higher than previously thought. Information collected for inclusion in the draft recovery plan concluded there had been 118 sightings of turtles in 10 years. An anonymous report by Environment Australia estimated that in the last 10 years, 4 turtle deaths occurred from entanglements in fishing gear (Anon, 1998). The death reported this year is consistent with this low incidence.

No interactions with marine mammals were reported this year apart from sightings of several species of whales, dolphins and seals.

16. Maturation of Male Lobsters and the Potential for Sperm Limitation

The reproductive contribution of male southern rock lobsters *Jasus edwardsii* has recently become of interest for managing this fishery as changes to the length of seasonal closures has shifted fishing effort towards males (Turner *et al.*, 2002). To assess size at onset of maturity, a total of 387 male southern rock lobsters *Jasus edwardsii* were collected using baited traps from 4 of the 8 fishery regions around the Tasmanian coast during July and August 2000. Sizes at onset of maturity in these samples were estimated by examining the vasa deferentia for evidence of the commencement of spermatid production. In addition, the total combined weight of the vasa deferentia and testis were compared with body size (as a gonad somatic index, GSI). Estimates of size at onset of maturity from the two methods were similar, although estimates from GSI appeared to have broader confidence limits. Although these physiological indices of maturity do not necessarily translate to functional maturity, they indicate that maturity is well below that of the legal minimum size of 110 mm carapace length used for managing the fishery (all estimates by either method for length at 50% sample maturity ≤ 70 mm carapace length). Production of sperm by males occurs below the size at onset of maturity of females from the same region and spatial patterns in maturity estimated by onset of spermatid production were similar to those of females, with the size at maturity increasing from southern to northern regions of Tasmania.

Further work is underway examining the relationship between functional maturity (ability to successfully mate) and physiological maturity (production of gametes). This research involves tank-based mating experiments with males at around the size at onset of physiological maturity.

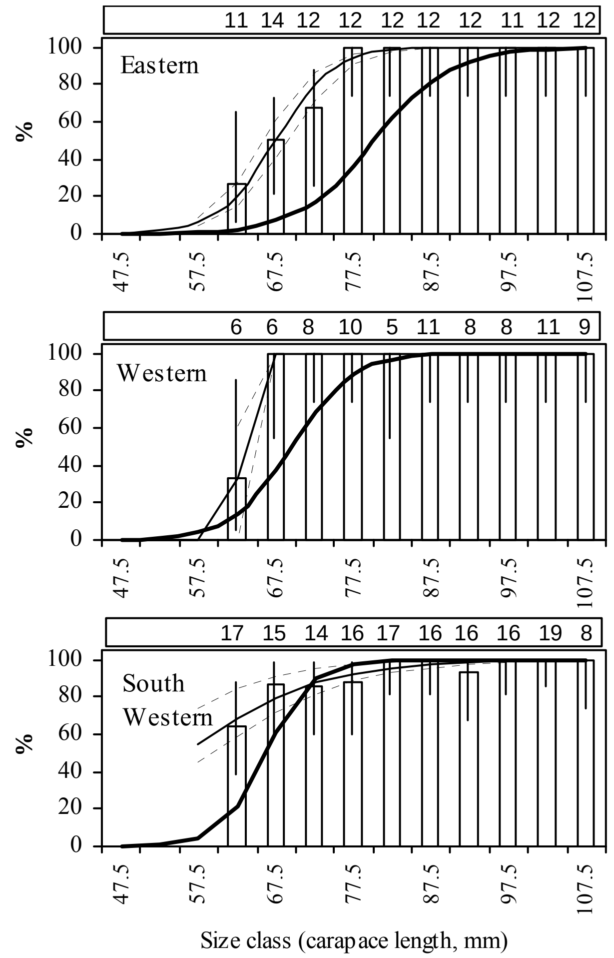


Figure 45. Increase in the proportion of males with sperm present in the vasa deferentia in relation to carapace length for different assessment areas with fitted logistic curves (light line). "Eastern" is area 2, "Western" is area 7 and "South Western" is area 8. 95% confidence limits for observed percentages in individual size bins are shown with error bars. 95% confidence limits around the logistic function were obtained by bootstrapping; note that these estimates are limited by lack of data for the western sample. Number of animals sampled per size class is indicated above columns. Onset of maturity of females from these areas is indicated (heavy line; from Gardner *et al.*, 2002). All individuals are below minimum legal size (110 mm CL).

17. Comparisons between Fished and Unfished Areas

In 1992 the Tasmanian Government declared a series of Marine Reserves. The largest of these is the Maria Island Marine Reserve and this Reserve has been continually monitored since 1992. Monitoring includes the counting of lobsters and estimating their size while diving along set transects. Transect were also established in adjacent sites external to the reserve which are open to commercial and recreational fishing.

Three trends are clear from the data. Firstly, there are relatively consistent patterns in the smallest size classes with peaks in 1994 and 1998 being reflected inside and outside the reserve (Figure 46). A peak in 2001 was observed in the external sites and this was not seen in the reserve survey. There appears to be no similarities between the external and the reserves sites for the 88-112mmCL size groupings. Neither does there appear to be a relationship between peaks in the 35-87mmCL and the 88-112mmCL. This could be explained by a combination of the broad size classes used and that female lobsters mature in the middle size grouping. Mature females grow substantially slower than males as they invest considerable energy into egg production. Thus a recruitment peak would be spread over a larger size range as the lobsters mature and grow. The final trend is the increasing number of larger lobsters appearing in the reserve population. This is not surprising as 113+ lobsters are above the legal size limit and would be harvested by commercial and recreational fishers in the external sizes.

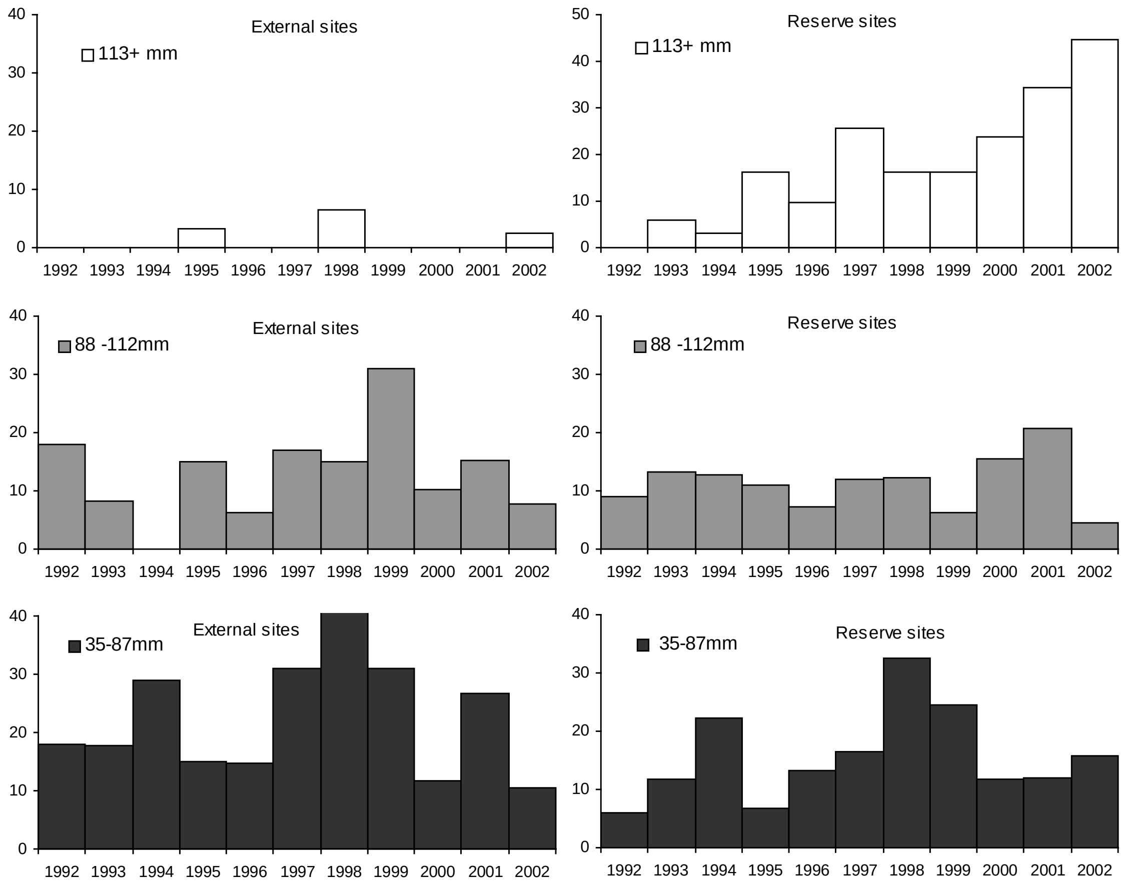


Figure 46. Comparison of the abundance of three size classes of lobsters inside and outside a marine reserve in Eastern Tasmanian (data made available by N. Barrett).

18. Evaluation of MPAs as a Fisheries Management Tool

The following is an unedited reproduction from Haddon *et al*. (2003) The effect of introducing MPAs on a commercial fishery – a rock lobster example. Fishing Today 16(1):17-20. This article is derived from research conducted on FRDC project 1999/162 (Evaluating the effectiveness of Marine Protected Areas as a fishery management tool).

It is frequently claimed that MPAs will have positive benefits for fisheries and at TAFI we are conducting a study to evaluate this claim. This article is based on a presentation given at the Aquatic Protected Areas conference held in Cairns during August last year.

The proposed benefit centres around the following arguments:

- Large areas, once closed to fishing, will recover and the animals inside the reserve will become larger and more plentiful.
- These animals will act as reproductive centers producing larvae that will replenish areas both outside and inside the reserve. Note the principal of protecting larval sources is well established e.g. shark nurseries. Because of the positive relationship between size and egg output it is reasoned that closed areas will produce large numbers of eggs and larvae.
- Fisheries adjacent to the reserve are likely to benefit from spillover effects when surplus fish exit the reserve.
- MPAs are a good option where other management is lacking and a good alternative to existing fisheries management where management information is absent.

However, there are also various situations where area protection may be of little advantage including:

- When the species under consideration are highly mobile or migratory.
- Where the protected species are so sedentary as to not move out of the area either as surplus adults or when larval migration is very limited.
- Where displaced fishing effort might harm the fishery in remaining areas following establishment of the reserve.

Given all of these factors and the vastly different characteristics of the many different species found in any one area, it is easy to appreciate why it is difficult to optimise the benefits of a reserve for anything other than a single species or group of species with the same characteristics.

Evidence for and against the various claims is not only hard to come by but is also of differing quality and generality, which is one reason that there is so much argument and discussion. If the evidence were convincing and general, much of the argument would not be required.

Our work, which is supported by the FRDC (Project 1999/162), is examining the issues from three perspectives:

- Comparing established MPAs with similar areas open to fishing (see last edition of *Fishing Today Dec2002/Jan2003*). Experimental manipulations aimed at testing the direct effects that MPAs have on fisheries.
- Modelling the dynamics of fished populations, with and without MPAs.

In this article, we will focus on results obtained from mathematically modelling using information that comes from our study of the Tasmanian rock lobster fishery.

To do this work we are forced to make two major assumptions. The first is that the closed area would make up a reasonably significant proportion of the overall area and production of the fishery. If only a tiny proportion (say < 0.5%) of the coastline or the production of a fishery were to be removed it would be extremely difficult to detect any effect given the lack of precision in fishery statistics and assessments. The second assumption is that there would not a reduction in effort and catch in the remaining fishery, in other words, effort is shifted from the closed area into the areas that remain open to fishing. To do otherwise would effectively confound our results because the introduction of the MPA would be unlikely to have any effect on the fishery beyond an immediate reduction in yield.

18.1 Difficulties associated with such modelling

We are the first to admit that there are limitations to such modelling. Unfortunately, there are many aspects that are difficult to describe due to a lack of previous experience or understanding. Just how will fishing behaviour change when a significant proportion of the fishery is closed? This is a problem related to the description of fleet dynamics. Would the fleet fish close by, in other areas that they have knowledge of, or in other areas with catch rates known to be high? We can only solve the problem of displaced effort by trying many alternatives and seeing if the alternative chosen alters the outcomes in any significant way.

In addition to the problem of fleet dynamics, there is also the problem that the simulation model of the fishery requires a description of recruitment to the fishery each year. Unfortunately, there are very few fisheries around Australia, or the world for that matter, for which we have an adequate understanding of the recruitment dynamics. Once again we elected to approach this problem by considering a range of alternative spawning stock and recruitment relationships.

Another problem is that mathematical modelling usually bores everyone to tears and is difficult to explain in a simple way, so if we haven't already lost you hang in there!

18.2 The Model itself

We wanted a model that was as general as possible but still realistic for the important invertebrate fisheries in Tasmania, using real data where possible to define the model. To this end, we have devised a spatially explicit (best way to model spatial closures), size-structured (cannot effectively age either abalone or rock lobster so we focussed on size), sex based model (male and female rock lobsters grow very differently). There was an annual time step to the simulations.

Not surprisingly, during the development of the model we found its behaviour to be specific not only to a particular fishery but also to the particular area of closure. In other words, the effects of a closure were minimal in some areas and very marked in others. To avoid fishery specific idiosyncrasies we based the work on the biology of the rock lobster fishery in the vicinity of Maria Island on the east coast of Tasmania. This was used to define a set of populations each with identical properties of growth, movement, catch history, and reproduction, so that the issues of different productivity, different catch history, unknown fleet dynamics, and differential recruitment were removed from consideration. These hypothetical populations could number either 10 or 20 to permit the simple closure of 10 or 5% of the fishery (by closing one population completely). The conclusions drawn from this simplified, idealized stock are therefore as general as we can make them.

The dynamics of a hypothetical stock of ten populations could thus be followed through time with or without fishing, and with or without an MPA. The simulation began by growing the population without fishing for a period that enabled the equilibrium levels of recruitment to be defined. Fishing mortality (catch) was then imposed on the unfished population and the consequent depletion in the stock (biomass and numbers) could be monitored. At any stage the so-called surplus production of the stock could be determined. This was the catch level that would leave the stock at the same productivity level each year (it would leave the population in equilibrium). By applying a series of different rates of fishing pressure the stock could be depleted to different levels. The surplus production at each level was determined and in that way a curve of surplus production against different depletion levels was determined. This is shown in Figure 47. Here one can see that productivity of a stock increases the harder we fish up to a certain level. It's a bit like your lawn, the more you cut it the faster it grows up to a point. If you cut it loo low it may die or if you don't cut it at all it stops growing so fast.

If an MPA is introduced by closing one of the ten populations this is equivalent to reducing the productivity by 10%. The absolute difference in the productivity (space between the two lines) is clearly greater near the maximum yield than where the stock is only lightly depleted (see Figure 47). In addition, the size-distribution of the stock changes with increasing levels of legal size biomass depletion in a manner that reflects what has been seen in the real fishery (Figure 48).

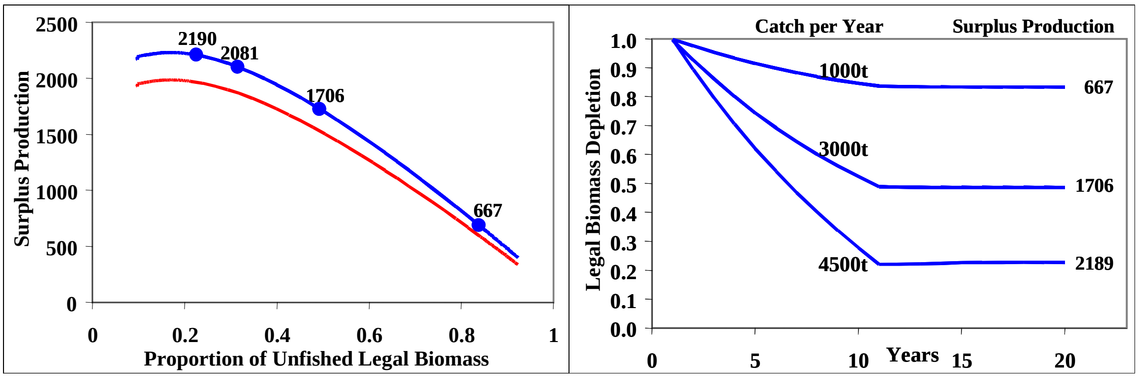


Figure 47. Fishing the ten hypothetical populations at high levels for ten years (catch per year) leads to different degrees of stock depletion. At each level of stock depletion there is a catch level that can be maintained through time, which is defined as the surplus production (right hand panel). By trying many different catch per year levels the curve of surplus production against stock depletion level can be determined (left hand panel). If one of the hypothetical populations is closed to fishing then the available productivity is immediately reduced to only 90% of the original (the lower line in the left hand panel)

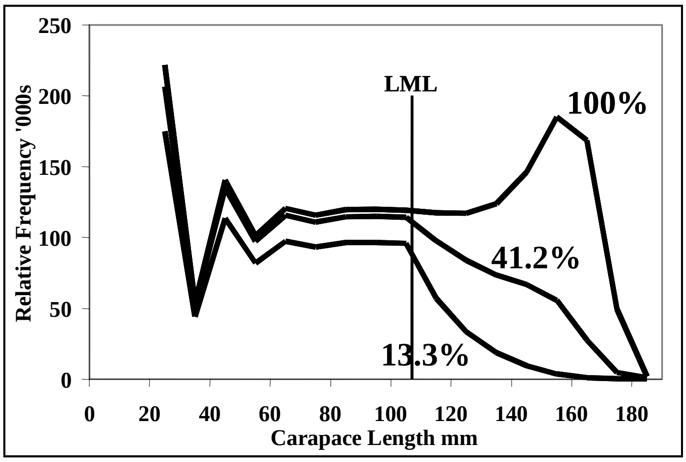


Figure 48. Changes to the expected size frequency distribution of male rock lobster when the legal biomass is depleted to different levels (percent figures). The fishing down of the large mode of accumulated older animals is apparent and reflects what has been seen in the fishery on the east coast of Tasmania. The peaks on the left of the figure at smaller size classes reflect particular cohorts growing into the population on the yearly time step following recruitment onto the reef at about 20mm carapace length. LML is Legal Minimum Length.

18.3 The effect of effort displacement following the introduction of an MPA

The introduction of an MPA without decreasing the TAC would displace effort into the areas remaining open to fishing and the effect is different depending on how heavily the stock is being fished.

When the stock is only lightly fished (slightly depleted) introducing an MPA has the same effect as an expansion of the fishery without effectively increasing the yield. The increase in fishing mortality brought about by concentrating the same amount of effort into a smaller area is absorbed by the fishery becoming more productive (see the explanation of Figure 47).

In Figure 47, the stock is fully exploited at the point marked by the dotted line and over-exploited to the left of this line. Introducing an MPA at this level and attempting to maintain the catch rate out of the remaining areas has serious negative effects on the fishery. The only way to retain equilibrium surplus production is to reduce effort in the remaining fished areas in proportion to the area closed to fishing. Unlike the lightly fished situation above, productivity cannot increase because it is at a maximum. Any increase in fishing mortality leads to stock depletion. In other words to maintain the previous catch levels the fishery is forced to catch more of the standing stock by fishing harder and harder (increasing effort). This is demonstrated in Figure 49. Quite insidiously, we found that these effects were not always immediately apparent and in some cases there was a long delay before the impact of the displaced effort became apparent.

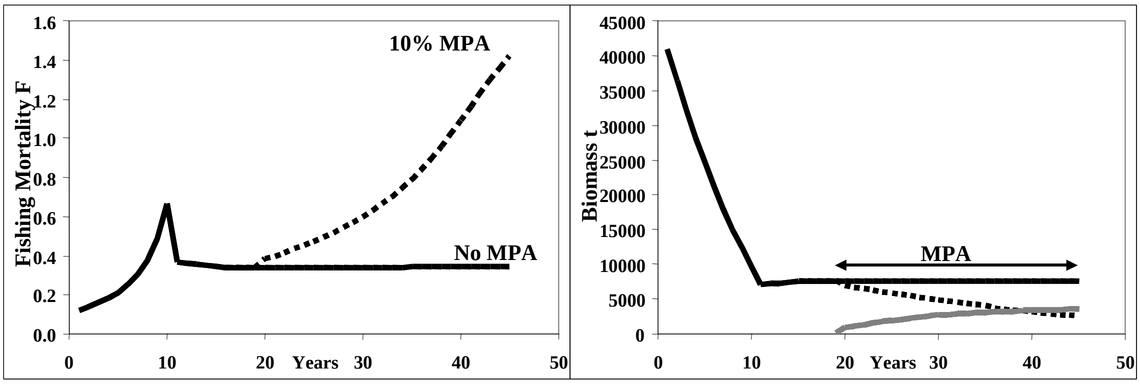


Figure 49. In this example, the impact of introducing an MPA into a fishery at or above its maximum production level is described. The initial situation in the left panel is equilibrium obtained by fishing for ten years at a high level leading to a depletion level of 18.4% unfished biomass (solid line). Introducing a 10% closure after 20 years forces a rapid increase in the level of fishing mortality to maintain the catch level in the areas outside the reserve (dotted line). The right panel shows the legal biomass without the MPA (solid line). After the introduction of the reserve the legal biomass inside the MPA increases and attains a new equilibrium (grey line). Outside the MPA the biomass declines steadily (dotted line) and does not reach a new equilibrium and the cumulative effect is an ever-decreasing overall biomass towards fishery collapse. Note that even in this extreme case it can take years before the fishery effects are obvious.

18.4 The effect of movement rate on the model outcomes

In the previous example, a movement rate in all size classes of 1% between adjacent areas was assumed. This level was a relatively generous rate of movement for Tasmanian rock lobster across the statistical catch reporting area boundaries used in the model. However, other levels of movement rate were investigated to see what effect this had on the outcomes and are shown in Figure 50.

Clearly higher adult movement may ameliorate the impacts of an MPA on the remaining fishery. However, it is often forgotten that this high level of movement has a negative effect on the success of the MPA because it reduces the effectiveness of the closed area in terms of a reduced ability to protect the animals in the reserve. This is explained in Figure 51. In effect, if there is a high level of movement then the MPA is ineffective at protecting the species concerned.

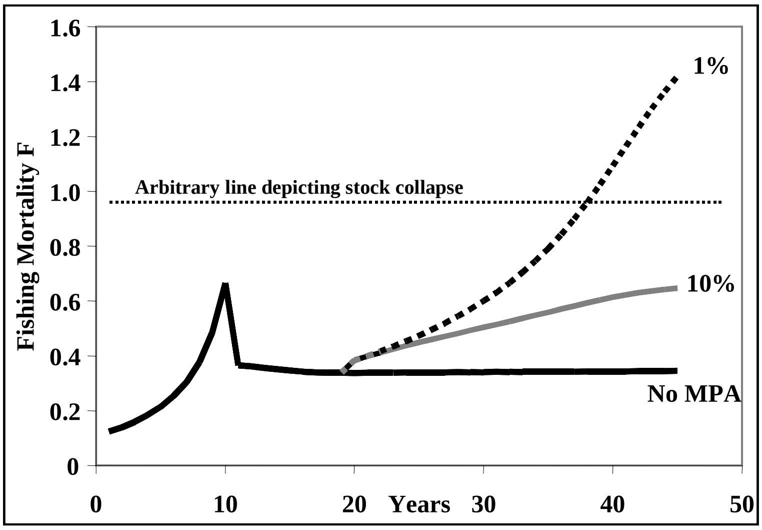


Figure 50. The rate of adult movement may have a significant effect on the model outcome. In this example we have started with the same population described in Figure 49 above (solid line). Introducing an MPA after 20 years with a 1% rate of movement (dotted line) leads to the same rapid increase in harvest rate and eventual collapse as the fishery attempts to maintain a stable catch. However, when there is 10% or greater movement (grey line), which is highly unrealistic for rock lobster but may be appropriate for some fishes, the depletion rate is greatly dampened and movement towards fishery collapse is slowed, although further legal biomass depletion certainly occurs.

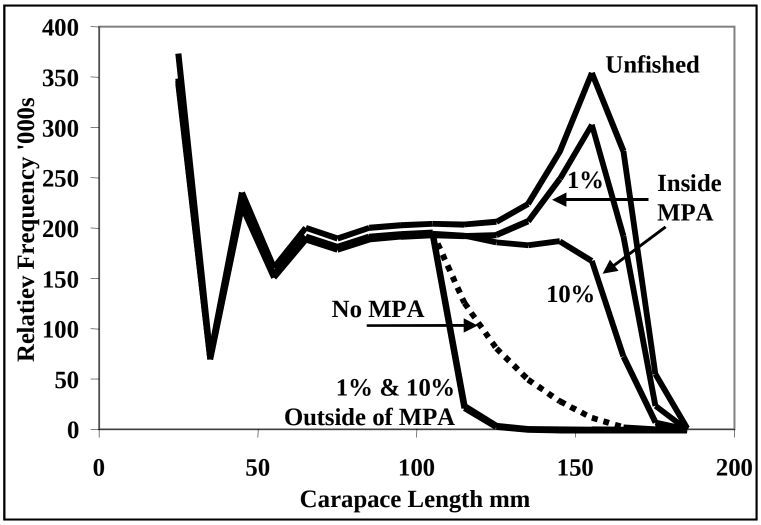


Figure 51. This example shows the number of animals in different size classes under a range of fishing scenarios. The unfished population (top line) shows two clear cohorts in the small fish below 50mm and a build-up or accumulation of animals in the larger size classes (we see this distribution in reserves that have been in existence for several years such as Maria Island). With 1% movement and no MPA (dotted line) this accumulation is fished down leaving a reduced size structure in which there are still animals up to 150mm. Introducing an MPA with the same 1% movement rate we see that the reserve population approximates the unfished state, whereas the fishery population collapses and the size structure is reduced to a remnant just above the legal minimum length (innermost line labelled Outside of MPA). With 10% movement the size structure in the reserve moves towards the dotted line reflecting a reduction in the effectiveness of the protection. Outside the MPA there is hardly any change to the size structure of the fished populations because any fish leaving the reserve are quickly taken in the fishery.

In this article, we have only touched on a few of the outcomes of the modelling project. In summary, what it demonstrates is:

- Because the effects of large MPAs (> 5% coast) tend to become apparent only over many years, the effects of small MPAs (< 0.5% coast) are hard to detect.

- Because of the dynamics of growth and recruitment, there is a time lag before any positive effects of the introduction of an MPA become apparent. In an exploited population, introducing an MPA without reducing catch appropriately is equivalent to increasing the TAC outside the reserve. It increases fishing mortality. If the stock is already in a depleted state, an MPA can hasten fishery collapse.The impact of introducing an MPA will depend on the biology of the species concerned.

Of great interest is the fact that when an MPA is introduced the stock depletion in the remaining fishery may only occur at such a slow rate as not to be detectable. Such slow depletion towards eventual collapse would provide a challenge for management.

Our study indicated that for rock lobster, in the presence of good traditional management measures, the introduction of MPAs was likely to have little positive benefit. On the contrary, the most likely effect would be to have a negative impact as effort was shifted into the remaining area.

Conversely, in the absence of any other management MPAs could become more significant as a management tool. Total stock collapse could be prevented and the MPA would provide some sort of a fishery, albeit a greatly reduced one at the margins. In countries such as Australia, where the legislation permits, it is hoped that when signs of fishery collapse became apparent, effort would be made to restrain catch and prevent such an event from occurring.

19. Species interaction - predators

19.1 Octopus

This article is adapted from Harrington and Semmens (2002) The Maori octopus and its impact on the Tasmanian Rock Lobster Fishery. Fishing Today 15(3):19-20. This research is supported by ARC Grant C00107233 (Life History and Ecology of *Octopus maorum* and Minimisation of its Impact on the Rock Lobster Fishery in Tasmania)

From June 2001, the Maori octopus (*Octopus maorum*) has been the subject of a research project being conducted at the TAFI - Marine Research Laboratories in Taroona. The project, entitled “The life history and ecology of *Octopus maorum* and minimisation of its impact on the rock lobster fishery in Tasmania”, is examining three main issues:

- The impact of octopus on the commercial rock lobster fishery in Tasmania

- The dynamics of the Eaglehawk Bay octopus fishery on the Tasman Peninsula
- Population dynamics of octopus within the Crayfish Point Reserve at Taroona

The preliminary results summarised in this article have been constructed from data provided by commercial rock lobster fishers around the state for the period June to December 2001. Due to gaps in the data, some locations that have been sampled are not represented here.

General Trends

Between June and December 2001, rock lobster fishers collected 163 octopus. Of these octopus, 120 have been examined with 61 being male and 59 female. The average weight of females was 3.26kg, while males were generally heavier, with an average weight of 4.23kg. There was no evidence to indicate that more octopus were caught at any particular time of year within the period examined so far.

For all the pots affected by octopus, 533 lobsters were killed at an average of 1.88 lobsters per pot. Of the lobsters killed, 36.2% were sized males, 22.3% undersized males, 20.6% sized females and 20.8% undersized females. For the south / southwest region of Tasmania (the only area with a complete monthly data set) there was no evidence that showed any particular month had greater numbers of lobsters killed.

Trends related to Moon Phase

Anecdotal evidence from lobster and octopus fishers suggests that moon phase / tidal cycles play a major part in influencing octopus catch rates. Therefore, to compare differences in octopus catch rates within months, months were broken up into the following moon phases: full moon to last quarter; last quarter to new moon; new moon to first quarter; and first quarter to full moon.

If you assume that fishing effort throughout a month was evenly distributed, Figure 52 clearly illustrates that both the number of octopus caught and number of pots affected by octopus were highest after the full moon and lowest after the new moon. Intermediate catches occurred at other times of the month. As *O. maorum* is a visual predator, increased catches around the full moon may result from the octopus being more active due to more light being available to hunt and locate prey. The fact that catches of octopus were lowest around the new moon is an interesting one, as anecdotal information from octopus fishers at Eaglehawk Bay suggests that catches of octopus peak during this phase, as well as at full moon. However, obvious difficulties may arise when comparing catch trends of two contrasting fisheries.

When lobster catches in pots affected by octopus are compared between moon phase, there was on average 2 dead lobsters per pot during all phases, with exception to the first quarter to full moon, which had an average of 1.5 dead lobsters per pot (Figure 53). The number of live lobsters per pot was found to be higher around the full moon (average of 3.6 live lobsters per pot), than around the new moon (average of 2.4 live lobsters per pot) (Figure 53). This data suggests that lobster catches are higher around the full moon (greater number of live versus dead lobsters) than the new moon. Consequently, it appears that lobster kills per pot are not dependent on the number of lobsters in the pot (there were the same number of dead lobsters in pots with higher numbers of lobsters). This apparent maximum number of lobsters an octopus can kill may result from satiation, toxin limitations (octopus use a venomous bite to kill the lobster and virtually liquefy its flesh before consumption) or time limitations in killing and eating individual lobsters.

Between and Within Location Variation

For the purpose of this report locations around Tasmania were broken into the following regions:

King Island	King Island
Northeast	St. Helens area (including some Bass Strait islands)
Southeast	Tasman Peninsula area
South / southwest	fishers based out of Hobart area who fish from Bruny Island to Low Rocky Point
Southwest	Southeast Cape to Low Rocky Point only
West	fisher based out of Strahan
Northwest	Sandy Cape to Woolnorth

If the total number of male and female octopus caught in each location are compared, King Island, the southeast and southwest regions had greater catches of female octopus, the northeast region had slightly higher catches of male octopus, and the south / southwest region had a substantially greater number of male octopus caught (Figure 54). Comparing the average weights of octopus caught in each region showed that the northeast, southeast and southwest had higher average male weights while all other regions had no obvious differences in average weights between sexes. There is no obvious explanation for this difference in size of males and females for the different regions. However, an examination of growth rates, which is under way as part of the larger project, may shed some light on these results.

To examine trends in lobster kills for each region, lobsters were categorised into 4 types: male legal size, male under legal size, female legal size and female under legal size. The western region had the highest kill rates, with an average of 1.9 per pot for both male under size and size, and 1.2 per pot for female under legal size but only 0.1 per pot for female legal size. King Island had high kill rates for sized lobsters (1.4 per pot for males and 1.1 per pot for females), but very low kill rates for undersize lobsters (<0.2 per pot). Similarly, the northeast had on average more sized lobsters killed; however, higher rates of undersized animals were killed in comparison to King Island. The south / southwest had the lowest kill rates (less than 0.5 per pot for each size class), however, in this region undersize animals were killed at higher rates than sized lobsters, with very few sized females killed. The above data corresponds to rock lobster size frequencies and distributions around Tasmania, with southern regions having very few sized females and northern regions having higher lobster growth rates and lobster sizes.

Information from King Island, the northeast and northwest showed that in more than 70% of pots affected by octopus the largest lobster was killed, with the highest rate being on King Island (93% of pots had the largest lobster killed). In other areas, the south / southwest region had 55% and the southeast, southwest and west had <50% of the largest lobsters killed. Furthermore, in the west and King Island no pots containing an octopus and either all live or no lobsters were reported. A similar trend occurred for the northeast, northwest and southeast regions, with 2 pots containing an octopus not having dead lobsters. The southwest and south / southwest regions did not follow this trend, with 8 pots containing an octopus, but no lobsters and 15 pots with all live lobsters and an octopus present. Why this trend of a difference between regions would occur is unclear. The result of octopus being in a pot with no lobsters present suggests that they have either gone into the pot after the bait or the lobsters escaped the pot. Underwater video footage taken in the Taroona reserve shows that octopus will come into a pot and only attack the bait and not the lobsters, with this possibly explaining live lobsters in a pot with an octopus. Alternatively, the octopus may not have had time to prey on the lobsters before the pot was pulled.

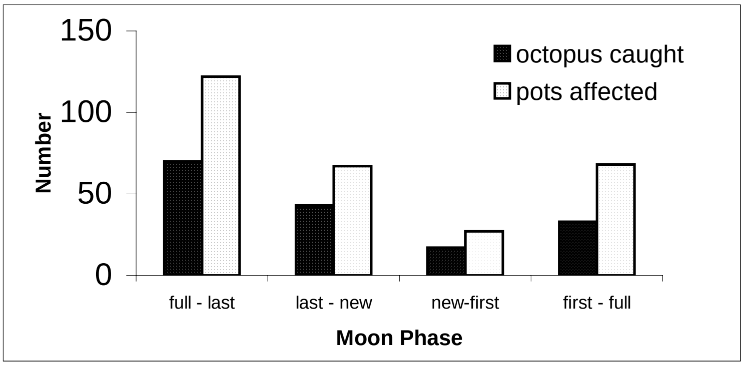


Figure 52. Comparison of the total number of octopus caught and total number of pots affected by octopus with moon phase. Data is combined for all Tasmanian locations.

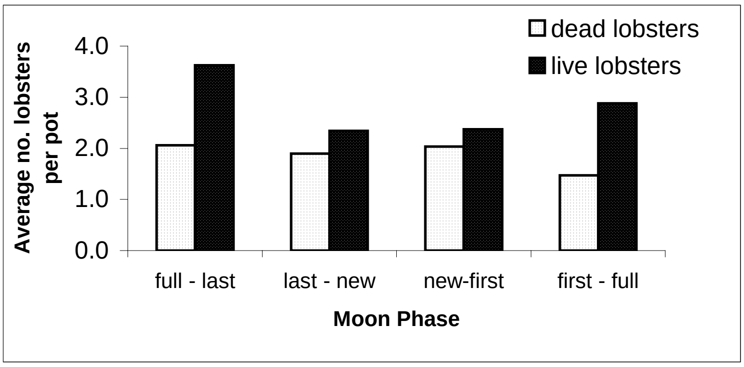


Figure 53. Comparison of the average number of both dead and live lobsters per pot with moon phase. Data is combined for all Tasmanian locations.

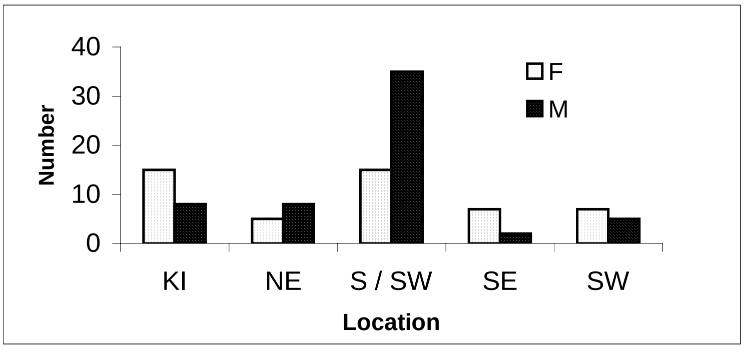


Figure 54. The total number of male (M) and female (F) octopus caught in each region of Tasmania. Locations KI = King Island, NE = northeast, S / SW = south / southwest, SE = southeast and W = west.

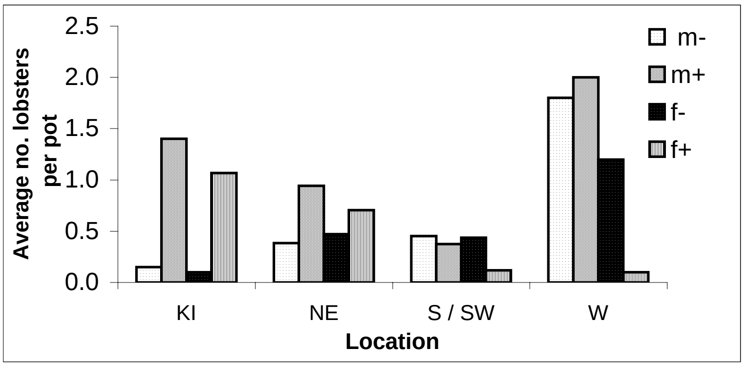


Figure 55. Average number of lobsters killed per pot for the different regions around Tasmania from June 2001 to December 2001. m- = male under legal size, m+ = male legal size, f- = female under legal size and f+ = female legal size. Location codes are same as for Figure 54.

19.2 Draughtboard Shark

To build on our knowledge of important ecosystem issues relating to rock lobster, a PhD proposal was developed in 2001 to look at the draughtboard shark (*Cephaloscyllium laticeps*). This species is commonly caught in rock lobster pots and, unlike most species, does not escape through escape gaps due to their size (Frusher and Gibson, 1999). Draughtboard sharks are considered to be predators of rock lobster (negative impact on lobster resource), octopus (positive impact on lobster resource), other lobster competitors (e.g. crabs – positive impact on lobster resource) and possibly urchins (secondary impact due to urchin barrens). In addition to ecosystem interactions, the draughtboard shark had a consistent disproportionate negative effect on lobster catchability although the cause is unknown (Brickhill, 2001).

The draughtboard shark is the most common catshark in coastal areas of southern Australia (Last and Stevens, 1994). The prey of the draughtboard shark is considered to be small reef fish, crustaceans and squid (Last and Stevens, 1994). Although Last and Stephens report that it is a nuisance to lobster fishermen in Bass Strait, it is a common by-catch species in lobster pots around Tasmania (Frusher and Gibson, 1999). The sharks are also commonly caught on fishing lines and in nets. Although no abundance estimates have been attempted the draughtboard shark is expected to be a major higher trophic level predator in southern temperate reef systems.

Draughtboard sharks are considered to be ‘tough’ and survival from lobster pots is considered to be high. Recently, there has been a trend for draughtboard sharks that have been caught in commercial gill nets to be retained and filleted for local consumption (‘flake’ market)(J. Lyle, pers. comm. Section Leader, Finfish Research). In general, sharks are considered vulnerable to targeted fishing pressure due to their reproductive strategies (low number of eggs) and growth rates. Draughtboard sharks are considered to have a high catchability rate in pots and nets and thus should be considered potentially vulnerable to increased harvests.

A small amount of preliminary research has commenced on draughtboard sharks over the last decade. Since 1992, draughtboards sharks, along with all by-catch, have been recorded in routine lobster catch sampling surveys. Over 1200 sharks have been recorded. These records show presence or absence and thus indicate spatial and temporal abundances. To determine growth and movement patterns the Crustacean Research Team commenced tagging draughtboard sharks during routine catch sampling trips to the East and Southwest coasts in 2000. In addition, draughtboard sharks have been tagged during routine lobster and octopus sampling trips in the Crayfish Point Reserve. During recent sampling in the reserve (56 pots by 4 days in late February 2002) 19 draughtboard sharks were captured of which 7 were recaptures. Several were recaptures from when tagging commenced in January 2000. This indicates that a portion of the population is residential and that tags are retained for up to 2 years.

The first part of this PhD study will focus on basic biological data: sex and size distribution, reproduction, diet and movements.

The second part of the study will use this data to describe the biological niche that the draughtboard shark utilises and its interaction with Tasmania’s valuable rock lobster (and to a lesser extent abalone) fishery.

20. Industry Issues

The Tasmanian rock lobster industry has identified the need to obtain robust estimates of exploitation rate and pre-recruit abundances as their top priorities. A major concern has been the poor performance of the change-in-ratio and index-removal techniques trialed in the FRDC project “Assessment of broad scale exploitation rates and biomass estimates for the Tasmanian southern rock lobster fishery” (see detailed summary in Section 3.2.4). Industry strongly supports further research into trialing multi-year tagging models to obtain exploitation rates. Tagging models are dependent on returns from Industry and preliminary trials suggest that return rates are too low. A concern raised by Industry was the amount of data that needed to be recorded for growth and movement studies using tags. As information to be recorded for estimating fishing and natural mortality from tagging data is substantially reduced, Industry believes that fishers will be more willing to return tags. An awareness campaign will be an essential component of any new tagging project.

Development of the tagging models to obtain more accurate estimates of natural mortality, particularly for pre-recruits is viewed as being essential for the development of more accurate stock assessments in the future. In addition industry believes that it is essential to develop an ‘early warning’ system to detect any decline in recruitment to the legal sized biomass. A combination of puerulus and pre-recruit monitoring is supported. In particular, in southern and western regions where puerulus monitoring sites are unavailable, pre-recruit monitoring is essential.

The need to obtain accurate estimates of recreational catch remains an ongoing area of concern to Industry. In a report by Forward and Lyle (2002), the increased popularity of recreational diving for lobsters is clearly demonstrated with an increase in effort from 17.7% of total recreational effort (days fished) in 1997/98 to 21.5% in 2000/01. Part of the increase is due to the success rate that divers have in capturing lobsters. The catch rate of divers in 2000/01 (2.5 lobsters per day) was substantially higher than recreational potters (0.88 lobsters per day). Concurrent with the increase in effort, the percentage of the total recreational catch taken by divers had increased from 32-34% in 1996/97 to 44% in 2000/01. The majority of recreational effort (diving and potting) is in the southeast of Tasmania. With over 47% of total effort and 45% of total catch taken from this area, there is a need to develop techniques for determining the impact that recreational fishing has on the inshore lobster resource. Current assessments indicate that legal sized biomass is increasing in southeastern Tasmania. However, the extent of recreational effort in this region may erode legal-sized biomass rebuilding in the shallower waters that support the recreational fishery. If the increase in legal-sized biomass is reflected in inshore waters, then it is believed that lobsters will become easier to catch and recreational effort will continue to increase.

Industry welcomes the move to incorporate depth in the regional assessments. Observations by fishers suggest that lobster catchability varies with depth both spatially and temporally. Currently catches from all depths are aggregated for assessment purposes and Industry believe that there are important trends in abundance that may be masked by ignoring depth. Industry believes that this refinement in the assessment process will improve the accuracy of the overall assessment of the fishery.

Finally, Industry endorses the need to evaluate ecosystem impacts of fishing to address the concerns raised by Environment Australia (EA) (Ford, 2001). Industry has always recognised that a healthy ecosystem is fundamental to sustainable exploitation of the rock lobster resource. Currently there is an additional need to demonstrate and document this for International accreditation if the Industry is to optimise a variety of overseas marketing opportunities. Industry supports moves to modify the assessment process to specifically address the concerns raised by EA, and that further modifications may be required to meet ESD requirements in the future.

21. Appendix 1: List of Management Objectives and Strategies

There are eight policy objectives in the current rock lobster fishery policy document (Anon, 1997). Although this document remains current, the introduction of the *Environment Protection and Biodiversity Conservation Act 1999* and the subsequent assessment of the fishery for export exemption under Parts 13 & 13A of the *Act,* has meant that these objectives are now interpreted, for the purposes of managing the fishery, under an overriding policy of ecologically sustainable development. The strategies adopted to achieve the existing objectives remain the management tools that are currently utilised.

To provide for ecologically sustainable development, the management objectives have recently been expanded and modified and will shortly be released for public comment as part of a new policy document. In line with the draft objectives, a number of changes to the management strategies are also proposed in the new policy document.

The proposed policy objectives listed in the draft plan are:

- The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range and within acceptable levels of probability.
- Where the fishery assessment suggests that the fish stock is below defined reference points, then the fishery will be managed to promote recovery to ecologically viable levels within a nominated timeframe.
- An appropriate compliance strategy that minimises the opportunity for illegal activity through monitoring, compliance and enforcement measures that are supported and aided by industry.
- Optimise the economic value of the fishery within the constraints of objective 1.
- Recover a financial contribution from both commercial and recreational rock lobster fishers to contribute to the real costs of management, compliance and research.
- Ensure that the rock lobster fishing fleet continues to provide employment and an economic return to Tasmanian coastal communities.
- The fishery is conducted in a manner, which minimises the effect on by-catch or by-product species.
- The fishery is conducted in a manner, which minimises mortality of, or injuries to, endangered threatened or protected species and avoids or minimises impacts on threatened ecological communities.
- The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.

- Maintain a fishery that is conducted in an orderly manner recognising different participants need to access shared fishing grounds.
- Provide reasonable recreational access to the fishery.
- Provide access to the fishery for Aboriginal people to undertake cultural activities.
- To promote and maintain handling and processing practices that attempt to ensure the highest quality rock lobster product.

22. Appendix 2: List of Performance Indicators and Trigger Point Strategies

22.1 Performance Indicators

The performance indicators for the Tasmanian rock lobster fishery are identified in the rock lobster fishery policy document (Anon, 1997). These are:

22.1.1 Catch per unit effort (CPUE)

Catch per unit of effort (or catch rate) is commonly used as an index of abundance. For the purpose of the Management Plan, CPUE is defined as the kilograms of lobster caught per pot lift and will be calculated separately from both commercial catch returns and independent research surveys.

22.1.2 Biomass

- While CPUE can provide a relative index of abundance, it does not provide an actual estimate of biomass. For the purpose of the Management Plan, biomass will be defined as the estimated tonnage of legal-sized lobster on the bottom at a stated point in time. Changes in the biomass are important because this will affect the catch rate, productivity, sustainable harvest level and egg production of the fishery.
- Biomass will be estimated by two different techniques. The first will be a length structured, spatial stock assessment model of the rock lobster fishery and the second method will be through independent research surveys in selected regions of the fishery. While these two techniques are different, the stock assessment model incorporates research data, which implies that the two sources of biomass estimates are not completely independent.

22.1.3 Egg production

- Maintenance of sufficient levels of egg production is crucial to prevent declining recruitment and eventual recruitment failure of the fishery. Unfortunately there is a high degree of uncertainty in terms of both the level of egg production required and whether there are certain regions, which are most important as the source of future recruitment. In light of this uncertainty, it is important to apply a precautionary approach and to ensure that both global and regional egg production does not fall below the lowest levels that have been experienced in the past.

- Both global and regional egg production will be estimated through the previously mentioned stock assessment model of the rock lobster fishery. For the purpose of this Management Plan, the term Egg_{low} will refer to the value of the lowest level of annual egg production experienced between 1970 and 1995 on a global or regional basis (depending on context). The Egg_{low} value will be used as a limit against which egg production in future years will be compared.

22.1.4 Relative abundance of undersized lobster

- CPUE, Biomass and Egg production reflect the performance of the fishery over the preceding fishing season. In contrast, a measure of the undersized component of the resource can give an indication of expected future harvests. This would allow for adjustments to catch levels to be made prior to problems being reflected in the fishery. For the purpose of the Management Plan, undersized lobster will be defined as the kilograms of lobster caught per pot lift in specified length classes. The size of the length classes will represent annual growth increments, taking into account the different regional growth rates.

- The relative abundance of undersized lobster will be estimated from independent and fishery dependent research surveys in selected regions of the fishery.

22.1.5 The total annual commercial catch

- The total annual commercial catch may fall below the TACC for a number of reasons, that must be accounted for before any action is taken. The total commercial catch will be monitored against the TACC for the fishery.

22.1.6 The size of the rock lobster fleet

- As the restructuring process occurs it is likely that the number of licenses and vessels operating in the rock lobster fishery will decline. It is important to monitor this decline to assess possible social and economic impacts on the coastal communities where rock lobster fishing is an important industry.

22.1.7 The recreational catch

- The recreational catch will be monitored through the continuation of recreational surveys. The recreational catch is not limited directly. While this is of little concern as the catch appears to have fallen over the past ten years, it is important to monitor the catch and to take corrective action if it increases above what it may have been in the past. In the last 10 years the recreational catch has ranged from 5% and 11% of the commercial catch.

22.2 Trigger Points

The trigger points for the Tasmanian rock lobster fishery are listed in the rock lobster fishery policy document (Anon, 1997).

22.2.1 Catch per unit effort (CPUE)

- Annual CPUE from commercial catch returns falls below 95% of the CPUE for the reference year with the lowest catch rate (i.e. 1993, 1994, or 1995). For the first year of the Management Plan only, catch rate will be permitted to fall to 90% of that in the reference year with the lowest catch rate. The analysis to assess this trigger point must standardise CPUE to take account of possible biases caused by changing fishing patterns on at least a monthly and regional basis.

- Annual CPUE from commercial catch returns for any region falls below 75% of the CPUE for the reference year with the lowest catch rate for that region, unless at least three other years for the same region between 1970 and 1995 had a lower catch rate. The analysis to assess this trigger point must standardise CPUE to take account of possible biases caused by changing fishing patterns on at least a depth stratified and monthly basis. This analysis should also take into account any other mitigating factors that might artificially affect regional catch rates.

- CPUE from research surveys in available regions declines significantly from matching surveys (location and month) from that of the reference year with the lowest matching survey catch rate. The analysis of this trigger point should consider mitigating factors such as variations in catchability due to weather or variation in moult timing or seasonal influences.

22.2.2 Legal-sized biomass

- The estimate of global (state-wide) legal-sized biomass from the stock assessment model falls below 95% of that estimated for the reference year with the lowest biomass.

- The legal-sized biomass estimate from the stock assessment model for any region falls below 75% of that estimated for the reference year with the lowest biomass in the related region.

- Legal-sized biomass estimates from research surveys in available regions declines significantly from one survey year to the next (technique being developed). Biomass specific research surveys will not commence till the 1997/98 season, hence it is not possible to use a past reference year in the trigger point. An exception to this trigger can be invoked if the stock assessment model or other models can adequately demonstrate that the decline in biomass seen through research surveys results in a biomass that remains higher than that which existed in the reference years.

22.2.3 Egg Production

- The estimate of global (state-wide) egg production falls below that of Egg_{low}. An exception to this can be invoked if the estimated egg production is within 5% of Egg_{low} provided that the reduction is restricted to areas with egg production levels which exceed 40% of that of the estimated unfished (virgin) stock.
- Any regional estimates of egg production falls to less than 95% of the related egg_{low} unless the affected regions have egg production levels which exceed 40% of that of the estimated unfished stock.
- For regions in which the estimated value of Egg_{low} is less than 10% of that of the estimated unfished stock, no reduction in egg production below that of Egg_{low} is permissible.

22.2.4 Relative abundance of undersized lobster

- Annual CPUE of undersized lobster in the pre-recruit size class falls below 95% of that estimated for the reference years already mentioned, for the same sampling region and sampling period. The analysis of this trigger point should consider mitigating factors such as variations in catchability due to weather or variations in moult timing.[1]

22.2.5 The total annual catch

- The total annual commercial catch falls below 95% of the TACC for any year. The analysis will consider the reasons for the actual catch falling below the TACC, these may include weather factors, quota availability factors or market factors.

22.2.6 The size of the rock lobster fleet

- The number of licenses operating in the fishery falls below 220. The analysis will consider factors that have caused the number of licenses to fall to this level. Action may be taken to ensure there is no further decline in the number of licenses if it is considered necessary by the industry or the Government.

22.2.7 The recreational catch

- The recreational catch exceeds 10% of the TACC in a year there will be a review of the recreational management arrangements.

[1] The Tasmanian rock lobster stock assessment working group considered this trigger point to be of questionable value, given the large annual variation in natural recruitment. It was suggested that future management plans incorporate a trigger based on trends in relative abundance of undersize lobsters over periods of several years.

23. Appendix 3: Fishery Description

23.1 General Overview

A detailed description of the Tasmanian rock lobster fishery follows below. For the purposes of this report the following points are especially important to understand:

(i) The fishery adopted an individual transferable quota system (ITQ) in March 1998

(ii) This assessment report contains information available up to the end of the fourth quota year in February 2002.

A summary of the main regulations that govern the commercial and recreational sectors are presented in Table 13. More detailed information is available in the rock lobster fishery policy document (Anon, 1997).

A recent initiative undertaken by the Tasmanian government was to investigate the potential for rock lobster aquaculture. While some consider there is potential for development of lobster aquaculture through ‘closing the life cycle’ and thus operating independently of the fishery, the initial development plans to source puerulus from the wild. Seven permits were issued in 2001 for collection of up to 50,000 puerulus per permit. As any quantities either extracted from or returned to the resource will impact on the resource, a chapter on aquaculture has been added to this report.

Table 13. Summary of rules for the Tasmanian Rock Lobster Fishery.

COMMERCIAL

Management zone	one management zone for the State
Limited entry	314 licenses
Limited seasons	In 2001: closed season 24th-28th February (both sexes); 1st September – 2nd November (both sexes); 1st May-1st October (females).
Limits of pots on vessels	minimum of 15 pots, maximum of 50 pots
Quota	Total allowable catch of 1502.5 tonnes
Restrictions on setting pots	pots cannot be set, or pulled, between two hours after sunset and two hours before sunrise
	pots must be hauled no longer than 48 hours after being set
Restrictions on pot size	maximum size of 1250 mm x 1250 mm x 750 mm.
Escape gaps	one escape gap at least 57 mm high and 400 mm wide and not more than 150 mm from the inside lower edge of the pot, or two escape gaps at least 57 mm high and 200 mm wide and not more than 150 mm from the inside lower edge of the pot
Minimum size limits	105 mm CL for females, 110 mm CL for males
Berried females	taking of berried females prohibited

RECREATIONAL

License requirements	rock lobster potting licence - 1 recreational pot per person, rock lobster diving licence, rock lobster ring license – 4 rings per person.
Daily limit	5 per recreational license holder
Limited seasons	In 2001: closed season 1st May-2nd November (females); 1st September-2nd November (males).
Restrictions on setting pots	as per commercial fishers
Restrictions on gear	Pots as per commercial fishers, rings no more than 1 m in diameter, capture by glove only when diving.
Escape gaps	as per commercial fishers
Minimum size limits	as per commercial fishers
Berried females	as per commercial fishers
Sale or barter of lobsters	prohibited
Marking	All recreational lobsters must be tail clipped within 5 minutes of landing. No tail-clipped lobsters to be sold.

23.2 History of Tasmanian Commercial Rock Lobster Fishing

The rock lobster commercial fishery dates back to the period of early European settlement in Hobart in 1804 and its early history is described by Winstanley (1973). Management restrictions were first imposed in the 1889 Fisheries Act after a Royal Commission on the Fisheries of Tasmania found "*the destruction of crayfish [rock lobster] is so serious in some localities as to threaten extermination at no distant date*". These first restrictions included a size limit, the ban on taking berried lobsters and a ban on the possession or sale of soft shelled lobsters. In 1912, a closed season was introduced from 1st November to 15th January to cover the moulting period as recommended in the Royal Commission. These regulations essentially still apply today although closed seasons on females and males supplement the berried and soft shelled regulations. Possession of soft shelled lobster is no longer banned. Closed seasons were first implemented in 1926 and have been adjusted on numerous occasions since (Gardner and Frusher, 2000).

In the 1950's licences for commercial fishers (pots allocated according to vessel size with a maximum pot holding) were restricted to participants principally dependent on the sale of rock lobster for a livelihood. At the same time, recreational fishers were restricted to use of a single pot. In 1967, a policy of licence limitation was adopted and this was followed in 1972 by fixing the number of pots in the fishery to 10,993 (Winstanley, 1973).

In the mid to late 1980's concern over the resource was again expressed by fishers as catch rates declined (Figure 56). A working group of fishers and government representatives was formed in the early 1990's to evaluate options to stem this decline (Anon, 1993). The working group clearly identified increased effort as the major problem and expressed concern at the potential for further increases, as latent effort was considerable. The lack of consensus on the appropriate management method to adopt resulted in a number of Industry polls. This culminated in a poll in 1996, which resulted in a marginal preference for quota management. In March 1998, an individual transferable quota (ITQ) management system commenced.

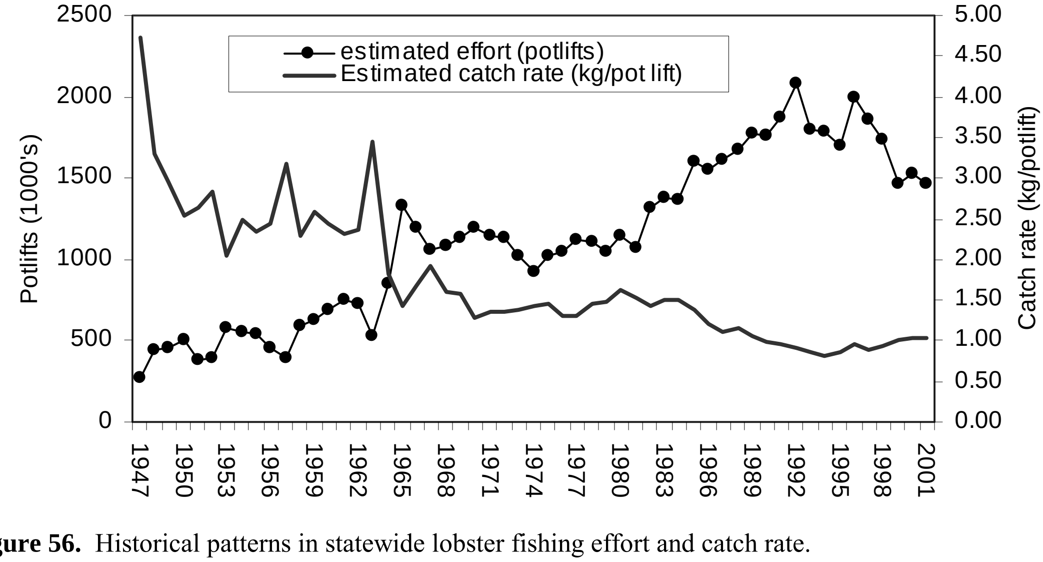


Figure 56. Historical patterns in statewide lobster fishing effort and catch rate.

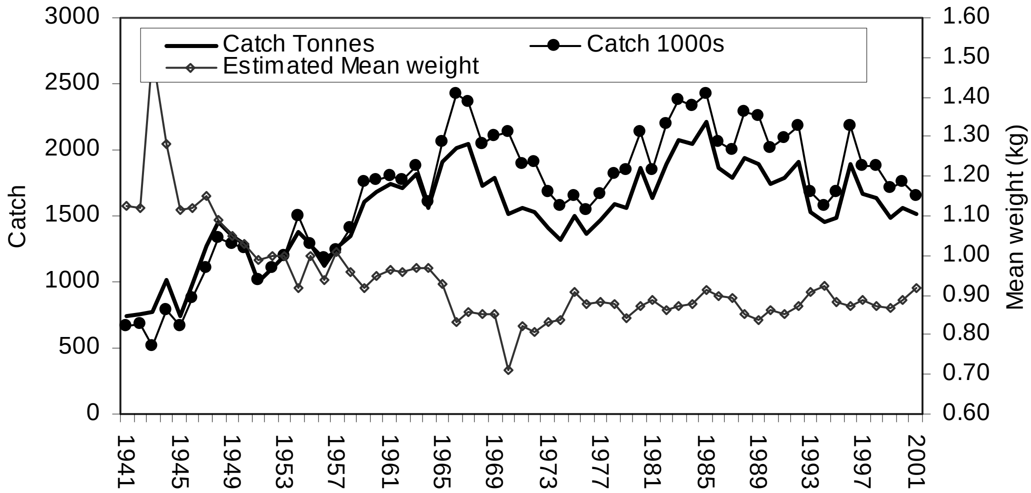
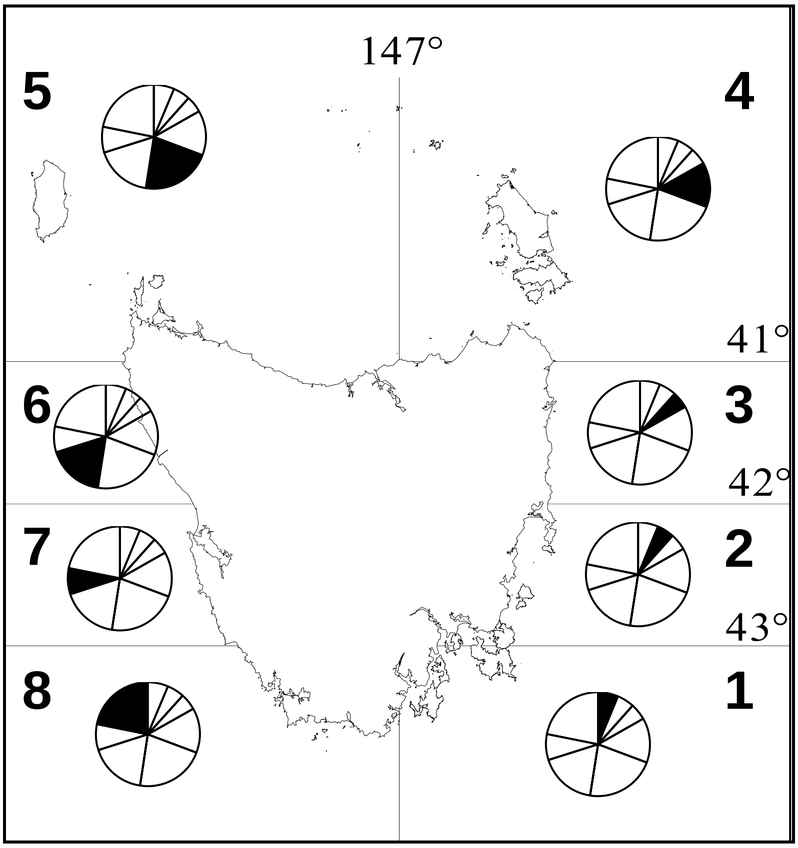


Figure 57. Historical patterns in statewide catch.

23.3 Commercial Rock Lobster Fishery

The Tasmanian rock lobster fishery targets the southern rock lobster (*Jasus edwardsii*) in the waters adjacent to Tasmania. Tasmania has jurisdiction for the fishery in waters generally south of 39 12', and out to 200 nautical miles from the coastline. This jurisdiction is provided to Tasmania by way of the Offshore Constitutional Settlement agreement of 1996, for invertebrates (see Commonwealth Gazette 31/12/1996 No. S531 for full details).

Since 1970, fishers have recorded their daily catch in degree blocks around Tasmania, which has allowed regional trends to be documented. In 1992, reporting blocks were further reduced in size to quarter degree blocks (30 nm X 30 nm). These blocks are aggregated into eight stock assessment areas, which are used in the current rock lobster stock assessment model (Punt and Kennedy, 1997; Figure 58).



Region	% of catch
1	8.3
2	7.3
3	5.8
4	17.1
5	21.9
6	12.9
7	8.0
8	18.7

Figure 58. Location of the eight regions used in this report and their percentage contribution to the 2001/02 commercial catch (March to February inclusive).

The distribution of the catch clearly shows the current importance of the west coast, particularly areas 5 and 8.

Although lobsters have been recorded from depths greater than 200m, few lobster are caught in depths below 125m (Figure 59). With the exception of area 6 where over 40% of the catch comes from waters deeper than 62m, most of the catch comes from waters less than 62 m. Shallow water grounds less than 18 m are especially important in areas 2 and 3 with greater than 30% of the catch from this depth range.

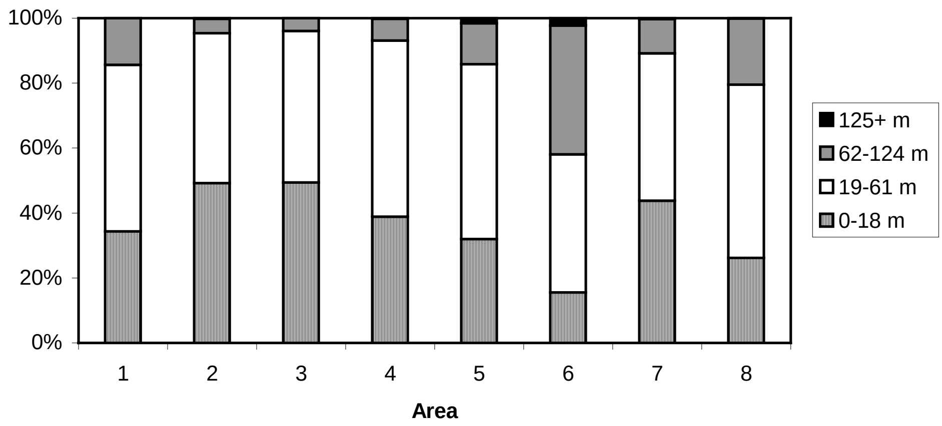


Figure 59. Regional depth distribution of catch from March 1998 to February 1999.

23.3.1 Fishing methods

The only commercial fishing method for rock lobster is the use of rock lobster pots. These are generally made from steel and mesh netting or from wooden "sticks" and steel mesh. Similar pots are used by recreational fishers. Recreational fishers can also dive for lobster or use hoop style lift nets (rock lobster rings).

Lobster pots are baited, usually with fish, such as jack mackerel, barracouta or Australian salmon. Pots are set for a number of hours, normally overnight or from dawn to dusk. The rock lobster are attracted by the bait and crawl into the pots. The neck of the pot is designed in such a way that it is difficult for the lobster to escape from the pot. Pots are required to have escape gaps to allow undersized rock lobster to escape from the pot.

Commercial pots are hauled by hydraulic lifters which is one factor contributing to the ability of commercial vessels to operate in deeper water than recreational fishers. After lobsters have been removed and checked against size restrictions, the pots are re-baited and either reset or stored on the vessel to be set later in the day.

The commercial sector uses colour echo sounders, radar and global positioning systems to assist them in locating suitable areas to set their pots.

23.3.2 Catching sector

In 1997 the rock lobster fishing fleet comprised 330 vessels and this had reduced to 314 vessels in February 1998 at the commencement of quota (Table 4). Since quota the number of active vessels has reduced to 246. Vessels range in size from 6-26 metres in length. The majority of vessels are used primarily for rock lobster fishing but have the capacity to diversify into other fisheries on a seasonal basis. The vessels are a mixture of wooden and steel hulls with a few fibreglass vessels. The majority of the fleet is of the displacement hull style with a small number of planing hull vessels. The average age of the fleet exceeds 15 years, with very few new vessels operating.

Each licence has a quota allocation ranging from 5 to 100 rock lobster quota units. Each vessel has a rock lobster pot allocation based on either the length or tonnage of the vessel. The pot allocation varies between a minimum of 15 and a maximum of 50 pots. A total of 10,507 pots were able to be used throughout the fleet in February 2001, however under quota less pots than this are being used. The majority of vessels are owner operated, but there is a trend toward the leasing of vessels and licences.

The market value of vessels participating in the fishery varies between approximately $15,000 to $750,000. Licences vary in price according to the number of pots and the types of fishing licenses on the package.

All rock lobster are landed live from the catching vessel and are generally purchased by a processor at the wharf, with most product destined for live export.

24. Appendix 4: Biology of the southern rock lobster

While it is beyond the scope of this report to go into any detail of the biology of rock lobsters there are aspects of the biology that will make interpretation of this report easier. The most important points are:

(i) Lobsters grow by a process known as moulting, where the external skeleton or shell is shed.

(ii) Mature female lobsters moult in autumn and males in spring.

(iii) Females incubate eggs under the tail for 3 to 5 months from May/June to September/ October.

(iv) Growth rates and size at onset of sexual maturity vary regionally in Tasmania. Fastest growth rates and largest size at onset of sexual maturity are found in northern Tasmanian waters and the slowest growth rates and smallest size at onset of sexual maturity are found in southern Tasmanian waters.

24.1 Reproduction

Development of the ovaries of the females commences almost immediately after the previous egg mass is extruded - so reproductive processes are virtually continuous year round. Female rock lobsters moult in autumn and are receptive to males for mating for the following few weeks. During mating males deposit a sperm mass known as a spermatophore underneath the body and between the walking legs. Within hours/minutes after deposition of the spermatophore the eggs are extruded from the ovaries, passed across the spermatophore where they are fertilised, and then attached to the pleopods (swimmerets) under the tail. The eggs are incubated under the tail for the next 3 to 5 months before the first larval stage hatches and swims to the surface. During the incubation period, lobsters are commonly referred to as being ‘berried’. The number of eggs a lobster incubates relates to her size with larger females carrying over 600,000 eggs compared with 35,000 for smaller females.

24.2 Larval Period

In spring the eggs hatch into the first larval stage called a naupliosoma. In a matter of minutes, this stage moults to the second stage (phyllosoma) and moves to the surface layers of the sea. Over the following months phyllosoma larvae grow and are carried away from coastal areas to the adjacent oceans. During their larval development they pass through 11 stages and have been recorded from depths greater than 200 meters and over a thousand kilometers from land. The duration of the phyllosoma stage is extremely protracted and ranges from 12 to 24 months

Recent work by CSIRO with support from fisheries organisations in Tasmania, South Australia and Victoria has shown that most rock lobster larvae are found in the upper 100m of water within a limited temperature range (around 12.2-15°C).

Most larvae tend to be found around the convergence zone of major currents, which is thought to be a factor influencing the variation in recruitment between years. The predominantly west to east current flow around Tasmania suggest that there is ample opportunity for larvae to be carried from the West Coast. Oceanographic information from satellites and drifters have shown that the movement of currents around Tasmania is complex. It appears that it is also possible for rock lobster larvae to be carried from the east coast to the west or to recruit back to the area where they originated from. This implies that the traditional strategy of managing egg production on a regional basis is appropriate on a precautionary basis.

The final larval stage is known as the puerulus stage and this is the first time that the shape of the larvae resembles that of the adult lobster. The puerulus swims from ocean waters across the continental shelf and settles on coastal reefs. At this stage the lobster is approximately 25mm long with a carapace length of 10-12mm.

Because of the dispersed distribution of larvae, the puerulus settling stage is the first point where future levels of recruitment to regional populations can be estimated. TAFI. (formerly DPIF) has been running a puerulus settlement monitoring project since 1990. There has been considerable variation in puerulus catches during the ten years that this project has been running which is useful for evaluating the link with future catch.

Annual trends in puerulus index and implications for future recruitment are discussed in detail elsewhere in this assessment (Section 6).

24.3 Growth

Rock lobsters grow by a process called moulting. Like most crustaceans (which includes crabs), rock lobsters have an external skeleton or shell. For a lobster to grow, the shell has to be shed which is followed by the expansion and hardening of the new soft shell over a period of weeks.

In terms of this stock assessment report, the moulting process has some important points. Firstly, during the moulting process the lobster is very vulnerable until the shell (its body armour) has hardened. As such, lobsters will not leave their refuge during moulting and are not catchable by pots. Also, the appetite of lobsters decreases prior to moulting so they are less attracted to baits. However, once the shell has hardened at the completion of the moult, the tissues within the lobster contain a large proportion of water. This causes the lobster to become extremely hungry and vulnerable to being caught in pots (Figure 60).

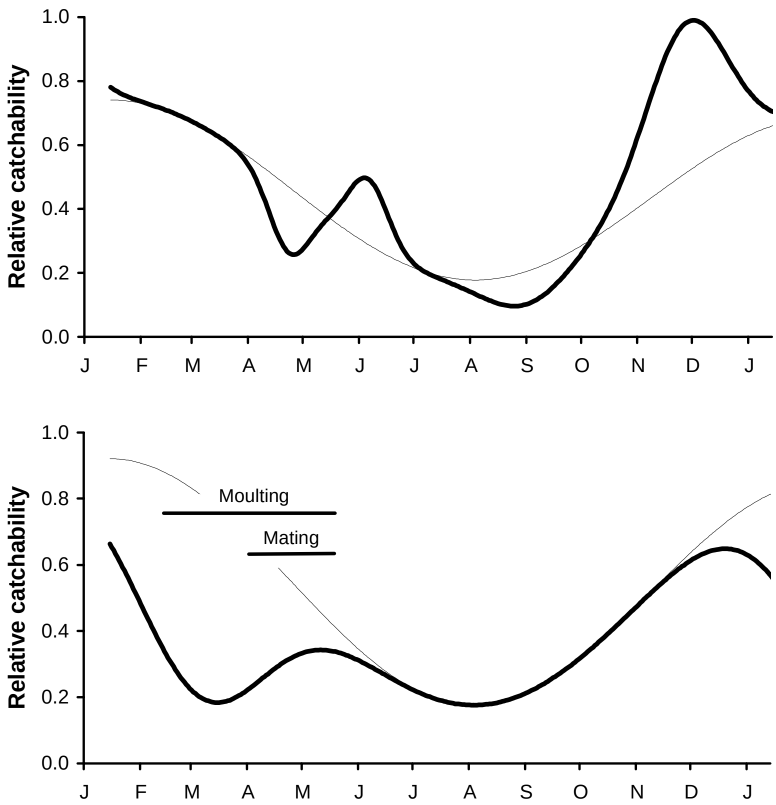


Figure 60. Monthly patterns of catchability of male (upper) and female (lower) rock lobsters from an unfished population at Crayfish Point. "Catchability" is a measure of how vulnerable lobsters are to being caught in pots. Heavy lines represent relative catchability, while thin lines represent change in water temperature. Catchability is influenced by temperature, with overlying affects from biological processes of moulting and mating. Mating reduces catchability of both sexes in April/May, which is followed by heightened catchability afterwards. Likewise, the male moult in September leads to reduced catchability, followed by heightened catchability in November, presumably due to compensatory feeding. While these general patterns are well known to fishers, the research shown here is important as it allows the seasonal changes in catchability to be quantified.

Moulting is relatively synchronised in rock lobsters with similar sized lobster moulting at approximately the same time in the same region. Male lobsters moult from August to November in southern Tasmanian and a little later in northern Tasmania. Because of this, the opening of the rock lobster season in November[2] just after the majority of male lobsters have moulted, is often classified by fishers as the 'run of new shellers'. Female lobster generally moult in April and May after which mature female lobsters carry eggs. The season for female lobsters is closed from the 1st of April to mid November of each year. Because of the male moult prior to the start of each season, catchability of lobsters is highest during November. These changes in catchability imply that some estimates of abundances such as catch per unit effort will vary seasonally. The problem

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[2] Prior to quota implementation in March 1998, the fishing season was from November to August of the following year. The season now runs from March to February of the following year with a closure from September to November. The exact dates of the closure vary from year to year although fishers still target 'new shellers' after the moult either in the extended opening of the fishery in September (see Cheshuk 2000, Cheshuk and Philips 2001) or when the fishery re-opens in November.

is overcome in the stock assessment model by incorporating this effect as a "catchability coefficient" which varies between months.

Recent research undertaken by TAFI has attempted to improve our understanding of these monthly changes by directly measuring the catchability of lobsters in an un-fished population (Figure 60). Catchability was best described as a function of the water temperature, moulting and mating (Ziegler *et al.*, in press). The use of an unfished region or reserve for this research allowed catch rate changes to be related directly to catchability changes. This direct link between catch rate and catchability cannot be made in fished regions, where catch rates also change during the season through depletion.

The greatest change in catchability was during the spring peak for males, which is associated with post moult and increasing water temperatures. Females, which moult in autumn, have lower catchability in spring. Female catch rates have a small peak in autumn, which is related to moulting and reproduction. The peak in males in June is considered to be due to post-reproductive activity. Both sexes have low catchability in winter when water temperature is at its lowest.

The second point of note in relation to the moulting process is that the process is physiologically stressful and recently moulted lobsters are fragile. Due to this fragility, fewer lobsters are acceptable for live shipment as the added stress of shipping (airfreight) lobsters often results in increased mortality.

Growth of lobsters is normally expressed in terms of an increase in their carapace length. The carapace is the hard shell, which extends from the base of the antennae to the start of the tail. As the carapace is a solid structure its measurement is fixed. This is the reason that the carapace length is the official minimum legal size limit measurement. The term used in this document as 'mm CL' refers to the length of the carapace in millimetres.

Growth rates of lobsters show substantial differences around the State with growth rates fastest in the north. At the legal size limit, male and female lobsters in the north undertake two moults annually compared to a single moult for lobsters in southern waters. The growth increment (change in the length of the carapace with each moult) is also substantially different with northern males at approximately the legal size limit increasing their carapace length by 11 to 13mm whereas their southern counterparts grow less than 6mm. Thus on an annual basis northern lobsters are growing up to 4 times faster than southern lobsters. Lobsters also grow faster in shallower waters than deeper waters. The main factors considered to influence lobster growth are water temperature (lobster grow faster in warmer waters) and food availability.

The size at which lobsters become mature appears to be related to age rather than size and thus faster growing lobsters mature at a larger size than slower growing lobsters. In southern waters greater than 40m in depth, female lobsters mature at 60 to 65mmCL. In contrast, in shallower (<40m) water in northern regions of the fishery, female lobsters mature at sizes greater than 110mmCL (Figure 61).

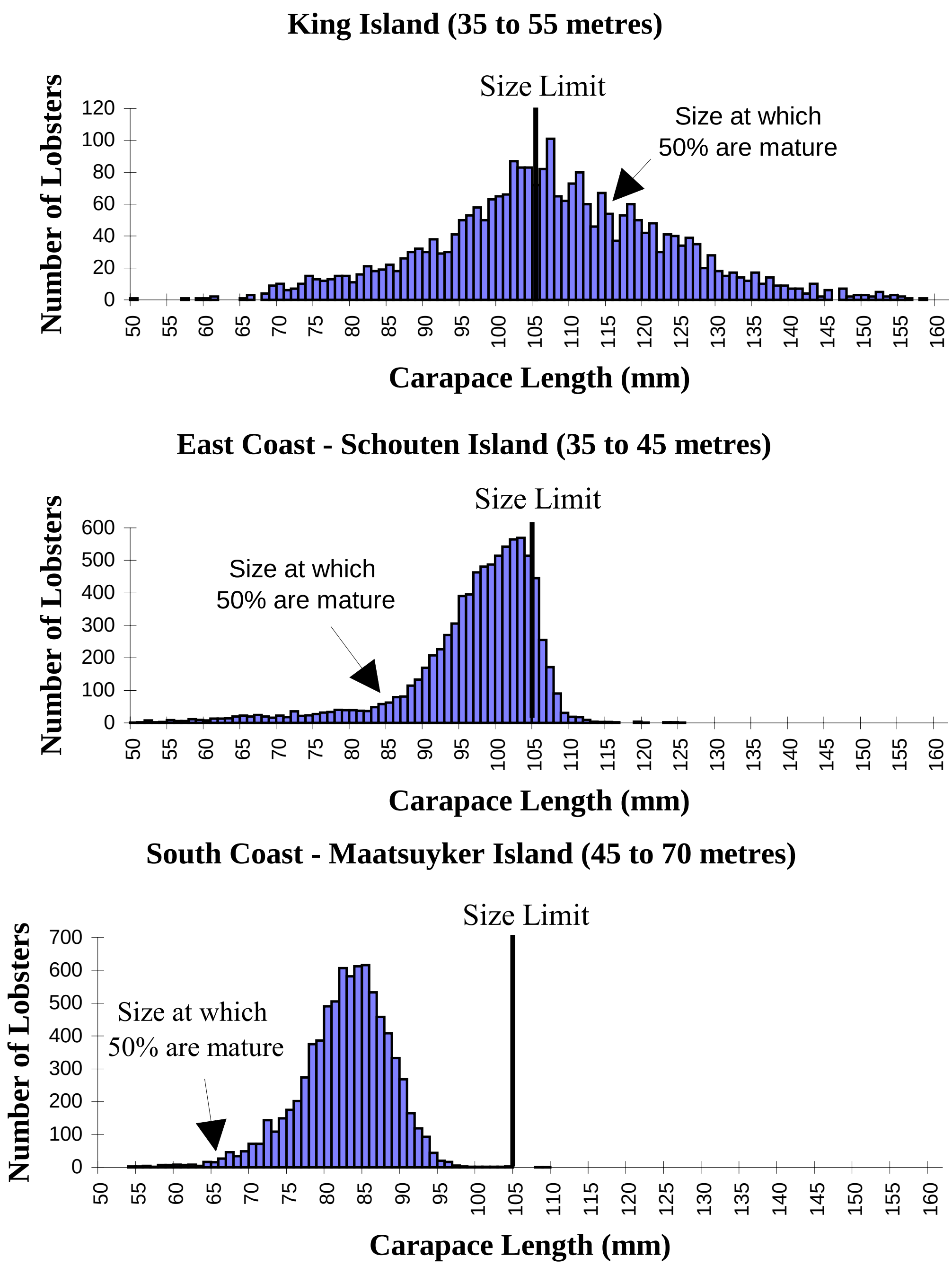

Figure 61. Size structure and size at maturity of female lobsters caught at three locations in Tasmania.

25. Acknowledgments

Membership of the RLAWG

Mr Stewart Frusher (Chairperson)	Crustacean Section Leader, TAFI
Assoc. Prof. Malcolm Haddon	Resource Modelling Section Leader, TAFI
Dr Caleb Gardner	Research Scientist, TAFI
Mr Graham Levitt	Manager, DPIWE
Mr Neil Stump	President, Rock Lobster Fisherman's Association
Mr Rodney Treloggen	Executive Officer, Rock Lobster Fisherman's Association
Mr Charles Wessing	Industry Representative

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