FISHERY ASSESSMENT REPORT

TASMANIAN ROCK LOBSTER FISHERY
2004/05

Jayson Semmens, Malcolm Haddon and Craig Mackinnon

July 2006

This assessment of the Tasmanian rock lobster resource is produced by the Tasmanian Aquaculture and Fisheries Institute (TAFI) and uses input from the Rock Lobster Assessment Working Group (RLAWG). These reports provide summaries of our current understanding of the state of the stocks rather than management recommendations.

Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Private Bag 49, Hobart, Tasmania 7001. E-mail: caleb.gardner@utas.edu.au

Ph. (03) 6227 7277   Fax (03) 6227 8035

Rock Lobster Fishery Assessment: 2004/05

Executive Summary

The state of the Tasmanian rock lobster resource was formally evaluated against a series of performance indicators (Table 1). These have been re-assessed for the most recent quota year: March 2004 to February 2005. The 2002/3 estimate of recreational catch had almost reached the trigger point of 10% of the commercial catch, which indicated that a management review was required. This review was completed and recreational management arrangements were discussed as part of the formulation of a new management plan. The recreational catch estimate for 2005 has now dropped below the trigger point to 7.8%. The undersized lobster CPUE trigger point was activated this assessment year for the Maatsuyker Island sampling sites, with this index at only 58% of the reference year (1995). However, this data is typically volatile.

The Australian Government Department of Environment and Heritage reviewed the monitoring and management of the Tasmanian rock lobster fishery as part of the strategic assessment for wildlife export accreditation. This process provided recommendations to consider the impacts of the fishery on other species (eg bycatch and protected species, comparison inside and outside of MPAs), and whether aspects of the fishery were risking the sustainability of the fishery (eg egg production and skew in sex ratio) (Table 2). Adequate responses are available to all recommendations with further improvements being developed.

The stock assessment model used for this assessment was altered with changes to the description of within quota year fishery dynamics, the use of additional detail in the standardised commercial catch and effort data, and updating the growth transition matrices using newly available tagging information.

Trends in biomass and catch rate were generally very positive. Catch rates were standardised to remove effects of depth, block, day/night, month and skipper. Assessment Areas 1 (SE), 8 (SW), and 7(W) all exhibited continued increases in standardised catch rates relative to 2003/04, and this was despite the catch taken from all three Areas increasing over those taken in 2003/04.

In assessment Areas 2 (E), 3 (E) and 4 (NE), the standardised catch rates exhibited a strong increase during 2004/05, reversing the previous trend of decline seen in 2003/04.

There has been an increase in the annual non-standardised commercial catch rate this quota year in all stock assessment areas except for Area 6 (W), where there was a 6% decline in the catch rate compared to the 2003/04 quota year. Catch rates in this Area are the highest for the State at 1.64 kg/potlift so this slight decline is of little concern and may be related to a continued shift of effort into shallower waters.

There has been a small increase in the non-standardised catch rates in the NE (Areas 3 and 4) over the past quota year suggesting stability or slight rebuilding of stocks in these Areas.

Since 1999, average lobster weight has tended to increase in many Areas of the State (Area 1, 3, 4, 5, 7 and 8). The concurrent increase in both average weight and catch rate in Areas 1, 3, 5, 7 and 8 is indicative of stock rebuilding in these areas.

All Areas show evidence of increasing catch-rates in shallower waters (i.e. <70 m) in the past quota year. Previous reports had expressed concern at declines in shallow water catch rates but this trend appears to have reversed to some extent over the last year in Areas 3, 4, 5 and 6.

Model estimates for exploitable biomass indicated relative stability, with only Area 3 (E) exhibiting a small negative change of 1.5%.

Egg production in all four northern Areas remains below the threshold of 25% of virgin egg production. Estimates of egg production in Areas 3 and 6 are only marginally below 25% and model projections indicate that these Areas are likely to move above this target level in the next few years. Areas 4 and 5 are of more concern. Although stock rebuilding in these Areas has been strong, the levels of egg production appear unlikely to increase above targets of 25% of virgin in projections of the current management arrangements.

The stock assessment model predicts that the current TACC continues to permit significant Statewide stock rebuilding for at least the next three years, with the median expected increase predicted to be an increase of about 10%. There remains a possibility that the exploitable biomass will remain stable rather than growing but this is not the most likely outcome. Some assessment areas are exhibiting stronger positive trends than others. Areas 1 and 8, for example, are exhibiting strong performance with increasing catches associated with increased effort and model predicted increases in exploitable biomass. While these model predictions are positive with regard to the stock status they are only for the next three years. Caution is still required, especially beyond the next three years, as the continued recovery of the Tasmanian rock lobster fishery is dependent upon the balance between catches and recruitment levels. Any further recovery will require future recruitment to the fishery to at least be similar to previous annual recruitment levels. The East Coast puerulus settlement indices for 2003 – 2005 are the lowest recorded to-date and the impact that these low values will have on the rebuilding process is currently unknown. If they do represent a hole in coming recruitment levels their impact is expected to influence the legal-sized biomass in approximately 2009 (about 6 years after first settlement).

There is currently a shift in the fleet dynamics with more effort being directed away from the North into the South, which opens the possibility of improvement in egg production in the north. Statewide egg production is predicted to increase slightly over the next three years with the median predicted total egg production just exceeding 50% of unfished production. Areas 4 and 5, in the north, are expected to remain stable or increase slightly, although they both remain below the target of 25% of unfished egg production.

Table 1. Formal performance indicators for the Tasmania rock lobster fishery.

Performance indicator	Trigger point	Status in 2004/05	
Statewide commercial catch rates	<95% of reference year	✔	140% of reference year
Regional commercial catch rates	<75% of reference year	✔	>135% of reference year
Fishery independent catch rates	Significant decline from matching surveys in reference year	✔	Area 2 <35m: 175% Area 2 35-50m: 81% Area 8 45-100m: 252%
Statewide legal-size stock biomass	<95% of reference year	✔	187% of reference year
Regional legal-sized biomass	<75% of reference year	✔	>26% increase in all areas
Regional biomass estimates from fisheries independent surveys.	Significant decline between years		Not available
Statewide egg production	< lowest year	✔	>10% increase vs lowest year
Regional egg production	<95% lowest year unless production >40% unfished state (no decline tolerated in Areas where production <10% unfished)	✔	>54% increase except where production already high (>40% unfished state)
Undersized lobster CPUE	<95% of reference year	✘	58% of reference year at Maatsuyker Is.
Total catch	<95% TACC	✔	>99% TACC
Size of the fleet	<220 active vessels	✔	231
Recreational catch	>10%TACC	✔	Most recent estimate 7.8%

Table 2. DEH recommendations for Ecosystem Based Management (EBM) of the Tasmanian rock lobster fishery applicable to this assessment.

Recommendation	Status, plus relevant section/s in 2004/05 fishery assessment
Recommendation 4. DPIWE to continue to monitor the situation with respect to the harvest of immature females in the northern part of the fishery to ensure any reductions in egg production or puerulus settlement are detected in a timely manner and develop a management response for implementation in the event that a major issue develops.	TAFI continues to monitor egg production in the north of the State. This is through model estimates of egg production based on commercial catch rates and research catch sampling. Regional importance of egg production sources is under investigation through a project on larval dispersal. Puerulus settlement continues to be monitored although this program will be reviewed in 2006.
Recommendation 6. Stock assessment processes should incorporate, if not already done, a risk assessment into the ecological impact of the potential skew in sex ratio caused by a longer fishing season on males.	TAFI monitors sex ratios at a number of locations around the State. There is no evidence that ecological impacts are likely to be sex-linked *per se*, however, fishery impacts in terms of regional egg production continues to be monitored around the State. It appears that the longer fishing season for males has a smaller impact on sex ratios than differences in growth rate and thus protection through the minimum size limit. This supports the current approach to monitoring of skew in sex ratio on a regional basis as per growth and egg production.
Recommendation 8. An analysis of measures to encourage the accuracy of by-product reporting should be conducted with a view to improving data collection, assessment and management responses.	Apart from Octopus, by-product was found to be a relatively insignificant component of the rock lobster fishery. Giant crabs (*Pseudocarcinus gigas*) are caught occasionally.
Recommendation 9. Mechanisms should be developed to ensure better recording of by-catch in the fishery. A more formal assessment of the risks posed to by-catch species should be carried out before the next assessment.	At present, the fishery does not record by-catch (except for by-product or protected species by-catch), although TAFI research catch sampling is conducted to monitor by-catch. The most common by-catch species are other crustaceans (crabs and hermit crabs), conger eels and the draughtboard shark. Small projects have been conducted on the biology of non-commercial crab species, although none are listed as threatened or endangered. A project on biology of the draughtboard sharks is currently underway at TAFI.
Recommendation 10. A structured	Information on the frequency and type of

reporting and monitoring program into interactions with protected species should be developed as high priority.	interactions between protected species and the fishery are cited in this assessment report. This is the second year that this data has been collected following adoption of new reporting systems in 2004.
Recommendation 11. DPIWE should establish a program monitoring fished and unfished areas in the fishery with a view to identifying changes in the wider marine environment that may be a result of the fishery.	Unfished areas have now been in existence for a decade and have been surveyed regularly throughout this period. Statistically significant differences in the abundance and size-structure of unfished populations of rock lobster have developed over time. The abundance of some other species has also altered. Monitoring of these sites continues.

1 Introduction

The modern fishery

The present commercial catch is taken from around the State and involves the annual harvest of around 1.6 million animals. There are currently 231 licensed vessels participating in the commercial fishery, with additional catch taken by approximately 15,000 licensed recreational fishers. Commercial harvests have been capped by a quota management system since March 1998, which has resulted in substantial and steady rebuilding of stocks in most Areas. This rebuilding can be seen in the historical trends in the fishery (Figure 1).

Although biomass rebuilding has been substantial, catch-rates have picked up more slowly due to the dynamics of the fishery changing (such as time of year when catch is taken). This is because fishers are increasingly their effort in locations and months when catch rates are lower, in order to supply markets when prices are highest.

Lobsters are harvested from all around the State with considerable variation in patterns of commercial fishing from region to region. Biological parameters also vary dramatically from region to region and this presents a major challenge for fishery management. An important step towards meeting this challenge is assessing different regions separately. For this purpose the State is divided into eight different assessment Areas (Figure 2).

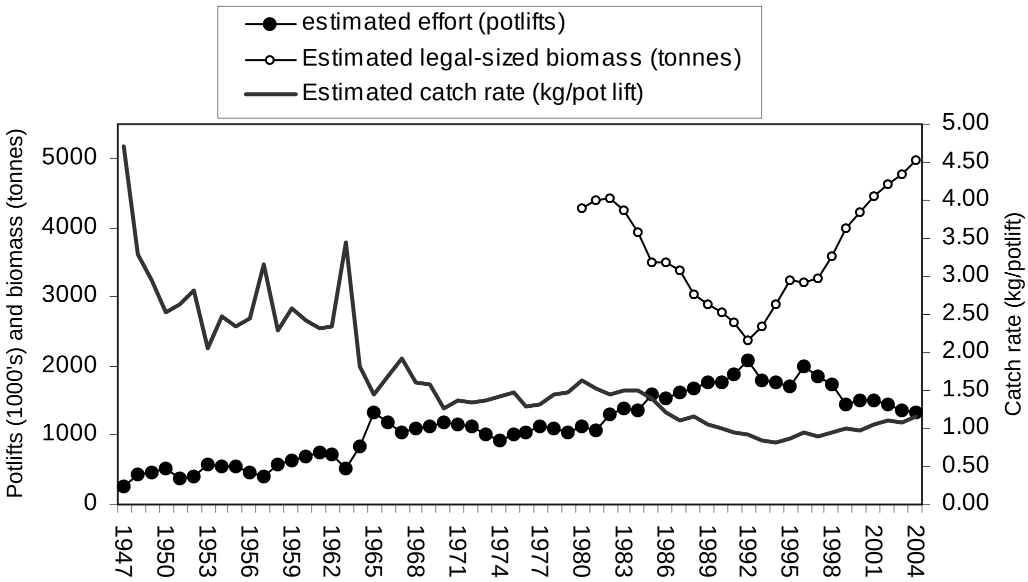


Figure 1. Historical trends in fishing effort (potlifts), catch-rate (kg/potlift) and estimated legal-sized biomass. Catch-rates after the 2nd world war and before the 1960s were much greater than those seen today. As fishing effort has risen, catch-rates have fallen. Legal-sized biomass can only be estimated for later years commencing from a time when the resource was already fished down. The general trend in recent years is encouraging with biomass estimates showing a steady increase while catch rates are recovering.

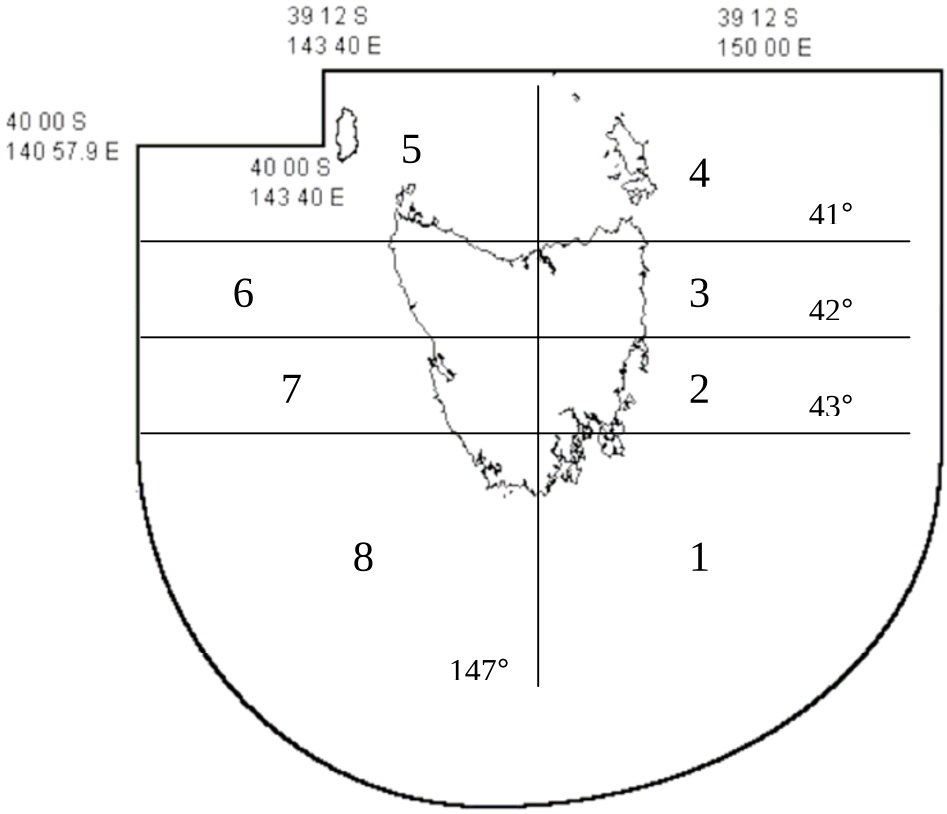


Figure 2. The boundaries of the eight Stock Assessment Areas and the area of State waters for the rock lobster fishery provided by the offshore constitutional settlement (OCS).

1.1 Economic and market status

While the commercial fishery for rock lobster is not the largest in Tasmania by value of landed product, it is the major fishery contributing to employment in Tasmania. This economic benefit is well distributed around the State, where an estimated 1,350 Tasmanian jobs are reliant on the rock lobster fishery (EconSearch 2003). Details of the economic analysis of the commercial Tasmanian fishery by EconSearch (2003) were reported previously (Gardner et al., 2004). At point of first sale, the present commercial catch is valued at $51 million (ABARE, 2004) or $184 million economic impact (EconSearch 2003; including secondary economic impacts). About 63% of this catch is currently taken off the exposed West Coast.

In addition to the commercial fishery there is a significant recreational fishery. The main objective of management of the recreational sector is social benefit rather than economic. Nonetheless, recreational lobster fishing also has an economic impact. The economic impact of all recreational fishing (lobsters, abalone, finfish etc), including secondary economic impacts, was estimated at $50 million (Lyle *et al*., 2003).

2 Recent Developments

2.1 The Recent Management History of the Fishery

The implementation of the quota system in the commercial fishery in March 1998 resulted in an increased focus on the value of the animals landed each season. Previous assessments have discussed the change in the dynamics of the fishing fleet since quota was introduced, the key observations being a shift in effort towards winter fishing when prices are highest plus a shift in effort towards shallower waters. This has the potential to bias the stock assessment as it could lead to localized depletion in inshore regions while leaving lower value (because of colour, shape and vitality) offshore stocks harvested at a lower rate. At the present spatial scale implemented in the assessment model such local effects would not be accounted for except where catch rates were standardized by depth (which is now done).

Changes in the market have impacted on the economic yield of the commercial fishery in recent years. In particular, the price received from processors exporting into China has declined (in $Australian) due to changes in the exchange rate.

Management of the recreational fishery has remained relatively stable although in 1999 the use of recreational rock lobster rings was licensed.

2.2 Developments in stock assessment analyses

2.2.1 Logbook changes

Commercial catch and effort logbooks are regularly reviewed to ensure effectiveness for assessment data collection. A recent significant change was the introduction of protected species interaction reporting. This assessment is the first to include a full year of data collection on protected species interactions, with results reported under “Ecosystem Interactions”.

2.2.2 Research catch sampling operations

The analyses in the assessment are based on a range of data sources. Information about temporal changes in lobster stocks are mainly driven by commercial logbook data, recreational surveys and research catch sampling surveys. These research surveys provide two main types of data for assessing temporal change in the resource; these are the size structure of lobster catches and measures of fishing mortality.

The options available for estimating harvest rate from research surveys were recently reviewed. Previously, attempts to use techniques based on the number or ratio of legal-sized lobsters in research catches (change-in-ratio and index-removal methods) had been made. However, with the introduction of quota, the extended season opening was continually compromising these methods. Alternative methods to measure fishing mortality using tagging data were developed by Frusher and Hoenig (2001) and were seen as the best alternate option. The FRDC has funded a study to apply these models in Tasmania. This project started in August 2003 and is looking at gaining estimates of harvest rate from broad regions of the fishery.

In the past, criticisms have been directed at a lack of sampling in certain regions of the fishery, at sampling in regions considered to be unrepresentative of the commercial fishery, and for using a research vessel that does not reflect a 'real' fishing operation. To obtain improved data from broader regions of the fishery, commercial vessels were used to collect data for the 2004/05 fishing season. This has allowed us to increase our coverage of the State to include Areas 1, 4, 6 and 8. A summary of the catch sampling undertaken in 2004/05 is shown in Table 3.

Table 3. Areas and depth ranges selected after consultation with industry for shallow and deep categories for the revised catch-sampling program.

	Shallow	Deep
Area 1	0-30 m	35-60 m
Area 4	10-35 m	40-70 m
Area 6	40-70 m	100-150 m
Area 8	5-35 m	40-100 m

Although catch sampling coverage of the State has increased, our ability to sample undersize lobsters has decreased due to the use of stick pots, rather than standard meshed research pots. These stick pots commonly used by commercial fishers have larger gaps, which influences the retention of undersize lobsters. This issue is a function of trap selectivity and we are uncertain what effect it will have on model outputs. Trials are underway to standardise for this effect so that we can better account for selectivity in future assessments.

Annual sampling of research sites established on both the east and south coasts in 1992 (Figure 3) was undertaken in October 2005 using *FRV Challenger*. Already this long-term data set has provided valuable insights into spatial and temporal changes in fisheries parameters such as size at maturity.

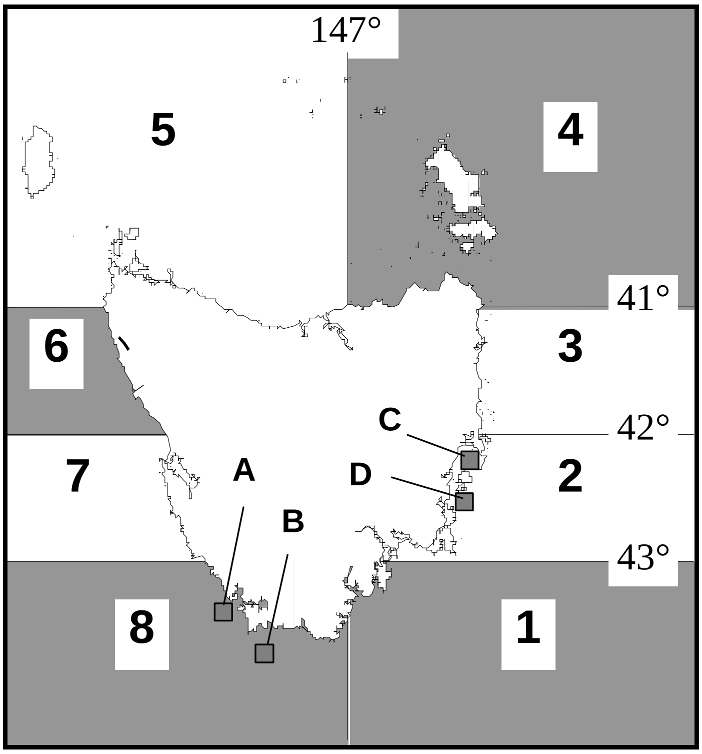


Figure 3. Fisheries-independent catch sampling coverage. Shaded areas represent Stock Assessment Areas covered by commercial vessels. Long-term survey sites sampled by research vessel (FRV Challenger) are indicated by shaded squares [A- Port Davey (2 sites), B – Maatsuyker Island (4 sites), C – Sandstone Bluff (3 sites) and D – Boy in Boat (1 site)].

2.2.3 Fisheries dependent data collection

Over the past eighteen months researchers from the Tasmanian Aquaculture and Fisheries Institute (TAFI) have been circulating electronic data loggers amongst the rock lobster and giant crab fleet to collect information about the size structure of the stocks.

Figure 4. Electronic data logger.

The units consist of a set of digital vernier callipers attached to a data logger, plus a small panel with buttons (Figure 4) for the selection of sex and presence / absence of eggs. They weigh less than one kilogram and are fully waterproof (IP 67) with a rechargeable power supply capable of lasting for up to 2500 entries and a total memory capable of holding in excess of 5000 individually timed and dated entries.

The loggers are supplied to fishers so that they can measure a portion of their catch, which provides a low-cost method for collecting size-structure data. Data from these loggers are used in stock assessments and are a critical input in conjunction with catch and effort data from compulsory paper logbooks. The advantage of such a logger system over the conventional observer compiled data is that data is collected over a much wider area of the fishery and over the entire season. In addition, the system eliminates the use of paper and manual data entry, which often leads to errors.

Figure 5. Measuring a lobster using an electronic data logger.

TAFI currently has 10 of these units in circulation around Tasmania concentrating particularly in areas with lower levels of research catch sampling effort. After the fisherman has collected data from several trips the logger is sent back to TAFI for downloading. TAFI then sends a report back to the fisherman. The logger is then either sent back to the same fisherman or circulated to a new crew who are interested in helping gather such data. The units can be used for either lobster or giant crab. Most fishers participating in the program are measuring a small number of animals each shot, say everything from 3 or 4 pots. This quickly develops into a considerable dataset.

2.2.4 Changes to the stock assessment model

The stock assessment model used in previous assessments (Punt & Kennedy, 1997) has now been altered in some major ways. The original model used a time step of one month when considering catch rate data and included growth occurring every three months. A serious problem with the monthly time step was the large number of months with no catch and therefore no catch rate data. Given the 35 years from 1970/71 to 2004/05, the 8 assessment areas, and the 12 months there were a total of 3,360 monthly periods in the assessment. However, across the years 451 of these months reported no catches; that is about 13.42 % of the total. For example, October has consistently been closed to fishing but in some years, so was September. November 1995 was closed to fishing in all assessment areas. These zero values destabilize the fitting process of the assessment model and add to the uncertainty in model outputs. One solution, that presently appears to be optimal, was to generate a new model structure using eight time periods in each year: these included six one monthly time steps through November to April, when most of the stock dynamics occur, followed by two three month time periods that were May-July and August-October. By using this arrangement there are only 10 of the possible 2,240 time periods that have zero catches (November 1995 contributes eight of these), which is only about 0.446% of the total. The resulting model is much more stable.

In addition to this time period change to the model structure it has also been modified to permit the use of the additional detail available in the standardised commercial catch and effort data since 1994/95 (which now includes half degree blocks, daily reporting, and depth data). The model now treats the commercial catch and effort data as two linked time series. In the original model there was a requirement to estimate a catchability coefficient for each month and region. Now there is a requirement to estimate a catchability coefficient for each of the eight time periods and Areas, plus each of the two time series. The effect of this change was to improve significantly the fit to the most recent years of the commercial catch and effort data.

A further alteration to the assessment was to transfer the model to the AD-Model Builder framework. This enables all 336 parameters of the model to be estimated at the same time. An advantage of this is that the model is more stable and cross-correlations between parameters are more clearly indicated.

The final major alteration to the dynamics of the stock assessment model was made with respect to the projections made during the risk assessment that are used to examine alternative management options for the fishery. In the old model random recruitment was used in conjunction with a given catch history and size limits to determine the effect of different TACs and size limits. The random recruitments were instigated following on from the final year of the assessment. The effect of this was that the projections began with very tight confidence intervals that progressively broadened.

In the previous model version the catch rates in a given year provide information to the assessment about recruitment that happened a few years previously. Thus, there can be a gap in the last few years in the analysis of recruitment variation simply because any animals recruited to the smallest size classes in the model will take a certain number of years to enter the fishery (which is when the assessment can begin to take account of them – see Figure 4). If this is ignored and recruitment variability away from average recruitment (either greater or smaller than average) does not begin until the year following the time series then the net result is that the variability in the possible stock trajectories can be badly underestimated. To avoid this problem of a time lag between the catch rates and the recruitment that gives rise to them, the projections in the new model now start adding random recruitment variation from when average recruitment is assumed in each Area (Figure 6).

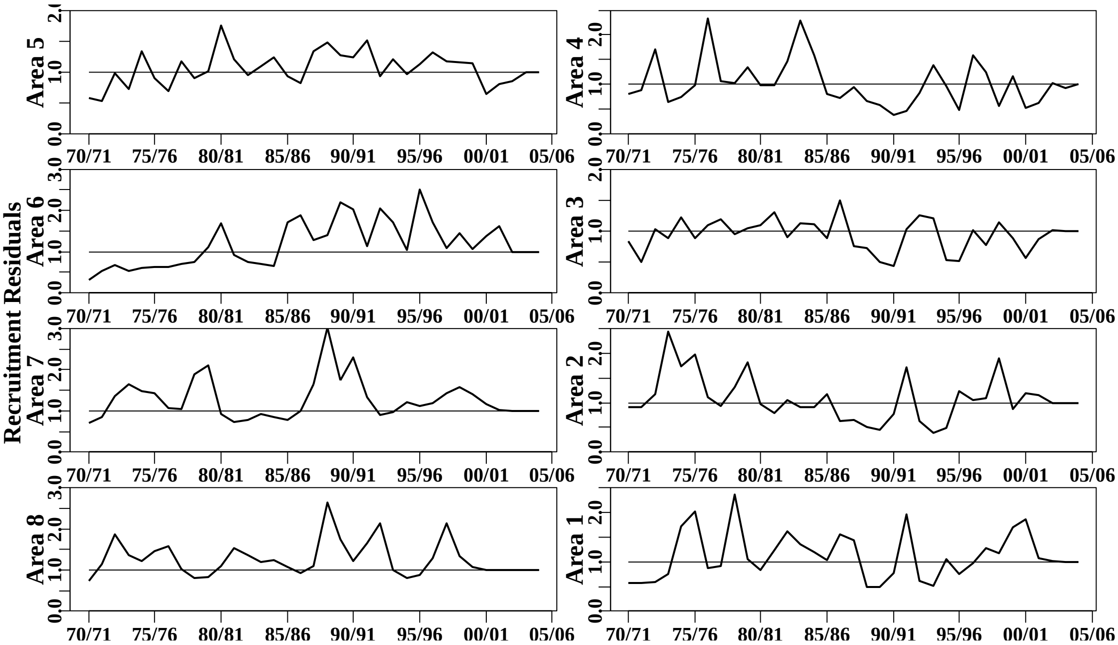


Figure 6. The predicted variation in relative recruitment (with respect to the average recruitment in each Area). Note the flat period of assumed average recruitment in the last few years in each Area. Fast growing lobsters in Area 5 only take 2-3 years to enter the fishery following recruitment while slower growing lobster in Area 8 take about six years. If stochastic recruitment is not imputed into these artificially flat years during the projections then the variation in future years is biased low.

As well as these structural changes over last year's model, the growth transition matrices have been updated to reflect the many more tag returns that can be used to characterize the growth of rock lobsters around the State. This modification is especially important as it has direct implications for the predicted egg production relative to the unfished egg production. The rock lobster in the assessment areas in the south are now not expected to grow quite so large so their relative egg production has increased. On the other hand, following a revision of the growth characteristics using new tagging data, female rock lobsters in the north are now expected to grow to slightly larger sizes and this implies that the relative egg production will appear to be smaller than in previous assessments. Improved information on the growth patterns of rock lobster about the State can have profound influences on the stock assessment. With the completion of the translation of the rock lobster research database into a modern format there will be even more tags available to characterize growth and these will be included in the analysis of growth ready for next year's assessment.

Technical documents describing these changes in detail are being prepared for distribution to interested stakeholders.

3 Fishery Assessment

3.1 Evaluation of Performance Indicators

The management plan contains performance indicators relating to:

- Commercial catch-rates
- Research catch-rates
- Estimated legal-sized biomass
- Egg production
- Abundance of undersize lobsters
- Total catch
- Size of the fleet, and
- Recreational catch

These indicators are intended to provide a guide to the status of the resource using as many sources of reliable data as possible. Acceptable limits, limit reference points, or trigger points have been set for each of these indicators; if these limits are breached then a management review is initiated.

The trigger points are often based on the 5-year period prior to the introduction of quota. For instance, regional catch-rates for the current year are compared with those from the 5 years before quota; if the current catch-rate falls below the lowest value from those 5 years, then the trigger is activated. Many of these trigger points have been in place for several years and were established at a time when the biomass was much lower than it is today. With the increase in biomass that has occurred since the late 1990s, these trigger points are being re-evaluated as part of the review of the management plan. Although the criteria used for EPBC accreditation are also assessed in this report, they are not formal performance indicators of the current management plan.

3.1.1 Commercial catch-rates

There has been an increase in the annual unstandardized commercial catch rate this quota year in all stock assessment areas except for area 6, where there was a 6% decline in the catch rate compared to the 2003/4 quota year (Table 4).

Table 4. 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 2003/04.

		Commercial catch rates (kg/pot lift)			% change		Catch stats (March 2004-Feb. 2005)	
Area	**Reference Year**	**Ref. Year**	**2003/04**	**2004/05**	**vs Ref. Year**	**vs 2003/04**	**Catch (t)**	**Effort (1000 potlifts)**
Statewide	1994	0.82	1.09	1.15	+40	+6	1502*	1301
1	1994	0.52	0.83	0.96	+84	+16	165	172
2	1994	0.54	0.89	0.96	+77	+7	130	136
3	1994	0.44	0.69	0.74	+68	+7	86	116
4	1994	0.63	0.97	1.04	+65	+7	178	171
5	1995	0.90	1.20	1.22	+35	+1	296	243
6	1995	1.21	1.74	1.64	+35	-6	185	113
7	1994	1.11	1.51	1.60	+44	+6	125	78
8	1993	0.77	1.18	1.25	+62	+5	338	271

* estimated catch from logbooks (where effort is also recorded) as compared to total (QMS) landed catch.

Statewide commercial catch rates for the 2004/05 quota year are higher than those recorded in the corresponding reference years and thus this trigger point has not been activated (Table 4). Statewide catch rate has generally increased over the last year (Figure 7), however, there was a small decline in Area 6 (Table 4 and Figure 8). Apparent declines in annual catch rates can be unrelated to declines in abundance when fishing effort shifts between seasons or depths. For example, if more effort is expended in winter when catch rates are low, catch rate can appear to decline. This problem is overcome by examining monthly trends in catch rate. Figure 10 shows trends in catch rates across months for the 2004/05 quota year, the previous 2003/04 quota year and the corresponding reference year for each assessment Area.

A decline in the rate of stock rebuilding in the NE was predicted in previous assessments, as this Area appeared to benefit previously from a recruitment pulse (Gardner et al., 2004). As this pulse has passed, catch rates have declined. However, there has been a small increase in the catch rates in the NE (Areas 3 and 4) (Table 4) in the past quota year, reversing the recent trend of a decline in stock rebuilding. Although the quota management system is intended to remove volatility from recruitment pulses, the NE remains driven by recruitment due to the relatively higher exploitation rate in this Area. Exploitation rates in these Areas are maintained at high levels due to several factors including proximity to ports and the more sheltered coastline.

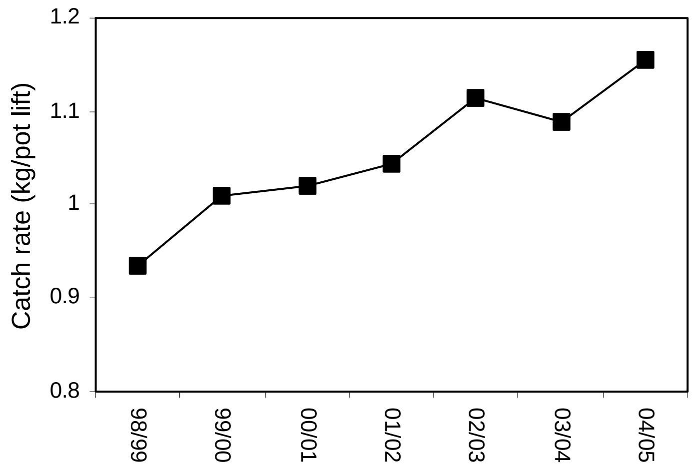


Figure 7. Change in Statewide non-standardised annual commercial catch rates since the introduction of the quota system in 1998.

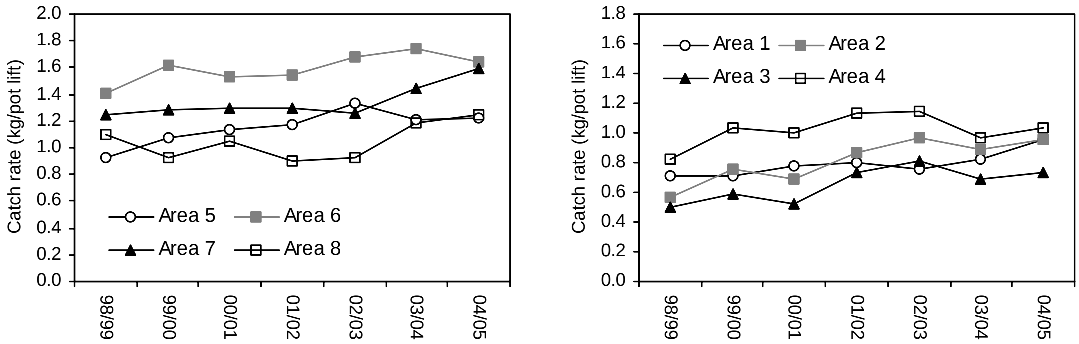


Figure 8. Change in non-standardised annual commercial catch-rates for quota years between 1998/99 and 2004/05 for assessment Areas on the west (left) and east coast (right). Note that catch rates are higher on the west coast. Data shown in this figure is expanded over a longer time series in Figure 9.

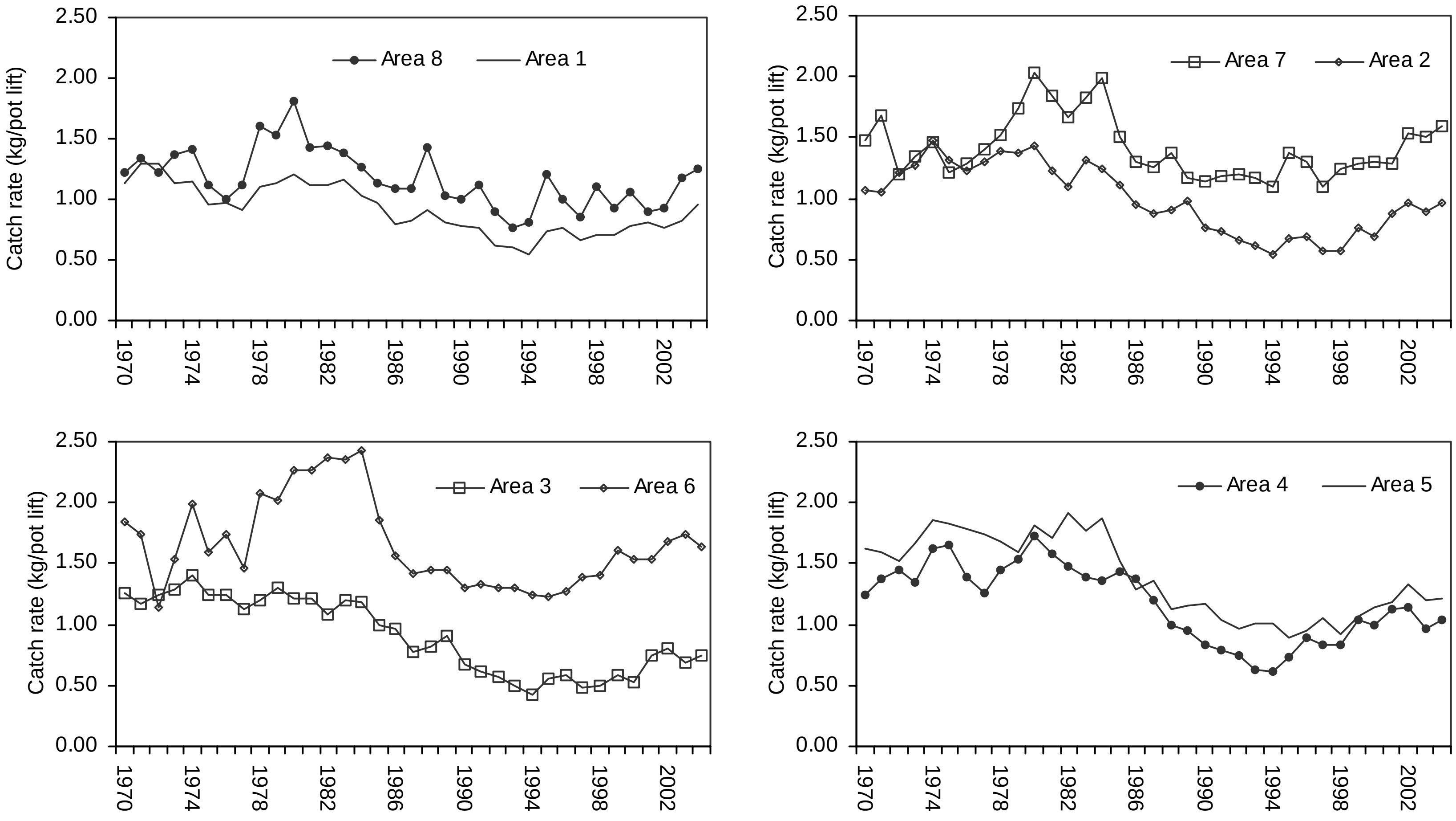


Figure 9. Regional non-standardised commercial catch rates since 1970. Data is presented on a quota year basis (i.e. March to February), so the last data point is for the period March 2004 to February 2005 inclusive.

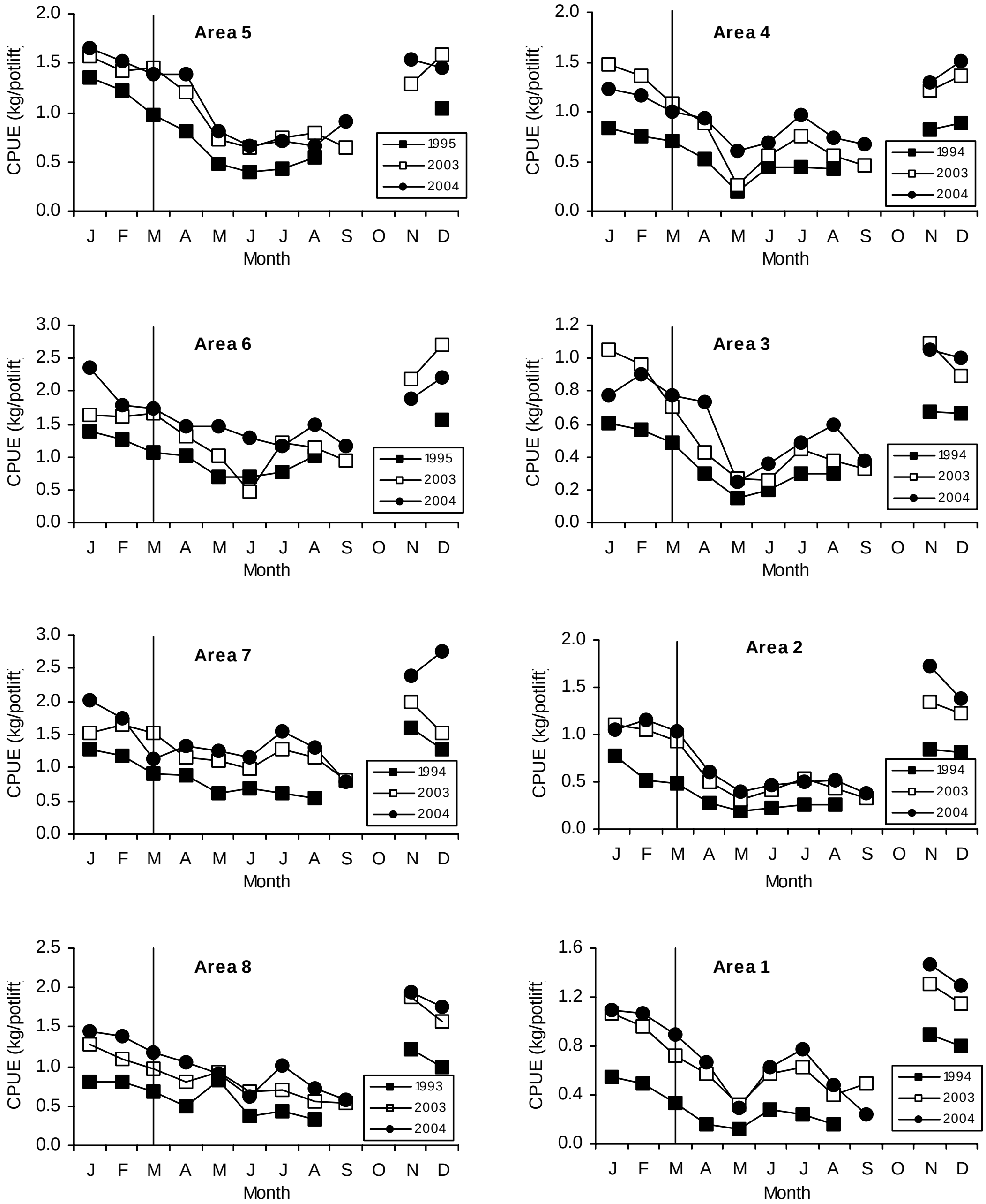


Figure 10. Change in non-standardised commercial catch rate (CPUE, kg/pot lift) between months for 2004 and the previous calendar year and for the reference year. The vertical line in each plot indicates the start of the quota season.

Since 1999, average lobster weight has tended to increase in many areas of the state (Area 1, 3, 4, 5, 7 and 8). The concurrent increase in both average weight and catch rate in 1, 3, 5, 7 and 8 is indicative of stock rebuilding in these areas (Figure 11). Note however that trends in average weight in these areas may also be affected by the timing of effort, with more of the catch composed of heavier males resulting from increased effort in winter.

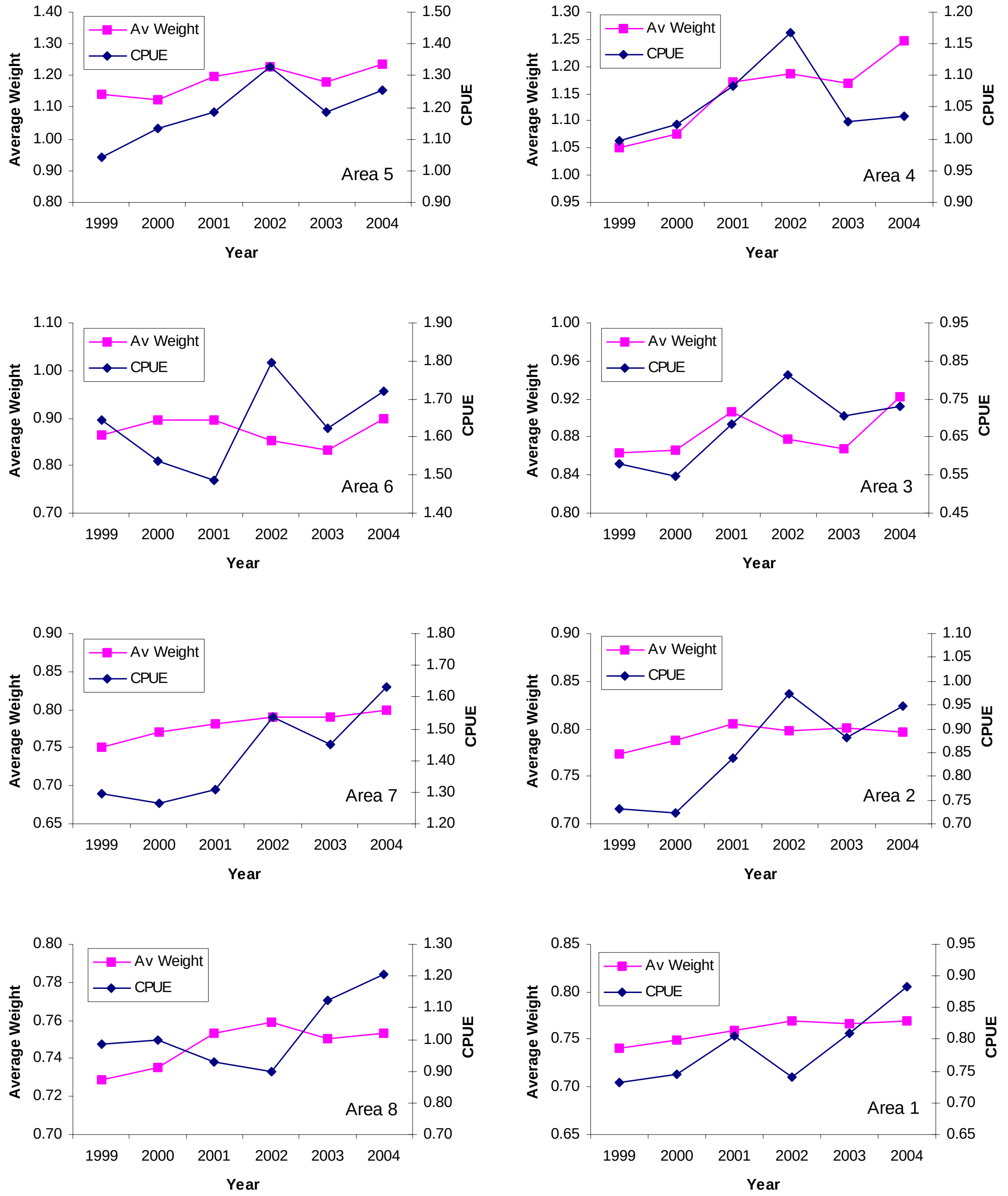


Figure 11. Regional change in non-standardised commercial catch rate (CPUE, kg/pot lift) and average weight since 1999.

In previous stock assessments there has been a focus on fishing effort in Area 6 as an example of declining catch rates accompanied by a shift in fishing effort from deep to shallower waters. Area 6 differs from the other Areas in that a higher proportion of the total catch for this Area comes from deeper waters (i.e. > 70 m); 31% of the total catch in the past assessment year, compared to less than 8% for the other Areas (Figure 12).

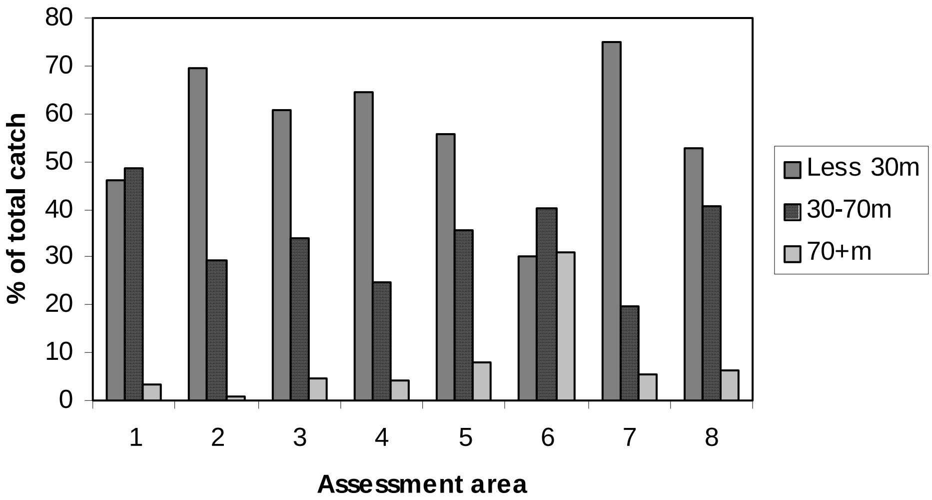


Figure 12. Percent commercial catch derived from depths <30 m, 30–69 m and >70 m for each Assessment Area during the 2004/05 quota year.

There has been an increase in fishing effort in shallower waters in Area 6 in recent years, to the extent where 72% of all fishing effort was expended in waters less than 50 m in 2003/04 – up from 55% of total effort in 2000/01 (Figure 13). This trend has been reversed in the past quota year, with a decrease in the total effort in shallower waters (<50m) to 65% (Figure 13).

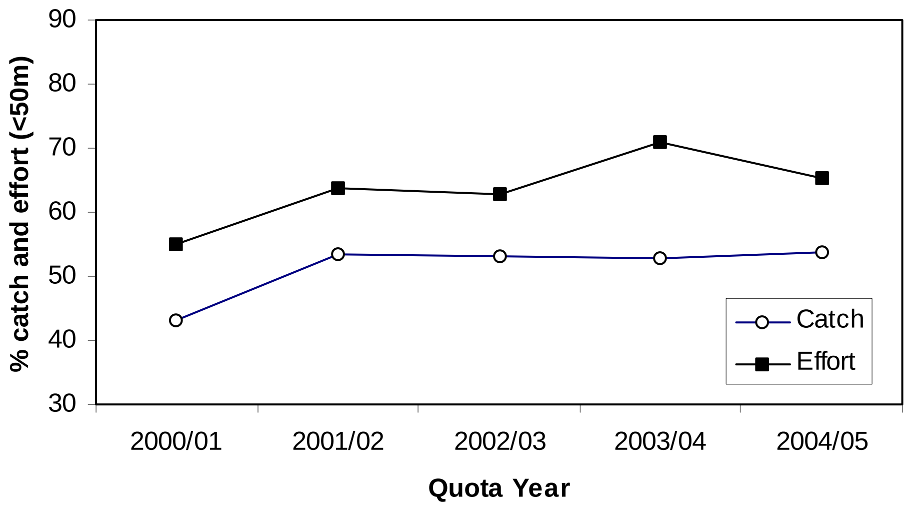


Figure 13. The percentage commercial effort and catch from shallow waters (<50 m) from Area 6 since 2000/01.

When stocks are divided into three depth categories (<30 m, 30–69 m and >70 m), catch-rates for the comparatively under-fished deeper stocks (>70 m depth) of Area 6 are higher than those in shallower waters. However, the rate has decreased in the past quota year for both those stocks between 30-70m and those greater than 70m, while the catch rates for waters less than 30m have increased to be almost at the same level as those for waters between 30-70m (Figure 14). The rates for 30m and 30-70m were essentially the same over the 2000/01 and 2001/02 quota years, diverging in 2002/3 and 2003/4 and now coming back together in the past quota year (Figure 14).

Collectively (across all Areas) the proportion of total commercial effort expended in waters less than 50 m has increased every year since 2000/01, except for the past quota year. Fishing in shallower waters less than 50 m now constituting approximately 88% of total fishing effort (slightly down from almost 89% in 2003/04) and approximately 81% of total catch (down from almost 83%) (Figure 15). Note that Figure 15 shows the proportion of catch in shallow water, not the absolute amount – thus the small decrease in the past quota year could be caused by either increased catch in deep water, or less catch from shallow water. The absence of a trend of increasing absolute catch in shallow water for most areas (Figure 16) shows that the main driver of change in the fishery is decreasing catch in deep water. Accordingly regional catch rates are highest in waters greater than 70 m in depth and lowest in waters less than 30m in depth, with the exception of Area 7, where the catch rates are similar for all three depth categories, following a decrease of effort in waters greater than 70 m in depth and an increase in those between 30-70 m (Figure 14). All Areas show evidence of increasing catch-rates in shallower waters (i.e. <70 m) in the past quota year (Figure 14). This increase, however, has generally been small and there is still the risk that continued high fishing effort from both sectors in shallower depths may be unsustainable in terms of maintaining catch rates at present levels.

Of particular interest is that the large difference in catch rates between depths has not impacted on the fleet dynamics. Fishers do not appear to be changing their shallow water fishing patterns despite catch rates in deeper waters being almost twice that of inshore waters. Fishers are considered to be responding to market demands for red coloured inshore lobsters and reduced fixed costs of inshore operations. The recent increases in fuel prices are expected to further impact on the fleet dynamics.

Note that the change in commercial catch rates at different depths does not imply increased interaction with recreational fishers. The absolute commercial catch taken from depths less than 20m has trended upwards in Areas 2 and 8, but has trended downwards in Areas 4 and 5, with no clear trend in other areas (Figure 16).

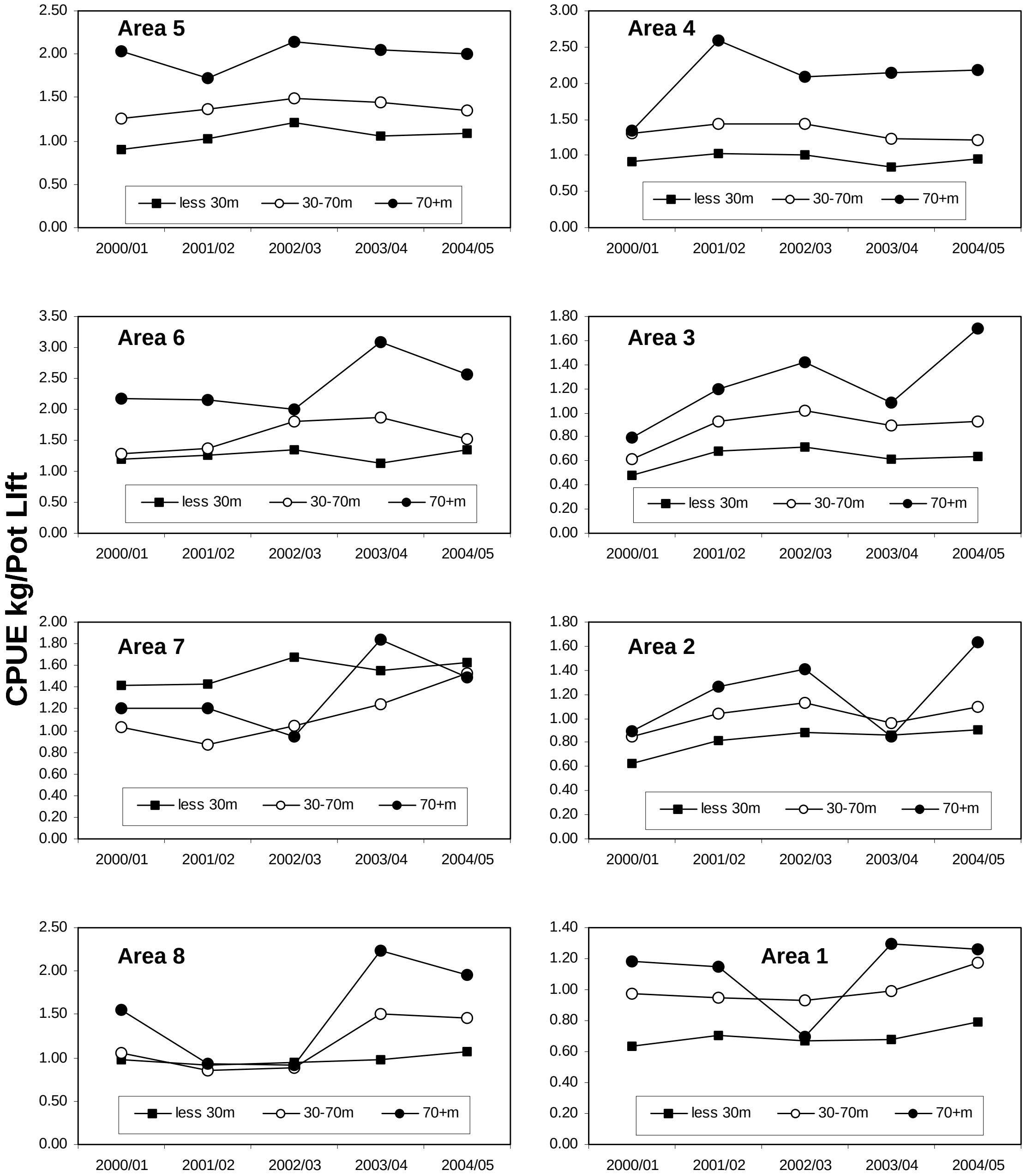


Figure 14. Regional change in catch-rates (CPUE, kg/pot lift) between quota years for depths <30 m, between 30-70 m and 70+ m since 2000/01**.**

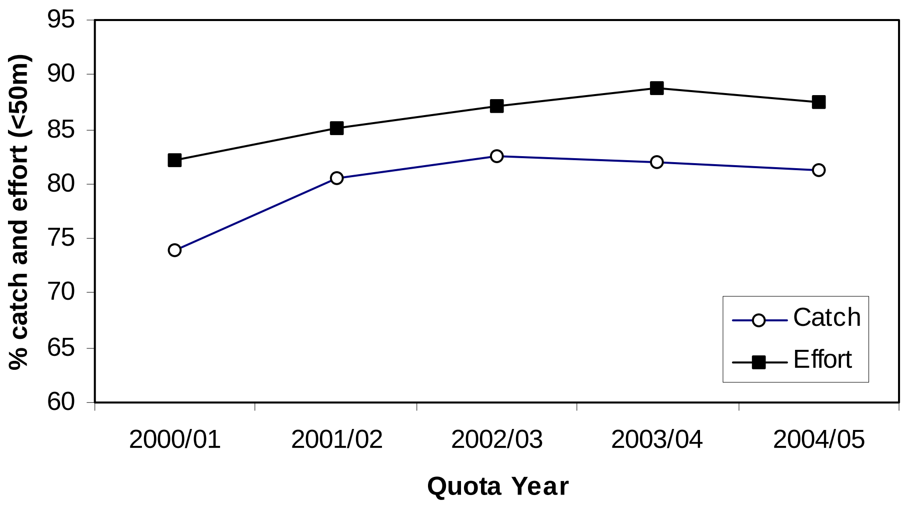
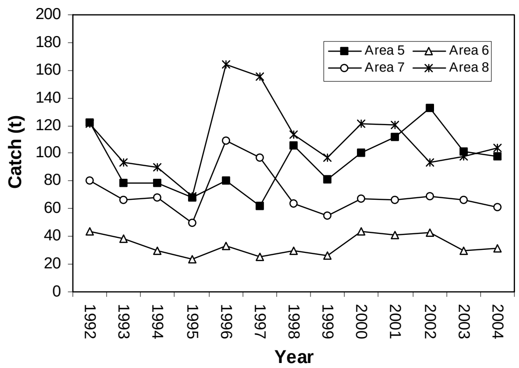


Figure 15. Percent effort and catch from shallower waters (<50 m) for all Areas combined since 2000/01.



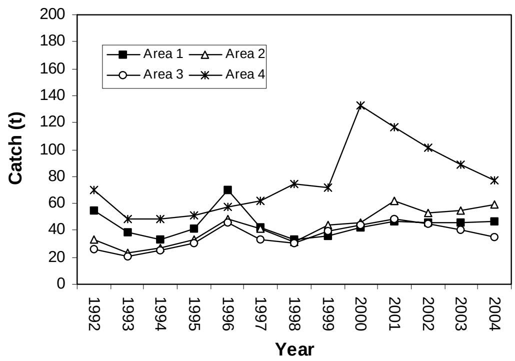


Figure 16. Change in annual catch taken by the commercial fishery from depths where there is most interaction between the recreational and commercial sectors (<20 m).

3.1.2 Standardised catch-rates

The Tasmanian rock lobster fishery has a long history stretching back into the 19th century (Winstanley, 1973). From 1970 to the early 1980s, catch and effort data are available as monthly totals across all vessels for the eight assessment regions around Tasmania. After 1983, data is available, again as monthly totals, but at a resolution of one-degree statistical blocks and for each vessel. Data across the whole fleet and quota year is available at half-degree resolution and with complete daily records from and including the 1994/95 quota year. From the mid-1980s depth information is available as a set of depth categories and after the early 1990s it is available as an estimate of the average depth of activity.

Quota Management was introduced into the Tasmanian rock lobster fishery in 1998/ 1999 (with a quota year running from March 1st to Feb 28th/29th). Change in the behaviour and composition of the fishing fleet after the introduction of quota has altered the interpretation of catch rate data. For example, there is now far more effort in relatively shallow water in Area 6 and 7, than in the past because the shallow water animals are of a higher value. As catch rates are lower in shallower water this has had an impact upon non-standardised catch rates so that they appear lower than if all depths were fished evenly. The dynamics of the Tasmanian rock lobster stock assessment model (now with large modifications to that described by Punt & Kennedy, 1997) are primarily driven by catch-rate data. The formal basis behind this is the assumption that catch-rates are an index of relative stock abundance. The suggestion that fisher behaviour is altering catch rates rather than changes to stock biomass therefore has important implications. It might lead to the conclusion that the stock status is less positive than it is in reality or conversely it may obscure a negative trend – that is, such effects may bias the assessment either low or high.

In fact, there are many factors that are likely to have an impact on observed catch rates that have nothing to do with changes in the stock biomass. These factors would include the precise location where fishing occurred, who was doing the fishing, whether they were fishing at night or during the day, and, of course, the depth of fishing. It is standard stock assessment practice to standardize commercial catch and effort data in an attempt to remove the influence of such factors as location, depth, vessel, and night/day. These attempts make the assumption that any variation left in the catch-rate data after standardization will be more closely related to what is happening to the stock biomass.

The most commonly used method of standardization is to include the various factors thought to effect catch rates into a general linear statistical model and to include year as a categorical factor, in this way the parameters derived for each year become the indices of relative abundance. The methods used are described in more detail in Appendix 7.

Eight different statistical models were fitted to the data from each assessment Area (Table 5). The optimal statistical models in each case only alter the trends in catch rates for each Area to a slight extent with the most influence being exhibited by the trends in Areas 1 and 8 (Figure 17).

Table 5. Definitions of the eight difference statistical models used in the standardization of the rock lobster catch rates for 1994/95 to 2004/05. Cst was a constant, Qyear was quota year, BoatDM was vessel distinguishing mark, DayNight was whether a shot was overnight or during the day, DepCat was a series of 10 fathom depth categories, Block was statistical block.

Model 1	Ln(CE) = Cst + Qyear
Model 2	Ln(CE) = Cst + Qyear + Month
Model 3	Ln(CE) = Cst + Qyear + Month + BoatDM
Model 4	Ln(CE) = Cst + Qyear + Month + BoatDM + DayNight
Model 5	Ln(CE) = Cst + Qyear + Month + BoatDM + DayNight + DepCat
Model 6	Ln(CE) = Cst + Qyear + Month + BoatDM + DayNight + DepCat + Block
Model 7	Ln(CE) = Cst + Qyear + Month + BoatDM + DayNight + DepCat + Block + Month*DepCat
Model 8	Ln(CE) = Cst + Qyear + Month + BoatDM + DayNight + DepCat + Block + Month*Block

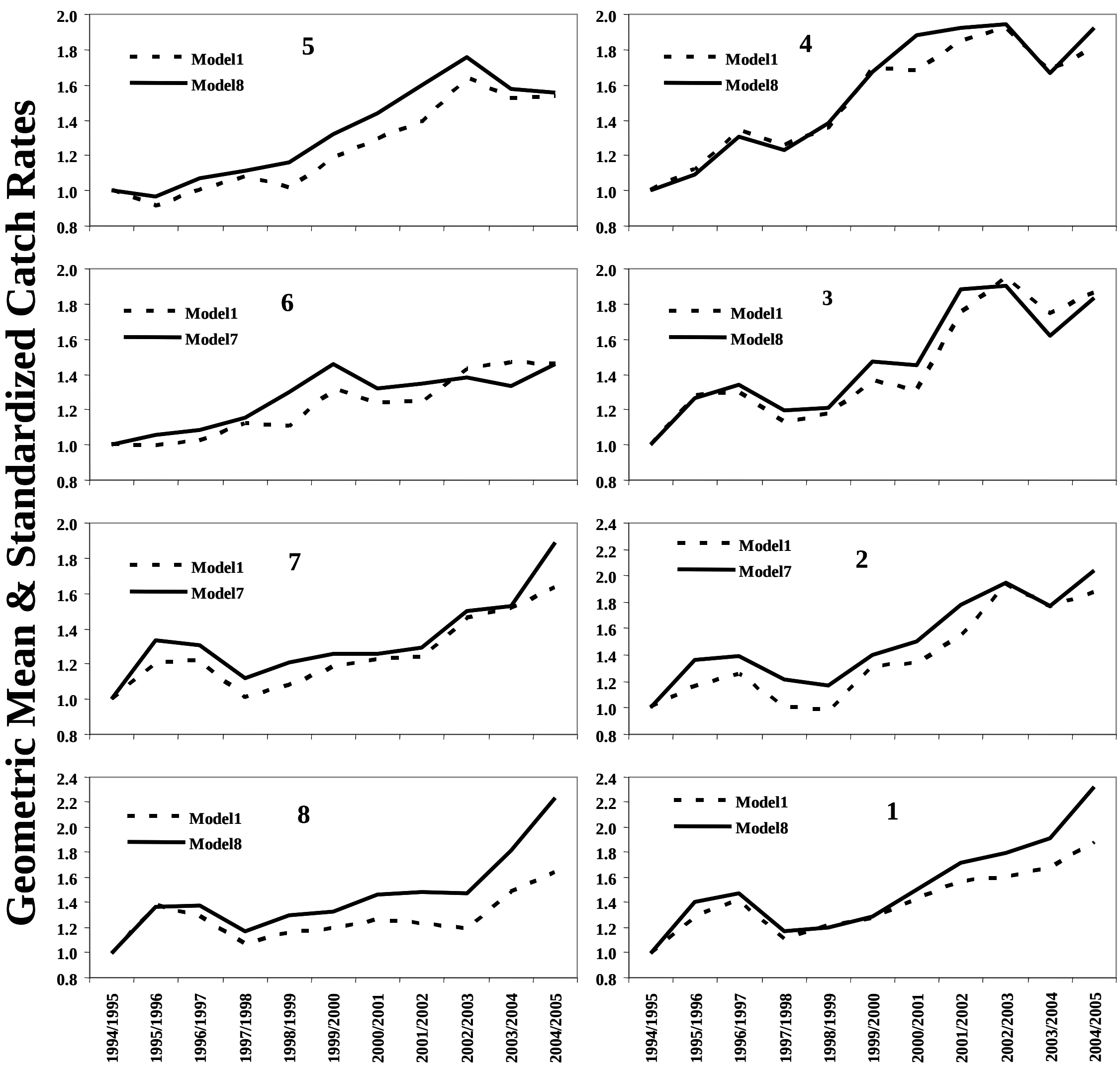


Figure 17. Geometric mean catch rates for each quota year compared with the optimal standardized catch rates for the eight assessment areas. In each case Model 1 was the geometric mean while the optimum statistical model was either Model 7 or Model 8 (see Table 5).

The various factors included in the statistical models described different amounts of variation in the catch rate data in different Areas (Table 6). The seasonality of the fishery is so marked that the factor *Month* accounted for most of the variations described by the statistical models in every Area except Area 6, where the vessel doing the fishing was most important. In Areas 1, 2, and 3 *Month* accounted for almost 70% of all variance described while *Vessel* accounted for about 15% (Table 6). In Areas 4 and 5 *Month* accounted for between 42 and 48.5%, but only about 35 to 37 % in Area 6 and 7. *Vessel* accounted for between 13 and 29% except in Area 6 where it was 44.5%. In general the *daynight* factor described more variation that the *depthcategory* factor, even in Area 6. In Area 7, *daynight* was almost as influential as *Vessel* (Table 6).

Despite the relatively minor influence of the depth category in the analysis, depth clearly has an effect on catch rates as can be seen if catch rates are plotted against depth (Figure 18).

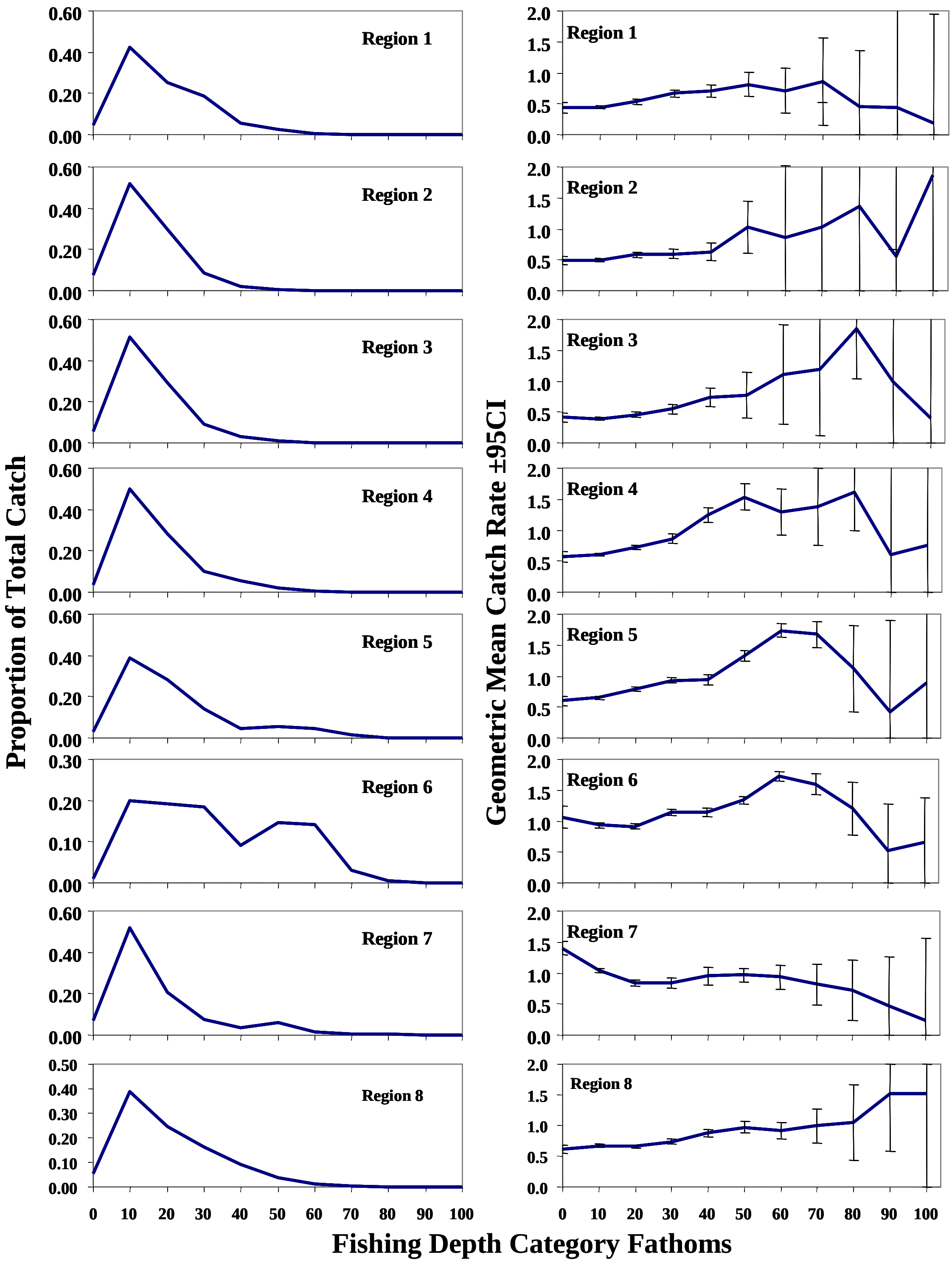


Figure 18. The proportion of the total catch and the geometric mean catch rate by depth category (10 fathom steps) for each of the eight rock lobster stock assessment areas. In most Areas the catch rates in the deepest areas derive from very few data points, hence the wide 95% confidence intervals; confidence intervals have been truncated at zero and 2.0. Data has been aggregated across all quota years from 1994/95 to 2004/05.

The trends in catch rates observed differ greatly between Areas with all Areas, except Area 5, exhibiting increases in standardized catch rates in the last quota year. Area 6 continued with relatively stable catch rates, while Areas 1, 2, 3, 4, 7 and 8, exhibited significant upturns in catch rates; in the cases of Area 3 and 4 reversing a downturn observed in the 2003/04 quota year (Figure 17). The changes in catch rate were not necessarily matched by changes in the catches taken from each Area (Figure 19), which were lower than the 2003/04 quota year in Areas 3, 4, and 5, but again higher in 1 and 8; Areas 2, 6, and 7 were relatively stable in their catches (Figure 19).

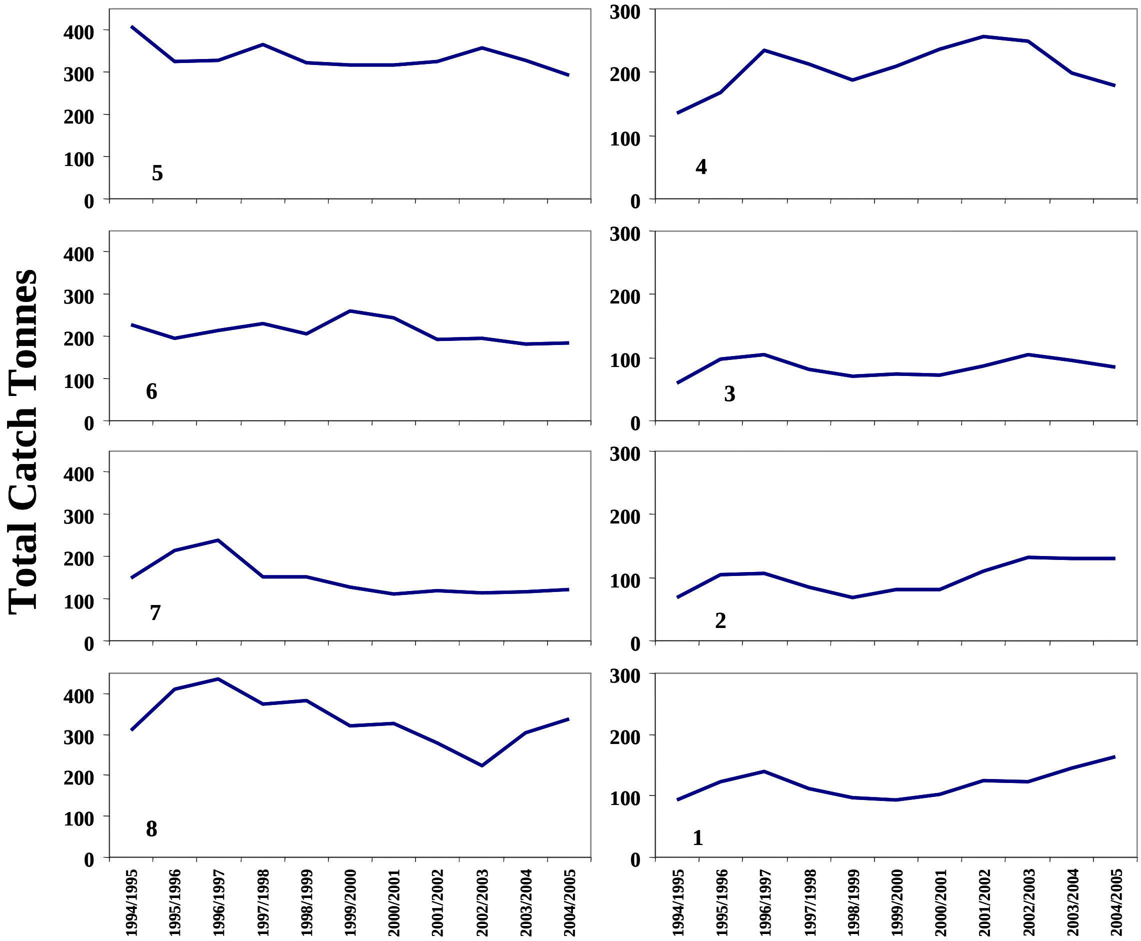


Figure 19. Total catch as tonnes by quota year for the eight rock lobster assessment Areas.

The catch rate trends observed before the start of the 2004/05 quota year are consistent with analyses conducted in 2003/04. Fortunately, the negative turndowns in catch rates observed in 2003/04 in Areas 2, 3, and 4 have been reversed and have recovered to approximately those rates exhibited in 2002/03. In Area 5 there had been a downturn in catch rates in 2003/04, and despite a decrease in the catch taken from the area, catch rates this last year did not recover though they did stabilize.

In both Areas 1 and 8, despite increases in catch, the reported catch rates continued to rise and the standardization had the greatest influence on the trends in these two Areas, increasing the improvement above that observed in the basic geometric mean catch rates. In Area 7, catches remained almost identical to that in 2003/04 but the standardized catch rates increased even more than the geometric mean catch rates.

The 2004/05 catch from assessment Area 6 was essentially the same as the 2003/04 level but the standardized catch rates improved although only to the extent that they became equivalent to the basic geometric mean catch rate.

The general trend across the fishery was that of an increase with the only real exception being in Area 5. This provides evidence that stock rebuilding is continuing.

It has been suggested that some high-grading of catch is occurring in parts of South Australia where very large lobsters are being returned to the water so that smaller but more valuable lobsters can be retained. This process has arisen because the lobster stocks there have recovered strongly. There are now suggestions that the same process may be occurring in the north of Tasmania, especially in Area 5. Currently the stock assessment model is almost completely dependent upon the time series of catch rates. The standardization is an attempt to obtain a clearer signal from available information. However, if high-grading occurs and the extent is unknown then this source of information will be compromised and any improvements in catch rates indicating a stock recovery will be obscured.

The fishery has begun to stabilize into a pattern of reducing catches in Areas 4 and 5, stable catches in Areas 2, 3, 6, and 7, and increasing catches in Areas 1 and 8. This on-going shift of catch away from the northern Areas to the two southern Areas will presumably begin to affect stock sizes. We would expect fleet dynamics to adjust to this pattern and respond to differences in regional catch rates.

Table 6. The variation accounted for by each factor (measured by total adjusted R^2) for each model for each assessment area. The models are described by adding each term down the left-hand side. QYear is quota year, DayNight is whether a shot was made during daylight hours or night, DepthCat were a set of 10 fathom depth categories, and block was the statistical block within each area. The bottom half of the table are merely the R^2 values converted to percent of the total for ease of comparison between areas.

	Area1	Area2	Area3	Area4	Area5	Area6	Area7	Area8
Qyear	3.94	7.74	5.87	6.51	4.62	3.23	2.77	2.17
Month	35.62	38.79	33.42	17.86	19.97	14.07	13.52	26.28
Vessel	7.52	7.54	7.58	11.40	11.74	16.94	11.34	10.51
DayNight	0.48	2.64	0.42	2.56	1.90	1.43	8.36	0.68
DepthCat	0.90	0.30	0.53	2.36	1.71	1.23	1.69	0.68
Block	0.64	0.22	0.03	0.91	0.42	0.34	0.05	3.14
Month*Depth	0.42	0.24	0.21	0.30	0.28	0.81	1.16	0.29
Month*Block	0.07	-0.15	0.10	0.30	0.50	-0.28	-0.61	0.12
Total R^2	49.59	57.46	48.16	42.19	41.14	38.05	38.91	43.86
Qyear	7.94	13.46	12.19	15.43	11.22	8.48	7.13	4.95
Month	71.82	67.51	69.38	42.32	48.55	36.97	34.76	59.91
Vessel	15.16	13.12	15.74	27.01	28.53	44.53	29.15	23.96
DayNight	0.97	4.59	0.87	6.07	4.62	3.77	21.49	1.55
DepthCat	1.81	0.53	1.11	5.59	4.16	3.22	4.35	1.54
Block	1.29	0.38	0.06	2.15	1.01	0.89	0.14	7.15
Month*Depth	0.85	0.41	0.44	0.72	0.69	2.14	2.98	0.67
Month*Block	0.15		0.22	0.72	1.22			0.27

3.1.3 Research catch-rates

Comparison of research-catch rates on an annual basis is currently only available for locations within Areas 2 and 8, although the scope of research catch sampling has recently been widened. Research catch-rates for 2004/05 are considerably higher than those recorded in reference years, with the exception of medium depth sites in Area 2, where they are 19% less than those recorded for the reference year (November 94). (Table 7).

Research catch rates declined significantly in all Areas (Table 7), with the largest decrease in medium depth waters in Area 2 (62%), following a slight decline in these catch rates in the 2003/4 quota year (22%). This pattern of decrease was not present in commercial catch-rates from Areas 2 and 8 over the past year (see Table 4), however, research catch rates are based on a relatively small sample size taken from a specific location within the larger fishing blocks. These catch rates are insightful in understanding the dynamic of annual changes in specific locations but are inherently more variable than commercial data. The variability is also reflected in the time series of comparisons between commercial and research catch rates (Figures 27, 29 and 31).

Table 7. Research catch rates from sampling conducted on the *R.V. Challenger* in late October 2004 (no. lobsters/pot lift) on the East and South Coasts of Tasmania. Commercial catch rates were calculated using data from the first week of season opening in November within the specified range of depths.

Area	Depth (m)	Commercial Catch rate 2004	Ref. Year	Catch-rates (#/ pot lift) Ref. Year	2003	2004	% change vs Ref. Year	vs 2003
Area 2	<35	2.37	Nov’94	1.06	2.74	1.86	+75%	-32%
Area 2	35-50	2.35	Nov’94	1.36	2.89	1.10	-19%	-62%
Area 8	45-100	3.88	Nov’93	0.97	4.53	2.44	+152%	-46%

3.1.4 Legal-sized biomass

Estimates of legal sized biomass from the new rock lobster model continue to indicate relative stability, though with Areas 1 and 7 exhibiting some slight rises over last year (Table 8). Only Area 3 exhibited a negative change in legal biomass relative to 2003/04 but this was only down by 1.5%.

All areas continue to show a marked increase in legal biomass relative to that predicted by the model for the reference years. It is clear that relative to 1994 there has been significant rebuilding. However, for the last three years, except for Areas 1 and 8, the rebuilding appears to have stalled and legal biomass levels have remained effectively constant (Figure 20). The distribution of catch continues to move away from the north and into the southern Areas with the central Areas staying relatively stable. How long these trends in fleet dynamics can continue is currently impossible to predict and make the projections used in the risk assessment, when exploring alternative management options, very difficult to predict appropriately.

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

Area	Ref	Sized biomass estimate (tonnes)			% change in 2004	
	Year	Ref. Year	2003	2004	vs Ref. year	vs 2003
Statewide	1993	1848	3339	3447	+86.5	+3.2
State (adj)	1993	847	1500	1548	+82.8	+3.2
1	1993	105	215	238	+26.7	+10.7
2	1993	88	231	232	+63.6	+0.4
3	1994	73	132	130	+78.1	-1.5
4	1994	286	535	544	+90.2	+1.7
5	1993	318	525	537	+68.9	+2.3
6	1995	138	187.5	187.6	+35.9	+0.1
7	1994	324	426	461	+42.3	+8.2
8	1993	622	1089	1118	+79.7	+2.7

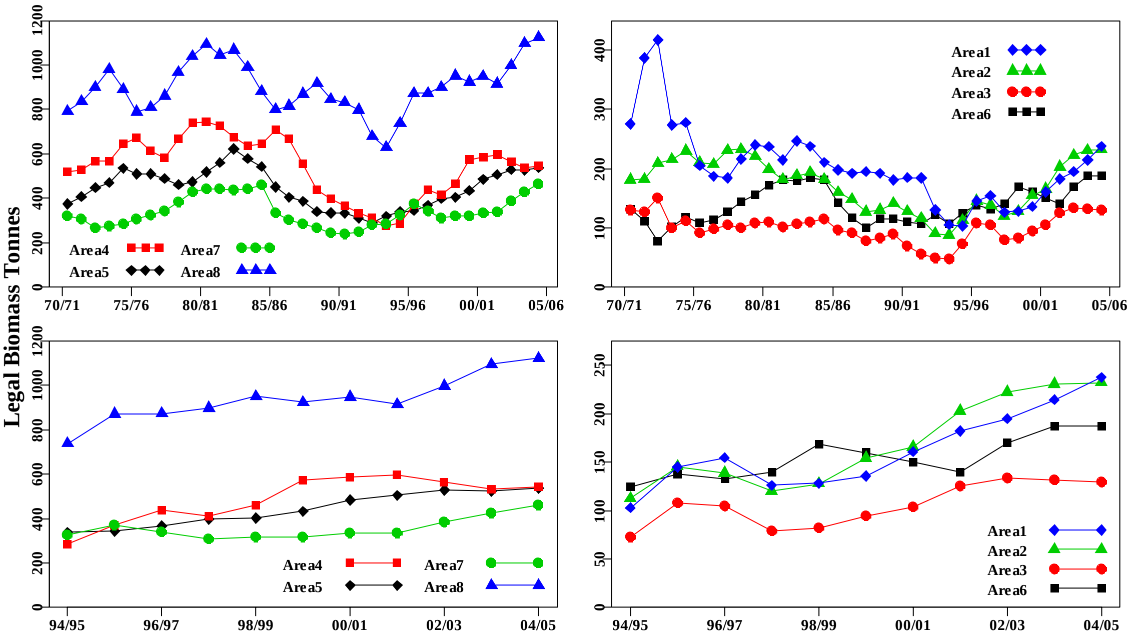


Figure 20. Legal-sized biomass estimates for the rock lobster fishery from (upper) 1970/71 to 2004/05 and (lower) from the historical lows of 1994/95 to the latest estimate in 2004/05. All estimates are for the end of October, immediately after seasonal growth and the main annual recruitment. Note the plots have different vertical scales. Total legal-sized biomass in Areas with large amounts of reef such as Areas 5 and 8 is mainly a function of size of habitat. Note the spike in stock size in 1995/96, which is most noticeable in Areas 1, 2, 3, 6, and 7.

3.1.5 Harvest rates

The rock lobster model estimates the seasonal harvest rates expressed in each assessment area (Figure 21). A change in fishing behaviour is apparent on the west coast since the 2002/03 season. In addition, the variation in fishing intensity (differences between the highs and lows of harvest rate within each year) appears to have declined since the introduction of quota management (Figure 21). There are indications that the overall trend has declined in the west coast areas relative to the late 1990s. There are also declines on the east coast but these are not so great and in fact areas 1 and 2 exhibit relative stability.

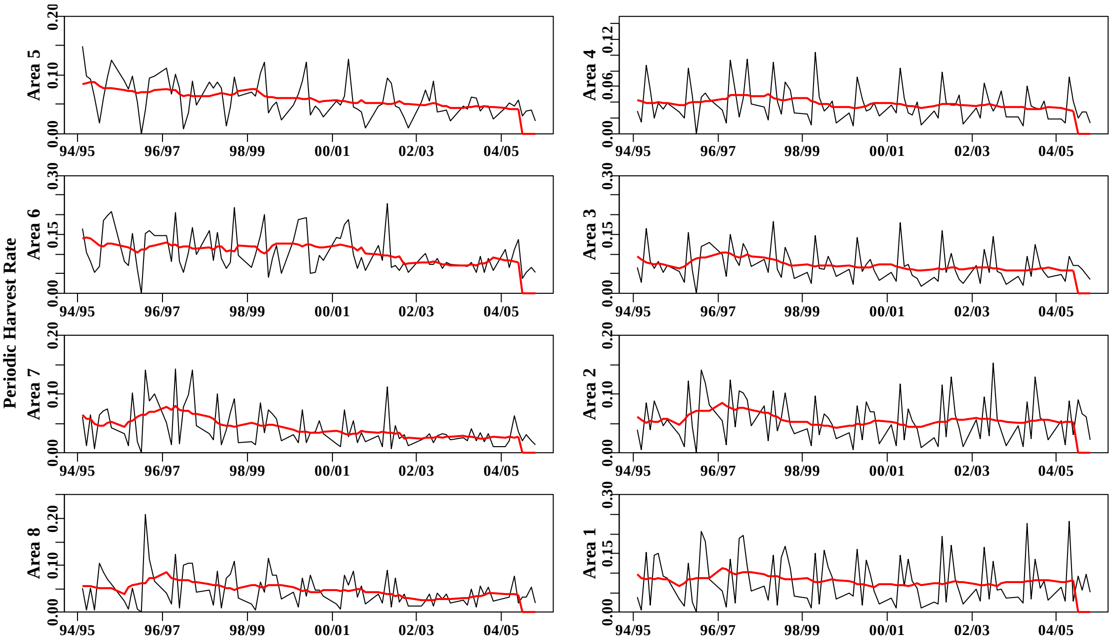


Figure 21. Seasonal harvest rates for the eight assessment areas. The overlaid trend line in each case is the 8 period moving average designed to provide an estimate of the annual trend (not the annual absolute harvest rate). Significant differences in the seasonality of the fishery are apparent between areas.

3.1.6 Egg production

At least for the last four years relative egg production has been effectively stable (Figure 22 and Figure 23), although in the last quota year overall production declined by about 1% (Table 9). The re-estimation of the growth transition matrices for the new model has led to changes in the expected maximum size (smaller in the southern Areas and bigger in the northern). These changes have led to a slight increase in the virgin egg production in the southern Areas and a slight decrease in the northern Areas. Areas 5 and 6 declined the most in the past quota year, -3.2 and -5.5% respectively. This is more important in Area 5 than Area 6 although both areas are producing less than 25% of virgin egg production.

Table 9. Change in statewide and regional 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. It is not intended to indicate the absolute level of egg production. Shaded lines are Areas with greater uncertainty in egg production estimates. “State (adj)” is Statewide data adjusted to exclude Area 6, where egg production is estimated poorly for recent years.

Area	Ref. Year	Relative Egg Production			% change vs		% virgin prod. in 2004
		Ref. Year	2003	2004	Ref. Year	2003	
Statewide	1993	1925	2159	2136	+10.9	-0.989	49.8
State(adj)	1993	1844	2056	2039	+10.6	-0.991	52.7
1	1995	203	224	224	+10.1	0	60.8
2	1992	103	153	154	+49.5	+0.06	48.2
3	1993	50.9	73.3	73.8	+45.0	+0.06	24.5
4	1993	117	175	175	+49.6	0	23.6
5	1992	72.6	156	151	+8.0	-3.2	16.2
6	1986	55.4	102.7	97.1	+75.3	-5.5	23.0
7	1989	263	307	305	+16.0	-0.07	83.8
8	1994	982	968	955	-2.8	-1.34	113.8

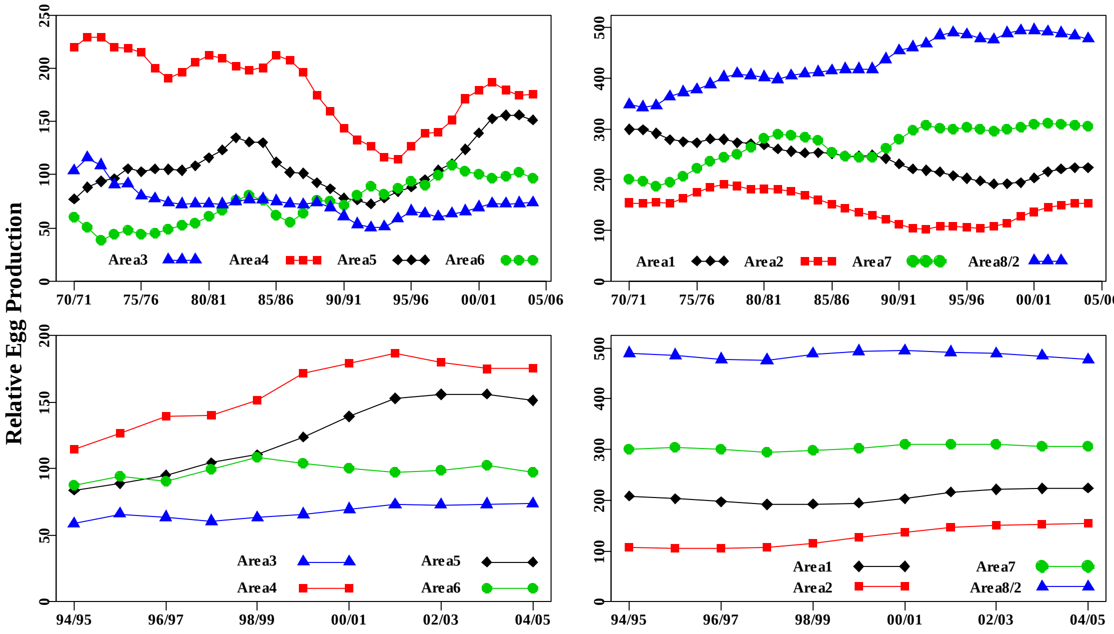


Figure 22. Relative egg production around Tasmania, northern Areas to the left, and southern Areas to the right. Area 8 was included by dividing each value by 2 to keep it on the same scale.

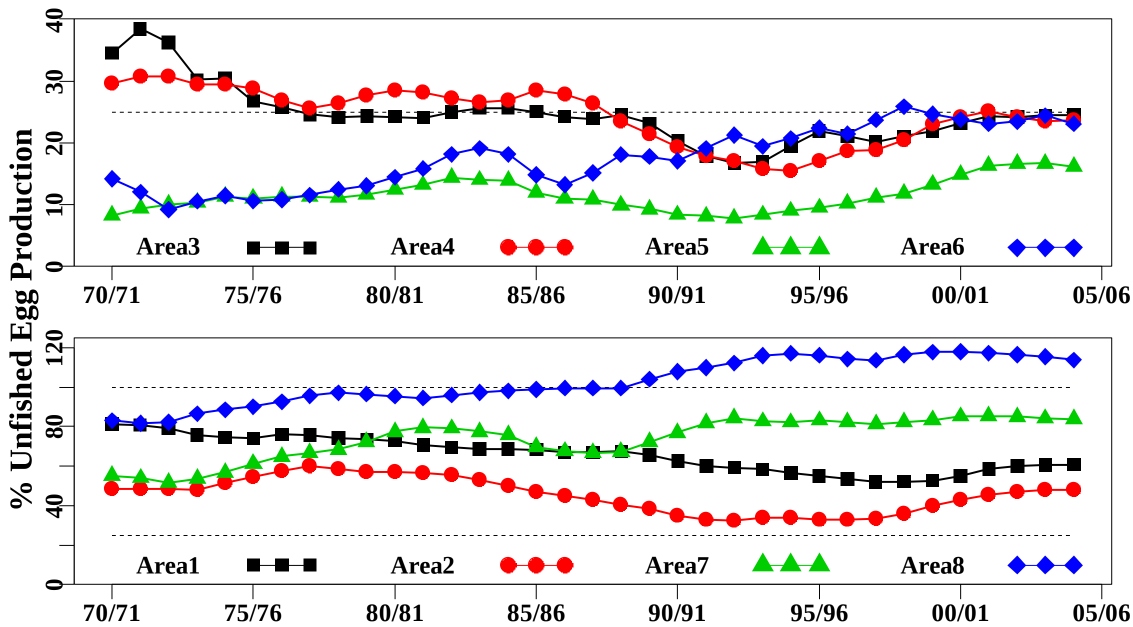


Figure 23. Percentage of virgin (unfished) egg production from eight Areas around Tasmania, southern Areas in the bottom panel, northern Areas in the top panel. The horizontal dashed line in each plot represents the management target of 25%, in the bottom panel 100% also indicated.

Egg production as a function of the expected unfished egg production remains lowest in the northernmost four Areas (3, 4, 5, and 6). All four Areas have exhibited improved levels of egg production relative to the reference years and 1994, although in Area 5 this improvement is only of the order of 8% (Table 9). Because the northern areas are so influential with egg production the overall improvement across the State is only of the order of 10 to 11 % since 1994 (Table 9). All four northern Areas remain below the threshold of 25% of virgin egg production, though for Areas 3 and 7 this is only just below 25%. The target of a minimum of 25% is based upon observations and management targets in other lobster fisheries. Unfortunately, the exact level of egg production at which a stock is more likely to collapse is unknown until it collapses. Because it is unknown which areas contributes most significantly to the recruitment dynamics of the stock there remains concerns about the northern four areas remaining below 25% of virgin production.

4.1.6 Relative abundance of undersized lobster

For the abundance of pre-recruit lobsters (undersized lobster equivalent to one growth increment below legal size) to be useful as a performance indicator, a relationship between the catch rate of undersized and newly recruited legal-sized lobsters needs to be established. A link between the abundance of undersized lobsters and subsequent legal-sized lobsters has only been defined for the south coast where catch-rates of undersized males between 102-110 mm CL provide an imprecise index of animals moulting to legal-sized in the following season.

Catch rates of undersized lobsters at Maatsuyker Island in 2004 decreased by 48% from 2003 catch rates and by 42% from the reference year (1995) (Table 10). However, combined Maatsuyker Island/Port Davey catch rates show an 88% increase from 2003, with no matching data available for the reference year. This provides an indication of the volatility of this data set and suggests that short term declines may be of limited concern.

Table 10. Comparison of fishery independent preseason (Oct/Nov) catch-rates of undersized lobsters in the size bracket 102-110 mm sampled from waters adjacent to Maatsuyker Island and these sites combined with sites from Port Davey (Maat + PD) in similar depths. For Maatsuyker Island, 390 pot lifts were undertaken in the reference year compared to 99 in 2003 and 100 in 2004. Samples from Port Davey are based on 50 pot lifts in 2003 and 100 in 2004. No sampling was undertaken at Port Davey in the reference year.

Location	Ref. Year	Catch-rates (N/pot lift)			Change (N/pot lift) 2004 vs		% change	
		Ref. Year	2003	2004	Ref. Year	2003	Ref. Year	2003
Maatsuyker	Nov'95	1.43	1.61	0.83	-0.60	-0.78	-42%	-48%
Maat + PD			3.04	5.71		+2.67		+88%

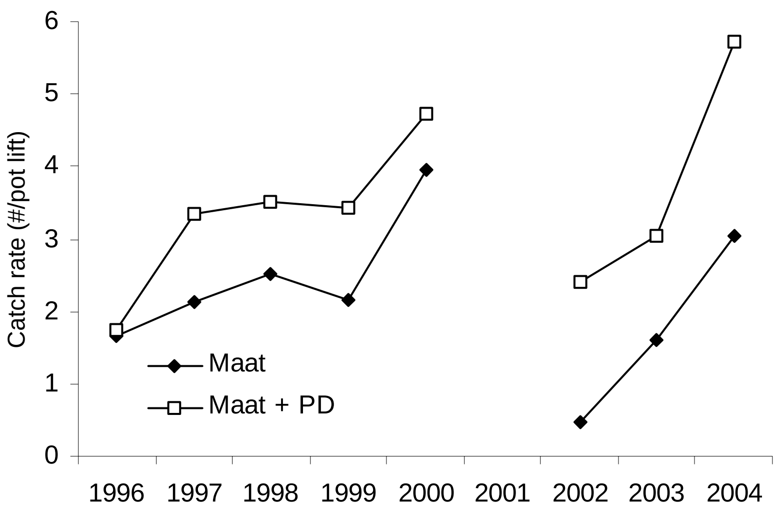


Figure 24. Pre-recruit (male lobsters 102-110 mm CL) catch-rates for Maatsuyker sites (Maat) and Maatuyker and Port Davey sites combined (Maat + PD) from November 1996 to November 2004. Note no catch sampling survey was conducted in November 2001.

3.1.7 The total annual commercial catch

The total annual commercial catch (TACC) is defined by output controls on the fishery. A TACC of 1502 tonnes was introduced for the first time in March 1998, but was subsequently raised to 1523 tonnes in March 2002. The management trigger is set at 95% of the TACC (1447 tonnes). The total commercial catch for the period March 2004 to February 2005 reported through the quota management system was 1513.8 tonnes and is thus is well above the management trigger (Figure 25).

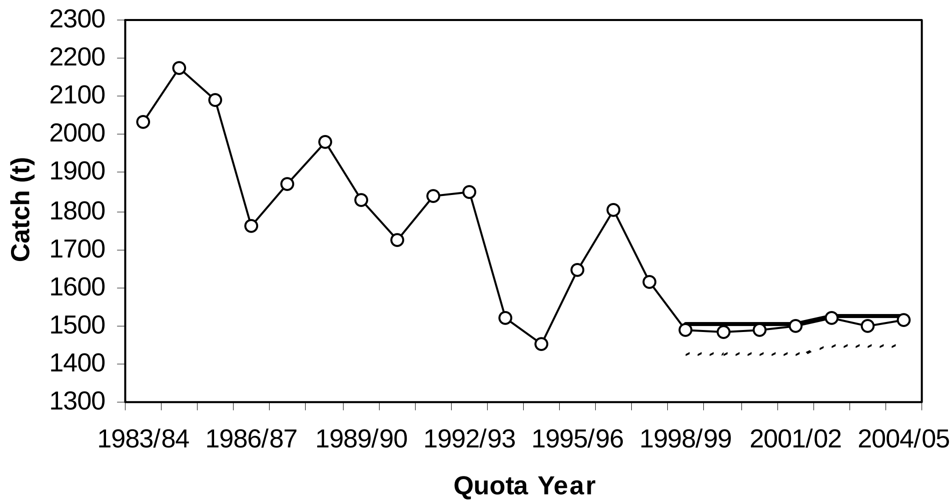


Figure 25. Change in annual commercial catch. The total allowable commercial catch (TACC) is shown as a separate solid line since its introduction in 1998 and the trigger point of 95% of the TACC is shown as a dashed line. Note the catch axis does not start at zero.

3.1.8 The size of the rock lobster fleet

The size of the active fishing fleet has declined steadily over the last decade. In 1993 there were 353 fishing vessels operating in Tasmanian waters, however, by 2004/05 this number had fallen to 231 active vessels (Table 11, Figure 26). Note that the number of active vessels is influenced by several factors including the fishing of more than one license from a single vessel and the replacement of vessels so that more than one vessel is active under a single license. The trigger point for this performance indicator is 220 vessels and this was not breached.

Table 11. Changes in the number of licences and vessels in the Tasmanian rock lobster fishery. Active licenses and vessels are those that recorded catch.

Year	Number of licences	Number of active licenses	% change	Number of active vessels	% change
1993/94	337	330	-	353	-
1994/95	334	329	-0.3	342	-3
1995/96	331	326	-0.9	348	2
1996/97	321	315	-3.4	332	-5
1997/98	316	309	-1.9	330	-1
1998/99	314	304	-1.6	314	-5
1999/00	314	269	-11.5	270	-14
2000/01	314	259	-3.7	254	-6
2001/02	314	250	-2.4	246	-3
2002/03	314	242	-1.2	247	+0.5
2003/04	314	234	-3.3	241	-2
2004/05	312	231	-1.3	231	-4.1

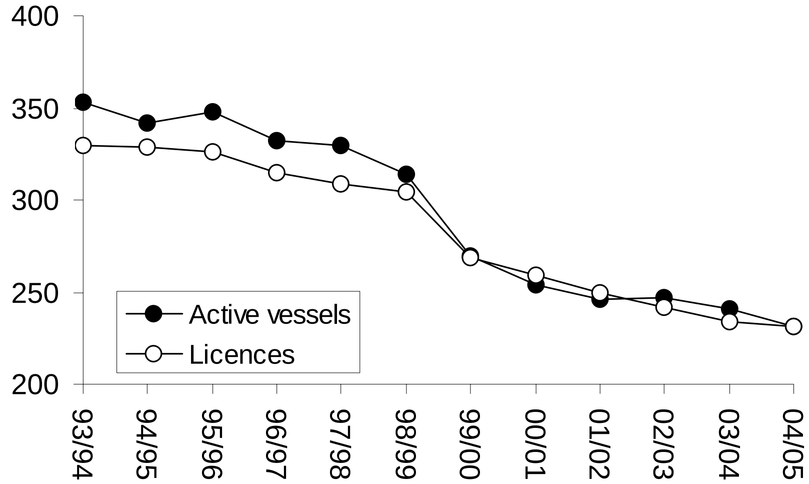


Figure 26. Trends in number of active licenses and active vessels in the Tasmanian rock lobster fishery over the last decade.

3.1.9 The recreational catch

Frequent and precise estimates of the recreational fishery are more difficult to obtain than for the commercial fishery. Reliable estimates of the amount of lobsters captured by recreational fishers are typically based on surveys. In recent years there has been a growing commitment to regular surveys of recreational fishers. It is intended that these surveys will be conducted on a biennial basis.

In the 2002/03 assessment report, we indicated that the trigger point for the recreational catch had likely been reached. The management plan quantifies recreational catch as a percentage of commercial catch and the trigger point states that if the total recreational catch exceeds 10% of the TACC in a year, there will be a review. Shortly after the 2002/3 assessment report, Lyle and Morton (2004) released a survey of the Tasmanian recreational rock lobster fishery that showed the recreational catch of rock lobster was around 10% of the total 2002/03 commercial catch (Figure 27). They noted that this value was an estimate (as with most performance indicators) and the true recreational catch could be slightly above or below the trigger point. The proximity to the trigger resulted in a review. In the 2004/05 season the recreational harvest represented 7.8% of the 2004 TACC of 1523 tonnes (Lyle and Morton 2006) and was thus below the 10% TACC trigger level.

More recreational licences were issued in 2004/05 than in 2003/04 and the total number of licence holders increased (Figure 28). This restored the temporal trend of increasing numbers of licences issued and total licence holders that was evident before the 2003/4 quota year. The number of both dive and pot licences increased while rings remained relatively steady (Figure 29). Pot licences remain the most commonly issued recreational licence and constituted 55% of all licences issued in 2004/05 (Figure 30).

Considerable regional variability exists in the recreational catch. For example, the recreational catch is estimated to represent 35% of the commercial catch in Area 1, but only 3% of the commercial catch in Area 8 (Figure 27). However, the recreational fishery is largely limited to shallower waters (i.e. <20 m). When recreational and commercial catches are compared for shallow waters, recreational catches were found to equate to about one quarter (26%) of the shallow water commercial catch for the State. In Area 1, where the recreational catch constitutes the highest proportion of the commercial catch, Lyle and Morton (2004) estimated that the recreational catch was equivalent to 95% of the total commercial catch in waters less than 20 m. In Areas 2 and 3 (on the east coast) recreational catches were estimated to be equivalent to around half (54 and 49% respectively) of the shallow water commercial catch. Elsewhere, recreational catches are equivalent to a much lower proportion of the shallow water commercial catch (i.e. less than 30%).

These findings imply that management of the ecological effects of lobster fishing needs to target both recreational and commercial fisheries. This is because regions of greatest concern are localized sheltered regions on the east coast where catch rates are reported to remain low while effort from both sectors remains high. Such localized effects are not detectable in this assessment.

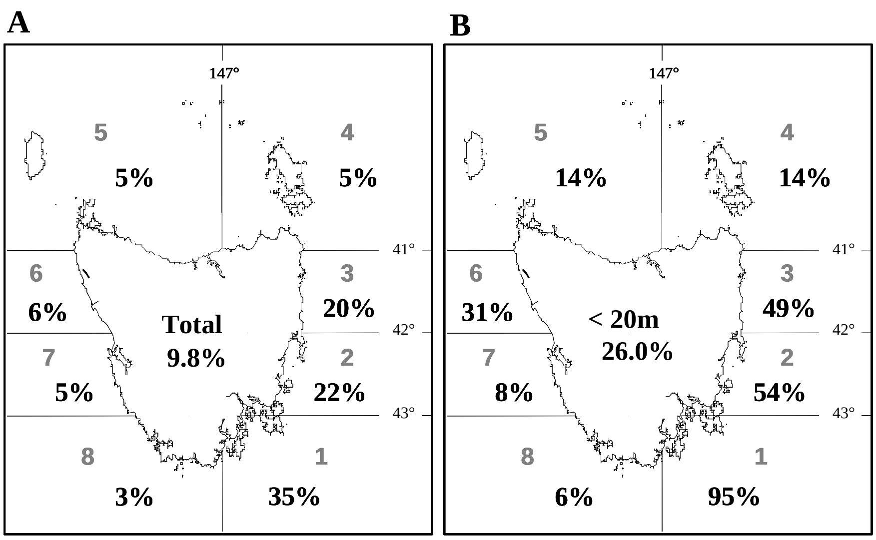


Figure 27. 2002/03 recreational rock lobster harvest (weight) expressed as a percentage of the commercial rock lobster catch: (A) based on total catches; and (B) based on catches from shallow waters (<20 m) (taken from Lyle and Morton 2004).

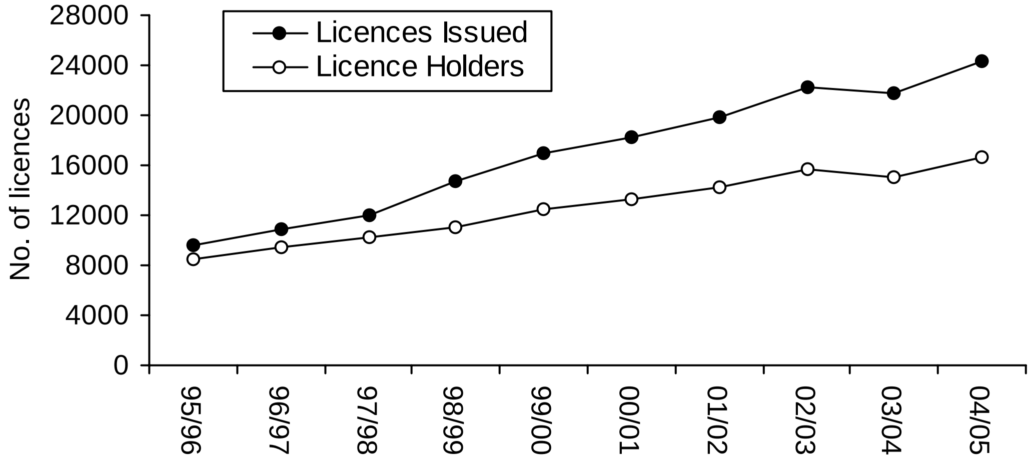


Figure 28. Comparison between the total number of recreational rock lobster licences issued (pots, dive and rings; solid circles) and the number of licence holders (open circles) from 1995/96 to 2004/05.

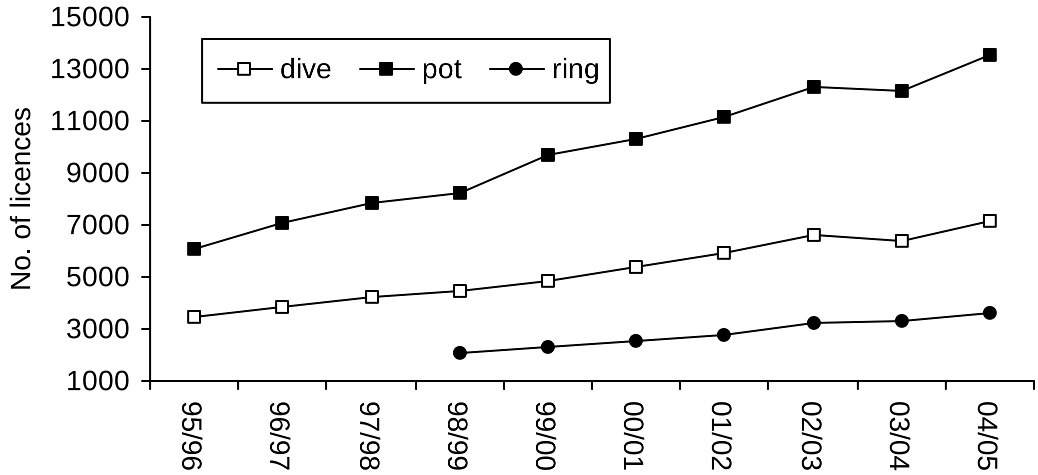


Figure 29. Number of recreational pot, dive and ring licences issued from 1995/96 to 2004/05.

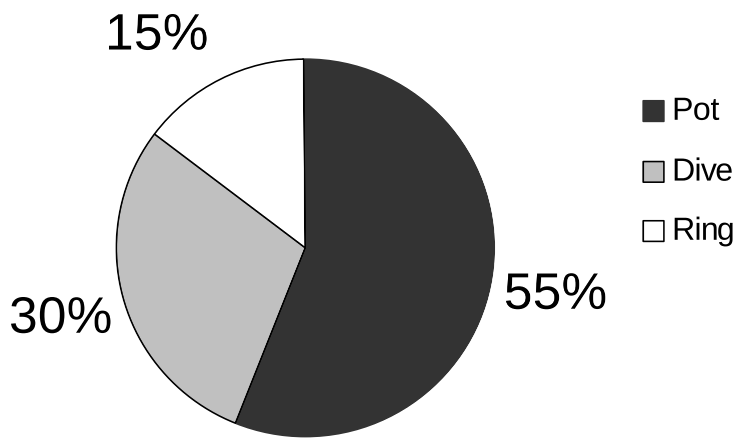


Figure 30. 2004/5 recreational licence breakdown.

3.2 Trends in fisheries-independent abundance indices

These abundance indices are collected through research sampling that is repeated in the same sites. The consistent sampling method eliminates biases present in the commercial catch rate data such as differences in the fishing behaviour of individual fishers. The limitation of fisheries-independent abundance indices is that sample sizes are typically low so that their main value is in examining longer trends, rather than annual fluctuations.

Formerly research catch sampling has been confined to localities on the eastern and southern coasts of Tasmania (Areas 2 and 8), however, in an effort to extend the spatial coverage of these indices, research catch sampling is now conducted from commercial fishing vessels in a range of other Areas (i.e. Areas 1, 4, 6 and broader sampling in Area 8).

3.2.1 East Coast – shallow depth

In general, research catch sampling in shallower waters off the east coast of Tasmania has had lower catch rates than in commercial samples (Figure 31). In the last year, research catch rates have undergone a dramatic decrease not reflected in the commercial catch rate derived from the remainder of the fishing block. A possible explanation for this sudden decrease in research catch rates can be provided by viewing the pre-recruit numbers at the research sampling site over the last two years (Figure 32). It would appear that the decrease in legal-sized lobsters is a direct response to a significant drop in the abundance of pre-recruit lobsters since 2003. Encouragingly, however, despite the recent decline the number of pre-recruits still remains high in comparison to the long-term trend, indicating there is still the potential for strong growth into the near future, as indicated in the previous assessment. Further sampling will be required to elucidate if commercial and research catch rates are actually comparable in magnitude because of the limited scope and size of the research catch sampling conducted in shallow waters.

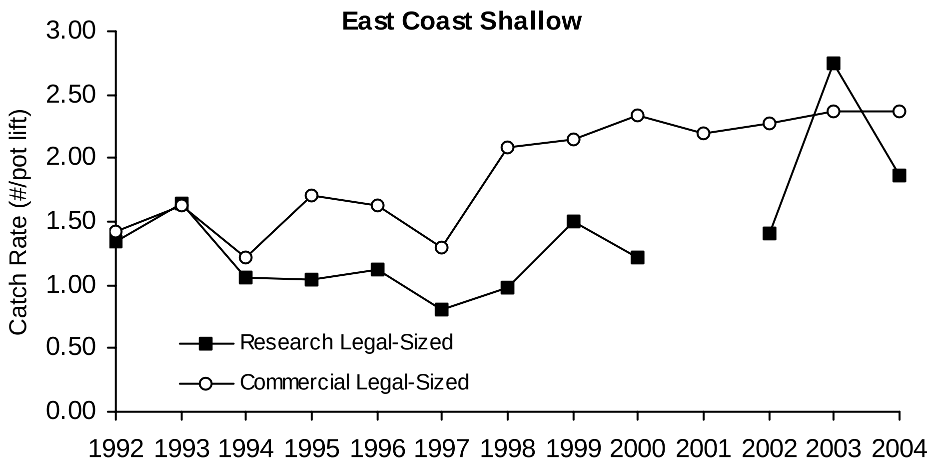


Figure 31. Shallow catch rates (<35 m) of legal-sized lobsters from research surveys and commercial fishing conducted on the east coast in late October/early November.

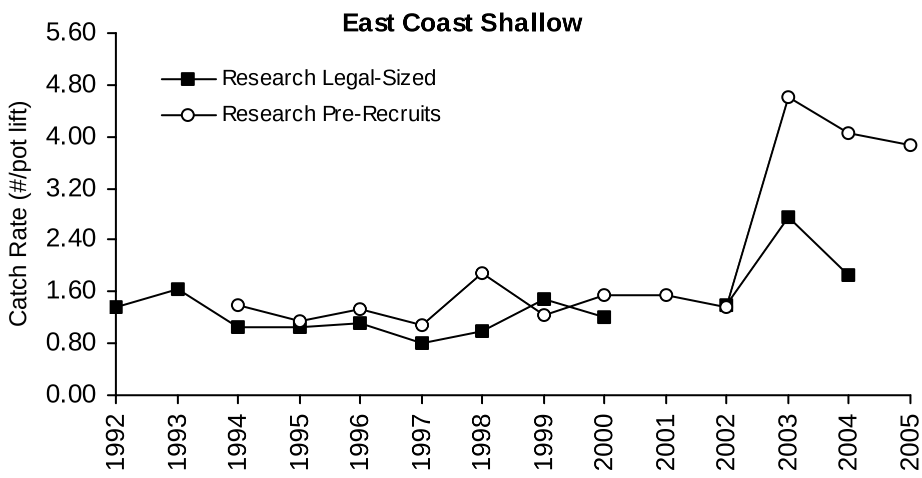


Figure 32. Shallow water catch rates (< 35 m) for legal-sized and pre-recruit lobsters on the east coast of Tasmania. The pre-recruits lobsters (males between 102 and 110 mm CL and females between 98 and 105 mm CL) have been advanced by 1 year to simulate growth of undersized lobsters to legal size.

3.2.2 East Coast – medium depth

Although research catch rates are variable from year to year, up until the past quota year they demonstrated a similar long-term trend to the commercial data (Figure 33), implying that the trends in commercial rates reflect a change in lobster abundance. However, in the past quota year there was a dramatic decrease in research catch rates to the lowest recorded level (Figure 33), despite a small increase in the commercial catch rate.

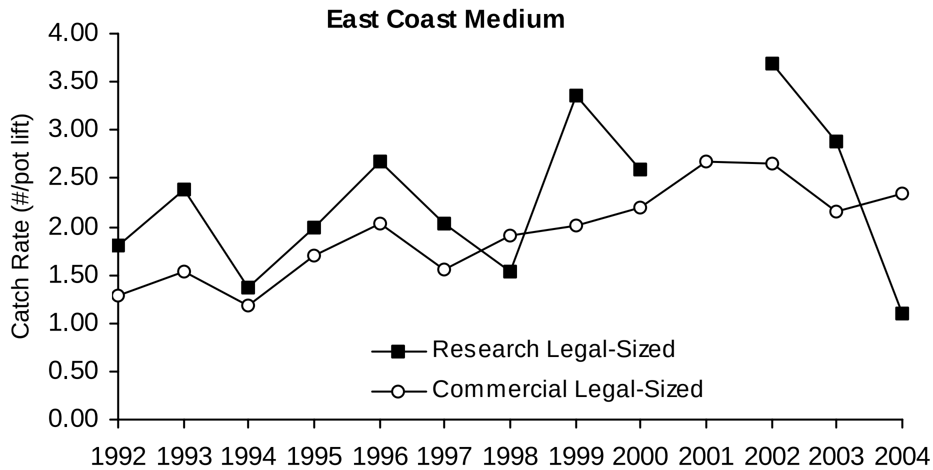


Figure 33. Medium depth (35-50 m) catch rates for legal-sized lobsters from research surveys and commercial fishing conducted in late October/early November on the east coast.

This decrease in the research legal-sized catch rate is matched by a similar trend for the pre-recruit lobster abundance in the past two quota years (Figure 34), suggesting that catch rates may decline further in the near future.

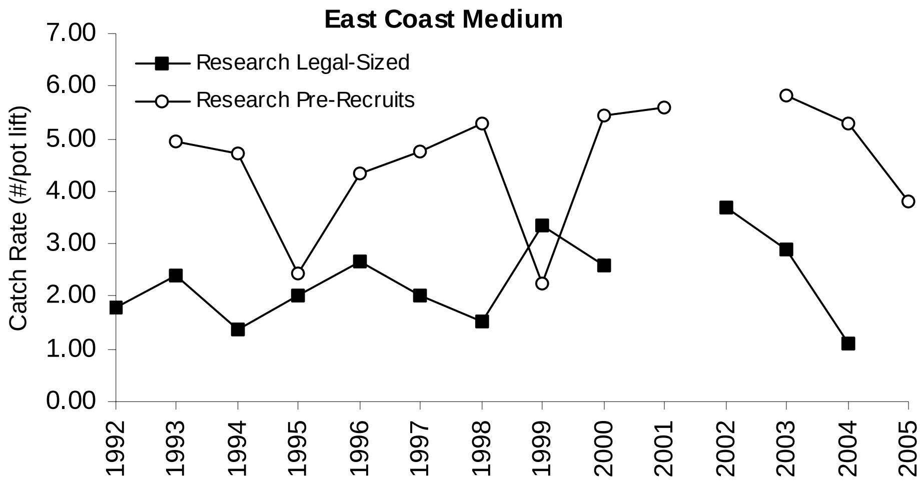


Figure 34. Medium depth (35-50 m) catch rates for legal-sized and pre-recruit (males between 102 and 110 mm CL; females between 98 and 105 mm CL) lobsters from the east coast. The pre-recruit catch rate has been advanced by 1 year to simulate growth of undersized lobsters to legal size.

3.2.3 South Coast – medium to deep depths

Research catch rates had a similar long-term trend to the commercial catch rates (Figure 35), including a dramatic increase among both research and commercial catch-rates in the 2003/4 assessment period, and a decrease in rates in the past assessment period, although the decrease was more dramatic for the research catch rate. This implies that the trend in catch rate in commercial areas reflects changes in lobster abundance or behaviour, rather than fisher behaviour.

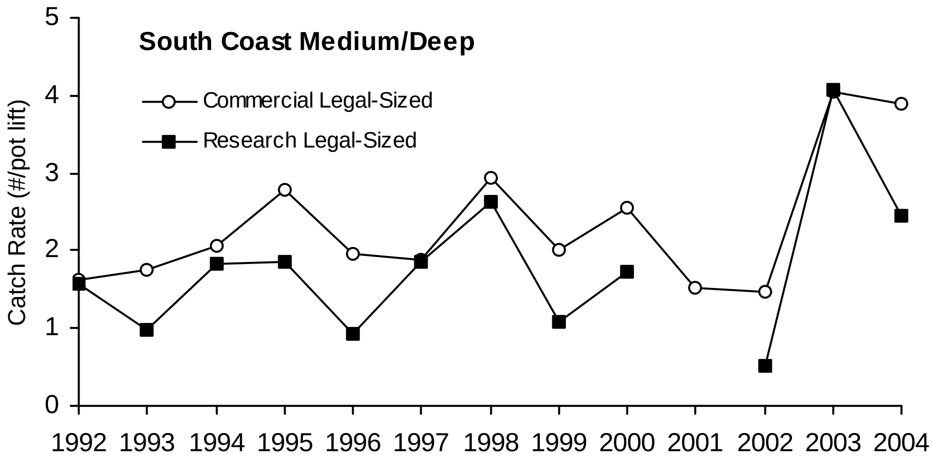


Figure 35. Medium to deep water (45-100 m) catch rates for the south coast of legal–sized lobsters from research surveys conducted in October/November and commercial fishing for the start of the fishing season (i.e. 1st week of November).

The dramatic increase in pre-recruit lobsters in 2005 to the highest level recorded (Figure 36) suggests that, despite the decrease in catch rates in the past quota year, there is the potential for strong growth in the near future. As an example of this potential growth, a dramatic increase in the research catch rates were seen in this area in the 2003/4 quota year, which was thought to be in response to high levels of pre-recruit lobsters observed at these sites between 1997 and 2000 (Figure 36).

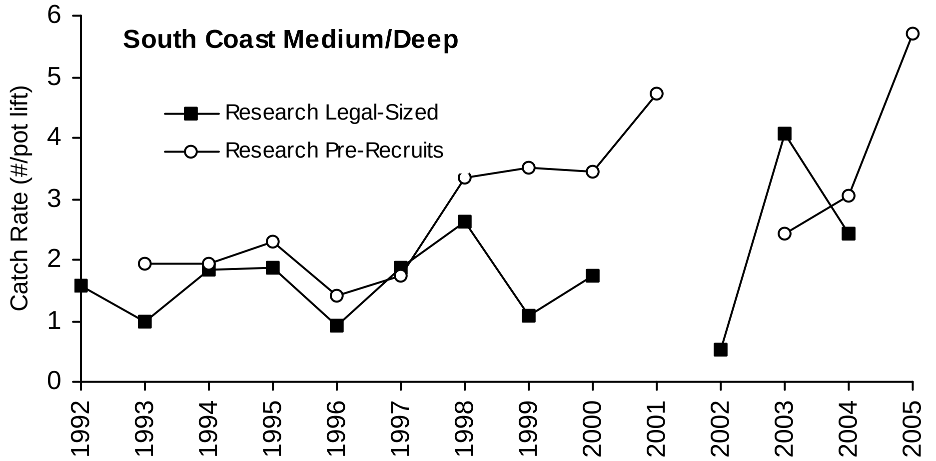


Figure 36. Medium to deep water (45-100 m) catch rates for the south coast of legal–sized and pre-recruit (males between 102 and 110 mm CL) lobsters from research surveys conducted in October/November. Pre-recruitment lobster numbers have been advanced by 1 year to simulate growth of lobsters to legal-size. Note no research survey was conducted in 2001.

3.2.4 Statewide fisheries-independent abundance indices

Prior to 2003, fisheries-independent catch data was restricted to sites in two of the eight assessment Areas (Areas 2 and 8) providing limited statewide coverage. In an effort to enhance the coverage of fisheries-independent data across Tasmania, TAFI commenced collecting catch-sampling data using commercial fishing vessels in the closed-season. This sampling has extended the range of sites sampled within Area 8, in addition to facilitating the comparison of research and commercial catch rates for Areas 1, 4 and 6 (Table 12). The commercial and research catch rates for each of the Areas considered are comparable, with research catch rates generally lying below commercially derived catch rates. For Areas 2 and 8 the research catch rates generally suggest lower rock lobster abundance than is reflected by the commercial rates (*i.e.* the research catch rates are appreciably lower), which is the opposite trend to that found in 2003. In Area 6, however, the research catch rates were appreciably higher, as was the case in 2003.

Table 12. Comparison of fishery independent catch-rates sampled in October 2004 with commercial catch-rates from the first fortnight of November (season opening) for Areas 1, 2, 4, 6 and 8. Shown also is the vessel utilised and the fishing block in which the vessel operated. Note FRV Challenger is TAFI's research vessel, all others are commercial vessels. *Commercial catch-rates were based in all cases on more than 1000 pot lifts.

Research surveys (Oct. 2004)	**Area 1**		**Area 2**		**Area 4**	**Area 6**	**Area 8**	
Fishing Block	7G1	7G2	6H1	6H3	4H3	5D2	7F3	7F3
Total catch (# lobsters)	790	622	161	90	530	1184	215	554
Total effort (# pot lifts)	500	411	150	50	577	400	100	338
Vessel	Commercial		Challenger		Commercial	Commercial	Challenger	Commercial
Catch rate (# lobsters/pot lift)	**1.58**	**1.51**	**1.07**	**1.80**	**0.92**	**2.96**	**2.15**	**1.64**
Commercial catch rate*	**1.71**	**2.03**	**2.21**	**2.85**	**1.35**	**1.57**	**2.99**	**2.99**

3.3 Alternative harvest strategy evaluation

The scenarios tested were:

Scenario #	Strategy	TACC (tonnes)	Recreational catch (tonnes)	Per pot quota allocation (kg)
1	Maintain status quo	1523	149	145
2	Increase TACC 1.72%	1550	151.5	147.5
3	Reduce the TACC 3.5%	1470	144	140

3.3.1 Projections of probable trends in legal biomass and egg production

Projections of probable trends in legal biomass and egg production were generated using the new rock lobster stock assessment model (modified after Punt and Kennedy 1997; - see Section 3.2.2 Changes to the Stock Assessment Model). Five alternative management and fishery scenarios of changes to commercial TAC and recreational catch were evaluated. The catch of the recreational and commercial sectors was apportioned in the model as follows:

- The amount and spatial distribution of catch by each sector was defined both empirically, on the basis of commercial logbook data, and as a result of survey data (Lyle & Morton, 2004).

- Catch for both sectors in each Area varied through time on the basis of logbook and survey data. As recreational catch data was not available for each year, missing years were estimated by linear extrapolation from the surveys before and after. Recreational catch prior to the commencement of surveys was set to be the proportion of commercial catch seen in the first survey (1995).

- Possible future harvests by the commercial sector were evaluated by allocating a global TACC and modelling the spatial distribution of catches on the basis of that observed since the 1998/99 quota year (through a statistical fleet dynamics model, updated this year).

- The current harvest by the recreational sector by assessment Area has been evaluated using a Tasmanian wide survey (Lyle & Morton, 2004). The recreational catch can be represented as a proportion of the commercial catch in each Area. Thus, if the TACC changes by 2%, the recreational catch is modelled to increase by the same proportion. Given the proportion of the commercial catch taken by recreational fishers in each Area the recreational take now is about 150 tonnes. To mimic the situation where the recreational fishers were taking about 170 tonnes the proportional take in each Area was increased by about 13.33% (170/150).

- Note that the model simulations of change in commercial quota and recreational catch do not account for localisation of effort or concentration into shallow depths or on particular reefs within assessment Areas. To assess an Area requires an estimate of growth dynamics, detailed catch and effort data, and ideally length distribution of the catch data. Currently there is insufficient data available to generate, for example, an independent assessment of the inshore and the offshore portions of Area 6.

Projections of future legal biomass and egg production relative to virgin levels were conducted using 1000 simulations with the median and 90% percentile bounds shown here. These percentile confidence intervals are meant to represent the uncertainty inherent in any analysis that projects into the future. Each projection is generated by selecting a random time-series of recruitment variation for each Area (as defined by what has already been exhibited in each Area over the past 30 odd years). These time series are used to grow the stock forward in the presence of the random recruitment variation and the catches implied by the TACC (Total Allowable Commercial Catch) distributed according to the fleet dynamics model along with the proportional recreational catches.

Note that egg production and legal-sized biomass can vary independently of each other as undersize females contribute a large proportion of egg production in southern regions. Furthermore, in some regions females never reach legal size and thus never contribute to legal-sized biomass.

Various projection scenarios were tested to explore the effects of altering the catch. Scenarios were based on round number change to the per-pot quota holding (with a total of 10507 pots in Tasmania) or proposed upper and lower extremes of the recreational catch. For each scenario the new rock lobster model was initiated using the same random number seed so that the variation seen between scenarios was solely due to differences in the harvest strategy and did not relate to using a different set of random recruitment residuals in the projections. Essentially the same results were obtained irrespective of which random seed was used to start the random number generator.

In this assessment we include scenarios for reducing the TACC in an attempt to increase the rate of stock rebuilding. Commercial fishers who were motivated by the economic benefit of being able to capture lobsters when the price was greater requested this scenario. They considered that the economic benefit of capturing lobsters when the price was greater (say $40/kg in winter vs $20/kg in summer) may outweigh the economic loss of a small percentage loss in total catch. Figure 37 shows seasonal patterns in catch rate for 2003 and earlier decades. Although data shown in this figure are influenced by changes in depths and location of fishing, the trends in the figure provide some evidence that rebuilding of stocks should facilitate taking lobsters during winter when prices are highest.

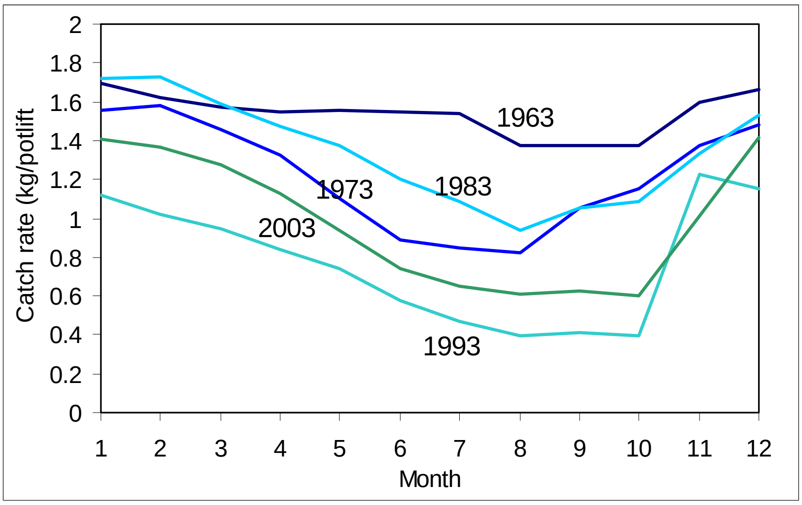


Figure 37. Change in monthly catch rate for the State for 2003 and preceding years in decadal time steps. Time series for each year is a 3 month moving average. Note that as stocks became depleted from the 1960's to the 1990's, the efficiency of fishers catching lobsters during winter decreased.

3.3.2 Biomass

Legal-sized biomass projections for the next three years, when all Areas are pooled, show an initial increase in available biomass with the rate of increase tapering off after three years (Figure 38 and Figure 39). This pattern appears to be consistent with the previous model with the possibility that the last year is biased downwards through a current inability of the fleet dynamics model to be as responsive to changes in available biomass as the fishery is to such changes. This pattern of initial increase with a flattening occurs with all Area scenarios considered, though with Areas 4 and 5 combined the 2007/08 prediction actually declined below that for 2006/07. The 90% percentile confidence intervals, derived from the recruitment variability observed since 1970/71, include the possibility that the stock, as a whole, will stand still and exhibit no increase.

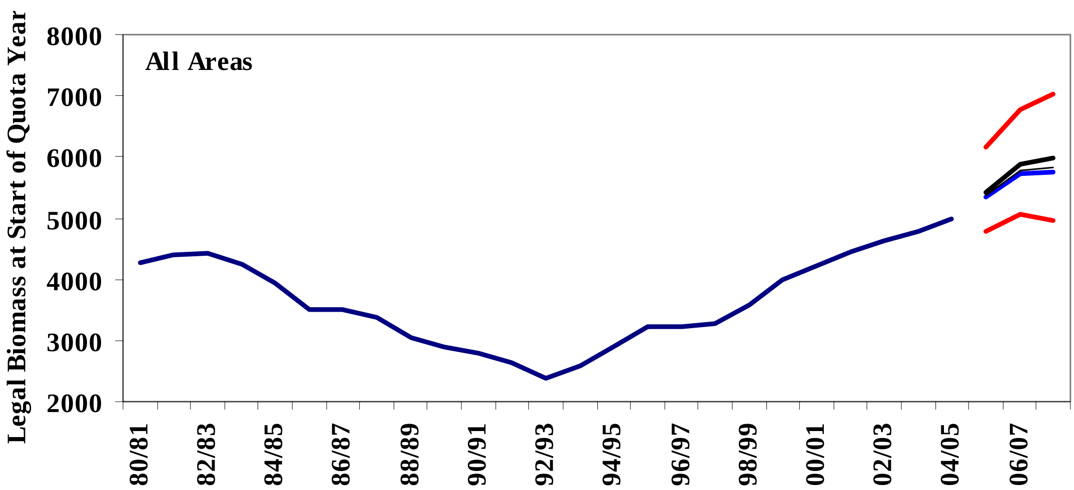


Figure 38. Statewide legal-sized biomass estimates from the start of the quota year in 1980/81 to the start of the quota year in 2005/06, with the median trajectories to 2007/08 of biomass for TACCs of 1470 (upper central line), 1523 (thin middle central line) and 1550 (lower central line), in addition the projected legal biomass is surrounded by the widest set of 90% percentile confidence intervals.

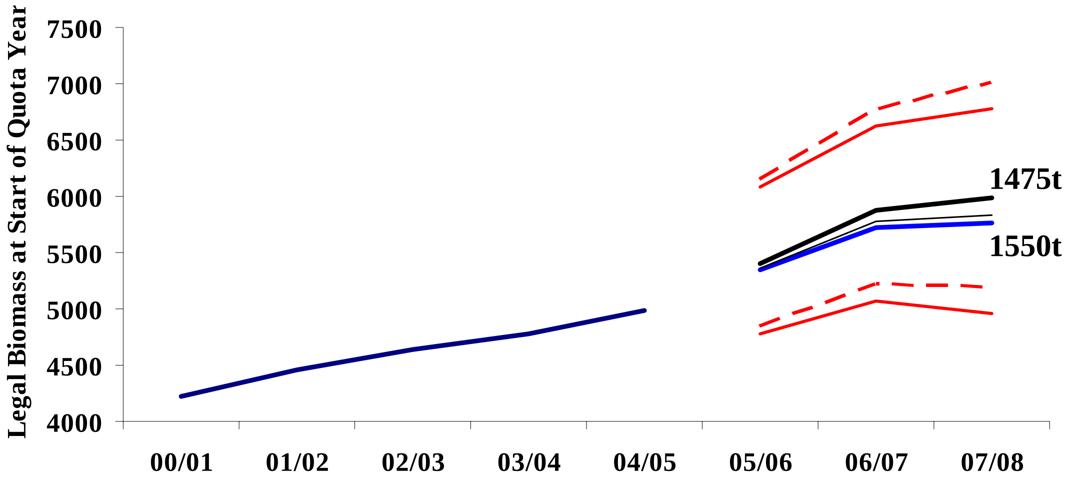


Figure 39. Statewide legal-sized biomass projections showing the same data presented in the previous graph (Figure 38) but focused on projections for the next 3 years in the context of the previous five years. Maximum and minimum ranges of the 1000 simulations are shown for the 1470 and 1550 tonne TACC scenarios (shown respectively by the dashed outer lines and plain solid outer lines). The median projections for the 1470 t and 1550 tonnes TACC are shown in the middle of the distribution. The fine line between them is the projection with a TACC of 1523 t.

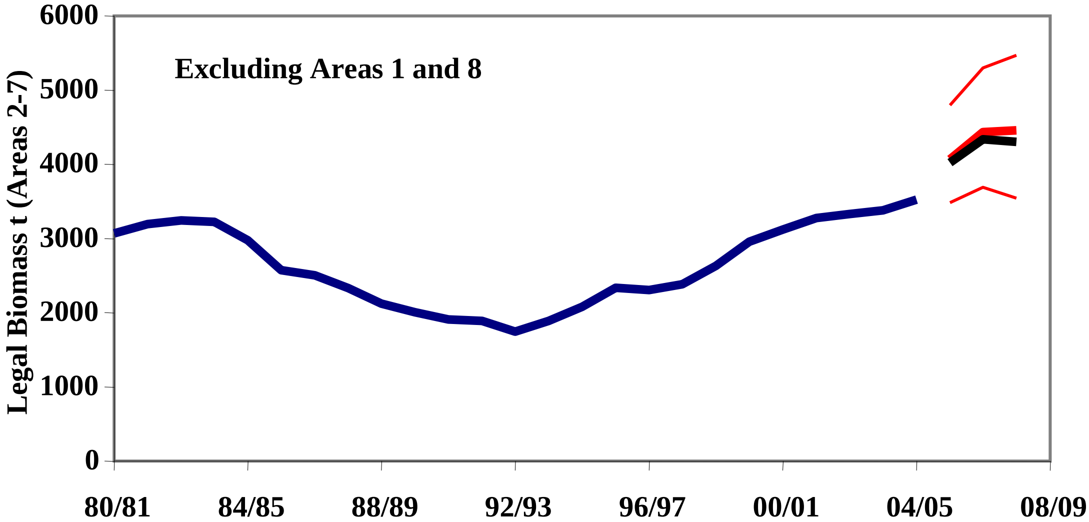


Figure 40. Legal-sized biomass estimates from the start of the quota year in 1980/81 to the start of the quota year in 2005/06 for Areas 2 to 7, with the median trajectories to 2007/08 of biomass for TACCs of 1470 (upper central line), and 1550 (lower central line), in addition the projected legal biomass is surrounded by the widest set of 90% percentile confidence intervals.

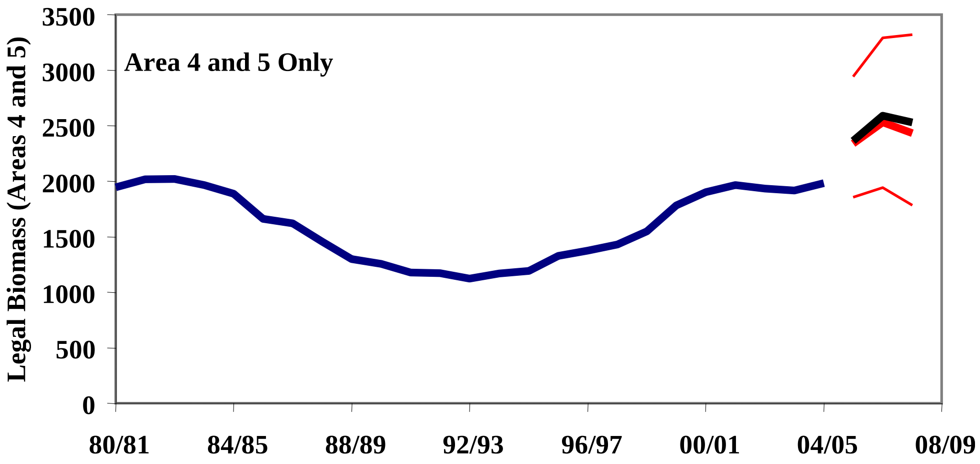


Figure 41. Legal-sized biomass estimates from the start of the quota year in 1980/81 to the start of the quota year in 2005/06, for Areas 4 and 5 only, with the median trajectories to 2007/08 of biomass for TACCs of 1470 (upper central line), and 1550 (lower central line), in addition the projected legal biomass is surrounded by the widest set of 90% percentile confidence intervals

3.3.3 Egg production

Patterns of egg production are being affected quite strongly by the fleet dynamics. As shown in Figure 19, catches have been reducing in the north of the State and increasing in the south.

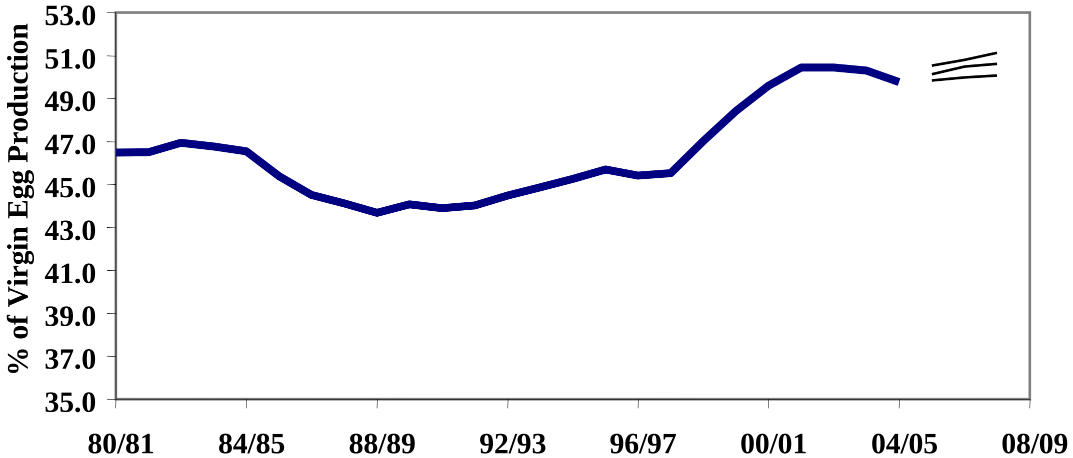


Figure 42. Averaged Statewide egg production as percent of virgin production under 3 TACC scenarios: 1470 (upper projection line), 1523 (middle projection line) and 1550 (lower projection line). All trajectories are the average of 1000 simulations.

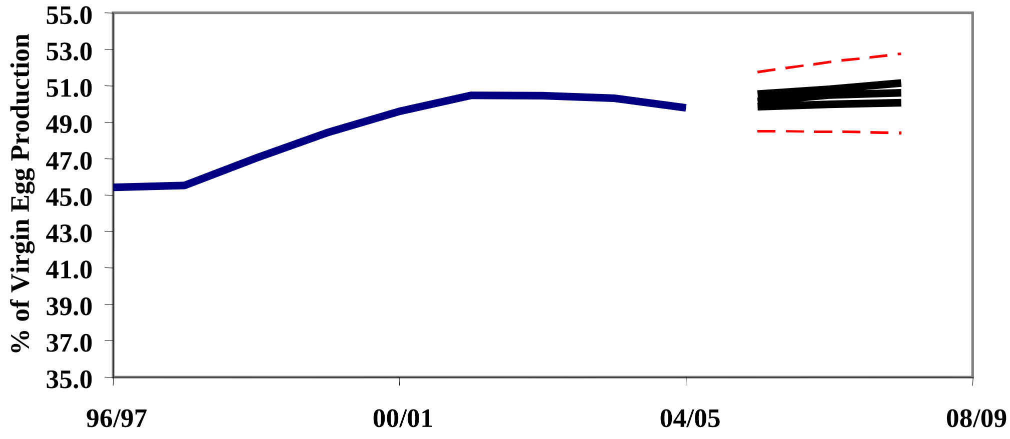


Figure 43. Statewide egg production projections (as % of virgin) showing the same data presented in the previous graph (Figure 42) but with more detail for the projections into the next 3 years. The 90% percentile confidence intervals of the 1000 simulations are shown for the 1470 and 1550 tonne TACC scenarios (shown as the dashed lines outside the projections).

This on-going shift in the fleet dynamics opens the possibility of improvement in egg production in the north. Nevertheless, while egg production for the next three years is predicted to be a positive increase it is only expected to be a relatively small positive increase (Figure 43and Figure 44). Even Areas 4 and 5 are expected to increase slightly (Figure 45 and Figure 46).

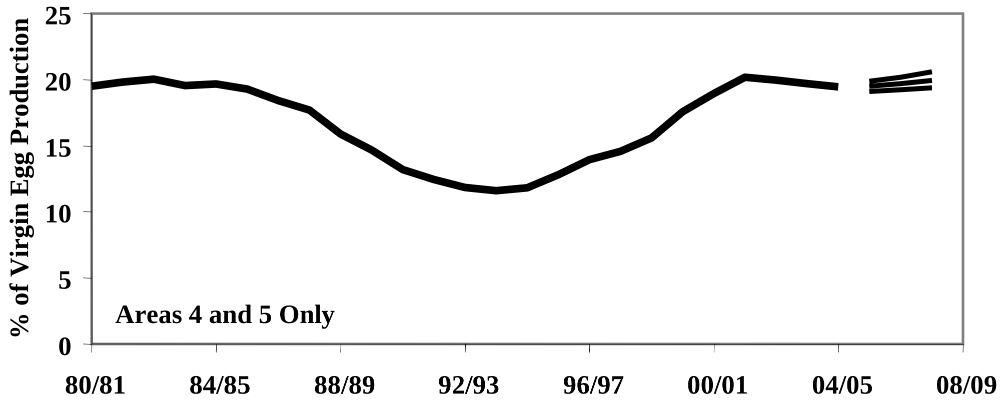


Figure 44. Mean egg production as percent of virgin in the north of the State (Areas 4 and 5) under 3 TACC scenarios: 1470 (upper projection line), 1523 (middle projection line) and 1550 (lower projection line). Medians are from 1000 simulations.

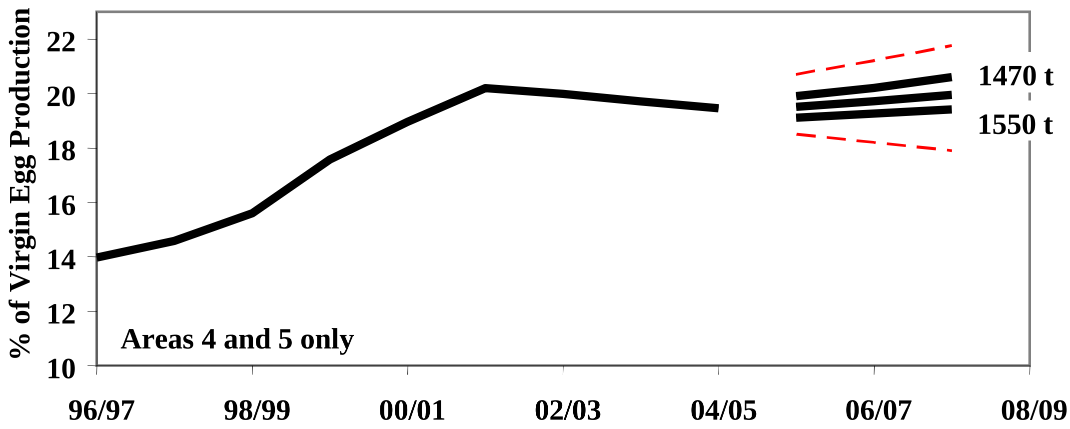


Figure 45. Egg production projections (as % of virgin) from Areas 4 and 5 combined showing the same data presented in the previous graph (Figure 44) but with emphasis on projections for the next 3 years. 90% percentile confidence intervals of the 1000 simulations are shown for the 1470 and 1550 tonne TACC scenarios (shown respectively by the dashed lines outside the main projection lines).

The trend in egg production in Areas 1 and 2, even with the status quo is to slightly reduce egg production. This is most likely a result of the altered fleet dynamics that has seen a change to continually increasing catches in these areas. This effect if it continues is likely to produce at least an equivalent or greater impact than the recreational catches. If these changes to the fishing patterns are being brought about by rising fuel prices then it seems likely that 2005/06 will only exaggerate this effect.

The changes in fleet dynamics, as demonstrated by the pattern of catches through time (Figure 19), is now one of reducing catches in the northern two Areas (4 and 5) and increasing catches in the southern Areas (1 and 8), with the middle Areas remaining relatively stable (a slight decline in Area 3). These trends make the projections in Areas 1, 4, 5, and 8 less reliable as the statistical fleet dynamics model can only predict a continuation of these trends. Whether this is likely to happen is unknown. Area 8, for example, continues to exhibit remarkable resilience in the face of greatly increased catches. The catch rates from Area 8 also continue to increase. It seems likely that the fleet dynamics will be very influential on the stock dynamics over the next few years.

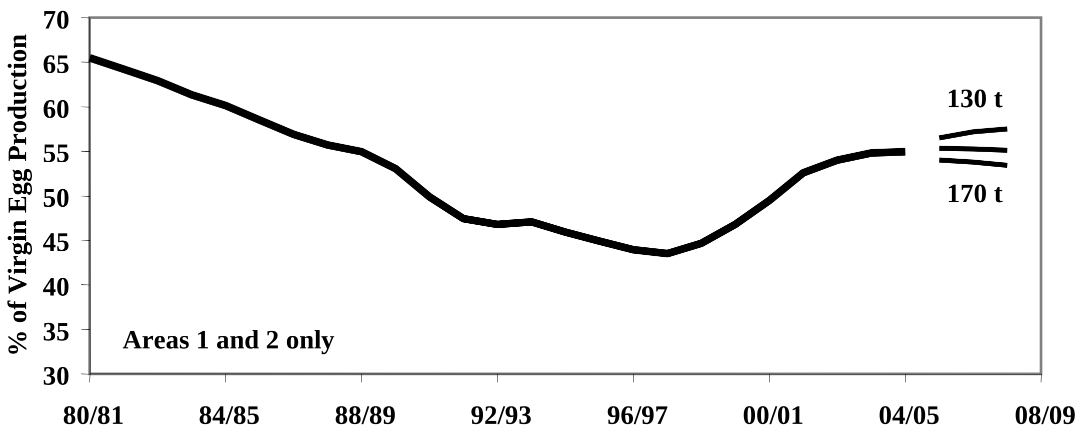


Figure 46. Egg production projections (as % of virgin) for Areas 1 and 2 for the next 3 years with alternative recreational catches (130, 149 and 170 tonnes). TACC was set at the current level of 1523 tonnes.

3.4 Lobsters removed by the commercial fleet, but not included in the quota

Under the current management plan, a commercial fisher is permitted to retain 1 lobster for personal use for each day of a fishing trip, up to a maximum of 5 lobsters for any one trip. Anecdotal evidence from fishers suggests that fish damaged by octopus or with legs missing etc which will not be handled by processors, are retained in preference to 'perfect' fish. Lobster retained for personal possession have to be tailed clipped in the same way as a recreational fisher would mark a lobster before the lobster leaves the site of unloading and the number recorded in the catch effort logbook. These lobsters may not be sold. The numbers of rock lobster reported under this provision in the catch effort logbook are not included as part of the commercial catch nor as part of the recreational catch. In addition, lobsters caught, but killed accidentally during transport to port (e.g. if freshwater contaminates the well) may also be reported and excluded from the quota. This provision is to ensure that this source of mortality is captured in the assessment process, rather than being ignored. Information for both these categories has been unavailable in previous years, but was recorded from May 2003.

Relative to the catch from either the recreational or commercial sectors, these sources of fishing mortality are trivial with a total of 1276 lobsters kept for personal use by commercial fishers from March 2004 to February 2005 (Table 13.). A further 3160 lobsters were reported accidentally killed during this period. Lobsters retained for personal use represent a loss to the fishing business so the small scale of the catch was predictable.

Table 13. Total number of rock lobsters retained for personal use by fishermen and killed accidentally for the last two quota years. Note. 2003/04 started in May.

	Total # rock lobsters	
	Personal Use	Accidental deaths
May 2003 - Feb 2004	2392	1791
March 2004 – Feb 2005	1276	3160

As expected, the retention of rock lobsters for personal use displays a seasonal pattern and generally mirrors the seasonal trend in catch (Figure 47). Most lobsters were retained during the warmer months, peaking around the Christmas–New Year period (i.e. December). Fewer rock lobsters were kept during the winter months when presumably lobster prices are higher and catches lower. Accidental deaths were also higher in the warmer months, following the closed season, loosely correlating with an increase in overall catch following the resumption of the fishing season. Most accidental deaths were recorded in December.

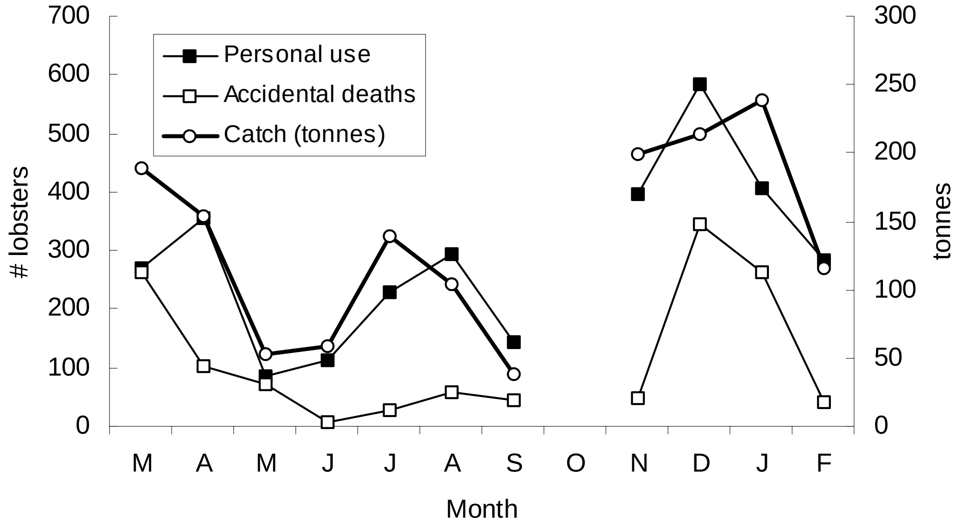


Figure 47. The number of lobsters retained for personal use and accidentally killed (left-hand axis) and the total commercial catch (right-hand axis) between March 2004 and February 2005.

3.5 Lobsters removed for research activities

One percent of the lobster TACC is allocated to research use. In 2004/05, this was used to fund catch-sampling exercises and a total of 11065 kg was harvested.

4 Recruitment

4.1 Recruitment monitoring and catch prediction

Settlement of puerulus is monitored at several sites around the Tasmanian coast as part of TAFI's pre-recruit monitoring program. Puerulus collectors are designed to mimic natural rocky reef with crevices that provide shelter for puerulus swimming in to shore from oceanic waters. These collectors have been deployed at Recherche Bay (Area 1), South Arm (Area 2), Bicheno (Area 3), Flinders Island (Area 4) and King Island (Area 5). Several attempts have been made to establish sites in the remaining Areas on the west coast; however, all of these attempts have failed due to low catch rates.

The objectives of the puerulus monitoring project are to provide a measure of recruitment of juveniles into the population. This information has a number of potential benefits including early warning of large increases or declines in settlement, an improved basis for future projections of the assessment model, and contributing to an improved understanding of larval sources. Analyses are presented below that compare estimated larval recruitment from the stock assessment model with observed larval recruitment from the puerulus-monitoring project. The estimates of larval recruitment from the stock assessment model are derived from commercial catch and effort data and research catch-sampling data. Estimates of recruitment are hindcast based on growth models within the stock assessment model. This means that catch and effort data from 2004 are used to estimate larval recruitment from previous years, say 1998 (*i.e.* in this case five years previous). We have contrasted these model estimates with actual observed puerulus catches; where the pattern between the two indices is close it implies that puerulus catches will be of value as a model input for future projections of the fishery.

Further analysis of this data is planned for 2006 and the results shown here are thus preliminary. Aspects that require further investigation include the time of year that should be compared for catches (comparisons here are simply for calendar year) and accounting for variation in growth rate of individuals.

4.1.1 South east coast

Puerulus catch rates and estimated recruitment have little contrast throughout the period for which there is corresponding data (1991-1998) (Figure 48). The last three years have had the lowest catch rates on record, although this low was preceded by the highest catch rate yet recorded in 2002. This contrast in interannular puerulus catches will provide a useful test of the relationship between puerulus settlement and fishery catch rates.

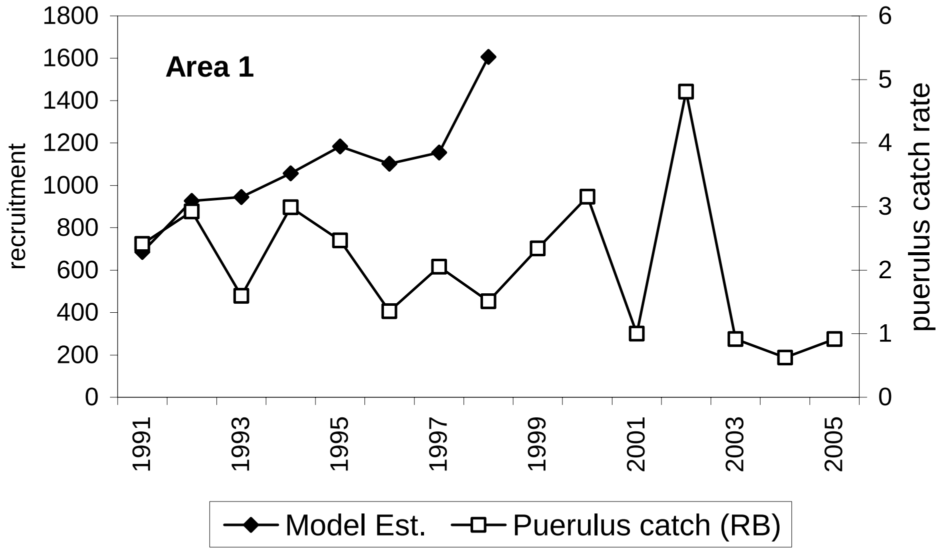
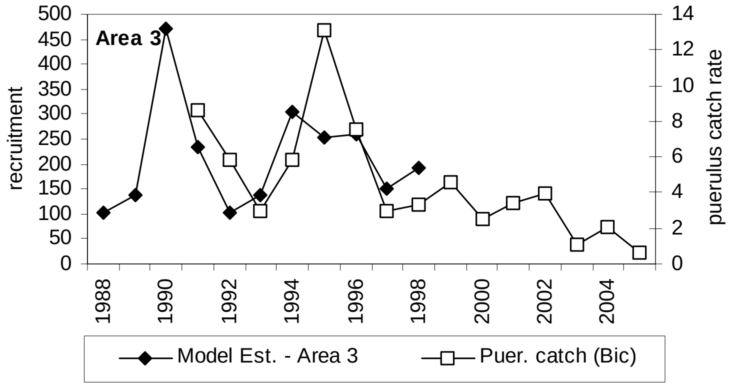


Figure 48. Puerulus catches (N/collector/month) from Recherche Bay (RB) contrasted with estimated recruitment from the stock assessment model. Estimated recruitment and puerulus catches show some congruence through the period 1991-1998.

4.1.2 East coast

The Bicheno puerulus-monitoring site lies close to the boundary between Areas 2 and 3 and therefore puerulus catch rates are contrasted against model estimates of recruitment from both these Areas. Model estimated recruitment appears to mirror puerulus catch rates more so in Area 3 than Area 2 (Figure 49). This could imply that puerulus catch rates derived from the Bicheno collectors are a better predictor of future recruitment in Area 3. However, the large spikes in both puerulus catch and recruitment from Area 2 suggest that peaks in settlement are being detected by both methods, but are out of phase. This lack of alignment of peaks would be caused by incorrect growth information in the stock assessment model. This appears a reasonable conclusion as growth of juveniles is poorly estimated by the model and has only been extrapolated downwards from growth of adults. In comparison to the early and mid 1990s, recent puerulus catch rates from this location are at an all-time low, suggesting that larval recruitment for this region has reduced in recent years.



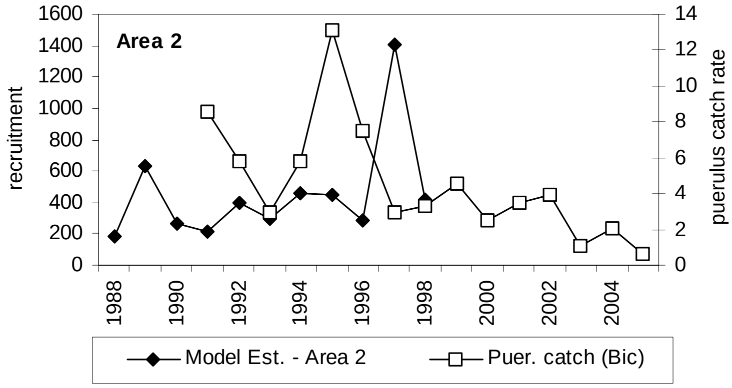


Figure 49. Puerulus catches (N/collector/month) from Bicheno contrasted with estimated recruitment from the stock assessment model for Area 3 (upper) and Area 2 (lower). Greater congruence between puerulus catch rates and estimated recruitment is demonstrated for Area 3 compared to Area 2.

4.1.3 North east coast

Puerulus catch data from this site has only been collected since 1996 so there is less data with which to make comparisons between estimated recruitment and puerulus catch rates. Nonetheless, with the exception of 1996, puerulus catch rates and recruitment exhibit similar trends (Figure 50). In light of this, the concern for this region is that puerulus catch rates have shown low and declining catch rates over the last four years indicating potentially low future recruitment to this region.

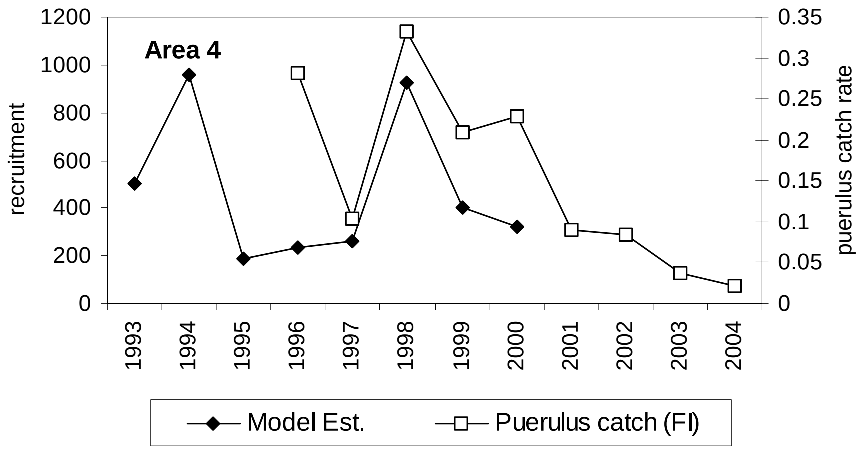


Figure 50. Puerulus catches from Flinders Island (FI) contrasted with estimated recruitment from the stock assessment model for Area 4.

4.1.4 North-west coast (King Island)

No data was available for 2004/5 at the time this report was produced.

4.2 Pre-recruit growth, mortality and effects of density.

Due to the difficulty in sampling small lobsters, very little is known about the basic biology of juveniles, such as growth rates and mortality schedules. Research on these issues was conducted in a collaborative project funded through FRDC involving researchers from TAFI, PIRVIC (Vic.) and SARDI (SA). That project was completed in the last year and the final report is available on the TAFI website.

Objectives of the project were:

1. To determine growth and mortality rates of juvenile (<80mm) lobsters throughout the range of the commercial fisheries.

2. To assess if increased juvenile density will translate to increased fishery production.

3. To evaluate techniques and obtain preliminary estimates of growth and mortality rates of puerulus / post-puerulus.

5 Ecosystem based management

5.1 Protected Species Interactions

For the period 2004/05, 237 protected species interactions were reported by fishers. The majority of these reports simply indicated that an interaction had occurred so the species and fate of the protected species was unknown (Figure 51). Approximately 26% of reported interactions (n=56) provided details of the species involved with all of these including seals, except a single reporting of whales swimming near the fishing vessel.

Distribution of interactions around the State was clustered with hotspots for reporting off King Island, St Helens and Tasman Peninsular. These areas are not known for especially higher density of seals and represent clustering of reporting effort by individual fishers rather than necessarily density of interactions. This type of human artefact would be expected as the reporting requirement for “interaction” is ambiguous: some fishers consider that a seal eating discarded bait is an interaction, while others do not. This point is clearly made by the reported whale interaction – one fisher considered that seeing a whale from their vessel constituted an interaction, yet this common event was otherwise unreported.

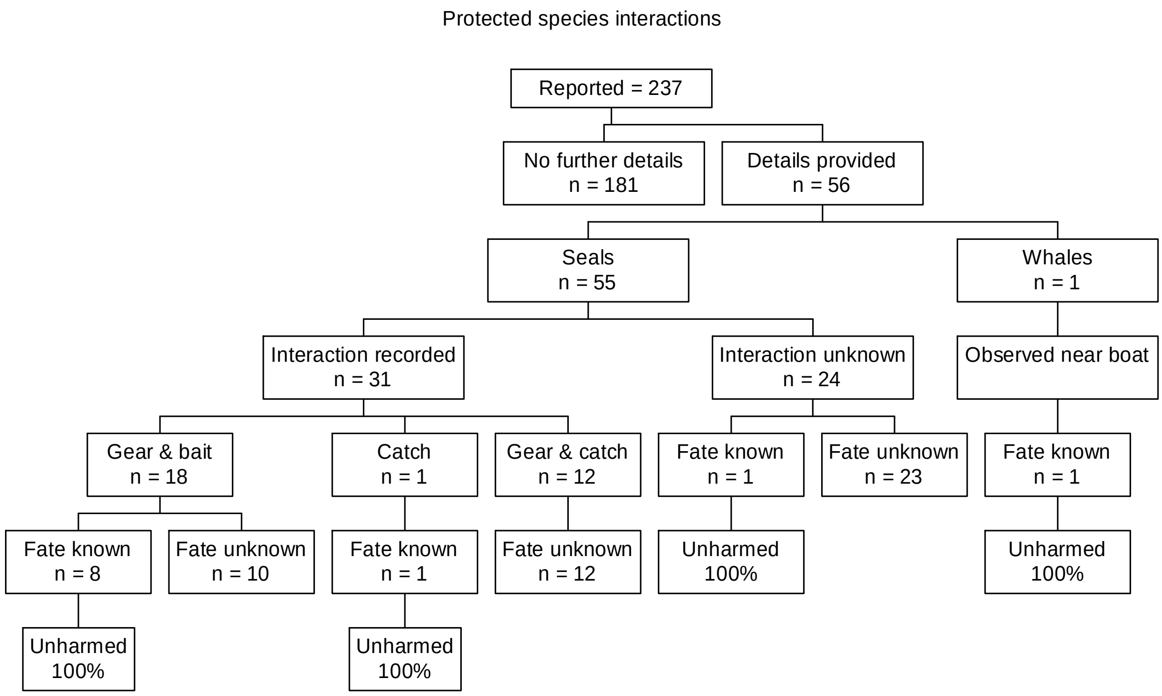


Figure 51. Schematic of reported interactions between commercial fishers and protected species.

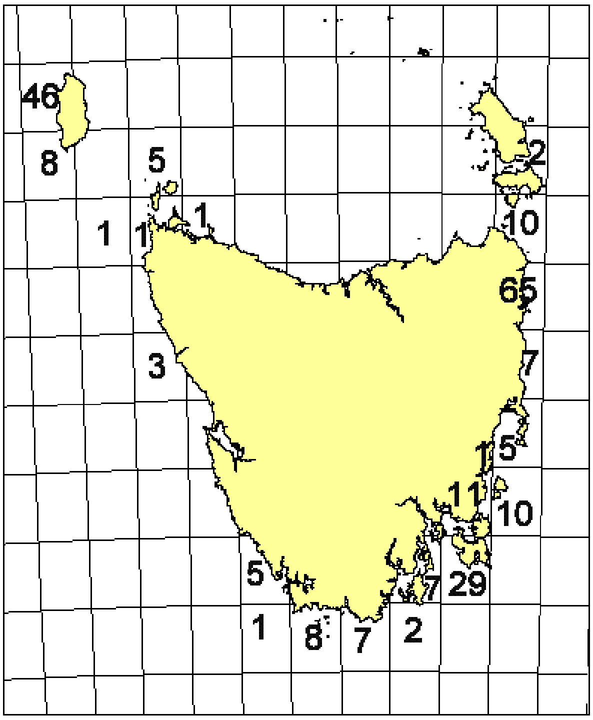


Figure 52. Distribution of reported protected species interactions with commercial fishing operations.

5.2 By-Product

By-product is by definition non-target species retained for sale rather than discarded at sea. Most by-catch species in the Tasmanian rock lobster fishery are released unharmed or with unknown discard mortality whereas by-product involves defined fishing mortality. By-product use of species captured in lobster traps has been reported through the general fish logbook system since 1995 so that catch of these species in lobster pots is included in separate assessments. Total reported by-catch of most fish types was small and only two fish types had reported annual catches greater than 1 tonne – cod and octopus (Figure 53). Catches of cod have declined since 1996/97 while little pattern is evident for octopus.

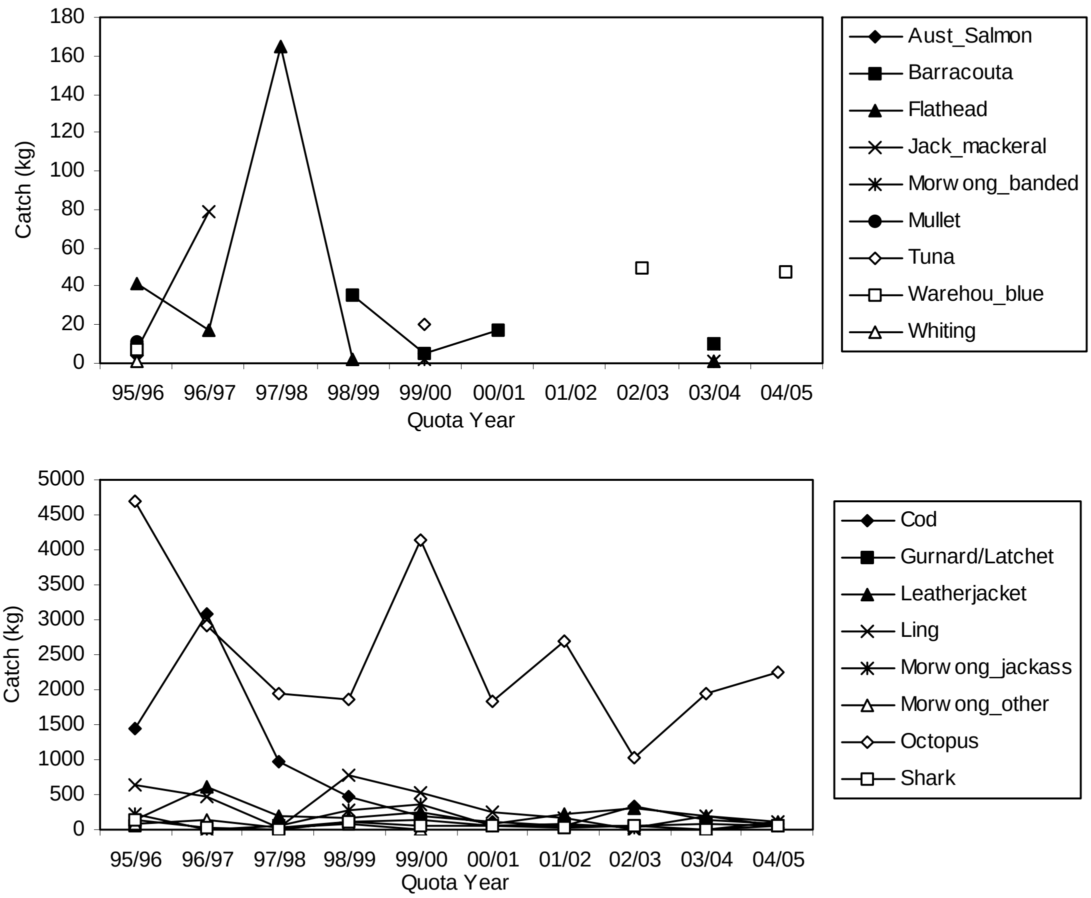


Figure 53. Reported by-product from rock lobster pots, January 1995 to February 2005. Data is grouped into quota years (March to February) so annual catches are incomplete for the 1995/96 quota year. Catches of minor species are shown in upper plot, those with greater catch are shown in the lower.

5.3 By-Catch

During October 2003, TAFI commenced a new catch sampling project aimed at sampling broad regions of the fishery using commercial vessels. In conjunction, a project was undertaken to assess the impact on by-catch from commercial potting by using pots with and without escape gaps. This project follows on from the earlier work of Frusher and Gibson (1999) and also compliments an 11 year ongoing fishery independent project that has, as a component of the project, recorded by-catch from research pots without escape gaps.

Catch sampling continued in October 2004, and similarly to 2003, seventy-eight percent of all by-catch recorded in the surveys were hermit crabs (*cf* 80% in 2003) (Table 14). The incidence of other by-catch species by comparison was scarce. This observation program will continue during 2005/06 to assist in documenting the impact of escape gaps on the fishery.

Table 14. Species list of by-catch caught in October 2004 from 3115 pot lifts.

Common name	**Scientific name**	**Total number**
Hermit Crab	*Trizopagurus strigimands*	2993
Rough Rock Crab	*Nectocarcinus tuberculosis*	235
Southern Conger Eel	*Conger verreauxi*	87
Draughtboard Shark	*Cephaloscyllium laticeps*	84
Red Gurnard Perch	*Halicolenus papillosus*	39
Cleft Fronted Shore Crab	*Plagusia chabrus*	36
Rosy Wrasse	*Pseudolabrus psittaculus*	35
Velvet Leatherjacket	*Parika scaber*	35
Octopus	*Fam. Octopodidae*	31
Bearded Rock Cod	*Pseudophycis barbata*	29
Barber Perch	*Caesioperca rasor*	21
Coral Perch		21
Blue-throat Wrasse	*Pseudolabrus tetrians*	18
Giant Tasmanian Crab	*Pseudocarcinus gigas*	18
Ascidian		17
Shark-Swell		15
Brown-Striped Leatherjacket	*Meuschenia australis*	12
Leatherjacket-unidentified		11
Rock Cod-unidentified		10
Southern Rock Cod		9
Starfish-unidentified		8
Morwong	*Nemadactylus macropterus*	6
Red Bait Crab		6
Degen's Leatherjacket	*Thamnaconus degeni*	4
Great Spider Crab	*Leptomithrax gaimardi*	4
Mosaic Leatherjacket		4
Perch-unidentified		4
Purple Wrasse	*Pseudolabrus fucicola*	4
Starfish	*Coscinasterias calamaria*	3
Wrasse-unidentified		3
Port Jackson Shark	*Heterodontus portusjacksoni*	2
Spider Crab-unidentified		2
Stripey Trumpeter		2
Urchin-unidentified		2
Cobbler		1
Cuttlefish	*Sepia sp.*	1
Fish-unidentified		1
Pink Ling	*Genypterus blacodes*	1
Six-Spine Leatherjacket		1

5.4 Ecosystem effects of fishing

5.4.1 Previous research activities

In previous years research relating to the ecosystem effects of fishing has focussed on population dynamics of benthic invertebrates that may be indirectly impacted by fishing activities. A three year research program conducted by Hugh Pederson examining the population dynamics of the common sea urchin *Heliocidaris erythrogramma*, investigated whether fishing of sea urchin predators, including rock lobsters (*Jasus edwardsii*) and scale-fish, could account for expansion of sea urchin populations on rocky reefs in Tasmania. In a series of manipulative experiments to determine whether predation mortality is an important mechanism structuring populations of *H. erythrogramma* in Tasmania, tethered juvenile and adult sea urchins experienced much higher rates of mortality inside no-take marine reserves where sea urchin predators were abundant compared to adjacent fished areas where predators were fewer. Mortality of tagged (but not tethered) sea urchins was also notably higher in marine reserves than in adjacent areas open to fishing. When a range of sizes of sea urchins were exposed to three sizes of rock lobsters in a caging experiment, juvenile sea urchins were eaten more frequently than larger sea urchins by all sizes of rock lobster, but only the largest rock lobsters (>120 mm CL) were able to consume large adult sea urchins. Tagging (but not tethering) juvenile and adult sea urchins in two separate marine reserves indicated that adult sea urchins experience higher predation mortality than juveniles, probably because juveniles can shelter in cryptic microhabitat more effectively. In a field experiment in which exposure of sea urchins to rock lobster (*Jasus edwardsii*) and demersal reef fish predators was manipulated, rock lobsters were shown to be more important than fish as predators of adult sea urchins in a marine reserve. It was concluded that predators, and particularly rock lobsters, exert significant predation mortality on *H. erythrogramma* in Tasmanian marine reserves, and that adult sea urchins are more vulnerable than smaller cryptic individuals. Reductions in lobster biomass on the east coast of Tasmania could be sufficient to account for increases in *H. erythrogramma* populations.

5.4.2 Current research activities

Current research being undertaken aims at extending our understanding of the impact of fishing activity, particularly in relation to extraction of key reef species that have the potential to alter ecosystem function. Both rock lobster and abalone fisheries are considered to be relatively benign with respect to the physical effects of fishing and by-catch species (both retained and non-retained). However, since the declaration of the Maria Island Marine Protected Area (MPA) over a decade ago the possibility of significant interactions between rock lobsters and abalone has been identified.

The research aims at evaluating the strength and nature of the interaction between rock lobsters and abalone. Over the next two years a series of surveys and manipulative experiments are planned to determine the interaction dynamics between the species and determine if the two fisheries can be co-managed to maximise productivity and ensure sustainability. This work is part of an FRDC funded research program being undertaken by TAFI to examine multi-species management of Tasmania's inshore reef fisheries.

6 Appendix 1: Historical overview

The following section is based largely on a synopsis of the history of the fishery compiled by Tony Harrison (http://members.trump.net.au/ahvem/Fisheries/Lobster/Crayfishery.html).

Tasmania's rock lobster resource is distributed around the coast although fewer animals are found along the central north coast bordering Bass Strait due to limited opportunity for recruitment.

Aborigines fished lobsters around the State and a small indigenous harvest continues, mainly in the northeast. The resource has been harvested commercially since European settlement with fishing effort initially focused on the East Coast. Accounts of historical catches provide insight into the abundance of lobsters in conditions with very low fishing pressure. When James Kelly called at Port Davey in 1815 he traded swans he had shot for crayfish; the local Aborigines quickly collected 3 tons (at least 1000 lobsters) by hand from the waters edge. In 1905, James Rattenbury caught 480 lobsters from the *Rachel Thompson* in six hours using only 6 "cray" rings in Wineglass Bay.

The commercial and recreational fisheries initially proceeded without records but the need for management of the fishery was recognised nonetheless. The first Act for the protection of Rock Lobster was passed by Parliament in 1885. This Act prohibited the possession of soft-shelled "crayfish" and egg-carrying females and introduced a minimum legal-size of 10 inches. This size limit is essentially equivalent to that used today and remains one of the main management constraints.

Some commercial catch information was collected in the late 1880's with around 60,000 lobsters a year landed into Hobart. This remains around the average annual commercial harvest from shallow waters in the SE of the State today (average of 39 tonnes in <10 fathoms for the period 2000-2003, Area 1; although it should be noted that now the recreational catch could match the commercial harvest).

In 1888 fisheries matters were placed under the control and management of a single Fisheries Board comprising 23 commissioners. Much of their time was spent debating the merits of different gear types.

Hemispherical cane pots (based on pots used for taking clawed lobsters in Cornwall, England) were used in Victoria while in Tasmania a baited hoop ("cray" ring) was the traditional (and preferred) method of catching rock lobsters. The two methods led to two quite different commercial fishing industries; one using larger, more robust boats that could operate pots and the other using smaller boats sufficient for operation of "cray" rings. These two fleets came into contact and conflict during periods around the moult when lobsters were too soft for freight to Victoria. Pots were subsequently banned in Tasmania in November 1902, later amended to latitudes south of 39° 31′ S in February 1904 and subsequently south of 40°38′S (*i.e.* north of St Marys) in July 1904. The Fishing Board ratified this ban in November 1905.

In response to further pressure from northern commercial fishers, a Parliamentary enquiry conducted by Joseph Lyons considered that pots were not destructive and recommended that pots be legalised. However, it wasn't until 1925 that pots were finally legalised as part of a new fisheries bill that placed responsibility for the management of sea fisheries with a newly appointed Sea Fisheries Board. The centrepiece of this new bill was the allocation of varying numbers of pots to commercial vessels depending on their size. For example, a limit of 30 pots was adopted for larger vessels with proportionately fewer pots allowed for smaller vessels. Inevitably, the use of pots led to dramatic increases in commercial catch due to greater efficiency, halted fleetingly by reduced market demand during the depression years (1930s) and the Second World War.

Markets have adapted to change in technology throughout the development of the fishery. The adoption of diesel engines during the Second World War meant that more product could be shipped to mainland Australia, which led to expanded markets. Soon after this, the development of refrigeration enabled a rapid expansion into the American frozen tail market. Most of the commercial catch is now transported live into Asia, the world's premium market for lobsters. The increased value of lobsters that has resulted from the development of these markets along with growing recognition of rock lobster as a preferred seafood is considered to be a motivating factor for the steadily increasing recreational effort.

The annual commercial catch reached its historical maximum in 1984 at 2250 tonnes, prior to falling to a recent historical low of 1440 tonnes in 1994, a reduction of 400 tonnes from the 1992 year.

Concerns about declining future catches led to a shift away from a commercial fishery managed by input controls (*i.e.* number of pots and licences etc.) to one managed through control of fishery outputs (or total catch limits). This resulted in the adoption of an individual quota system in March 1998 for the commercial fishery.

7 Appendix 2: Management

Management regulations were first introduced in 1885 and 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 largely protected by a seasonal closure.

Since the inception of catch records in the 1880's, the reported annual catch steadily increased in the commercial rock lobster fishery to a high in 1984 of over 2,250 tonnes. During this period of growth in catches, concerns were expressed about overfishing in the commercial fishery, which resulted in changes in regulations. The most important changes were the legislation of design of pots in 1926, introduction of closed seasons to limit the harvest of soft-shelled lobsters in 1947, the restriction of the number of licenses in 1966, and a ceiling on the number of pots in the fishery set at 10,993 in 1972.

From the record high catch of 1984, the reported annual catch declined to a low of 1,440 tonnes in 1994 reflecting a decline in the available biomass. In recognition of the declining trend in biomass, an individual transferable quota (ITQ) management system was introduced for the commercial fishery in March 1998 following an industry ballot to decide whether to accept the system.

Management of the commercial fishery has remained relatively stable since the introduction of quota. Quota was initially set at 1503 tonnes for the 1998/99 fishing season. After three years of successive improvements in biomass, the quota was increased to 1523 tonnes for the 2001/02 fishing season. As catch is now constrained by quota, seasonal controls in the fishery have been relaxed. Lengths of seasonal closures have varied since their introduction in 1926 but complete closure of September and October was in place from 1963 to 1998. In 1998, the first 2 weeks of September were opened, to provide fishers with flexibility to take hard-shell lobsters that command a high price or fish for the lower priced soft new-shell lobsters that have a higher catchability after their moult. Timing of the September closure has changed regularly since 1998 with complete access in 2000. There remains some concern about fishing in September due to negative impacts on markets.

Management of the recreational fishery has proceeded in parallel with that for the commercial fishery. A rock lobster license is required to take lobsters recreationally or to deploy gear. Many regulations are shared by both sectors, such as size limits, closed seasons, and pot specifications. Key differences include the ability of recreational fishers to harvest lobsters by diving, a cap on the daily bag limit of 5 lobsters, and the absence of an output control mechanism.

8 Appendix 3: Previous Assessments

This report is the tenth assessment report since regular reporting commenced in the 1995 calendar year (Table 15). This report uses data available up until 28th February 2005. It includes data for the first seven years since ITQ implementation.

Table 15. Previous Tasmanian rock lobster fishery assessment reports.

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
7	February 2002	Frusher, Gardner, Mackinnon and Haddon, 2003
8	February 2003	Gardner, Mackinnon, Haddon and Frusher, 2004
9	February 2004	Gardner, Hirst and Haddon, 2005

9 Appendix 4: 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.

10 Appendix 5: Present Performance Indicators and Trigger Point Strategies

10.1 Performance Indicators

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

10.1.1 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.

10.1.2 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, spatially explicit, 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.

10.1.3 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 reference point against which egg production in future years will be compared.

10.1.4 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 reflect the annual growth increments needed to grow into the fishery, 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.

10.1.5 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. The reference point is currently set at 95% of the TACC, dropping below this will trigger a fishery review.

10.1.6 The size of the commercial rock lobster fishing fleet

- As the restructuring process occurs, following the introduction of the quota system, it is likely that the number of active commercial 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 commercial rock lobster fishing is an important industry.

10.1.7 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.

10.2 Trigger Points

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

10.2.1 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 Area 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 Area 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.

10.2.2 Legal-sized biomass

- The estimate of global (Statewide) 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 Area 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.

10.2.3 Egg production

- The estimate of global (Statewide) 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 Areas have egg production levels which exceed 40% of that of the estimated unfished stock.

- For Areas 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.

10.2.4 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 Area 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]

10.2.5 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.

10.2.6 The size of the commercial rock lobster fleet

- The number of commercial 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.

10.2.7 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.

11 Appendix 6: Summary of Rules

Table 16. 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 24-28 February (both sexes); 1st October – 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 1523 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
Possession limit	10 for holders of recreational licenses, 5 for those without a rec. license (a receipt of purchase is required if more are held). No possession on State waters without a recreational license.
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.

12 Appendix 7: Methods for standardisation of catch rates

The General Linear Models were all conducted using SAS version 9.1.1. The analysis was conducted to provide standardized catch rates for what would have been each quota year of the fishery, that is, each quota year was treated as a separate parameter estimate. The factors available for analysis included month, vessel distinguishing mark, 10 fathom depth-categories, half-degree statistical block, and the day/night flag. By including QYear as a dummy variable into the statistical model the parameter estimates for each QYear constitute the indices of relative abundance. When these are examined they should provide a cleaner representation of the status of the rock lobster stock through time. This year the analysis of catch rates was restricted to vessels that had been fishing for more than one year since 1994/95 (a single year's fishing merely adds noise to the statistical model) and who had had a median annual catch of greater than one tonne.

It should be noted that the output from a GLM does not guarantee that a relation exists between stock size and standardized catch per unit effort. It is possible that factors not included in the GLM (through no other information being available) may be obscuring any effects of changes in stock biomass. This is model uncertainty at its most fundamental and implies that while the standardization should be an improvement over using the raw catch rates, they may still be biased or significantly influenced by factors for which we have no information.

It is possible to define the so-called 'full model' for the set of factors being considered. This would include all of the factors and the entire set of interaction terms possible between them. It would be difficult to provide a real interpretation for some of the interaction terms possible and their value in describing the data is marginal. In fact, it is not possible in a fixed factor analysis to include interaction terms with the QYear terms as this would distort and alter the meaning of the original parameter estimates. For example, if we were to consider the catch rate trends across the whole fishery, but the trends differed between Regions, this would be tantamount to claiming that there was a significant interaction between the QYear terms and Region. To avoid this likely problem we proceed by conducting a separate analysis for each assessment Region.

A further complication arises because there is no doubt that the more terms or parameters used in a statistical model the more likely we are to describe a larger proportion of the variation in the available data. But just adding more and more parameters to a model is not necessarily an improvement when there can be correlations among them. To illustrate the point with an extremity, we could obtain a perfect fit to the data simply by having the same number of descriptive factors as we had data points. What is required is a compromise between the variability of the data described by the statistical model and the model's complexity.

One way of selecting such a compromise is the adjusted R^2, which gives a better estimate of total variability described by the statistical model (Neter *et al*, 1996) than the simple R^2, with $n\text{-}p$ degrees of freedom, and SSTO, with $n\text{-}1$ degrees of freedom, is the SSE plus the variation due to the statistical model:

$$R^2 = 1 - \frac{SSE}{SSTO} \quad R_A^2 = 1 - \frac{\frac{SSE}{n-p}}{\frac{SSTO}{n-1}} = 1 - \left(\frac{n-1}{n-p}\right)\left(\frac{SSE}{SSTO}\right) \tag{1.1}$$

"This adjusted coefficient of multiple determination may actually become smaller when another X variable is introduced into the model; because any increase in SSE may be more than offset by the loss of a degree of freedom in the denominator *n-p*" (Neter *et al*, 1996, p. 231).

13 Acknowledgments

This report received comment from members of the Rock Lobster Assessment Working Group :

Assoc. Prof. Stewart Frusher (Chairperson)	Sustainable Fisheries Program Leader, TAFI
Dr Caleb Gardner	Crustacean Section Leader, TAFI
Assoc. Prof. Malcolm Haddon	Resource Modelling Section Leader, TAFI
Ms Hilary Revill	DPIWE, Manager – commercial fishery
Mr Rod Pearn	DPIWE, Manager – commercial fishery
Dr Howel Williams	DPIWE, Manager – recreational fishery
Mr Neil Stump	President, Rock Lobster Fisherman's Association
Mr Rodney Treloggen	Executive Officer, Rock Lobster Fisherman's Association
Mr Charles Wessing	Industry Representative
Mr Michael Holmes	TARFish Representative
Mr Albie Setcliff	TARFish Representative

This report includes contributions from a range of sources:

Recreational fishing - Dr Jeremy Lyle and Alastair Morton through funding by the Recreational trust fund and FRDC.

Pre-recruit growth, mortality and effects of density - David Hobday, Assoc. Prof. Stewart Frusher and Adrian Linnane – (FRDC 2001/070)

Ecosystem effects of fishing – a) *Heliocidaris erythrogramma* research: Dr Hugh Pederson and Prof. Craig Johnston through funding by the ARC. b) interaction between rock lobsters and abalone: Dr Hugh Pederson and Assoc. Prof. Stewart Frusher through funding from FRDC.

Shane Fava, Pip Cohen, Sam Ibbott, Craig Mackinnon and Dane Jones are thanked for their field support and data analysis.

14 References

ABARE 2004, Australian Fisheries Statistics 2003, Canberra.

Anon, 1997. The rock lobster fishery policy document. DPIWE.

Aslin, H. and Byron, I.G. 2003. Community perceptions of fishing: implications for industry image, marketing and sustainability. Bureau of Rural Sciences.

EconSearch, 2003. Economic Indicators for the SA Southern Zone Rock Lobster Fishery 2001/02, report prepared for Primary Industries and Resources South Australia.

Frusher, S.D., 1997a. Stock Assessment Report : Rock Lobster. Dept. Prim. Ind. Fish. Internal Report No. 35, 79pp.

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

Frusher, S. D. and C. Gardner, 1999. Tasmanian Rock Lobster Fishery 1998, Tasmanian Aquaculture and Fisheries Institute. Stock Assessment Report.

Frusher, S. and Gibson, I., 1998. Bycatch in the Tasmanian rock lobster fishery. In *Australian Society for Fish Biology Workshop Proceedings: Establishing meaningful targets for bycatch reduction in Australian Fisheries* (ed. C. Buxton and S. Eayrs), pp. 73-81. Hobart: Australian Society for Fish Biology.

Frusher, S.D. and Hoenig J.M., 2001. Estimating natural and fishing mortality and tag reporting rate of southern rock lobster from a multi-year tagging model. Canadian Journal of Fisheries and Aquatic Sciences 58, 2490-2501.

Frusher, S., Gardner, C., Mackinnon, C. and Haddon, M., 2003. Tasmanian rock lobster fishery 2001/02. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report. Tasmania, Australia.

Gardner, C., 1999. Tasmanian Rock Lobster Fishery 1998. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report.

Gardner, C., Frusher, S.D. and Eaton, L., 2001. Tasmanian rock lobster fishery 1999/2000. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report. Tasmania, Australia. 90 pp.

Gardner, C., Frusher, S.D., Eaton, L. Haddon, M. and Mackinnon, C., 2002. Tasmanian rock lobster fishery 2000/2001. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report. Tasmania, Australia. 117 pp.

Gardner, C., Mackinnon, C., Haddon, M., Frusher, S.D., 2004. Tasmanian Rock Lobster Fishery 2002/03. TAFI, pp. 81.

Gardner, C., Hirst, A. and Haddon, M., 2005. Tasmanian rock lobster fishery 2003/2004. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report. Tasmania, Australia. 79 pp.

Lyle, J.M., Henry, G.W., West, L.D., Campbell, D., Reid, D.D. and Murphy, J.J., 2003. National recreational fishing survey. In: The National Recreational and Indigenous Fishing Survey (Editors, G.W. Henry and J.M. Lyle). NSW Fisheries Final Report Series 48.

Lyle, J.M., and Morton, A. J. 2004. Survey of the 2002/03 Tasmanian recreational rock lobster and abalone fisheries. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report. Tasmania, Australia. 33 pp.

Lyle, J.M., and Morton, A. J. 2006. Tasmanian recreational rock lobster and abalone fisheries – 2004/05 fishing season. Tasmanian Aquaculture and Fisheries Institute Internal Report. Tasmania, Australia. 27 pp.

Neter, J., Kutner, M.H., Nachtsheim, C.J. and Wasserman, W. 1996. Applied Linear Statistical Models. 5th Ed. Irwin, Chicago.

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

Winstanley R.H., 1973. Rock Lobster fishing in Tasmania, 1904-1972. Tasmanian Fisheries Research 7, 1-29.