FISHERY ASSESSMENT REPORT

TASMANIAN ROCK LOBSTER FISHERY

2006/07

Malcolm Haddon and Caleb Gardner

January 2008

This assessment of the rock lobster fishery is produced by the Tasmanian Aquaculture and Fisheries Institute (TAFI) and uses input from the Crustacean Assessment Working Group (CAWG).

CAWG met on 9 October 2007 to consider the draft assessment report and provide input into the assessment. The Working Group participants were:

Jeremy Lyle	TAFI (chair)
Caleb Gardner	TAFI
Malcolm Haddon	TAFI
Philippe Ziegler	TAFI
Hilary Revill	Fishery manager DPIW
James Parkinson	Fishery manager DPIW
Rodney Treloggen	Commercial sector (TRLFA)
Charles Wessing	Commercial Sector
Neil Stump	TFIC
Miroslav Hanek	RecFAC
Brett Clearly	TarFish

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

Executive Summary

Current Stock Status

Relative to the stock's lowest point in 1993/94 there has been significant rebuilding in terms of legal biomass with significant increases in catch rates and biomass. This rebuilding has been so successful that none of the original performance measures (except area-based egg production) provide useful insights into the current stock status and how it has performed in recent years (Table 1.1). The fishery performance measures are currently under formal review and consequently, for this year, details of model based performance measures are given in order to characterize the status of the resource. Tasmania also considers details relating to Ecosystem Based Fisheries Management (Table 1.2), although these do not play any direct part in the stock assessment they are an important part of the management.

The distribution of effort and catch (fleet dynamics) continues to exhibit strong trends which appear to be related to a particular sequence of recruitment events. Effort peaked in 1992/1993 (2.07 million pot lifts), with current effort only 62.2% of that amount (1.29 million pot lifts). Current effort is 67.6% of a secondary peak of pre-quota effort in 1996/1997 (1.90 million pot lifts), and 80.9% of effort in 1998/1999, the first year of the quota management system (1.59 million pot lifts). The level of rebuilding is evident in the reduced amount of effort required to catch the Total Allowable Commercial Catch (TACC). This is especially significant given that there has also been a shift to more winter fishing, when catch rates are generally lower. The slight increase in effort this year reflects a reduced rebuilding in some areas.

The geographical distribution of effort has changed with the amount of effort dropping significantly in assessment areas 1, 2, 4, and 5 and continuing to rise in areas 7 and 8 (with very slight increases in Areas 3 and 6). At the same time, catches are dropping or stable in the Eastern and Northern assessment areas and are rising in the South-Western areas (7 and 8). Combining these trends in effort and catch, catch rates are rising slightly or stable in Areas 3 to 5, with reductions in Areas 1, 2, and 6. Standardized catch rates in Area 7 continue to rise and have remained stable in Area 8. Consequently the stock is continuing to rebuild in the southwest while rebuilding appears to have slowed or even begun to reverse in the north and east of the State.

The number of vessels reporting any catches of rock lobster in 2006/2007 is down to 214 from 344 in 1994/1995.

Model Based Performance Measures

The rock lobster stock assessment model is fitted to catches, catch rates, and, where available, length frequency of the catch data. The combination of length frequency data and catch rate data provide an insight into the underlying processes affecting stocks in different regions. For example, increases in catch rates combined with large numbers of relatively small lobsters in the catch indicate recent recruitment and rebuilding (observed in the southern four assessment areas). In contrast, stable or lowering catch rates combined with relatively few smaller lobsters in the catch indicate relatively low recent recruitment and a decline in stock size brought about through a lack of recruitment (observed in the northern four assessment areas).

Legal biomass is no longer rising in all assessment areas, with significant declines in Areas 1 and 6. Nevertheless, there were significant increases in Areas 3, 5, and 7, although the rise in Area 5 is more due to a reduction in catches than any recovery. The rise in Area 7 continues to reflect the strong recruitment pulse that occurred in 2000/2001.

The model attempts to explain the patterns visible in the various data streams by implying that recently there has been below average recruitment in assessment areas 3, 4, and 5. On the other hand, there have recently been spikes of recruitment in areas 1, 7, and 8 which have influenced catches, catch rates, mature biomass and egg production. The strong recruitment that influenced Areas 8 and 1 last year appears now to have fully recruited to the fishery and its influence is declining in Area 1.

Egg production over the whole State declined this year, which matches continued declines in the mature biomass, which has declined each year for the last three years.

The average weight of landed lobsters continues to increase slightly in areas 4, 3, 2 and 8, and remains stable or has declined slightly in the other areas. Average weight is a difficult performance measure to interpret. Changes may be due to the harvest rate dropping (the proportion of legal biomass removed by fishing is reduced) leaving more lobsters in the water for longer. Alternatively, it could also be due to there being low recruitment in some areas so that the only animals available are those that are growing bigger.

No new estimate of recreational catch is available since the 2004/2005 estimate of about 120t, but recreational licences have increased in numbers again. A new survey for the 2006/07 fishing season is nearing completion.

There were very low puerulus catches on the East coast from 2003/04 to 2005/06. This unusually low series suggests there may be a potential gap in the recruitment intensity that will only appear in a few years. In 2006/07 there were some signs of recruitment, especially in the far south (Recherche Bay).

Implication of Future Harvest Strategies

All statements about the model projections assume that the fleet dynamics have remained static over time (including the proportion of recreational catch by assessment area). In addition, the projections assume that historical recruitment patterns will continue to occur. The fact that the model predicts both low recruitment in the north and recent spikes of recruitment in the south, suggests that the recruitment dynamics have recently taken on a different pattern. The significance of this for the risk assessment is that the use of the full historical recruitment dynamics as a pattern for recruitment in the future projections, especially in the north of the State, may generate overly optimistic predictions about the future of the stock.

State-wide legal biomass projections suggest that with TACCs between 1,475t and 1,600t (implying between 115.7t and 125.4t of recreational catch) rebuilding will continue. With a TACC of 1,523t, legal biomass has a >60% chance of increase over the next five years in all assessment areas except in Area 2 (40% chance) and Area 7 (51% chance). The areas with the lowest chance of stock rebuilding over the next five years are areas 2, 7, and 6, in that order. Area 6 is the most uncertain in the assessment and in the projections because of its history of discovery of new grounds, leading to highly variable recruitment dynamics. With a TACC of 1,600 tonnes the probability of stock rebuilding continuing becomes less than 36% in Area 2 and less than 55% in Areas 3, 5, 6, and 7. These projections are strongly influenced by the fleet dynamics assumed to occur into the future. It is possible that effort would move from those areas that are predicted to do worst into those which are expected to do better. Under such circumstances, the probability of maintaining stock rebuilding is likely to reduce in the better areas and improve in the worst areas.

Overall Conclusions

Stock rebuilding is continuing at a state-wide level but the signs of poor recruitment (model outputs and very low puerulus catches on the East coast for three recent years) suggest that stock rebuilding may continue to slow, or even reverse, in the next few years.

So much stock rebuilding has occurred since the reference years (1994/1995) that the performance measures currently in place in the management plan are now uninformative when devising management advice.

The low recruitment levels in the northern areas combined with the recent recruitment in Areas 1 and 8 becoming fully available to the fishery, combined with the low puerulus counts on the East coast both add uncertainty to the assessment and projections. Because of the uncertainty and the particular recruitment patterns recently exhibited by the stock, the potential rebuilding of the stock predicted by the model may be misleading (biased high). As a consequence of this potential bias it would be prudent to be cautious in the management of the stock.

Table 1.1. Formal performance measures for the Tasmania rock lobster fishery.

Performance measure	Trigger point		Status in 2006/07
Statewide commercial catch rates	<95% of reference year	✔	46% increase above reference year
Regional commercial catch rates	<75% of reference year	✔	>25% of reference year in all cases
Statewide legal-size stock biomass	<95% of reference year	✔	99.9% increase above reference year
Regional legal-sized biomass	<75% of reference year	✔	>25% increase in all areas
Regional biomass estimates from fisheries independent surveys.	Significant decline between years		Not available
Statewide egg production	< lowest year	✔	117% of lowest year
Regional egg production	<95% lowest year unless production >40% unfished state (no decline tolerated in Areas where production <10% unfished)	✔	>103% of lowest year in all areas
Total commercial catch	<95% TACC	✔	100.9% TACC
Size of the fleet	<220 active vessels	**X**	214
Recreational catch	>10%TACC	✔	Most recent estimate 2004/05: 7.8%

Table 1.2. DEH recommendations for Ecosystem Based Fisheries Management (EBFM) of the Tasmanian rock lobster fishery applicable to this assessment.

Recommendation	Status
Recommendation 1: *The DPIW to advise the DEH of any material change to the TRLF management arrangements that could affect the criteria on which Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) decisions are based, within three months of that change being made.*	The annual stock assessment document will provide these requirements.
Recommendation 2: *Reports to be produced and presented to DEH annually, and to include:* • *Information sufficient to allow assessment of the progress of DPIW in implementing the recommendations made in the Assessment of the Tasmanian Rock Lobster Fishery 2007;* • *A description of the status of the fishery and catch and effort information;* • *A statement of the performance of the fishery against objectives, perform-*	The annual stock assessment document will provide these requirements.

ance indicators and measures; and • *Research undertaken or completed relevant to the fishery.*	
Recommendation 3: *Within 2 years, DPIW to develop and implement an education program for fishers on species recognition, mitigation measures to minimise interactions and the requirement to accurately report interactions under the EPBC Act.*	Changes to protected species interaction reporting in the RL catch effort logbook and associated information package were implemented in April/May 07. The main emphasis is on encouraging fishers to provide more information about interactions and to be more specific about the definition of an interaction. The current data will be analysed to determine whether any particular issues with respect to species identification needs addressing.
Recommendation 4: *DPIW, in collaboration with industry, to continue to encourage the adoption of programs that minimise protected species interactions and pot loss. DPIW, in collaboration with other jurisdictions, to investigate and implement, where appropriate, the use of seal exclusion devices other than seal spikes to reduce the impact of the fishery on seal species.*	Work with TRLFA through the Clean Green Program. Analyse interaction data to review nature and frequency of seal interactions annually to assess if risk of seal mortality changes to warrant exclusion devices. Collect data from fishers with respect to real levels of pot loss.
Recommendation 5: *DPIW to ensure that there is ongoing data collection of bycatch species in the fishery and that bycatch data analysis includes information on temporal and spatial patterns relevant to the TRLF.*	Ongoing data collection of non retained bycatch occurs as part of ongoing fishery data collection programs (catch sampling). Retained bycatch (byproduct) will be continue to be collected from all fishers through the RL catch effort logbook program. This byproduct data can be analysed for temporal and spatial patterns. Catch sampling programs provide validation of this data.
Recommendation 6: *Within 3 years, DPIW to review the stock assessment model and model predictions for the TRLF to ensure that TAC levels continue to permit significant stock rebuilding for the rock lobster stock. DPIW to consider environmental factors, such as urchin barrens, when setting the TAC annually for the TRLF.*	The stock assessment model continues to be developed and improved. The technical documentation will identify these changes. The assessment and catch sampling programs were externally reviewed in 2007. Main findings are summarised in this report. New performance indicators will be documented in the strategic policy document currently being finalised. This will include details of Limit and Target reference points for stock rebuilding, with a recognized timeframe that will inform the

	annual TAC setting process. Environmental factors such as urchin barrens are already being considered. This will be clearly documented.
Recommendation 7: *DPIW to continue to monitor egg production levels in northern regions and to develop and implement management measures to assist with increasing rock lobster egg production levels in this zone.*	Stock assessment report will continue to report on egg production estimates on a regional basis. The new strategic policy document will have performance measures relating to egg production, including limit and target reference points and timeframes. Develop of measures to assist with improving egg production has been ongoing since 2005 review identified this as important issue for the fishery. In progress : • draft rule to prohibit possession of immature females even if they are legal size • development of a proposal for alternative size limits in the north • investigation of the use of translocation as a tool for a number of issues including egg production in the north.
Recommendation 8: *DPIW to continue to monitor the level of fishing effort in shallow waters and determine whether further management measures are required to decrease fishing pressure on inshore rock lobster stocks.*	Analysis of fishing effort by depth is ongoing in the stock assessment process. Inshore issues and appropriate management measures will continue be discussed in consultation with the CFAC/RecFAC working group.

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1 Introduction

1.1 The modern fishery

The present commercial catch is taken from areas all around the State and involves the annual harvest of around 1.6 million animals. In the 2006/2007 season 214 licensed vessels reported catches of rock lobster, which is the first time so few vessels have contributed to the fishery. In addition, there were approximately 15,000 licensed recreational fishers (taking about 119 tonnes in 2004/2005). Commercial harvests have been controlled by a quota management system since March 1998, which has resulted in substantial stock rebuilding in all assessment Areas. This rebuilding can be seen in the historical trends in the fishery (Figure 1) with estimated legal biomass continuing to increase. However, in this latest year, catch rates are slightly less than in 2005/2006 and the effort required to catch the TAC was slightly increased.

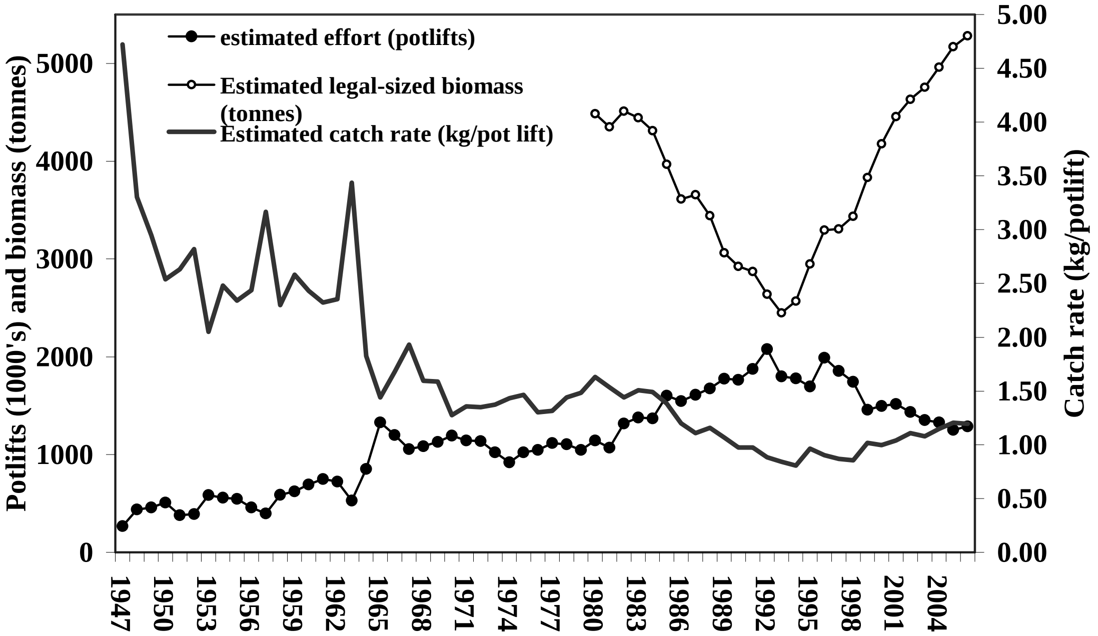

Figure 1. Historical trends in estimated fishing effort (pot-lifts), estimated catch-rate (kg/pot-lift) and estimated legal-sized biomass. Catch-rates after the 2nd world war and before the 1960s were much greater than those seen today. As fishing effort rose, catch-rates fell. Legal-sized biomass can only be estimated for later years commencing from a time when the resource was already fished down. The general trend in recent years exhibits a steady increase in legal biomass, with catch rates also recovering. This information is given in calendar years rather than quota years for ease of comparison with pre-1998 years.

Although legal 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 increasing their effort in locations and months when catch rates are lower but the value of the lobsters taken is higher.

Lobsters are harvested from all around the State with considerable variation in patterns of commercial fishing from region to region and from year to year. Biological parameters also vary dramatically from region to region and all these sources of variation present major challenges for fishery assessment and management. An important step towards meeting these challenges is the use of a spatially explicit stock assessment model that considers eight different assessment Areas separately (Figure 2).

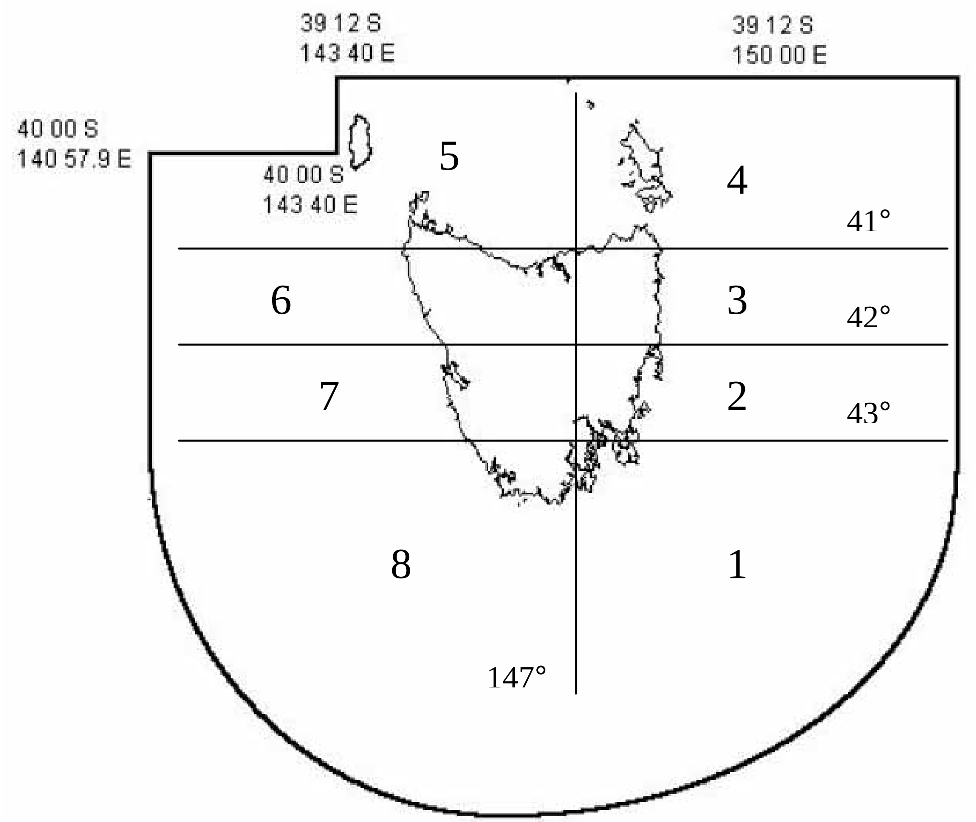

Figure 2. The boundaries of the eight Stock Assessment Areas and indicative area of State waters for the rock lobster fishery provided by the offshore constitutional settlement (OCS).

1.2 Economic and market status

The economic impact of the Tasmanian rock lobster fishery is far greater than would appear from simple comparisons of total annual revenue (ie gross value of product). This is because the resource is a wild fishery with constraints on production, so that a very high "scarcity rent" is obtained.

Scarcity rent in the lobster fishery is illustrated by the lease price of quota units, which currently trade at around $18 to $20 per kg. This implies a scarcity rent of more than $28.5 million dollars from total commercial revenue (GVP) of around $50 million (at a lease price of $19/ kg)[1]. This return on the resource is many times greater than can be achieved by other primary industries. Scarcity rent is thus an important concept to understand when comparing economic impact (because GVP is only loosely related to economic impact). For example, most aquaculture industries have retained earnings of around 10% of gross revenue, which implies that they would require $285 million GVP to achieve the same earnings as the Tasmanian lobster fishery.

[1] Retained profits are actually much greater than this amount because a commercial fisher who leases quota and then goes fishing makes additional profit.

The economic benefit from the Tasmanian commercial rock lobster fishery is well distributed around the State, with an estimated 1,350 jobs reliant on the 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 of secondary flows (EconSearch 2003). Capitalisation of quota units implies an industry value of $439 million in June 2007, excluding vessels and other tangible assets.

Lobsters are largely sold into Asian markets although a marketing project is underway with the aim of expanding into markets in the USA. Since the introduction of quotas about 64% of this catch is taken off the exposed West Coast (averaged across 1998/99 to 2006/07).

Nominal beach price received by fishers has not grown in any significant manner over the last 15 years, which implies that real beach price would have declined, if corrected by CPI (Figure 3). This would normally be assumed to imply that the economic rent from the resource had declined or remained stable. However, the trend in quota unit capitalisation tells a different story because there has been a three-fold increase in the capitalisation over the last decade to $439 million. This rapid rise in capitalisation represents a real increase in wealth and is driven by a reduction in costs.

Costs have declined because catch rates have risen, as seen by the fall in potlifts required to take the same TACC (Figure 4). In fact, the number of vessel days used to take the 1500 tonne TACC is now less than half of that required when the fishery commenced quota management in 1998.

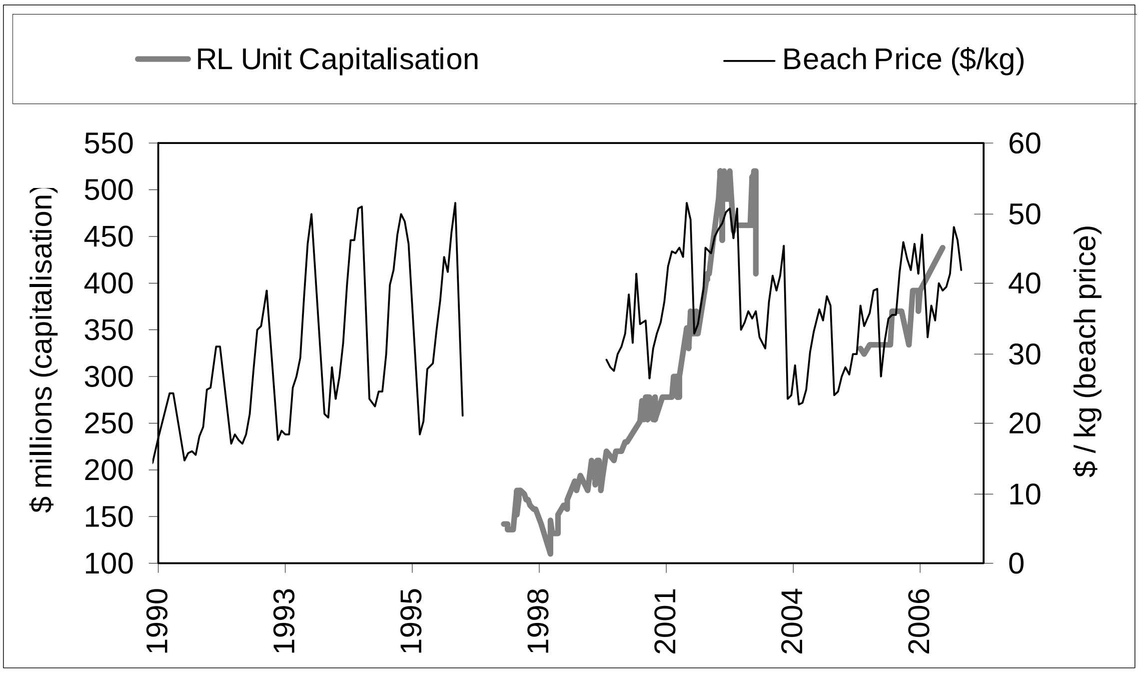

Figure 3. Monthly weighted average beach price and monthly market capitalisation of the Tasmanian commercial rock lobster quota units. This capitalisation is a function of the number of units on issue and the market price. Gaps in the series are where data is missing.

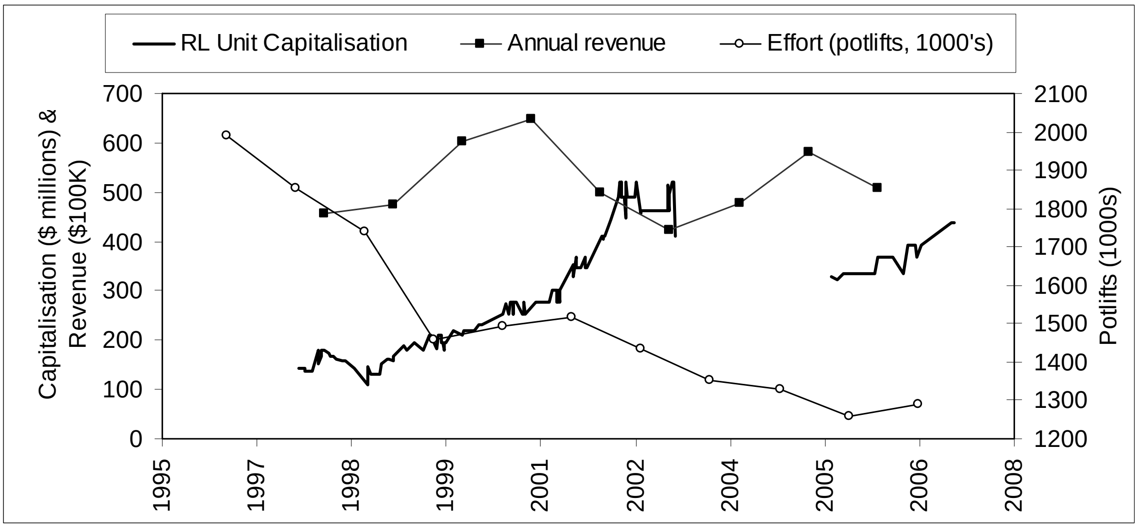

Figure 4. Trends in annual commercial rock lobster revenue (plotted in units of $100,000), market capitalisation of quota units (plotted in $millions) and potlifts (1000s). Capitalisation has risen three-fold despite no increase in nominal revenue (ie not adjusted for inflation). The explanation is that costs have declined as seen in the reduction of potlifts.

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, nevertheless, recreational lobster fishing also has an economic impact. The economic impact of all recreational fishing (lobsters, abalone, finfish etc), including secondary economic impacts, has been estimated at $50 million (Lyle *et al*., 2003).

2 Recent Developments

2.1 Management History of the Fishery

The implementation of the quota system in the commercial fishery in March 1998 resulted in an increased focus on profit rather than simply trying to maximize catch and revenue. 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 and shallow water to maximise value (Frusher *et al*, 2003). This has the potential to bias the stock assessment as it could lead to localized depletion in inshore regions while harvest rates in offshore stocks remain low due to the lower price of deep water, pale lobsters. This is principally an issue in assessment area 6 and 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 for the data since 1994/95). 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 with a daily legal catch limit of five lobsters. Licensing has been now been introduced for all methods of recreational lobster fishing and this provides information about levels of participation.

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 third to include a full year of data collection on protected species interactions, with results reported under "Ecosystem Interactions". A revised rock lobster log book design was introduced for the 2006/2007 season, and this included a monthly reporting sheet for byproduct and threatened and protected species interactions.

2.2.2 Research catch sampling operations

The analyses in the assessment are based on a variety of data sources. Information about temporal changes in lobster stocks are mainly driven by commercial logbook data, research catch sampling surveys, and recreational surveys. The research surveys currently provide data on the size structure of lobster catches. In addition, this data may provide independent estimates of harvest rates in the future, with methods under development.

The assessment and catch sampling operations were externally reviewed in 2007 and a more extensive sampling will occur as a result in 2008. Recommendations from the review were:

1. The catch sampling program has obvious difficulties associated with small sample sizes in some regions and at some times. Provision of more data with better spatial coverage as an input to the assessment model is a priority. The proposed

observer program will largely address this, although it is spatially restricted to the fished stock.

2. Length data from the legal sized catch landed at processors would be of value for assessment modelling and will be pursued in conjunction with regional observer based sampling.

3. Improving the spatial and temporal resolution of growth estimates is a high priority. Coverage of historical data has been limited by reliance on charter and TAFI vessels – this will be addressed by the tagging of discarded lobsters by observers.

4. Existing tag recapture data should be analysed for spatial patterns in growth and this used to update the model. Growth parameters should also be updated as data accrues in the future.

5. Improving spatial and temporal resolution of undersized lobsters from catch sampling should provide the best option for guidance on recruitment and will assist in the setting of quotas. The amount of data will be increased so that undersize data can provide useful information.

6. Ideally more than one method should be used to estimate biomass and fishing mortality. This information is currently only estimated through the model. Tagging models appear to provide a second option and the data required will be collected within field programs.

7. Long term monitoring sites are of tremendous importance for fisheries research and management. An expansion of the long-term monitoring program is required with the aim of increasing the spatial coverage of both fished and non-fished sites. A target of one fished site in each assessment area will be pursued with sampling to occur on an annual basis. These sites will build on historical sampling where possible.

8. The need for review of the assessment model was noted, which requires the completion of a technical document outlining the model structure and also documenting the database extracts.

2.2.3 Changes to the stock assessment model

The model projections required for the risk assessments of different management options use a description of the fleet dynamics to predict harvest rate in each assessment area. The observed fleet dynamics are exhibiting some very strong trends that can lead to unrealistic predictions if these trends are projected forward using a statistical model (either the original one from 1997 or a new improved statistical model). To avoid this unrealistic behaviour, alternative fleet dynamics models were developed that attempted to average the fishing behaviour over the last few years. By constraining the time frame over which the fleet dynamics are characterized the projection of trends into implausible situations is avoided. If recruitment occurs in the north and the stocks there begin to improve and effort shifts north again, then there will be a need to redevelop a statistically based fleet dynamics model, which can respond dynamically to such changes. Uncertainties in the description of the fleet dynamics add to the uncertainty inherent in the predictions from the risk assessment projections.

An additional development is the construction of a simple Excel front-end to facilitate running the model by members of the Crustacean Research Group. This permits the exploration of alternative size limits in the eight different assessment areas. To complement the simplified front end a suite of routines in the statistical package *R* have been written which are used to plot up and tabulate the results of the model runs.

More recent innovations include the possibility of projecting the model for much longer than five years, being able to estimate conditions in the unfished stock, and estimation of biological performance measures involving parameters such as the maximum sustainable yield. The implementation of this option has weakened the value of the Excel front end because of the increased flexibility required, however, for exploring the more extreme possible changes in size limits the ability to project a long way into the future was required.

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

3 Fishery Assessment

3.1 Performance Measures

The management plan contains an array of different performance measures relating to:

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

These performance measures are intended to provide a measure of the resource status across a board range of the properties of the Tasmanian rock lobster stock. The values for each of these performance measures are compared to standards, termed Limit Reference Points or trigger points, which have been defined for each of these measures. If these limits or triggers are breached then a management review is initiated to determine what action, if any, is required. Limit Reference Points define undesirable states for the fishery (see Appendix 5). Ideally, in addition to Limit Reference Points there would be Target Reference Points, which define the desirable state of the stocks and fishery. By default, at present, the targets for this fishery are any status greater or better than the Limit Reference Points. While not explicitly stated, there is a stock rebuilding strategy in place whose implicit objective is to increase the spawning stock biomass to something larger than that available when the stock was severely depleted in 1993/94. No target level has yet been set for the rebuilding strategy.

The current performance measures with their associated Limit Reference Points and triggers are under review but presently the Limits and triggers are often based on the 5-year period prior to the introduction of quota in March 1998 (which generally includes the lowest point for the stock in each of the eight assessment areas). For example, 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 (see Appendix 5). Many of these Limit Reference Points and trigger points were established at a time when the stock biomass was much lower than it is today. The standards against which the performance measures are evaluated are now being reviewed along with the management plan. Because of the success of stock rebuilding almost none of the performance measures currently used have any real value in characterizing the present stock status. Because of this reduced value, this year, only a rapid review will be made of the standard performance measures. However, in addition, a closer inspection of the rock lobster stock assessment model will be made with the stock status being summarized from an interpretation of the model outputs. This will provide an explicitly spatial description of the state of the resource.

Finally, although the criteria used for EPBC accreditation are also briefly assessed in this report they do not constitute formal performance measures in the current management plan.

3.2 Catch

Catch in the Tasmanian lobster fishery occurs through a range of sectors / systems: commercial catch, recreational catch, research catch, commercial personal use provisions; non-quota well mortalities; indigenous catch; and illegal catch. Additional mortality occurs as a result of fishing through octopus mortality in traps and discard mortality. Data is available on the scale of each of these sources of fishing mortality except for indigenous catch and illegal catch. Discard mortality is assumed, in the model, to be negligible. The commercial sector accounts for the majority of catch followed by the recreational catch and then the mortality due to octopus with other sources being essentially trivial (Figure 5).

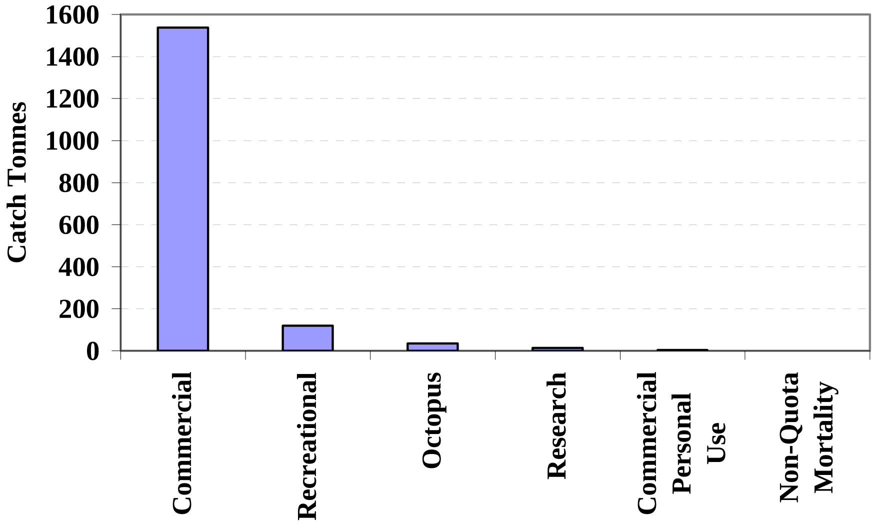

Figure 5. Different sources of fishing mortality in the Tasmanian rock lobster fishery.

3.2.1 Statewide Commercial Catch

Total commercial catch for 2006/07 taken through the quota management system was 1537.335 t, which is greater than 100.9% of the TACC of 1523 t (Figure 6).

3.2.2 Regional Commercial Catch

The total State-wide reported catch of rock lobster grew from about 1,500 t in 1970/71 to a maximum of 2,172 t in 1984/85, declining to 1,611 t in 1997/98. In 1998/99 a Total Allowable Catch (TAC) of 1,500 t was introduced, which was increased to 1523 t in 2002/03 (Figure 6; Appendix 8). Total State-wide effort (as pot lifts) followed a similar trend but with a peak in effort in 1992/1993 and another in 1996/1997, with effort declining strongly since then. The stock assessment model is a size-based model modified from Punt & Kennedy (1997). The predicted legal sized biomass at the end of November each quota year has exhibited a strong decline from a peak in 1982/1983 to a minimum in 1993/1994. Since 1993/94 the stock has rebuilt strongly, especially after the introduction of the quota management system in 1998/1998. The exploitation rate (as State-wide catch divided by the November legal biomass) follows a pattern similar to the distribution of effort but with changes brought about by changes in legal biomass (Figure 6).

The State-wide trends demonstrate the success of the rebuilding strategy introduced since the heavily depleted situation of the mid-1990s; first as input controls (for example, November 1995 was closed to lobster fishing) and then as a conservative Total Allowable Catch (TAC) of 1,500t (now 1,523t). However, because of the regional differences in productivity interacting with the fleet dynamics, the rebuilding has not proceeded at an equal rate around the State. Because of regional differences only considering the State-wide figures can be misleading.

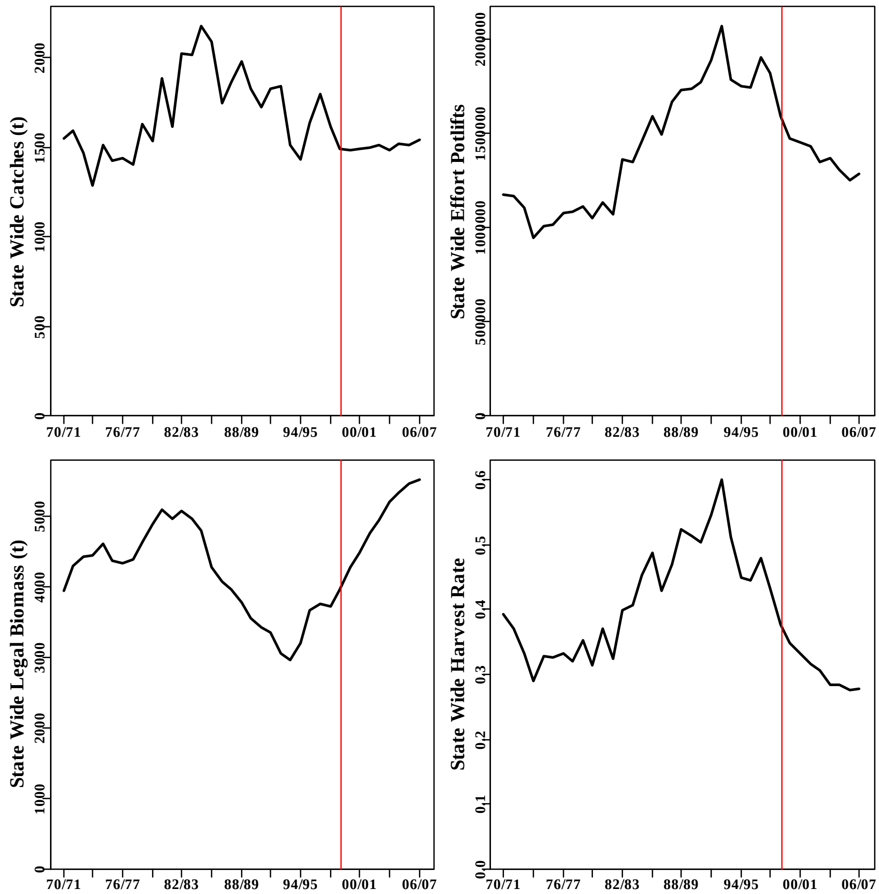

Figure 6. State-wide catches as tonnes, effort as thousands of pot lifts, legal biomass in November as tonnes, and the State-wide harvest rate approximated as the total catch versus the November legal biomass. The vertical lines represent the beginning of the quota system.

3.2.3 Non-Quota Commercial Catch

Non-quota commercial catch occurs in three ways: personal use provisions, well mortalities, and octopus mortalities. Formal reporting of these additional sources of mortality was introduced in 2003/04. Reporting was introduced so that firm data could be collected on the scale of these activities. In particular, there was a perception that fishers might discard dead lobsters at sea to avoid having these deducted from their quota holding. This practice would lead to the under-estimation of commercial catch in the assessment process. The introduction of mandatory reporting of these discards without penalty provides a more objective basis for examining the scale of this potential source of mortality.

Provisions for both personal use and reporting of well mortalities have been the subjects of a great deal of debate, however, both practices are of a very minor scale and have a trivial impact on the estimation of stock size (Figure 7). Octopus mortality, on the other hand, represents up to 2.5% of the commercial catch (Figure 8).

Commercial fishers are allowed to retain up to five lobsters per commercial trip through personal use provisions. These lobsters are typically unhealthy when unloaded so that the fisher would receive a discounted price. Although these lobsters are not sold, and are thus not commercial, they are not considered to be recreational catch because they are taken outside the recreational permitting system. A total of 3800 lobsters were taken through this provision in 2006/07, which equates to around 17 lobsters per active vessel per year.

Well mortalities were also trivial in scale with only 618 lobsters landed but not deducted from commercial quota in 2006/07. This equates to less than 2.9 lobsters per active fishing vessel.

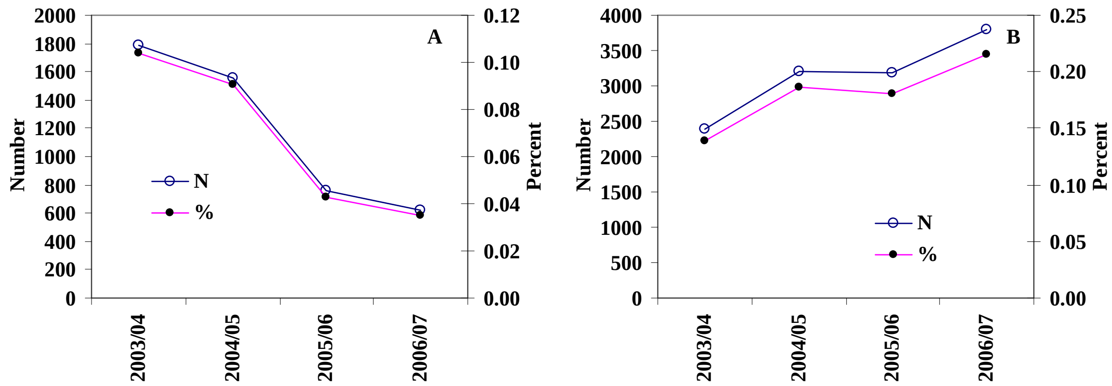

Figure 7. Trends in commercial catch outside the quota management system. Well mortalities that were not deducted off quota are show in the left-hand panel (A), lobsters retained for personal use in the right-hand figure (B). Percentage values are the number of lobsters relative to the total harvest.

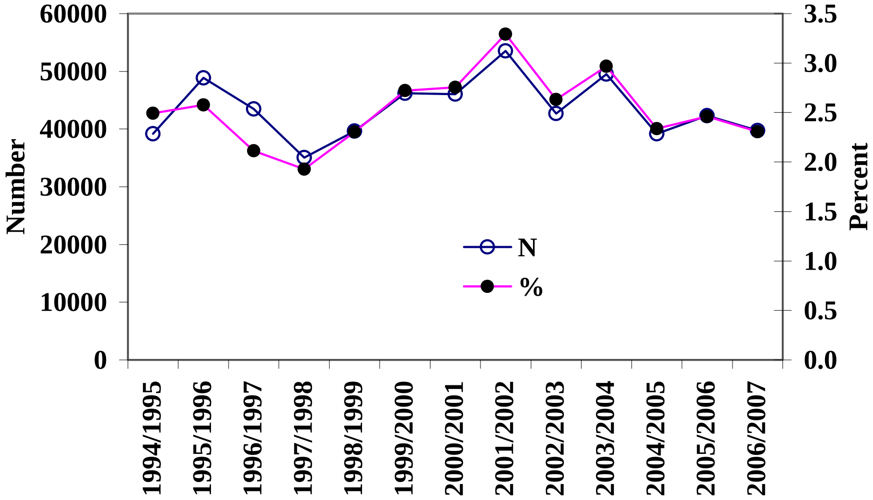

Figure 8. Trends in reported mortalities due to octopus predation. Percentage values are the number of lobsters relative to the total harvest in each quota year.

3.2.4 Research Catch

Research effort on the Tasmanian rock lobster resource is partially funded through the allocation of 1% of the quota for the support of research. The main use of this quota is as payment for vessel charter to conduct catch sampling research. A total of 14 tonnes were utilised in 2006/07.

3.2.5 Recreational Catch

The last recreational survey of rock lobster catches relates to the 2004/2005 fishing year (Lyle and Morton, 2006). Since then the number of rock lobster recreational licenses has increased again but there are no new estimates of recreational catches by area. A summary of the surveys and other estimates that have been made (as they have been included in the stock assessment model) indicates that recreational catches rose steadily from 1992 until 2002/2003 after which they appear to have declined slightly (Table 3.1). The estimates of the proportion of the commercial catch taken by recreational fishers in each assessment area have also changed through time (Table 3.2). The latest recreational survey is currently being analysed and will be available for the 2007/08 rock lobster assessment.

Table 3.1. Estimated total weight of recreational catches by area and season. The recreational surveys were usually conducted over a fishing year (November until October – with September and October assumed closed to recreational fishing). However, these figures have now been associated with given quota years. Spatial resolution of the surveys has increased through time.

Area	1996/1997	1997/1998	2000/2001	2002/2003	2004/2005
1	39.533	35.355	51.891	43.596	42.777
2	20.403	13.173	26.988	29.211	16.113
3				21.318	15.781
4	6.0075	4.813	19.57	13.506	7.343
5	10.381	8.058	6.272	17.595	17.437
6	13.361	8.271	22.084	11.866	8.225
7				5.497	7.889
8				5.937	3.791
Total	89.686	69.670	126.805	148.526	119.356

Table 3.2. Recreational catch as a percentage of commercial catch in each area for each survey.

Area	1996/1997	1997/1998	2000/2001	2002/2003	2004/2005
1	39.658	34.402	48.756	34.912	29.480
2	12.813	10.088	17.411	26.944	14.040
3	11.073	9.728	17.401	29.170	22.172
4	2.806	2.472	8.931	6.477	3.693
5	3.247	2.456	1.941	5.396	4.720
6	3.120	1.903	5.002	8.023	4.370
7	1.863	1.509	4.444	5.627	7.916
8	1.162	0.711	1.940	2.911	1.432
Start	Dec-96	Nov-97	Nov-00	Nov-02	Nov-04
Finish	Aug-97	May-98	Aug-01	Oct-03	Aug-05

3.3 Commercial Catch and Effort Analysis

Catch rate data from the commercial sector is presented in two parts.

First, rational mean (total catch/total effort) and geometric mean catch rate data are presented. These provide basic guidance on trends in catch rate. Both rational and geometric mean catch rates are based solely on catch and effort data; they differ in the mathematical process used to calculate the value of catch rate in each case.

$$\overline{I}_{R,t} = \frac{\sum C_t}{\sum E_t} \qquad \overline{I}_{G,t} = \exp\left[\frac{\sum Ln\left(\frac{C_t}{E_t}\right)}{n}\right] \qquad (1.1)$$

where there are a total of n C_t Catch and E_t effort records for a particular time interval t, and $\overline{I}_{R,t}$ is the rational mean for time t, and $\overline{I}_{G,t}$ is the geometric mean for time t.

In addition to this first approach, standardized catch rate estimates are also presented. The statistical process of standardisation accounts for many of the factors that influence catch rates aside from the abundance of lobsters. The standardised catch rate data presented here show the trends in catch rate after removing the effects of month, boat, depth, day / night fishing, and ½ degree fishing block within the assessment area. This means that changing fishing practices, such as increasing effort in winter and shift of effort to shallow depths, should not bias trends in standardised catch rate data as they would ratio and geometric catch rates (see Appendix 1).

3.3.1 Rational and geometric catch rates

State-wide commercial rational or ratio mean catch rates for the 2006/07 quota year were higher than those recorded in the corresponding reference years and thus this trigger point has not been activated (Table 3.3). On the other hand, a comparison of the rational mean catch rates between 2005/06 with 2006/07 indicated that catch rates in some areas had stopped increasing and had decreased instead (Table 3.3, Table 3.4). Inter-annular trends were similar for both rational catch rates and geometric mean catch rates although were spatially variable both between areas and between fishing blocks within assessment areas (Table 3.4, Figure 13 and Figure 15).

The State-wide catch-rate has exhibited a sustained pattern of increase, which implies ongoing rebuilding of stocks, although in the very latest year there was a very slight decline (Table 3.3, Figure 9). As catch is limited by quota, the improved catch rates have led to a decline in total effort so that in 2006/07 there was only 65% of the effort expended in 1996/97 (Figure 10, Table 3.5). This level of effort was a slight increase (~2.8%) on that observed in 2005/06.

The State-wide trend of a slight decrease in rational mean catch rate is mirrored by approximately 10% declines in Areas 1, 2, 6, and 7, although catch rates in Area 3 increased as well (Table 3.3, Figure 11 and Figure 12). Apparent declines in rational mean catch rates can be caused by factors unrelated to abundance. Standardised catch rates provide a better guide for these regional trends and are shown in the following section. In particular, the standardized catch rates for Area 7 show a very different, more positive, pattern relative to that shown by the ratio catch rates. The problem of seasonal change in effort leading to a bias of ratio catch rate data is partly overcome by examining monthly trends in catch rate (Figure 16). The seasonality trends indicate that catch rates in the northern assessment areas 4, 5, and 6 are relatively stable while the southern four assessment areas 1, 2, 7, 8, and 3 all show increases in the average catch rate relative to the previous ten years, especially in the period November through to March.

Table 3.3. Annual rational mean commercial catch-rates.
Negative values of change indicate a reduction. The reference year is defined as the year with lowest CPUE among 1993, 1994 and 1995.

		Commercial catch rates (kg/pot lift)			% change		Catch stats (March 2006-Feb. 2007)	
Area	**Reference Year**	**Ref. Year**	**2005/06**	**2006/07**	**vs Ref.Year**	**vs 2005/06**	**Catch (t)**	**Effort (1000 pot lifts)**
Statewide	1994	0.82	1.20	1.19	+46	-1	*1537	1288
1	1994	0.54	1.12	1.00	+85	-11	190	191
2	1994	0.54	0.96	0.88	+63	-9	103	117
3	1994	0.43	0.69	0.79	+83	+15	75	96
4	1994	0.61	1.04	1.08	+77	+3	156	145
5	1995	0.89	1.09	1.18	+33	+8	223	189
6	1995	1.23	1.72	1.53	+25	-11	156	101
7	1994	1.10	1.86	1.66	+51	-11	206	124
8	1993	0.77	1.34	1.32	+71	-1	428	325

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

Table 3.4. Annual geometric mean commercial catch-rates.
These are calculated only for those records with catch-rates > 0, with vessels present in the fishery for > 1 year, and with median annual catches > 1 tonnes. Negative values of change indicate a reduction. The reference quota year is defined as the quota year with the lowest CPUE among 1993/94, 1994/95 and 1995/96.

		Geometric Mean catch rates (kg/pot lift)			% change		Catch stats (March 2006-Feb. 2007)	
Area	**Reference Year**	**Ref. Year**	**2005/06**	**2006/07**	**vs Ref.Year**	**vs 2005/06**	**Catch (t)**	**Effort (1000 pot lifts)**
Statewide	1994/95	0.541	0.891	0.887	63.9	-0.4	*1537	1288
1	1994/95	0.371	0.815	0.708	90.8	-13.1	190	191
2	1994/95	0.404	0.776	0.705	74.5	-9.2	103	117
3	1994/95	0.318	0.546	0.611	92.0	11.8	75	96
4	1994/95	0.465	0.813	0.831	78.6	2.2	156	145
5	1995/96	0.611	0.872	0.954	56.0	9.4	223	189
6	1995/96	0.926	1.372	1.284	38.6	-6.4	156	101
7	1994/95	0.812	1.519	1.318	62.3	-13.2	206	124
8	1994/95	0.547	0.966	0.985	80.0	1.9	428	325

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

Table 3.5. Summary of state-wide commercial catch and effort statistics.
1996/97 had the maximum level of effort since 1994/95 and other years are scaled to this peak. QYear is quota year (Mar 1st – Feb 28/29th). State CPUE is the total catch divided by the total pot lifts.

QYear	Catch	Pot Lifts	% of 96/97	State CPUE
1994/1995	1434.669	1752975	91.99	0.818
1995/1996	1636.899	1745920	91.62	0.938
1996/1997	1799.143	1905561	100.00	0.944
1997/1998	1611.474	1823317	95.68	0.884
1998/1999	1487.512	1592206	83.56	0.934
1999/2000	1485.585	1471364	77.21	1.010
2000/2001	1491.988	1455457	76.38	1.025
2001/2002	1498.338	1433289	75.22	1.045
2002/2003	1510.598	1350900	70.89	1.118
2003/2004	1482.723	1370621	71.93	1.082
2004/2005	1516.663	1309267	68.71	1.158
2005/2006	1508.782	1252846	65.75	1.204
2006/2007	1537.335	1288179	67.60	1.193

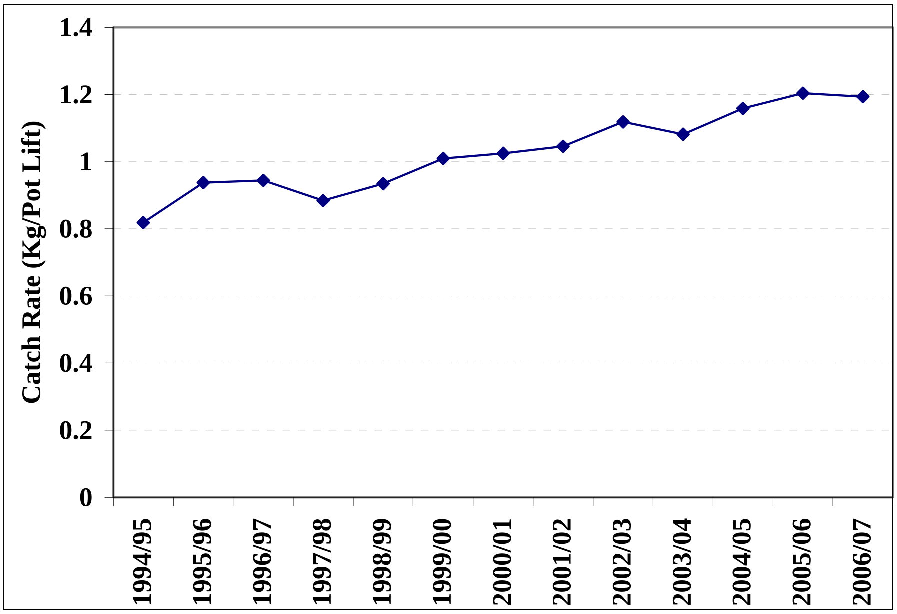

Figure 9. Change in State-wide ratio annual commercial catch rates since before the introduction of the quota system in 1998/99. The 1994/95 quota year was when catch rates (as sum of catch/sum of pot lifts) reached their lowest point state-wide.

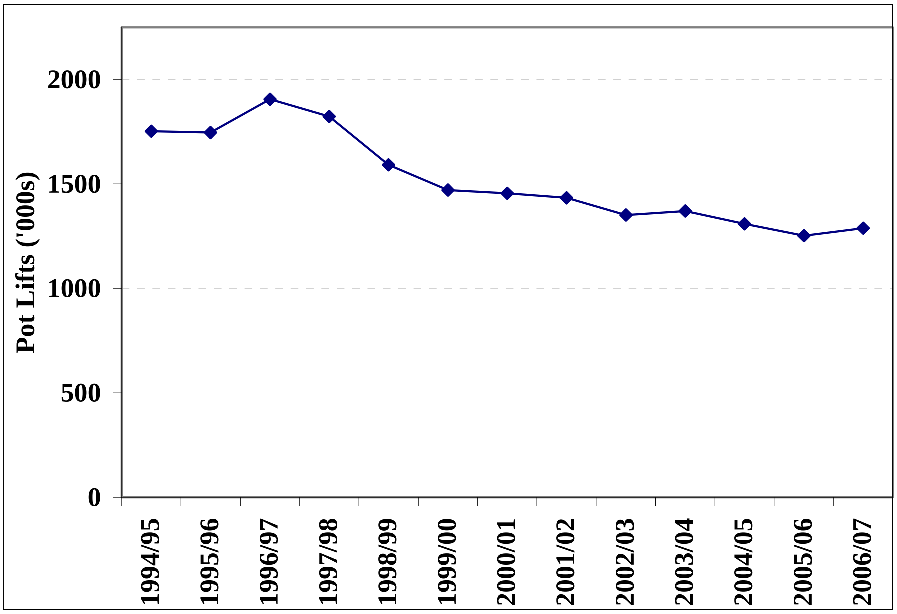

Figure 10. Change in State-wide commercial fishing effort as thousands of pot lifts since the 1994/95 quota year (quotas introduced in 1998/99).

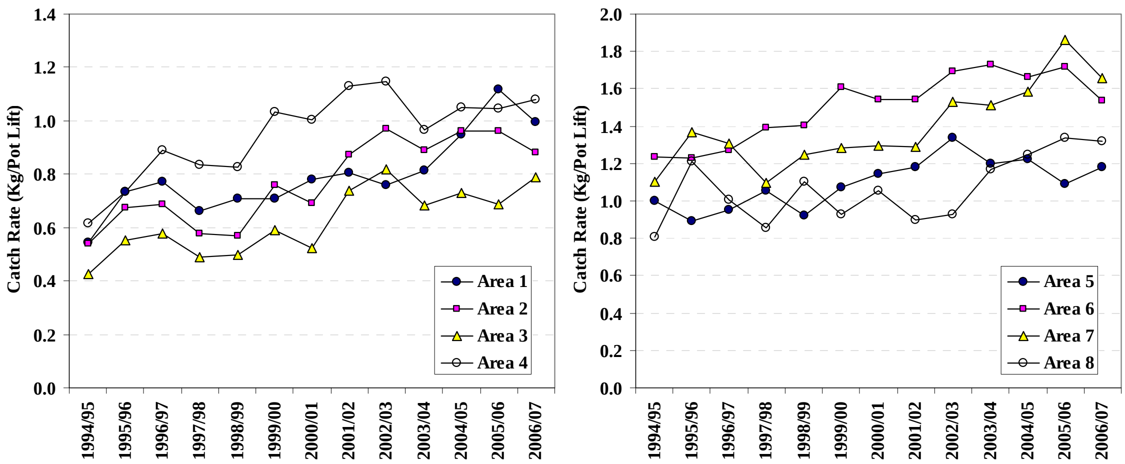

Figure 11. Change in ratio annual commercial catch-rates for quota years between 1994/95 and 2006/07 for assessment Areas on the east (left) and west coast (right). Data shown in this figure are expanded over a longer time series in Figure 12.

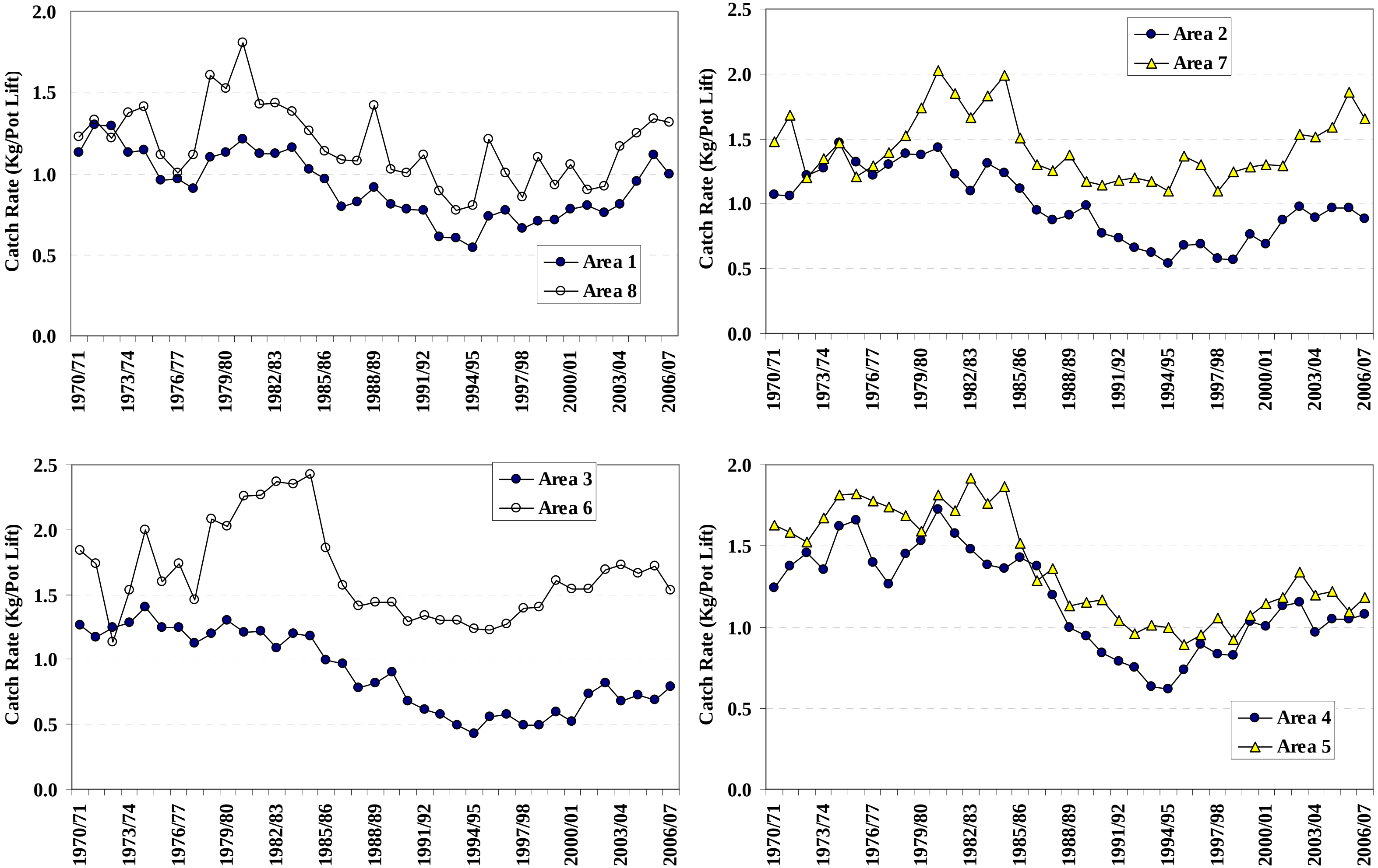

Figure 12. Regional ratio commercial catch rates since 1970. Data is presented on a quota year basis (i.e. March to February), so the last data point is for the period March 2006 to February 2007 inclusive.

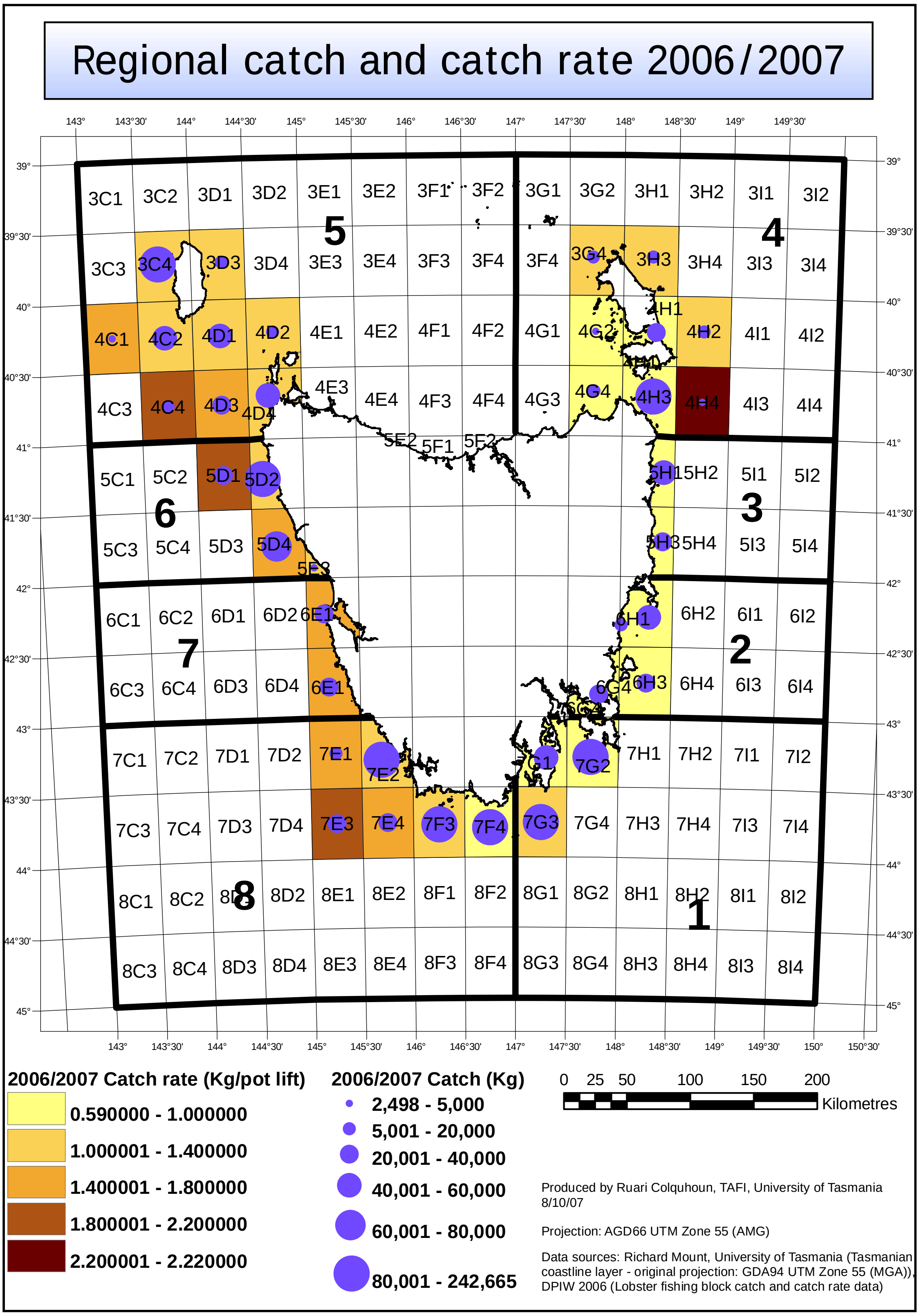

Figure 13. Catch rates and catch by fishing block. Total catch for the 20060/07 quota year is illustrated by the circles within each block. Blocks with catch of less than 2.5 tonnes were excluded.

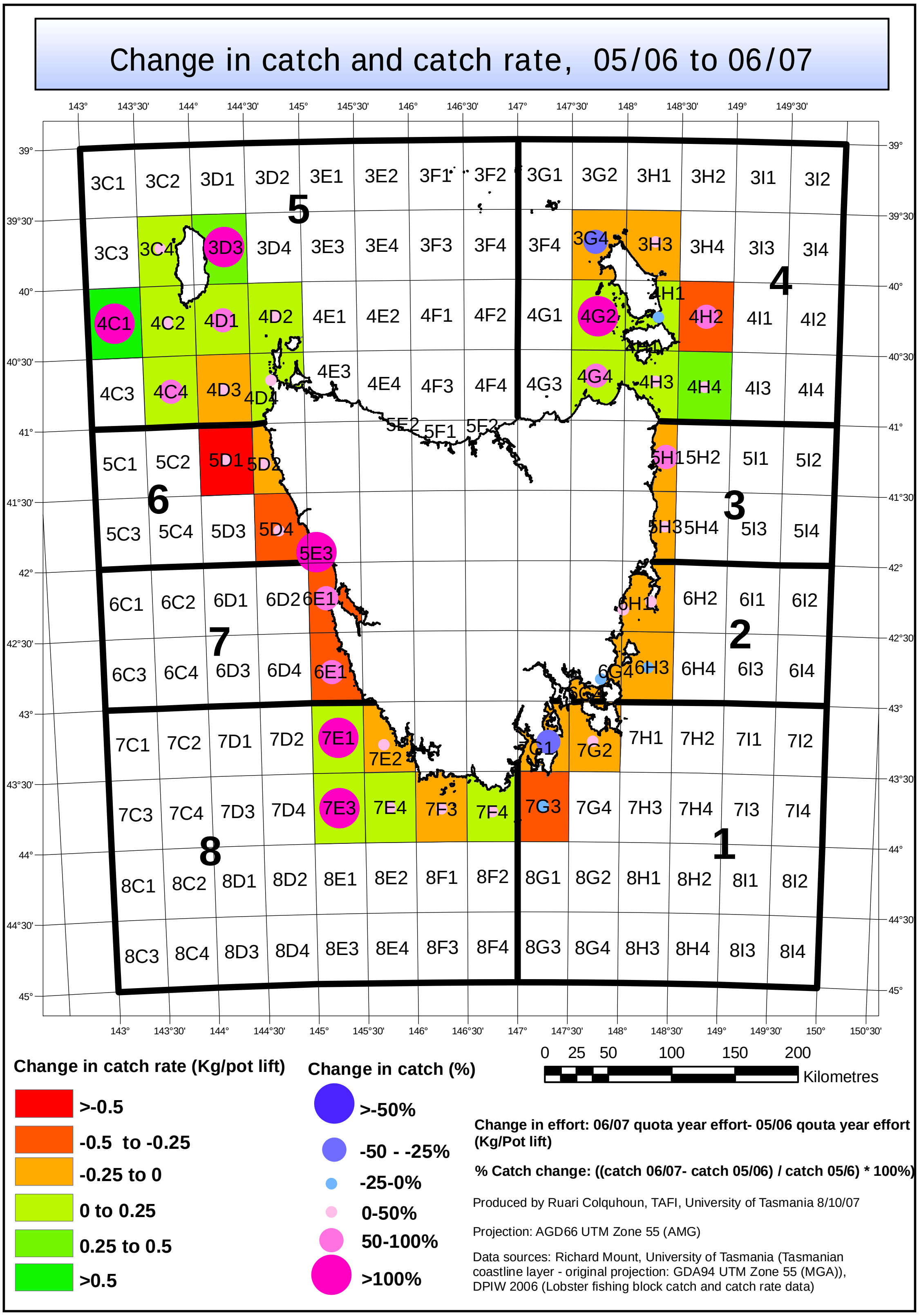

Figure 14. Change in catch rates and catch by fishing block from 2005/06 to 2006/07. Blocks with catch of less than 2.5 tonnes were excluded. Note that a large percentage change in catch and catch rate is more common where the total catch is very small (eg 4C1 off King Island).

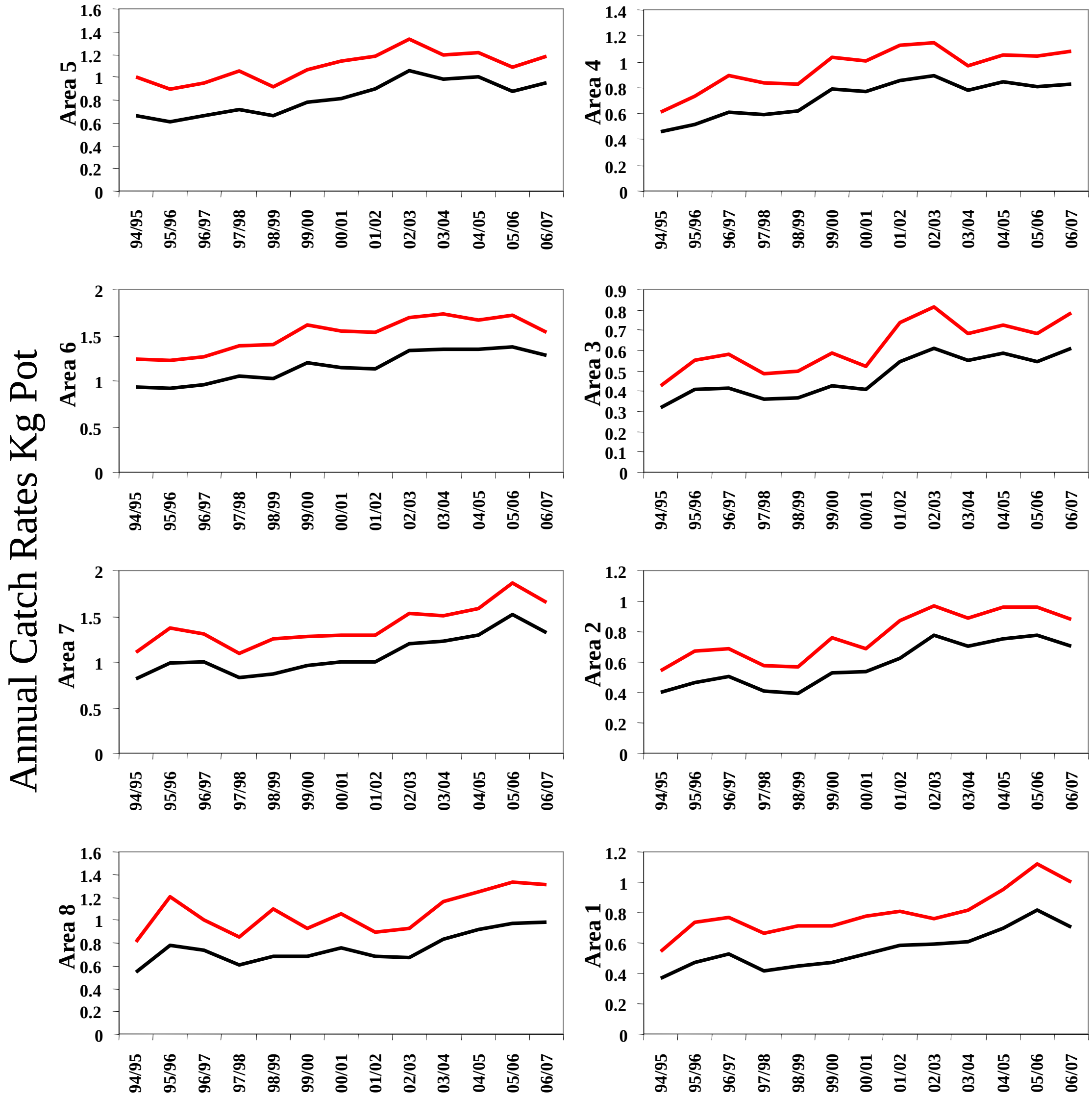

Figure 15. Comparison between geometric and ratio catch rates (kg/pot) for each year for each assessment area. The lower line in each case is the geometric mean catch rate while the upper is the arithmetic mean catch rate. This illustrates that the ratio catch rate tends to over-estimate the typical catch rate of the fleet, and also that trends are similar with the two approaches.

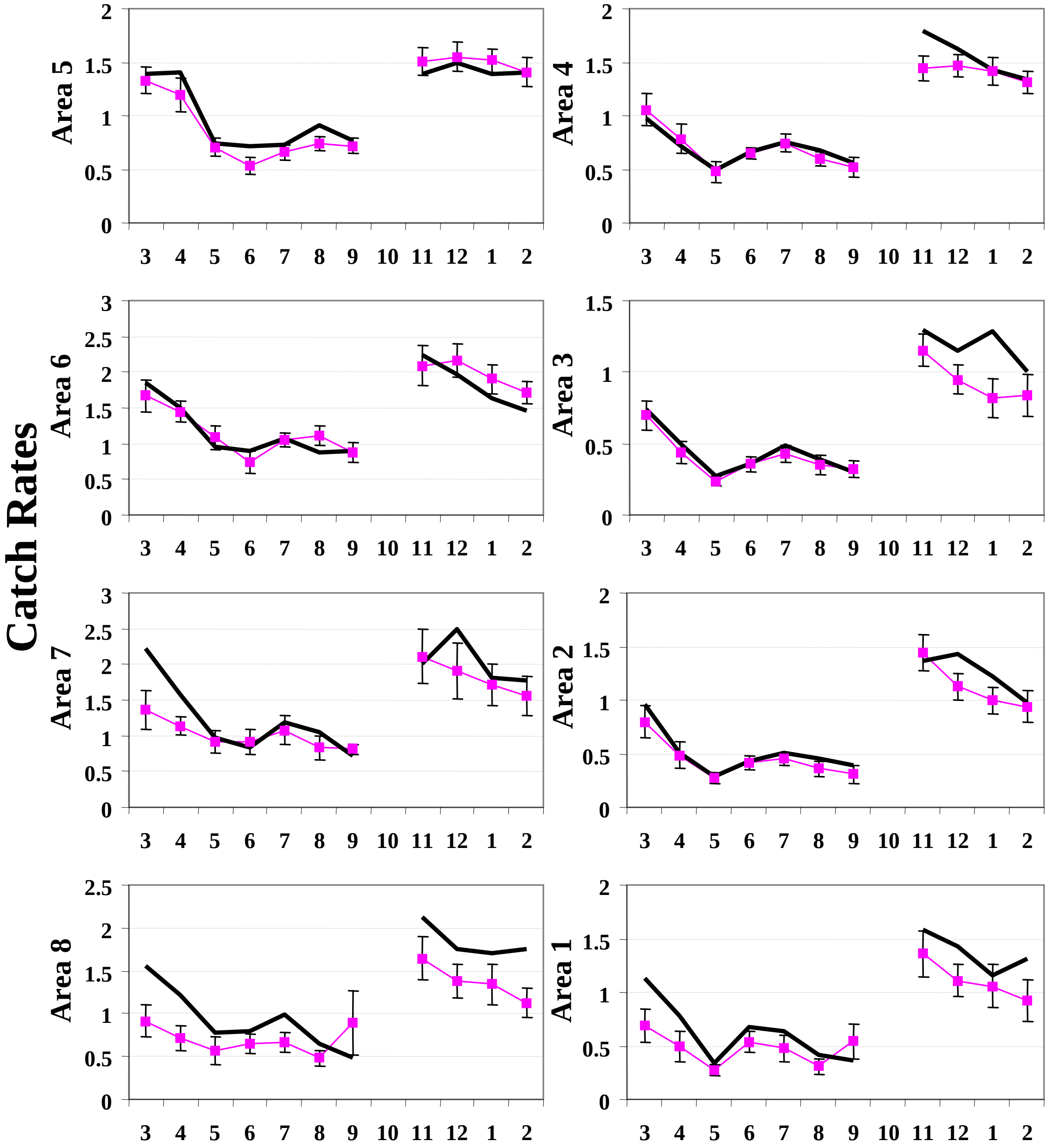

Figure 16. Change in ratio commercial catch rate (CPUE, kg/pot lift) between months for 2006/07 (the smooth line) and the mean of the previous ten quota years 1996/97 – 2005/06 (the line with dots and 95% confidence intervals). The vertical grey dashed line in each plot indicates the start of the quota season. The month of October is closed to fishing.

3.3.2 Standardised Catch Rates

Catch rates can alter in response to factors that have nothing to do with changes in the stock biomass. These include differences in the time of year, location, skipper, night vs day and depth. It is routine stock assessment practice to standardize commercial catch and effort data in an attempt to remove the influence of these factors. This process means that any variation left in the catch-rate data after standardization is more closely related to what is happening to the stock biomass. The method of standardising catch rate is described in detail in Appendix 1.

Optimal standardisations for each area were one of two forms. The first (termed “model 7”) accounted for the effects of quota year, time of year (8 periods), boat ID, day/ night shot, depth, fishing block and an interaction between the time of year and depth. The second (termed “model 8”) was equivalent except it included an interaction between the time of year and fishing block, rather than the time of year and depth.

The process of catch rate standardisation did not change the trends greatly from the geometric means (Figure 15 and Figure 17). This year Areas 1, 2, and 8, in the south, all exhibited reduced catch rates relative to last year, only Area 7 continued to exhibit a continuing increase in standardized catch rates. In contrast, three of the northerly Areas, 3, 4, and 5, all exhibited slight increases in catch rates with Area 6 exhibiting a continued decline in catch rate (Figure 17). The changes in catch rates in the north appear to be due to reduced catches being taken from those areas (Figure 19).

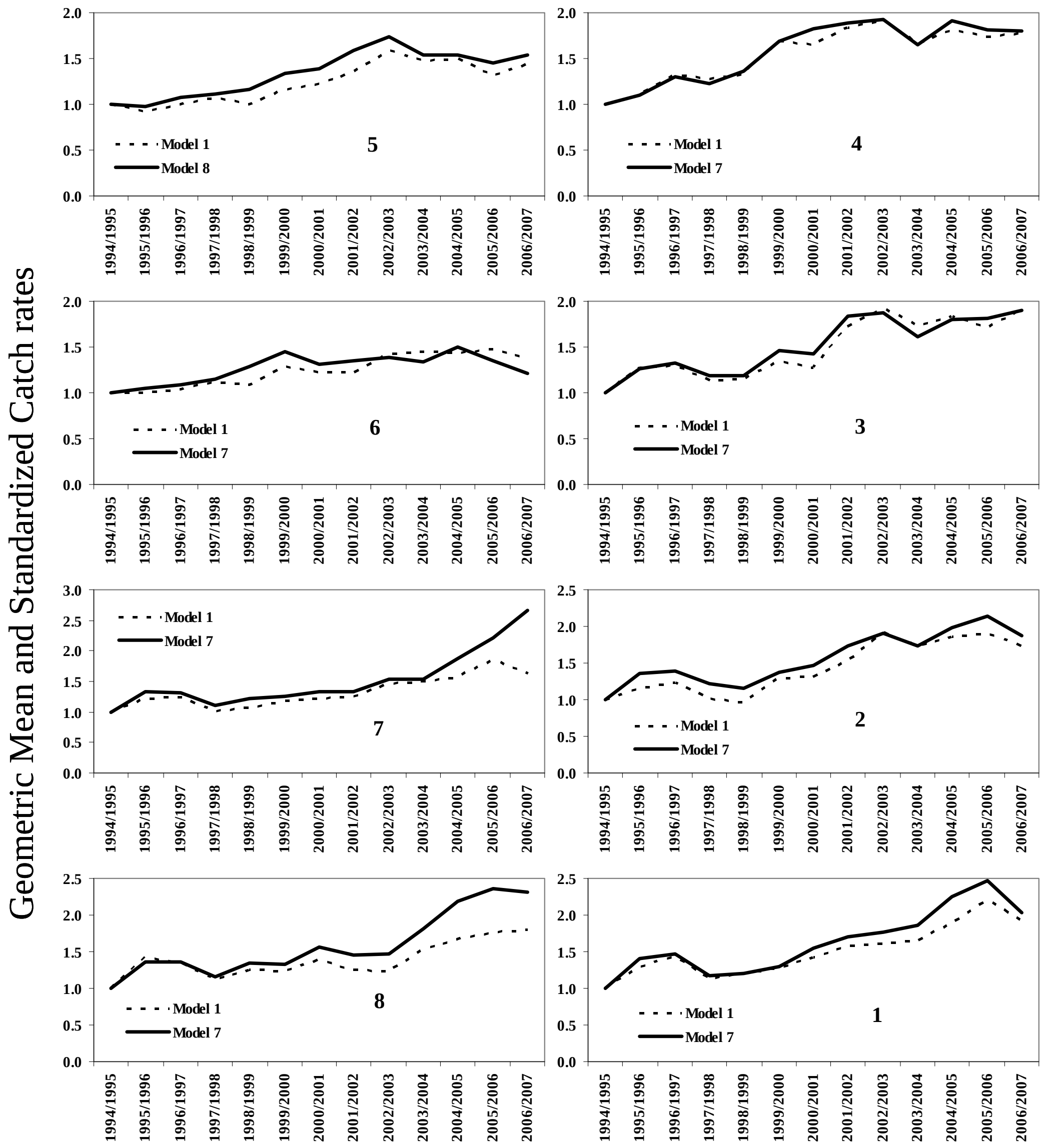

Figure 17. Geometric mean catch rates for each quota year compared with the optimal standardised catch rates for the eight assessment areas. Model 1 was the geometric mean in each case while the optimum statistical model was Model 7 for all areas except Area 5 where Model 8 was optimal (see Appendix 1). Note that these catch rates are scaled against the first year (1994/95) and should not be read as kg per pot lift.

3.3.3 Trends in Commercial Catch and Effort

There has been a general trend of declining effort in the commercial sector over the last decade, which is reflected in a range of data. As noted in section 3.3.1, potlifts have declined by 65% over the past decade.

The number of records reported each quota year has also declined since 1998/1999 (Figure 18 and Table 3.6), although the number increased by about 500 in 2006/07. This provides another measure of effort from potlifts, and is a better indication of a reduction in the days fished. In Areas 3, 6, 7, and 8 there were small increases in the last year but elsewhere the number of records has declined.

Table 3.6. Number of records from each quota year in each assessment area where catch was greater than zero.
The year with the maximum number of records is highlighted in bold.

Qyear	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Total
94/95	5897	4457	4876	6955	**11339**	**5625**	3752	11464	54365
95/96	5882	**5394**	6177	7181	10203	5105	4406	9630	53978
96/97	**6327**	5393	**6243**	**7978**	9675	5164	**5070**	**12653**	**58503**
97/98	5947	5235	5561	7858	9801	4848	3819	12574	55643
98/99	4375	4144	4748	6459	8721	3924	2998	9201	44570
99/00	3978	3412	3687	5401	7034	4096	2312	8794	38714
00/01	3748	3418	3928	5964	6344	3982	1954	7661	36999
01/02	4021	3642	3068	5635	6141	3074	2072	7718	35371
02/03	4219	3672	3252	5219	6064	2720	1640	5657	32443
03/04	4283	3767	3227	4845	5879	2321	1646	5859	31827
04/05	4196	3613	2849	4176	5204	2622	1646	6134	30440
05/06	5021	3150	2199	3500	4479	1966	1770	6472	28557
06/07	4549	3057	2321	3404	4077	2066	2547	7159	29180

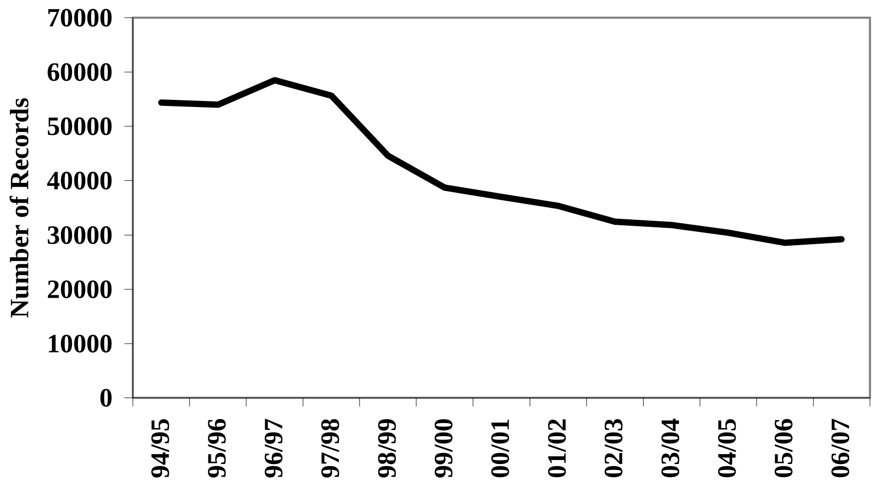

Figure 18. The total number of records across all assessment areas where catch rates are greater than zero. Only complete years are included. The Total column from Table 3.6.

The geographical patterns exhibited in the catch rates were related to the patterns in the distribution of catches and effort (Figure 19 and Figure 20). Catches increased in Area 3 and 7 where catch rate rose, presumably because the fleet is mobile and fishers shifted effort to regions with better catch rates. However, the reduced catches in areas 4, and 5 appear to have led to a slight increase in catch rates. Catches declined in Area 1 in line with the reduction in catch rates there, although catches remained high in Area 8 where catch rates stabilized. It seems possible that the recruitment pulse that was driving the fishery in the south is being fished down except in Area 7 where recruitment success continues. The lack of new recruitment in the north appears to remain a problem.

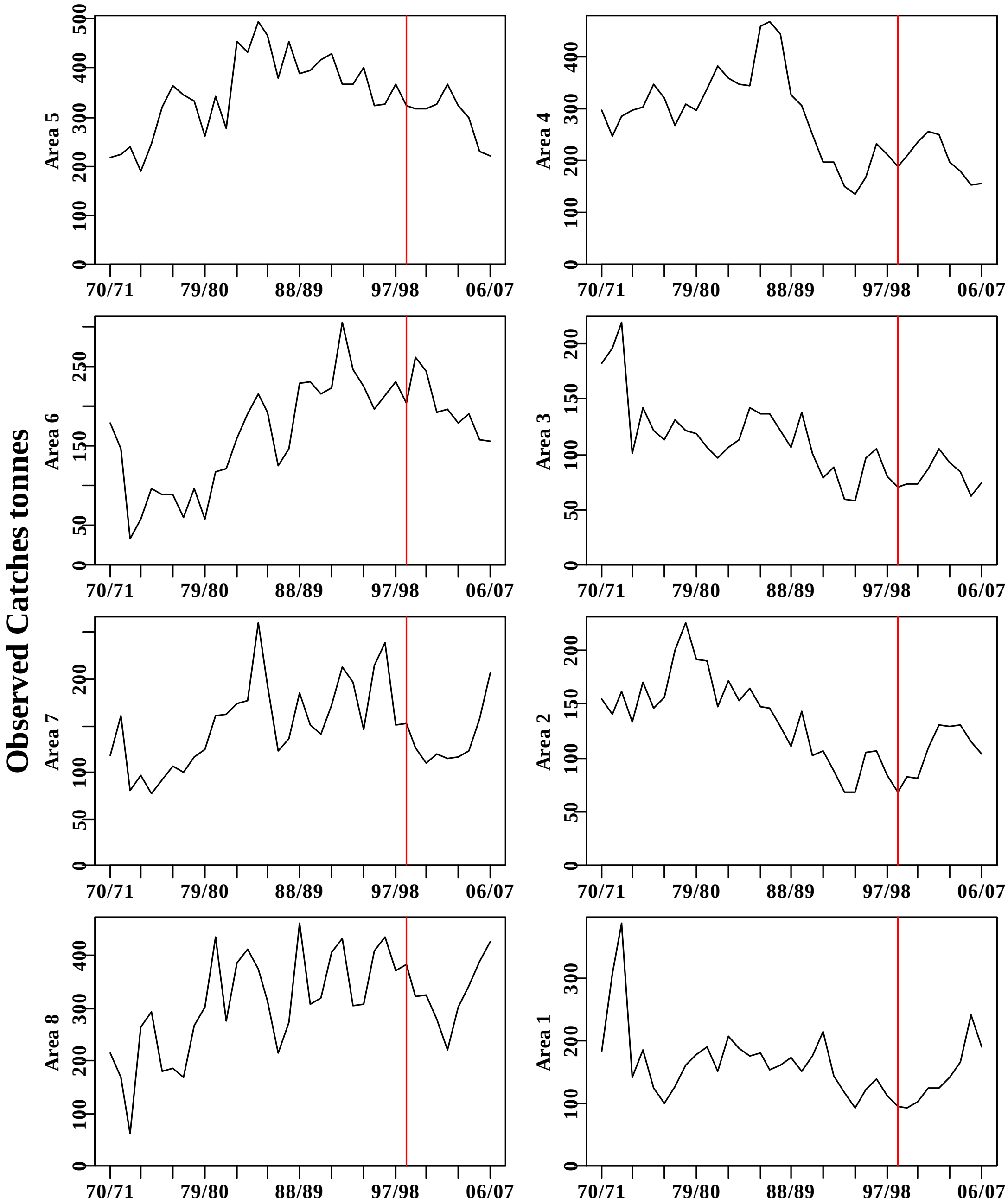

Figure 19. Total catch by quota year for the eight rock lobster assessment Areas. Note the y-axes have different scales.

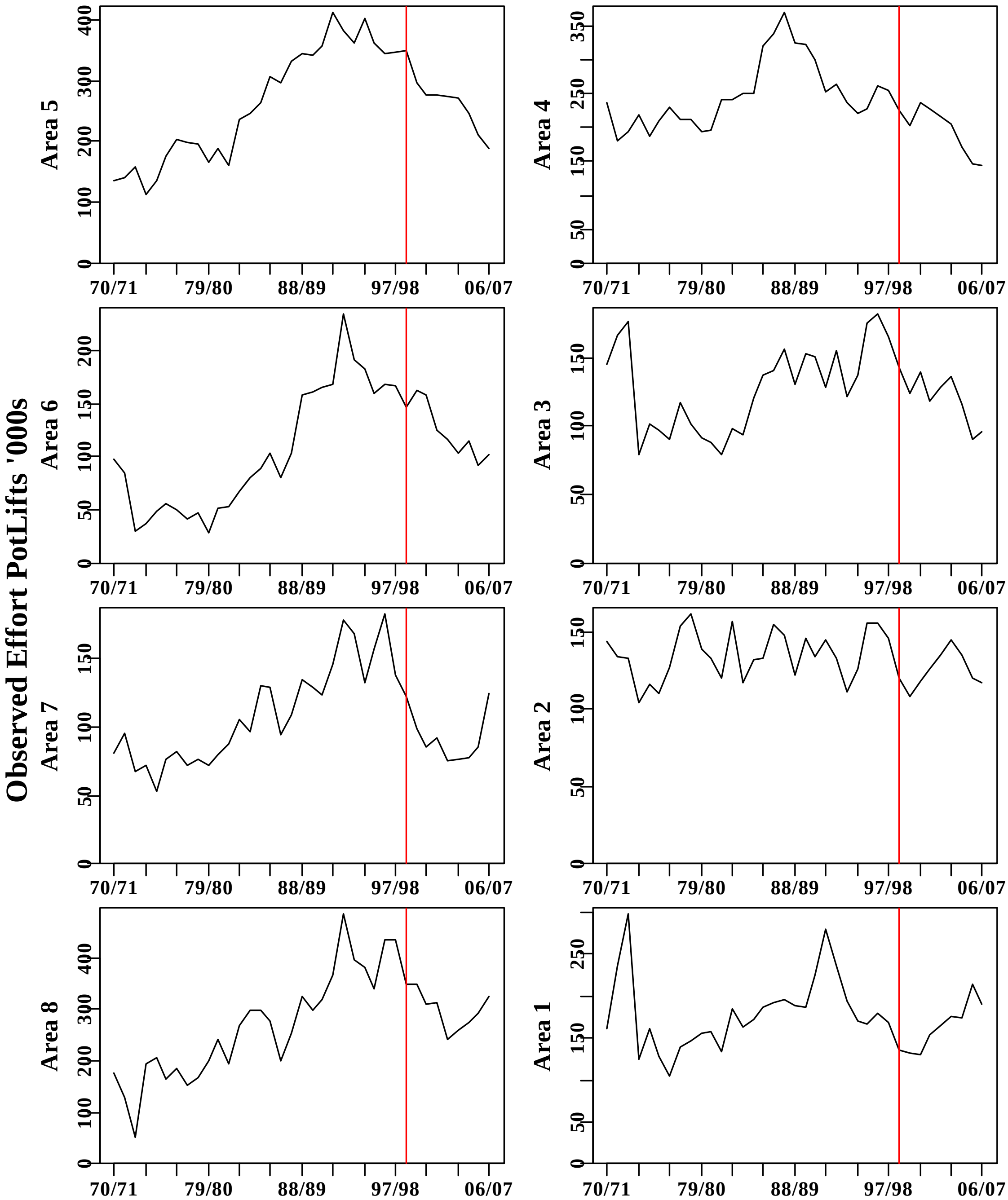

Figure 20. Annual total number of pot lifts as effort expressed in each assessment Area.

3.3.4 Trends in Depth of Fishing

Despite the relatively minor influence of depth category in the analysis of catch rate standardisation (see Appendix 1), depth clearly has an effect on catch rates as can be seen if catch rates are plotted against depth (Figure 21).

Catch rates are higher in deeper waters in Areas 4, 5, and 6 but an allocation of effort and catch to deeper waters only appears to occur in Areas 5 and 6 (Figure 21). In other areas there are slight trends in catch rates either up or down but the confidence intervals in the deeper areas are wide (because of a lack of observations). With depth plotted as metres details of effort distribution are visible with Areas 1, 5, 6, and 8 exhibiting significant activity in the 50m depth category; this tends to be obscured when fathoms are used as a measure of depth (Figure 21 and Table 3.7). Whether this activity relates to specific middle depth reefs is unknown.

In Area 6 there have been some changes in fisher behaviour with respect to depth of operation through time (Table 3.7, Figure 21). In all cases the number of records, the amount of effort (as pot lifts), and the amount of catch taken in 50 m or shallower has increased since the 1998/1999 quota year (the start of the quota system).

Prior to the introduction of the quota system there were signs of a shift to deeper water as catch rates and catches were higher at depth. Since the introduction of quota management the trend has been towards maximizing the value of the catch rather than maximizing the catch. To achieve this new objective it is more profitable for fishers to fish in shallower waters and obtain the optimum size and colour of rock lobster desired by the markets.

Table 3.7. Number of records and proportion of records, effort, and catch from Area 6 in greater than 50 m and less than or equal to 50 m.

Qyear	# Records <=50M	# Records > 50M	Records %<=50M	Effort %<=50M	Catch %<=50M
1994/1995	3101	2548	54.9	47.8	38.9
1995/1996	3068	2071	59.7	52.7	47.0
1996/1997	2952	2253	56.7	50.0	45.7
1997/1998	2275	2591	46.8	40.7	33.5
1998/1999	2384	1553	60.6	55.7	44.7
1999/2000	2298	1820	55.8	50.8	40.1
2000/2001	2424	1564	60.8	55.3	43.2
2001/2002	2061	1016	67.0	63.7	53.3
2002/2003	1804	918	66.3	63.2	53.4
2003/2004	1700	637	72.7	71.0	53.0
2004/2005	1791	851	67.8	65.1	53.2
2005/2006	1387	583	70.4	70.2	64.9
2006/2007	1445	621	69.9	70.6	63.1

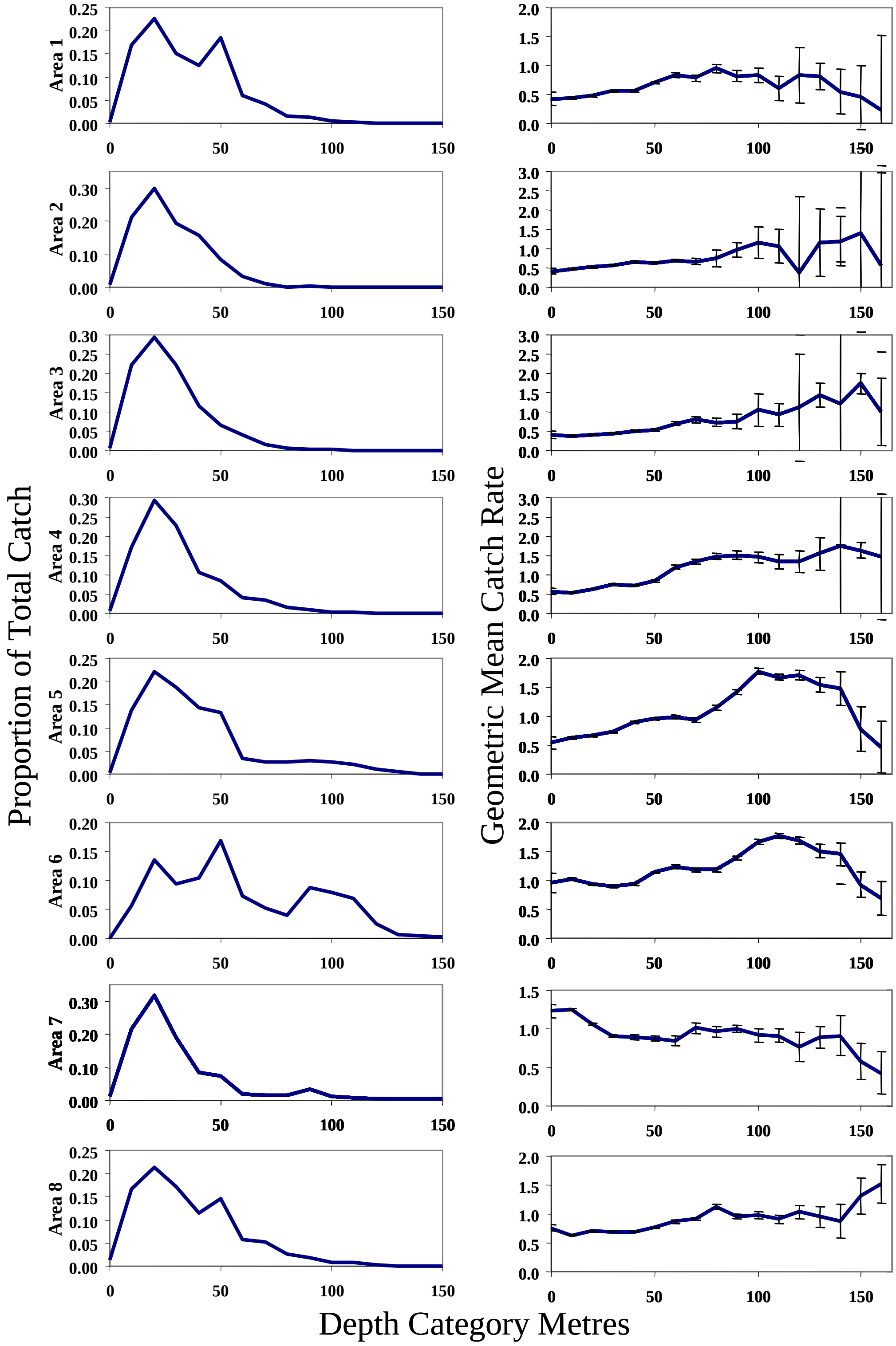

Figure 21. The proportion of the total catch and the geometric mean catch rate by depth category (10 metre steps) for each of the eight rock lobster stock assessment areas. In most Areas the catch rates in the deepest areas derive from very few data points, hence the wide 95% confidence intervals. Where the upper confidence bound is above 3.0 the graph is truncated to retain detail in the main body of the catch rate data. Data has been aggregated across all quota years from 1994/1995 to 2006/2007, but the patterns do not differ greatly between years, except in Area 6 (see Figure 22).

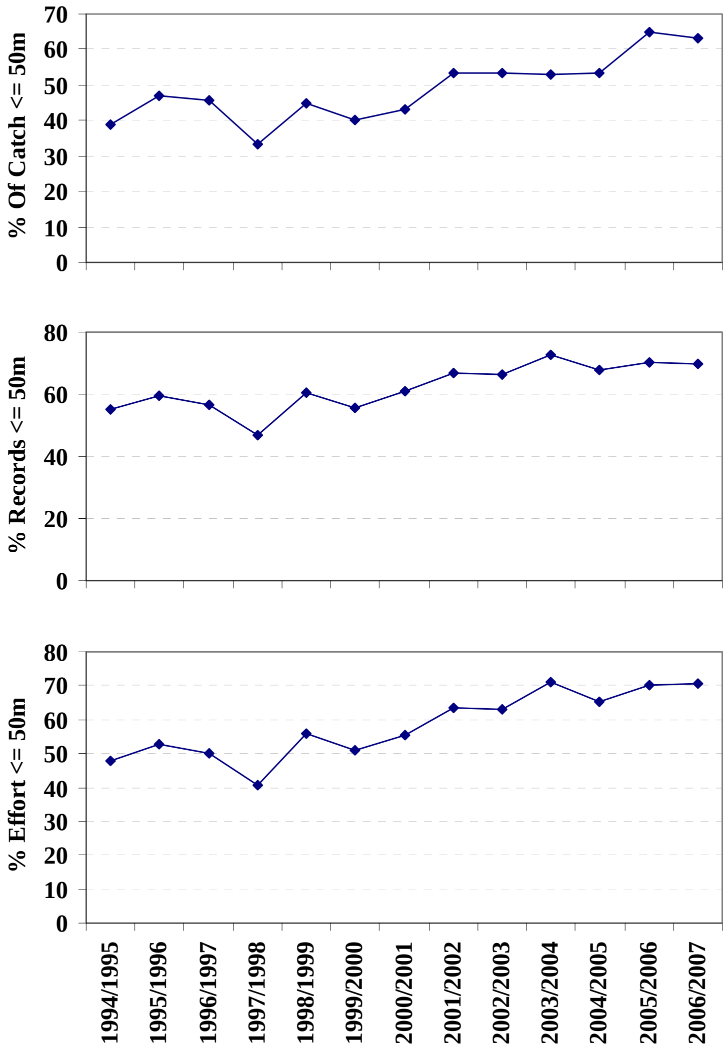

Figure 22. The proportion of effort (pot lifts), total catches, and number of records in Area 6 found in depth categories <= 50 m depth (*i.e.* <= 55 m). See Table 3.7.

3.4 Discussion

The behaviour of the rock lobster fleet continued to follow major trends, as depicted by the catch taken and effort applied in different assessment Areas. Catches in Areas 7, and 8 continued to rise, although catches in Area 1 have started to decline. Catches in Areas 7 and 8 were as high as they were in the mid-1990s. In Area 2 the catches continued their slight decline whereas in Area 3 they increased slightly. In Areas 4, 5, and 6, however, catches have continued to decline with catches in Area 4 reaching record low levels and catches in 5 and 6 being very low relative to their history.

These fleet dynamic changes were partly reflected in the catch rate indices. Important changes have occurred in 2006/07. In the southern Areas 1, 2, 7, and 8, the geometric mean catch rates all either declined or stopped increasing. In the case of Areas 1, 2, and 8 the standardizations effectively followed the trends exhibited by the geometric mean catch rates. However, in Area 7, the standardization indicated a continued strong increase in catch rates, in contrast to the simple geometric mean catch rates. In the northern Areas 3, 4, and 5, both geometric mean and standardized catch rates either increased slightly or became effectively static, which reverses the trends from last year. These changes appear to be the effect of reduced catches being taken from the north, although in Area 3 effort and catch slightly increased as well so this change in catch rates may be a positive sign. While catch continued to decline in Area 6 effort increased slightly and both geometric mean and standardized catch rates were down on 2005/06.

Although all areas have exhibited a marked improvement in catch rates since 1994/1995 the process of rebuilding appears to have stalled in many of the assessment areas, with Area 7, and possibly Area 3, as exceptions.

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 parts of Tasmania, especially in Region 5, which could obscure trends in catch rates. The logbook is being redesigned to capture this information in future years.

3.4.1 Management Advice

Effort remains high in Areas 1, 7, and 8 with standardized catch rates remaining high in these areas. Catches in the two south-western areas continues to increase strongly (7 and 8). The recruitment pulse in Area 7 may still developing but that apparent in Areas 1 and 8 appears to have fully entered the fishery and catch rates in Area 8 may now be expected to drop unless more recruitment has occurred.

In the northern four assessment areas catches remain low. The standardized catch rates appear to be improving slightly in response but this is not evidence for continued rebuilding but is rather a sign of the fleet avoiding relatively weak areas. The northern four assessment Areas should remain of concern, especially Areas 4, 5, and 6. If the model predicts similar things are happening to the exploitable biomass then the concern should become real and would presumably be a reflection of relatively poor recruitment settlement in the northern Areas. Such a disparity in fishery performance between the north and the south would be likely to drive the continued radical change in fleet dynamics observable in the distribution of catches between the areas through time. If these trends continue then some form of explicit spatial management may become a necessity.

3.5 Research Catch Rates

Currently the coverage and number of observations available for characterizing catch rates from research sampling are marginal, leading to results that may not strictly be comparable from year to year. If the level of sampling can increase in the future then this performance measure may become valuable but presently it fails to provide useful information and is being omitted from consideration.

3.6 Biomass

Estimates of legal sized biomass are produced for the start of the month of November. Although this is not the start of the quota year November is used because stocks then represent the status at the opening of the fishing season following the September/October closure, when moulting and growth is common. Estimates of current legal sized biomass from the new rock lobster model are exhibiting rather mixed signals that are being affected by the relatively low catches being taken from the northern areas. Thus, in areas 4 and 5 the model indicates some slight increase in legal biomass in the most recent year. However, rather than representing stock rebuilding this appears to be more a result of continued reductions in catches combined with ongoing growth of lobster still present. Legal biomass in Area 6 has continued to decline, whereas Area 3 exhibited a slight increase, which, in this case, may constitute minor signs of rebuilding (as catch and effort had increased over that seen in 2005/06). The model also indicated there were changes in the southern four areas. Legal biomass in Area 1 declined sharply in 2006/07 whereas in Area 2 the stock remained relatively stable. Area 7 continued to increase significantly whereas Area 8 appears to have reached a plateau. With respect to the legal biomass present in November in 2005/06, state-wide there was an increase in 2006/07 by a minimum of 3.5%, however, not all areas had increased. Area 1 decreased by 13.9% and area 6 by 5.2%, but Areas 3, 5, and 7 all increased by about 10% (Table 3.8; Figure 23).

All areas continue to show a marked increase in legal biomass relative to that estimated for the reference year (1993/94; 13 years earlier). It is clear that there has been significant rebuilding, especially in areas 1 to 4, 7 and 8. With an overall increase of 20.5%, Area 6 has the lowest increase of all areas since 1993/94 (Table 3.8). The spikes in recruitment seen in areas 1, 7, and 8 in recent years relates directly to the increases these areas are exhibiting now (Figure 24). Conversely, the low levels of recruitment in areas 3, 4, 5, and 6 reflect the lowered catches and catch rates from those areas.

The model is fitted to catches of legal sized lobsters and catches rates, with the catch rates providing the index of relative abundance through time. This means that estimates of recruitment can only be determined once the animals have grown into the minimum legal sizes (105 mm for females and 110 mm for males) from the size of recruitment represented in the model (60 mm). For this reason the recruitment levels in the most recent years appear to revert back to the average due to the fact that it takes several years for new recruits to enter the legal sized fishery. Because growth rates differ so much around the State each assessment area has a different time-lag between recruits entering the modelled stock at 60 mm and the animals growing into legal sizes. It takes the longest in Area 8 and the shortest time in Areas 4 and 5.

Absolute recruitment levels are very variable around the State with very high average levels occurring in Area 8 and the lowest average levels occurring in Areas 3 and 6 (Table 3.9; Figure 25).

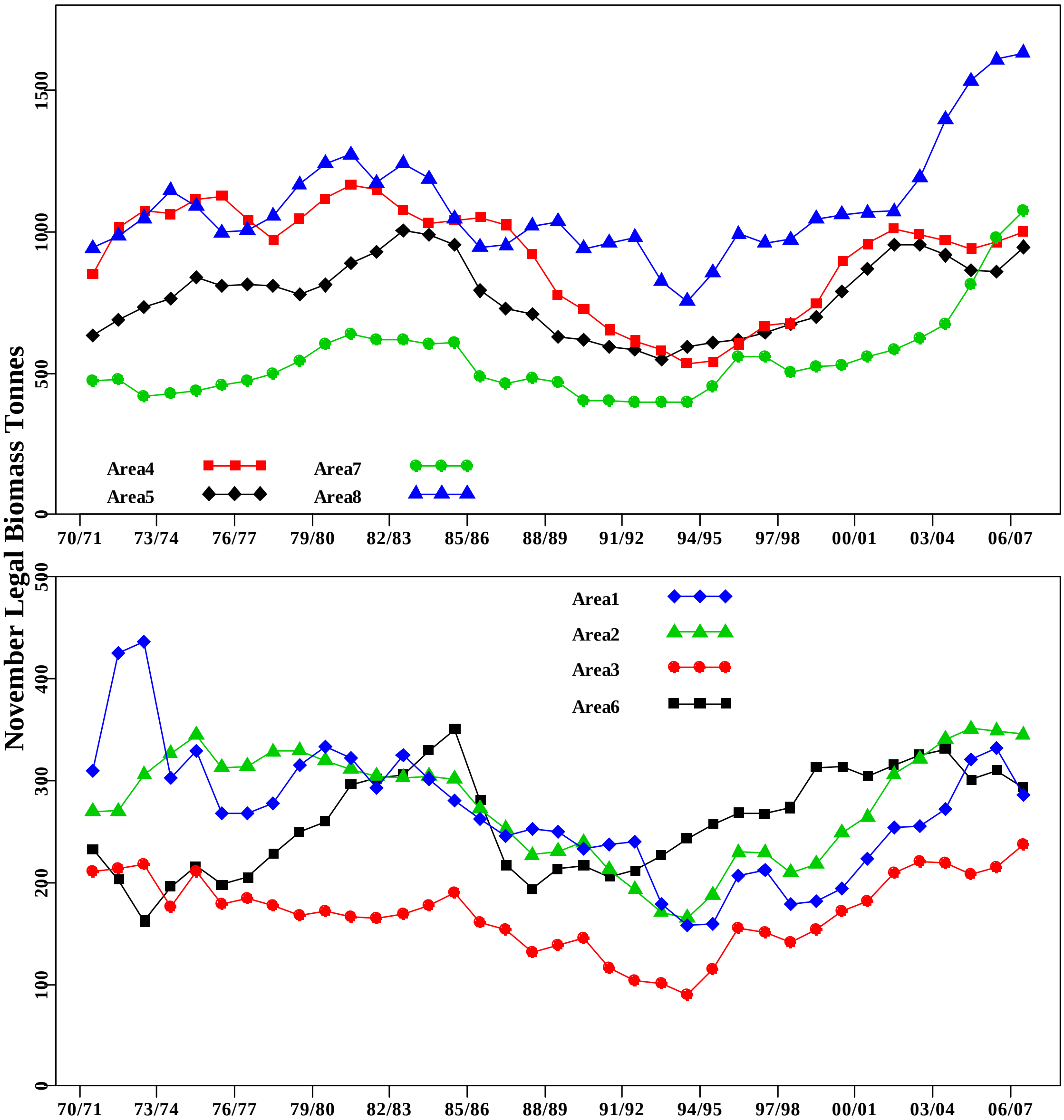

Figure 23. Legal-sized biomass estimates for the rock lobster fishery from 1970/71 to 2006/07. Note the plots have different vertical scales. Total legal-sized biomass in Areas with large amounts of reef such as Areas 5 and 8 is mainly a function of size of habitat. Note that for recent years the biomass has remained stable rather than rebuilding in areas 3, 4 and 5.

Table 3.8. Change in legal-sized biomass in November.

Area	Ref Year	Sized biomass estimate (tonnes)			% change in 2006	
		Ref. Year	2005	2006	vs Ref. Year	vs 2005
Statewide	1993/94	2930	5612	5807	98.2	+3.5
1	1993/94	157	332	286	81.8	-13.9
2	1993/94	165	348	345	108.7	-1.0
3	1993/94	90	214	236	163.6	+10.2
4	1993/94	533	963	999	87.2	+3.7
5	1993/94	593	859	945	59.5	+10.0
6	1993/94	243	309	293	20.5	-5.2
7	1993/94	396	978	1075	171.5	+9.9
8	1993/94	753	1607	1628	116.2	+1.3

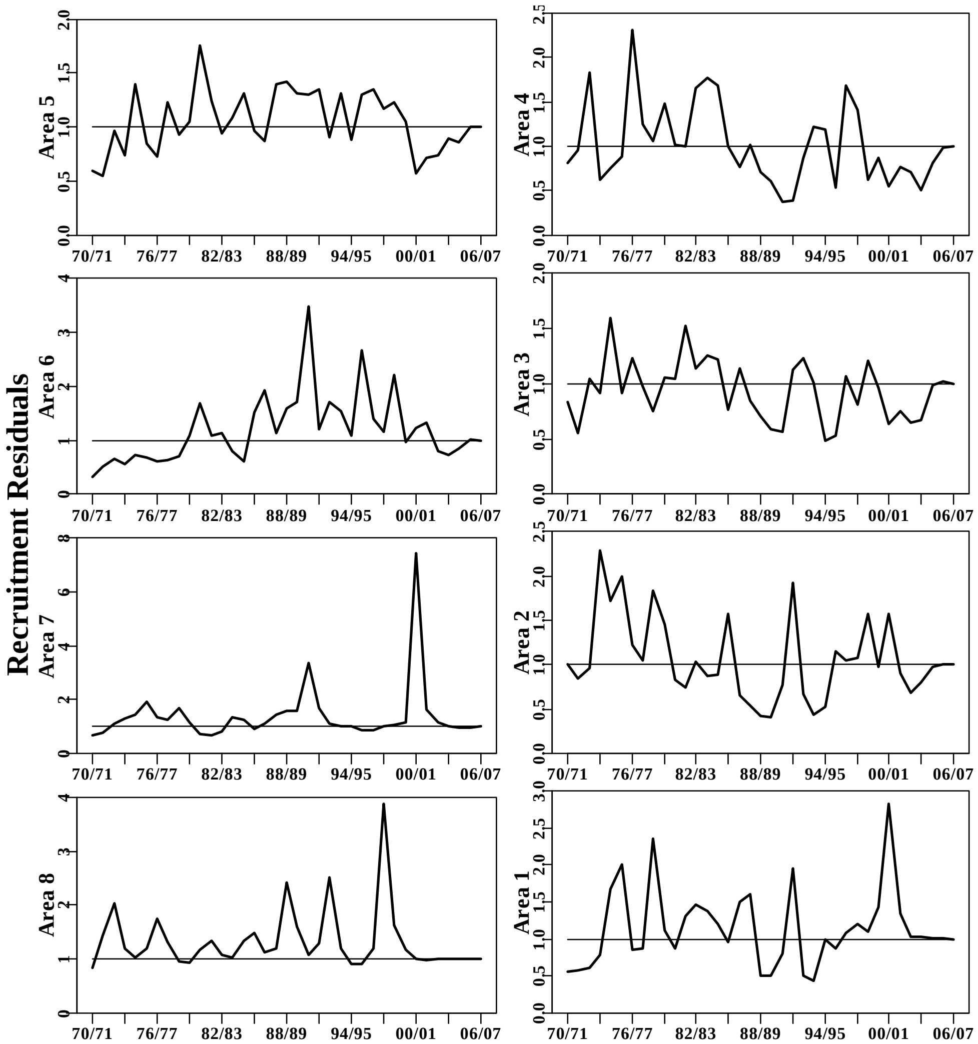

Figure 24. Recruitment residuals illustrating the relative recruitment strengths within each region through time. The absolute predicted recruitment levels are very different in the different assessment areas (see Figure 25).

3.7 Egg production

Relative egg production has been declining slowly for the last two or three years (Table 3.10 and Figure 26) and production declined in the 2006/07 year by another 0.6% (Table 3.10). Area 6 declined the most in the past quota year, falling by -5.2%. Areas 5 and 6 are both producing less than the Limit Reference Point of 25% of unfished production, with Area five only producing 14.9% of unfished levels (Table 3.10).

Egg production remains most depleted in the four northern Areas (3, 4, 5, and 6). All northern Areas have improved levels of egg production relative to the reference years, by 30% or more, but, typically, this was relative to a very low base (Table 3.10). The overall improvement across the State is only about 17 % since 1993/94 because so much of the total egg production is by sub-legal females in the south that are essentially unaffected by changes in management (Table 3.10).

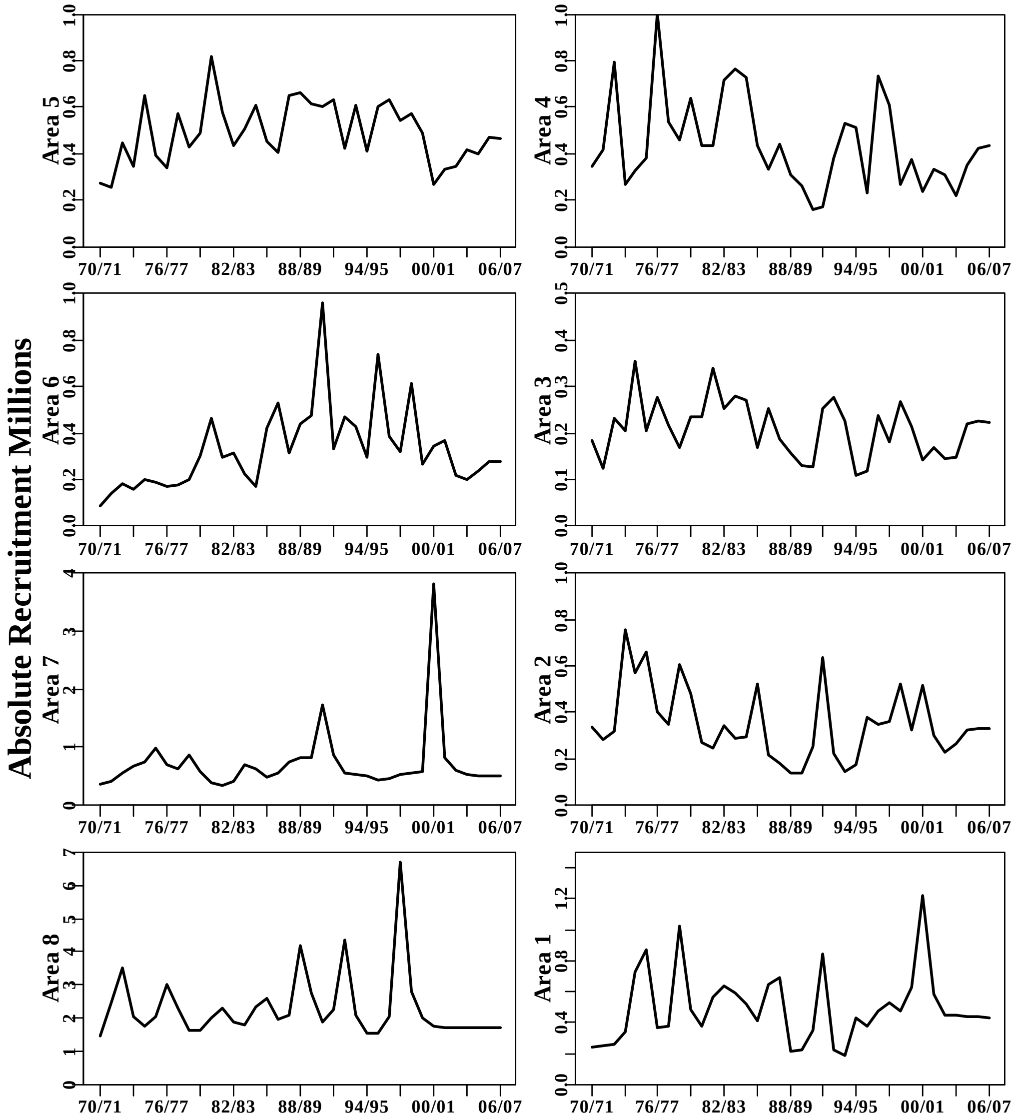

Figure 25 Absolute recruitment levels within each region through time. Note the y-axes vary greatly (Table 3.9).

Table 3.9. Geometric mean of absolute recruitment in each assessment area (date from 1970/71 to 2006/07).

Area	Recruitment	% of Area 8
1	450544	20.81
2	322547	14.89
3	201189	9.29
4	403127	18.62
5	473370	21.86
6	292303	13.50
7	625233	28.87
8	2165482	100.00

Three out of four northern Areas remain below the threshold of 25% of virgin egg production, though for Area 4 this is only just 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 contribute most significantly to the recruitment dynamics of the stock there remain concerns about those northern areas that remain with egg production below 25% of virgin production.

Table 3.10. State-wide 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 a measure of the absolute number of eggs produced.

	Ref.	Relative Egg Production			Virgin	% Change vs		% Virgin Prod.
Area	Year	Ref. Year	2005/06	2006/07	Egg Prod	Ref. Year	2005/06	in 2006/07
State	1993	1933	2273	2257	4290	+16.76	-0.7	52.6
1	1994	202	233	230	302	+14.13	-1.3	76.4
2	1992	101	140	140	288	+38.74	-0.5	48.5
3	1992	50	66	71	285	+42.02	+7.0	24.9
4	1993	112	169	172	728	+53.76	+1.5	23.6
5	1992	70	125	135	920	+91.35	+8.0	14.6
6	1986	57	79	75	421	+31.51	-5.9	17.7
7	1988	265	439	429	417	+61.75	-2.2	102.8
8	1994	973	1021	1005	929	+3.32	-1.6	108.2

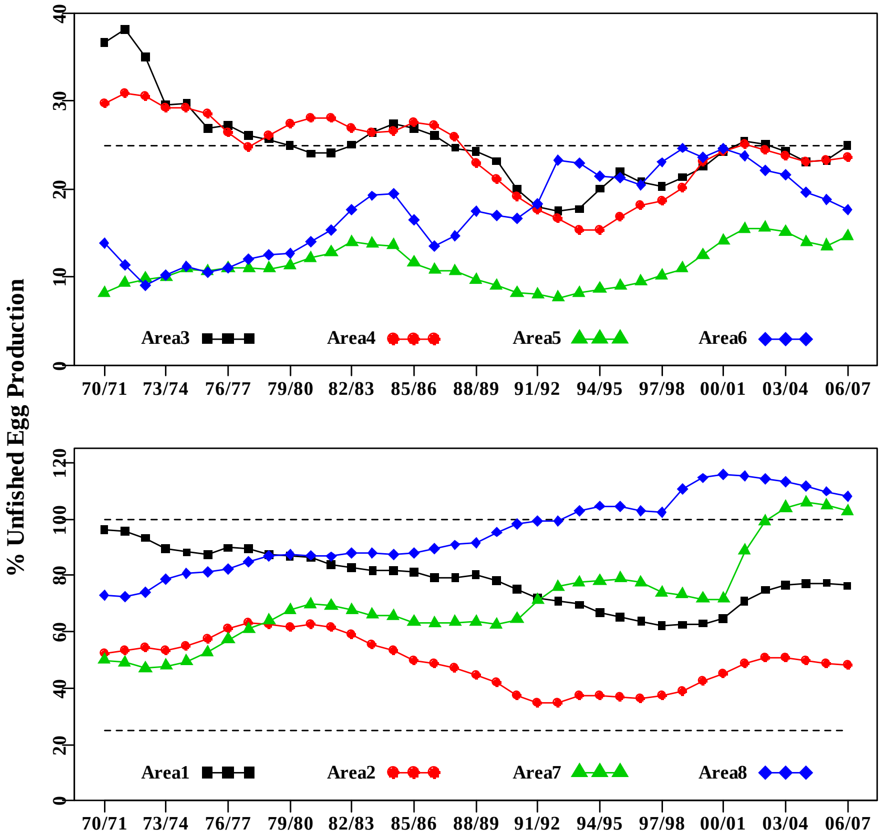

Figure 26. Percentage of virgin (unfished) egg production from eight Areas around Tasmania. The horizontal dashed line in each plot represents the management target of 25%, in the bottom panel 100% is also indicated.

The value of egg production as a guide for management is often debated by industry as there is uncertainty about the fate of larvae produced in different regions. This issue was addressed in an FRDC funded project 2002/007 by Bruce *et al.* (2007). It showed that although larvae could self-recruit to most regions around Tasmania, the relative importance of areas differed. Eggs produced in the NW had the lowest probability of contributing to stocks as they could be lost into the shallow waters of Bass Strait. Larval production from outside Tasmania was also important, especially that produced in SE South Australia.

There is also debate about the appropriate target level for egg production. The 25% target used in Tasmania is different to that used in Victoria (20%) and South Australia (no formal limit, but management consider the current level of ~12% to be acceptable).

3.8 Mature Biomass

Mature biomass has been reducing State-wide for the last few years (Figure 27) and this is now reflected in the total egg production, which also decreased this year. This relationship is not simple because the exact size distribution of females also influences exactly how many eggs are produced (Figure 28). However, with the declining mature biomass, if no further recruitment occurs then further state-wide reductions in egg production can be expected.

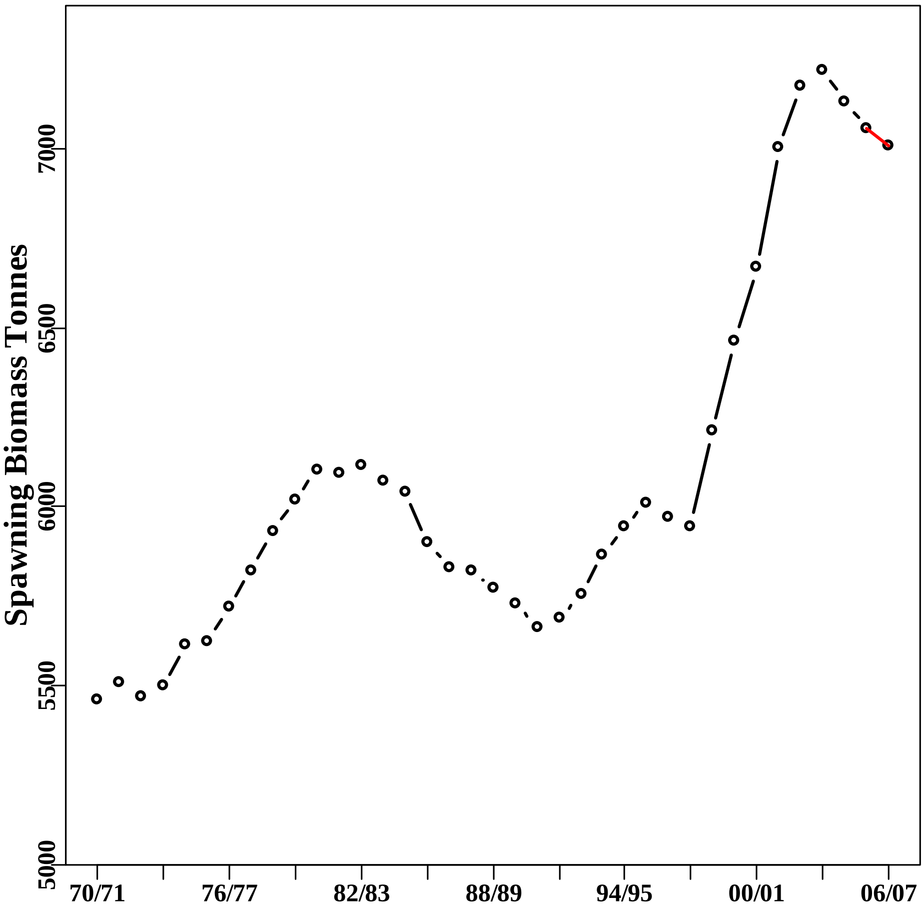

Figure 27. Total State-Wide female spawning biomass at the end of the October period. Note the Y-axis begins at 5,000 tonnes.

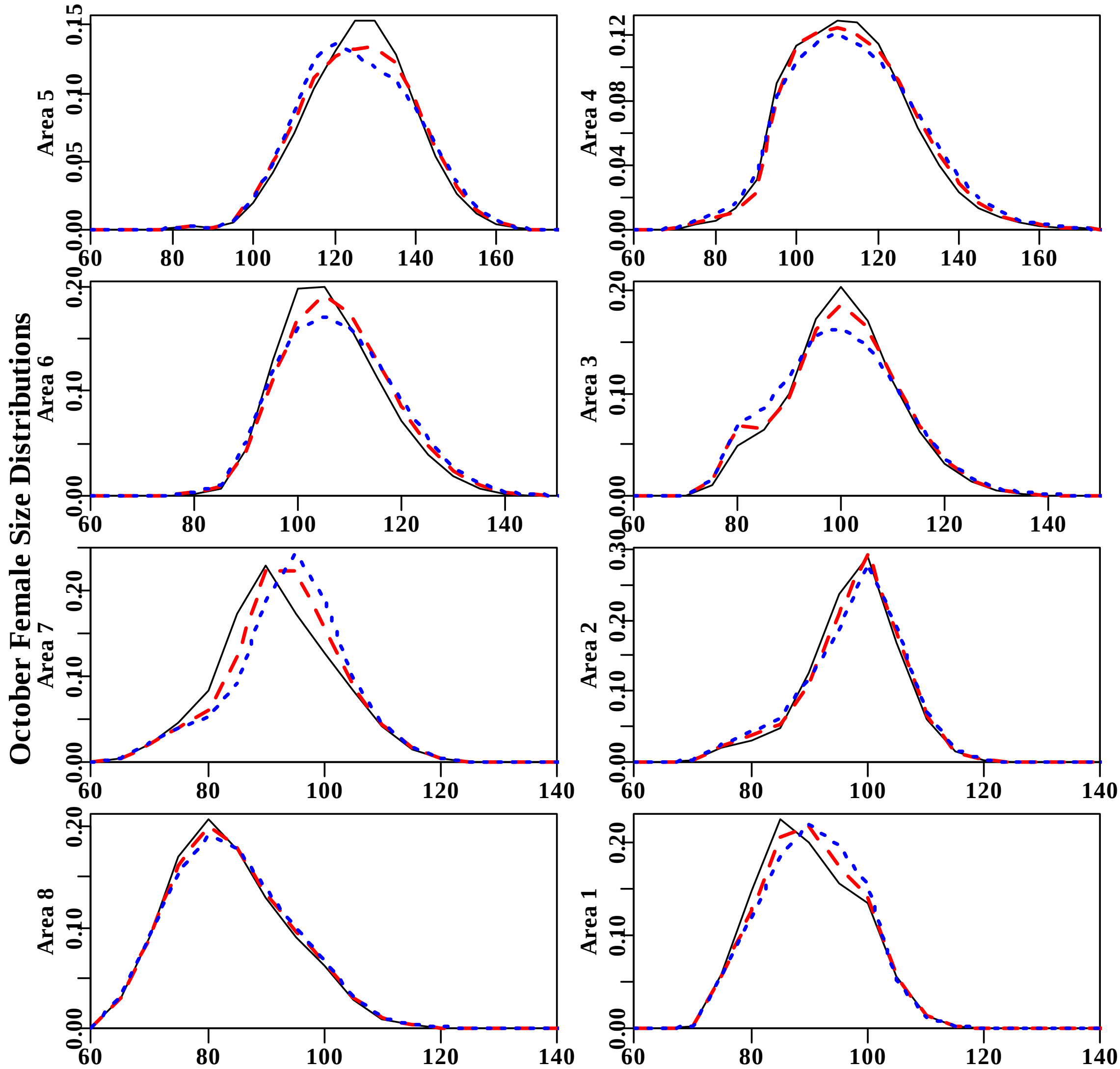

Figure 28. Female size distributions for 2004/2005 (fine black solid line), 2005/2006 (thicker red dashed line) and 2006/2007 (dotted blue line). The balance between increases or decreased relative abundance and the fecundity at size is what changes the relative egg production. The reduction in mature biomass in Area 5 and its increase in Area 7 is apparent from the ordering of the three lines.

3.9 Active Licenses

The number of active licences is assumed to be less than or equal to the number of active vessels (defined as those vessels reporting any catches of rock lobster). A Limit Reference Point of 220 active licences has been put into place and the number of vessels reporting any catches was 214 in 2006/2007 (Figure 29; Table 3.11). It should be noted that this is below the Limit Reference Point for the fishery but no consequent management action has been defined.

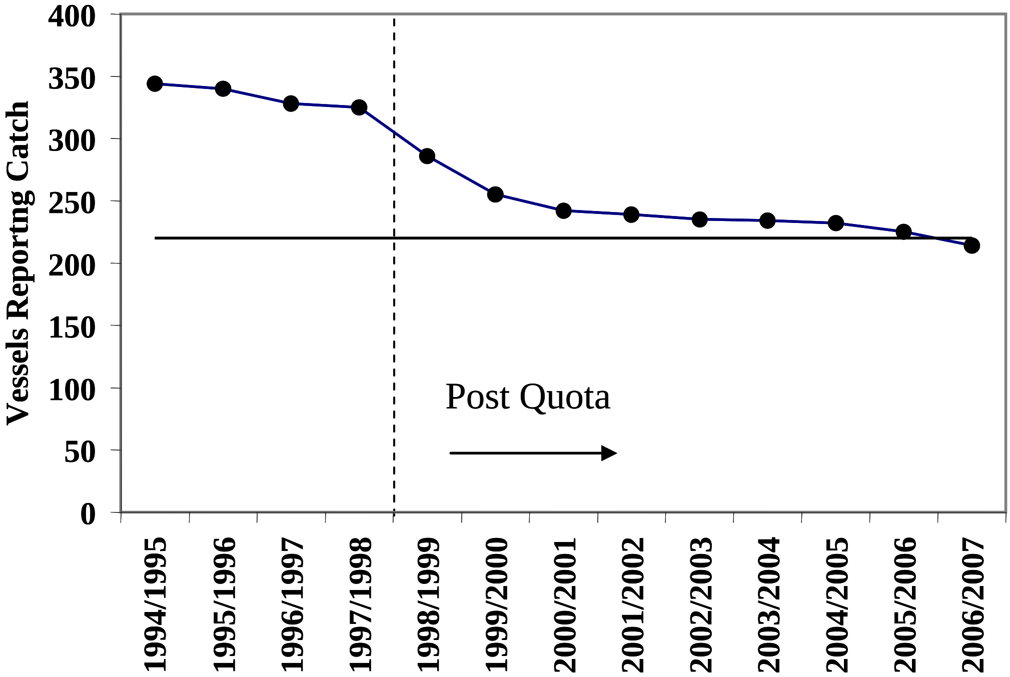

Figure 29. Number of vessels around the State reporting any rock lobster catch. The fine black line is the Limit Reference Point (220); see Table 3.11.

Table 3.11. Number of active vessels reporting any catch of rock lobsters across the State.

Quota Year	Total
1994/1995	344
1995/1996	340
1996/1997	328
1997/1998	325
1998/1999	286
1999/2000	255
2000/2001	242
2001/2002	239
2002/2003	235
2003/2004	233
2004/2005	232
2005/2006	225
2006/2007	214

3.10 Mean Weight

The mean weight of lobsters in catches has slowly been increasing through time since minimum values occurred sometime between the mid-1990s and the late 1990s (Figure 30). This is a complex performance measure to interpret because a reduction could be due to both overfishing of larger lobsters or the influx of large numbers of recruits.

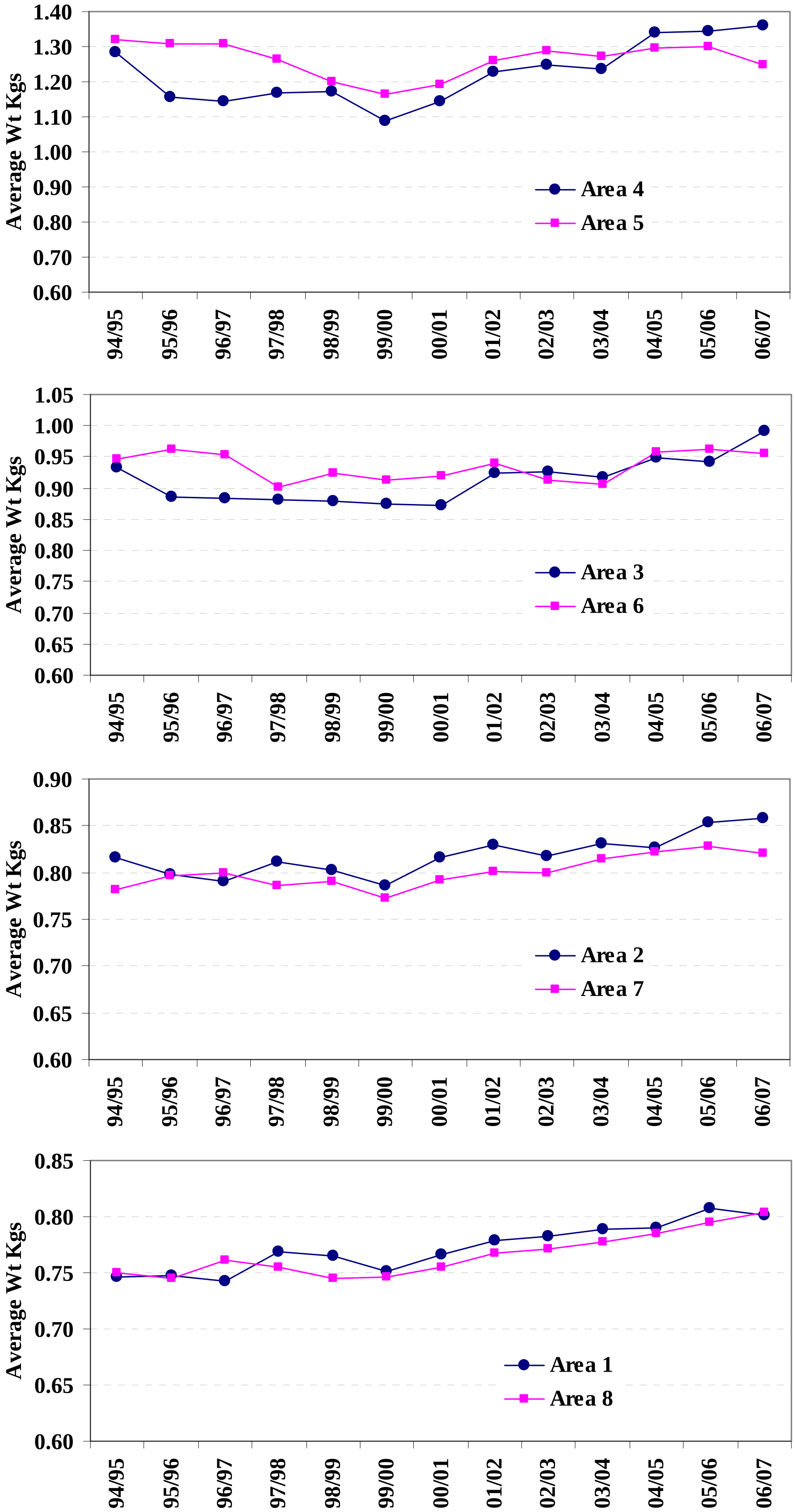

Figure 30. Average weight as kg, by each quota year and assessment area. Each latitudinal pair of assessment areas are illustrated on separate graphs. Since a minimum in each assessment areas during 1999/2000 there has been a slow increase in average weight in each area.

3.11 Recruitment monitoring

Settlement of puerulus is monitored at several sites along the southern Australian coast as part of pre-recruit monitoring programs at TAFI, SARDI and DPI Victoria. Puerulus collectors are designed to mimic natural rocky reef with crevices that provide shelter for puerulus swimming in to shore from oceanic waters.

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.

Catch rates of puerulus have exhibited some interesting regional patterns with a consistent pattern of increase from 2001/02 to 2002/03 then a fall the following year (2003/04) at most sites. Since then, there has been a divergence between SA and Western Victoria compared with Eastern Victoria and Tasmania. Sites in South Australia and Port Cambell have been trending upwards over the last few years to reach record highs, while catches off eastern Victoria and Tasmania have been trending down towards record lows.

Bruce et al. (2007) concluded that larval supply from SW South Australia is especially important for larval recruitment across this region. The change in patterns that have occurred over the last few years may be due to change in currents dispersing larvae from this region. That is, larval dispersal eastwards may have been virtually blocked over the last few years with greater retention of larvae in western areas.

The low level of recruitment along eastern Tasmania over the last few years is of concern, although some recovery may have occurred at Recherche Bay in the last period. (Figure 31). A number of years will need to pass for these new recruits to the stock grow to become legal sized. If the puerulus levels are indicative of future recruitment to the legal fishery then these results suggests that the outlook for rebuilding on the east coast is poor for the next few years. Certainly the lack of recruits in recent years suggest that rebuilding may be less positive than indicated in the risk assessment shown in Section 4, which relies on a continuation of average recruitment levels (with added noise).

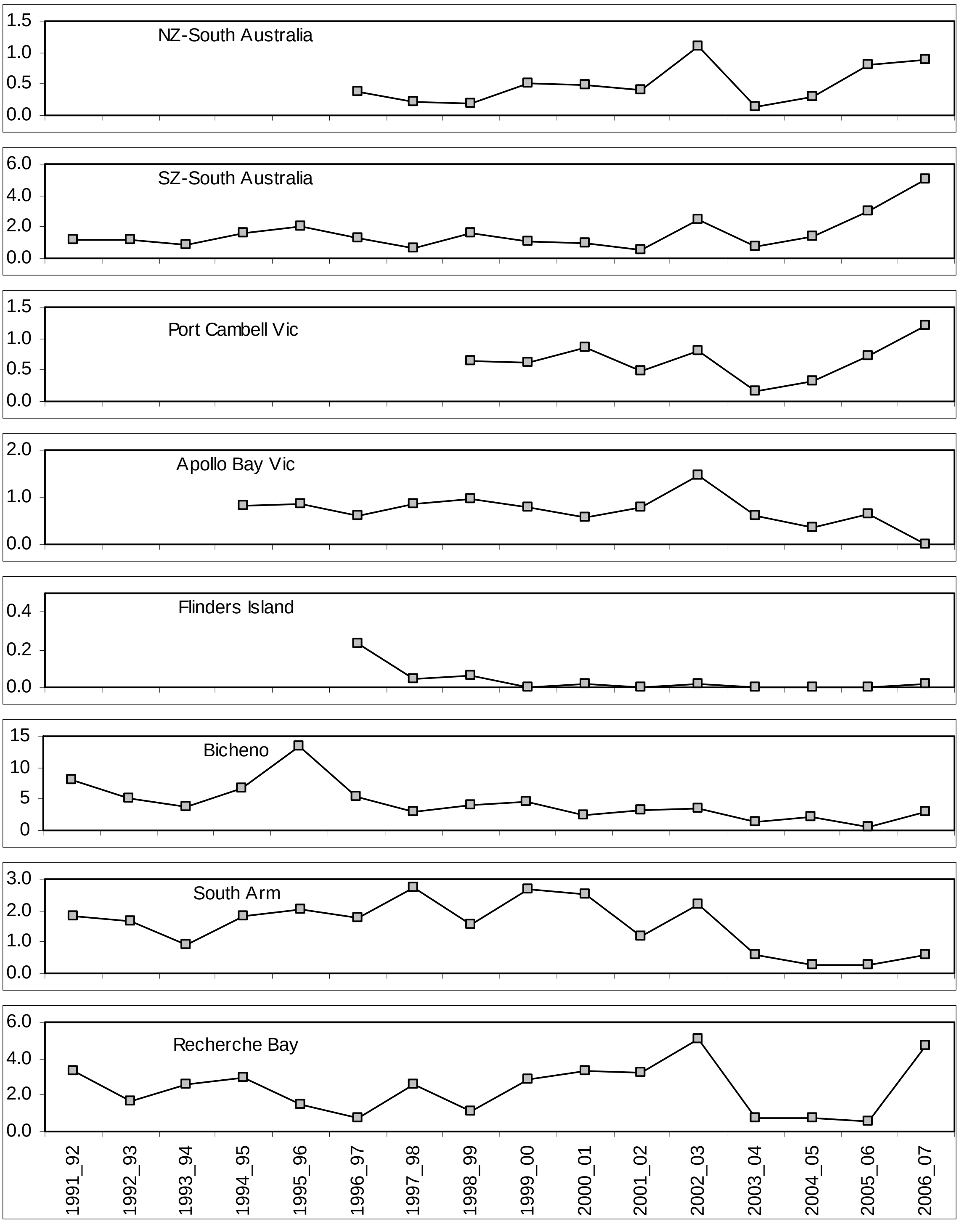

Figure 31. Puerulus catches from long term monitoring sites across southern Australia. Units are the average number of puerulus per individual collector check. "Pueurlus years" run from July to June, excluding low catch months where collectors are not serviced (Bicheno –March to June; South Arm – March to May; Recherche Bay – April to June). South Australian and Victorian data provided by Adrian Linnane (SARDI) and David Hobday (DPI Victoria).

4 Risk Assessments

4.1 Biomass

Risk assessments for the fishery were conducted by projecting the dynamics of the stock forward under different TAC arrangements and determining the consequences. These projections are based upon randomised recruitment series which reflect the previous observed recruitment levels. If such projections are repeated many times it becomes possible to ask questions such as what proportion of the projections indicate that the legal biomass in 2011/12 will be greater than or equal to the legal biomass in 2006/07, given a particular TAC. If the result is 50% or less this suggests that the chance of continued stock rebuilding is equal to or less than the chance of the stock declining (Table 4.1).

Table 4.1. Probability of the legal sized biomass in 2011/2012 being greater than the legal biomass available in 2006/07 with a TAC at the current level of 1523 t.

Assessment Area	Probability of $B_{2011/12} > B_{2006/07}$ (%)
Area1	71.6
Area2	40.6
Area3	65.6
Area4	94.0
Area5	66.0
Area6	58.4
Area7	51.0
Area8	67.6

The modelling process involved in the risk assessments also needs to consider how the catch will be distributed around the State. The current strong trends in the fleet dynamics continue to be driven by singular recruitment events in the south combined with a lack of recruitment in the north, but the projections rely on average recruitment patterns and do not necessarily reflect the particular pattern presently seen (Figure 24). Whether future recruitment really will reflect the average behaviour exhibited over the last decades will only be known after it has happened. However, the puerulus sampling project has failed to find significant numbers of puerulus on the east coast for at least the years 2003/04, 2004/05 and 2005/06, although there were good catches of puerulus in the south (the boundary of Areas 1 and 8) during 2006/07. Despite this most recent year, if the lack of puerulus indicated limited future recruitment to the legal sized fishery then the weak years suggest that the projections may well be overly optimistic.

Given those provisos, State-wide legal biomass appears likely to continue to rebuild over the next five years (Figure 32). However, such increases need not occur in every assessment area (Figure 32 and Figure 33). Note that in the projections for the individual assessment areas the 90% percentile confidence intervals tend to be wider reflecting the greater uncertainty when only single areas are considered. In many cases the lower bound includes the possibility of the stock becoming smaller rather than larger.

The model outputs suggest that in all assessment areas the chance of the stock in 2011/12 being greater in size than the 2006/07 quota year is always greater than ~60% except in Areas 2 and 7 where it is only 40% and 50% respectively (Table 4.1). Some areas exhibiting much higher chances of rebuilding, especially areas 4, 1, and 8. Under current conditions the areas with lowest probability of rebuilding are areas 2, 6, and 7. Part of the reason for the lower value in area 6 is that recruitment variability in that area is greater than elsewhere. This is a result of the expansion of the fishing grounds into deeper water in the mid-1980s. The model interpreted this as a simple increase in stock size and could only account for this by increasing the apparent recruitment levels. While Table 4.1 suggests that there is a high likelihood of stock rebuilding in most areas with the current management strategy, it is important to note that the model outputs have historically erred towards more positive predictions.

The outcomes of the risk assessment are sensitive to the fleet dynamics assumed for the projections. It would be possible to redistribute the catch so that some of the rebuilding in some areas would be reduced but this would improve the chances of stock rebuilding in other areas. The fleet dynamics are not completely predictable, as was seen this year when catches continued declining in areas 4 and 5 despite catch rates improving slightly.

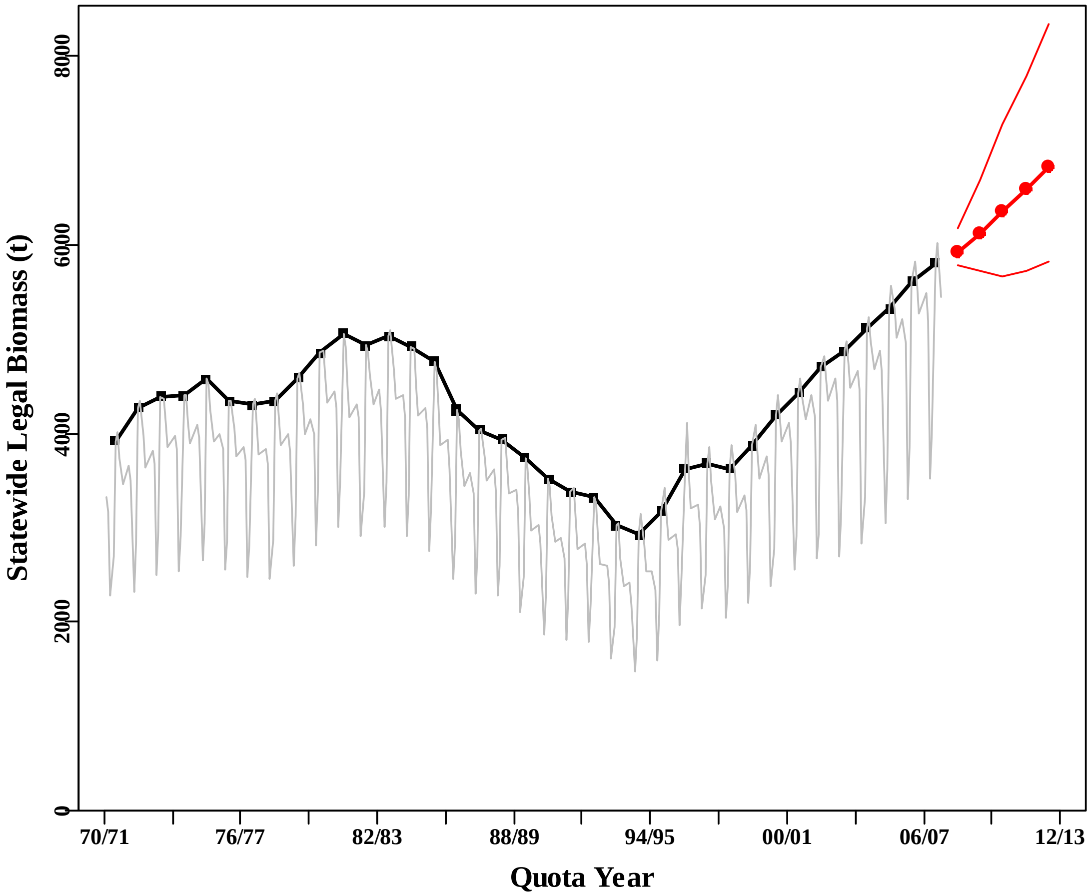

Figure 32. The State-wide legal biomass in tonnes at the end of November from 1970/1971 to the present and projected forward five years until 2011/2012. The central thick line is the expected median legal biomass with the current TAC of 1,523t The outer projection lines are the upper and lower 90% percentile confidence bounds on stock size from a TAC of 1,523 t. The fine grey line relates to Legal Biomass throughout each quota year.

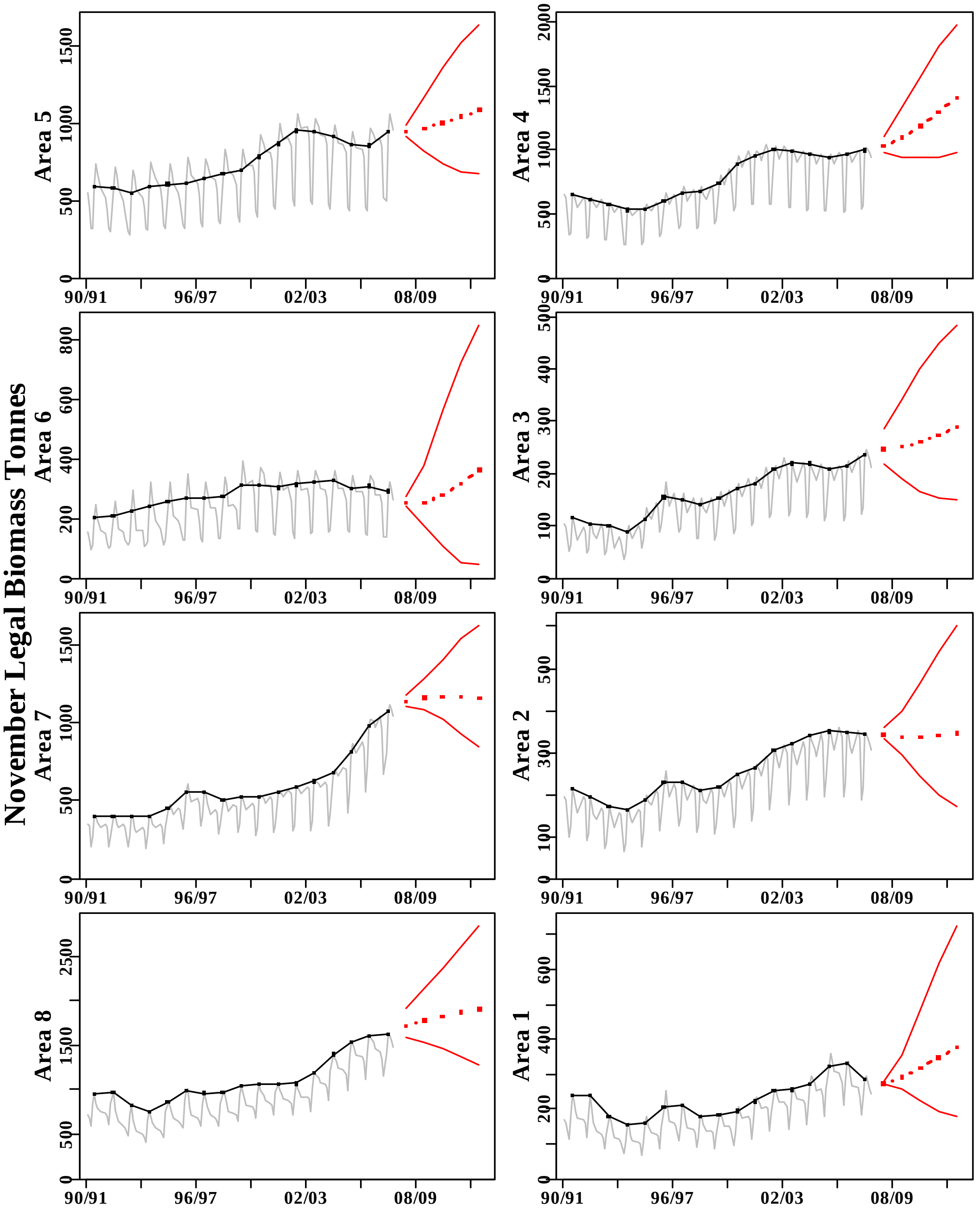

Figure 33. Risk assessment projections of legal biomass of Tasmanian rock lobster for the more recent quota years and all assessment areas. The points in the historical portion represent the November legal biomass. The projected points represent the median predicted legal biomass and the fine lines surrounding these are the 90% percentile bounds on predicted legal biomass given a TACC of 1,523 t. The fine grey line represents the exploitable legal biomass in all eight periods of each quota year. These projections assume that recruitment patterns in the future reflect those observed since 1970/1971. The distribution of catches is similar to 2006/2007 except about 5% more is taken from Area 7 and this amount is reduced from areas 1, 5, and 6.

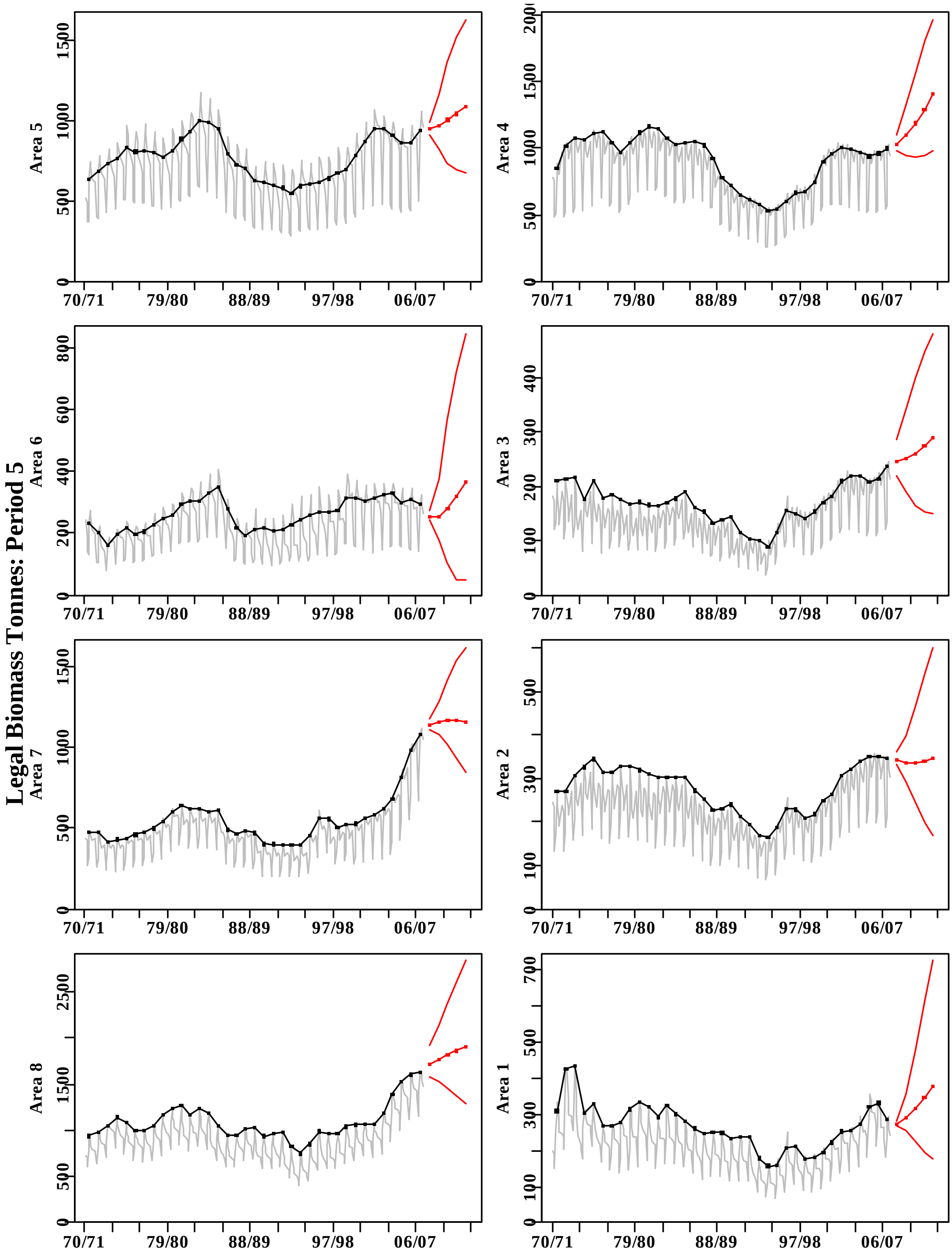

Figure 34. Legal Biomass at the end of November each quota year combined with five years of projection under a TAC of 1,523 t. This repeats information shown in Figure 33 but over a longer time series.

Table 4.2. Estimated probability (%) that the legal biomass at the end of November in 2011/2012 will be greater than the legal biomass at the end of November in 2006/2007 under different levels of Total Allowable Catch (TAC).

The fleet dynamics are assumed to be the average behaviour of the fleet in the last four years. Values less than 60% are bolded.

Area	TAC 1475	TAC 1500	TAC 1523	TAC 1550	TAC 1600
1	78.4	75.0	71.6	67.2	62.0
2	**45.2**	**42.2**	**40.6**	**39.2**	**35.2**
3	70.2	68.0	65.6	62.0	**53.8**
4	95.4	95.2	94.0	93.2	91.8
5	75.2	71.0	66.0	61.2	**52.2**
6	63.8	60.8	**58.4**	**55.2**	**51.4**
7	**55.2**	**52.6**	**51.0**	**46.8**	**41.8**
8	70.6	69.2	67.6	65.6	61.8

5 Ecosystem Based Management

5.1 Protected Species Interactions

Protected species interaction data is collected through the commercial logbooks and also through research sampling, which provides validation of logbook data.

Research sampling data on protected species interactions has traditionally recorded only significant interactions where the protected species was harmed.

A total of seven harmful interactions with protected species have occurred in research sampling from 1990 to the end of 2007, each involving the drowning of a cormorant. This has occurred with a total of 69441 potlifts and thus represents an incidence of around 0.000101 cormorant deaths per potlift in research pots. If similar rates were experienced by commercial and recreational fishers then the average annual number of cormorant deaths in lobster pots would be around 140 (given estimated potlifts). This estimate presumably significantly overstates probable cormorant deaths as research sampling is biased to shallow water.

Reporting of benign interactions with protected species in research sampling commenced in 2007 and insufficient data is available for analysis at this stage. Most interactions have involved seabirds eating discarded bait or dolphins riding the bow-wave.

The number of reports of interactions by fishers increased in 2006/07 to the highest level in the 4 years of data recording (Figure 35). The need for better compliance with protected species reporting was emphasised at port meetings in that year and this message seems to have translated to more records - a positive development.

Over the last year a revised logbook was introduced to the commercial fishery which facilitated better protected species data recording. The database for this revised data was nearing completion at the time of preparation of this report. This will enable information on the species and nature of interaction to be summarised in the next assessment.

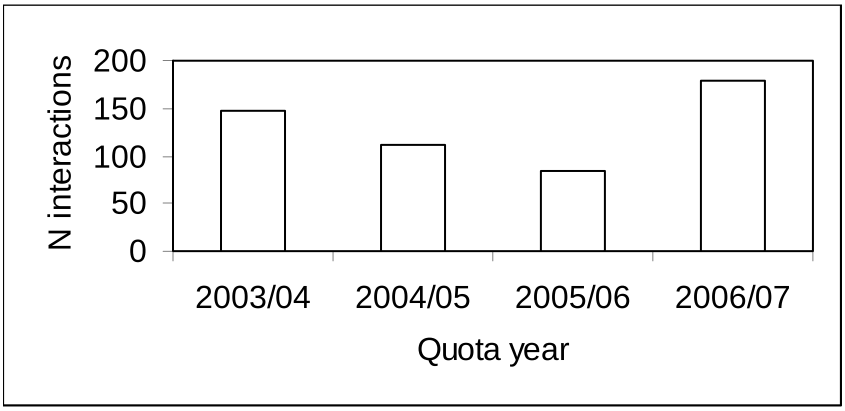

Figure 35. The number of reported interactions between commercial fishers and protected species by quota year.

5.2 By-catch Survey Results

Bycatch information is reported on periodically with the most recent analysis in the previous assessment for the 2005/2006 assessment period.

5.3 Byproduct

All reported byproduct from lobster pots was of a trivial volume, the largest being octopus, which averages around 2.2 t per annum and almost 3 tonnes in 2006/07 (Table 5.1).

An analysis of byproduct captured in research pots versus that reported by the fishery demonstrates that under-reporting occurs on a large scale, especially for animals used as bait. For example, research sampling indicates that around 100 t of blue throat wrasse are likely to be captured by fishers, yet only 0.06 t are reported on average each year as byproduct (around 0.27 kg or less than 1 fish per vessel per annum). Likewise research sampling indicates that around 57,000 Maori octopus are caught each year by the commercial fishery. These average over 2 kg per animal so the total byproduct weight is estimated at around 100 t, yet only 3 t is reported.

There appears to be two sources to this problem of potential under-reporting. First, many fishers believe that catch only needs to be recorded if it is sold. Secondly, the recording of byproduct in a separate general fish logbook complicates data recording for fishers. Both these problems are being addressed by altering the rock lobster log book to include bycatch, with specific mention of the use of byproduct as bait. A new logbook was introduced at the start of the 2007/08 fishing season, so we anticipate greatly improved recording of byproduct in the next assessment report.

Table 5.1. Estimated bycatch and byproduct relative to reported byproduct.
Bycatch data was obtained from research catch sampling. This was scaled up to estimated annual commercial catch on the basis of pot lifts. While there was no account of spatial differences between research and commercial data, the results demonstrate under-reporting of byproduct. This relates to the use of bycatch as bait and is being addressed through a combined log book.

	Research RL trap bycatch		**Estimated commercial RL trap bycatch**	**Reported retained catch (t) by commercial lobster fishers**	
Species	**Total**	**Average per pot**	**Catch N (1000s)**	**Ave. 2000-2007**	**2006/07**
LOBSTERS				1520	1537
Hermit Crab	28260	5.8065	7964	0	0
Rough Rock Crab	4127	0.8480	1163	0.05	0
Rosy Wrasse	675	0.1387	190	0	0
Degen's Leatherjacket	584	0.1200	**165**	**0.18***	**0.23***
Barber Perch	533	0.1095	150	0	0
Southern Conger Eel	467	0.0960	**132**	**0.41**	**0.36**
Red Gurnard Perch	423	0.0869	**119**	**0.05**	**0.01**
Blue Throat Wrasse	364	0.0748	**103**	**0.06**	**0.06**
Purple Wrasse	246	0.0505	**69**	**0.12**	**0.30**
Draughtboard shark	237	0.0487	67	0.06	0.5
Brown-striped Leather-jacket	214	0.0440	**60**	**-**	**-**
Octopus	204	0.0419	**57**	**2.19**	**2.97**
Rock Cod	162	0.0333	**46**	**0.31***	**0.09***
Cleft Fronted Shore Crab	94	0.0193	26	0.08	0
Morwong*	77	0.0158	**22**	**0.88**	**0.08**
Toothbrush Leatherjacket	70	0.0144	**20**	**-**	**-**
Velvet Leatherjacket	52	0.0107	15	-	-
Butterfly Perch	40	0.0082	11	0	0
Senator Wrasse	30	0.0062	8	-	-
Spider Crab	19	0.0039	5	0	0
Giant Crab	11	0.0023	3	0.05	0
Catshark	8	0.0016	2	0	0
Mosaic Leatherjacket	8	0.0016	2	-	-
Crab unidentified	3	0.0006	1	-	-
Sponge Crab	3	0.0006	1	0	0
Rosy Perch	2	0.0004	1	0	0
Gummy Shark	1	0.0002	0	0.01	0.03
Ling	1	0.0002	0	0.03	0
Pie Crust Crab	1	0.0002	0	0	0
Port Jackson shark	1	0.0002	0	0	0
Rock Ling	1	0.0002	0	0.07	0
Southern Cardinal Fish	1	0.0002	0	0	0
Trumpeter (striped)				0.34	0.03
Barracouta				0.13	0.06
Stargazer				0.07	0.04
Sand crab				0.01	0
Warehou (blue)				0.02	0
Trumpeter (bastard)				0.02	0
Total	**36919**	**7.6**	**11082**	**5.08**	

* unspecified species

6 Bibliography

Bruce, B, R, Griffin, D., Booth, J., Gardner, C, , Hobday, D., Linnane, A., 2007. Oceanographic dispersal of southern rock lobster, Draft *Final Report to FRDC 2002/007*, CSIRO, Hobart.

Burnham, K.P. and D.R. Anderson (1989) *Model Selection and Inference. A Practical Information-Theoretic Approach*. Springer-Verlag, New York.

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, December 1997. Dept. Prim. Ind. Fish. Internal Report No. 37, 25pp.

Frusher, S. and C. Gardner (1999) Tasmanian Rock Lobster Fishery 2001/02. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 43 p.

Frusher, S., Gardner, C., Hirst, A., MacKinnon, C., and M. Haddon (2003) Tasmanian Rock Lobster Fishery 2001/02. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 92 p.

Gardner, C. (1999) Tasmanian Rock Lobster Fishery 1998/99. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 58 p.

Gardner, C., Frusher, S., and L. Eaton (2001) Tasmanian Rock Lobster Fishery 1999/00. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 90 p.

Gardner, C., Frusher, S., Eaton, L., Haddon, M. and C. MacKinnon (2002) Tasmanian Rock Lobster Fishery 2000/01. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 117 p.

Gardner, C., Frusher, S., Barrett, N.S, Haddon, M. and C. Buxton (2006). Spatial variation in size at onset of maturity of female southern rock lobster *Jasus edwardsii* around Tasmania, Australia. *Scientia Marina* **70**(3): 423-430.

Gardner, C., MacKinnon, C., Haddon, M., and S. Frusher (2004) Tasmanian Rock Lobster Fishery 2002/03. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 81 p.

Gardner, C., Hirst, A., and M. Haddon (2005) Tasmanian Rock Lobster Fishery 2003/04. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 79 p.

Haddon, M. and C. Gardner (2007) Tasmanian Rock Lobster Fishery 2005/06. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 63 p.

Kimura, D.K. (1981) Standardized measures of relative abundance based on modelling log(cpue), and their application to Pacific Ocean perch (*Sebastes alutus*). *Journal du Conseil Permanent International pour l'Exploration de la Mer* **39**: 211-218.

Maunder, M.N. and A.E. Punt (2004) Standardizing catch and effort data : a review of recent approaches. *Fisheries Research*. **70**: 141-159.

Neter, J., Kutner, M.H., Nachtsheim, C.J., and W. Wasserman (1996) *Applied Linear Statistical Models.* 4th edition. Irwin Chicago. 1408 pp.

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

Semmens, J., Haddon, M., and C. Mackinnon (2006) Tasmanian Rock Lobster Fishery 2004/05. *Fishery Assessment Report* Tasmanian Aquaculture and Fisheries Institute, University of Tasmania. 78 p.

Venables, W.N. and C.M. Dichmont (2004) GLMs, GAMs, and GLMMs: an overview of theory for applications in fisheries research. *Fisheries Research*. **70**: 319-337.

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

7 Appendix 1. Standardized Catch Rate Series

7.1 Introduction

The behaviour and composition of the Tasmanian fishing fleet has altered significantly through time and this has had effects on the catch rate data. For example, there is now far more effort in relatively shallow water in Area 6, and perhaps in Area 7 as fishers pursue higher valued, deeper red lobsters. This pattern has had an impact upon nominal catch rates, making them look lower than if all depths were fished evenly. These changes in the fleet dynamics have important implications in assessing stock biomass and, if not accounted for, 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.

Many factors 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 at 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.

As Kimura (1981, p211) states: “Since the 1950s it has been recognized that fishing power generally differs among vessels, and if c.p.u.e. is to be proportional to abundance, effort measurements must be standardized.” The most commonly used method of standardization is to include the various factors thought to effect catch rates into a general linear model and to include year as a factor, in this way the parameters derived for each year become the indices of relative abundance (Maunder & Punt, 2004; Venables & Dichmont, 2004).

Detailed catch and effort data with associated vessel, depth, and location information is only available for a full year from 1994 onwards so it was decided to provide a standardization of this 13 year period (1994/95 – 2006/07) to see if it were possible to detect and reduce the effect of, at least, depth of fishing on catch-rates.

7.2 Methods

The General Linear Models fitted to the available data 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 period (eight separate periods in each quota year; Table 7.1), vessel distinguishing mark, 10 metre depth-categories, half-degree statistical block, and the day/night flag (Table 7.2). 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 1994/1995 and who had had a median annual catch of greater than one tonne. If a vessel has only been fishing for a single year it cannot be successfully compared with other years and only adds statistical noise. This combined with a median catch of one tonne is a first attempt to focus on vessels taken to be seriously targeting rock lobster.

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 continue to obscure any effects of changes in stock biomass.

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 valid in a fixed factor analysis to include interaction terms with the QYear terms as this would distort and alter the meaning of the individual QYear parameter estimates. For example, if we were to consider the catch rate trends across the whole fishery, but the trends differed between Areas, this would be tantamount to claiming that there was a significant interaction between the QYear terms and Area. To avoid this potential problem we proceed by conducting a separate analysis for each assessment Area.

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 parameters 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, which is becoming more accepted as such a criterion, is the use of the Akaike's Information Criterion (AIC). In our own case, after log-transformation, the statistical residuals of the statistical model are normal and additive. The AIC is usually based around a maximum likelihood framework but, in the special case of a least squares estimation with normally distributed additive errors, the AIC can be expressed as:

$$\text{AIC} = n.\text{Ln}\left(\frac{\text{SSE}}{n}\right) + 2p \qquad (1.2)$$

where SSE is the sum of the squared residuals, n is the total number of observations, and p is the number of parameters (Burnham & Anderson, 1989). An alternative definition is:

$$\text{AIC2} = \text{Ln}\left(SSE\right) + \frac{2p}{n} \qquad (1.3)$$

In addition, the adjusted R^2, gives a better estimate of total variability described by the statistical model (Neter *et al*, 1996) than the simple R^2, with *n-p* degrees of freedom, where SSTO (total sum or squared residuals), with *n-1* degrees of freedom, is the SSE plus the variation due to the statistical model:

$$R^2 = 1 - \frac{SSE}{SSTO} \quad R_A^2 = 1 - \frac{\frac{SSE}{n-p}}{\frac{SSTO}{n-1}} = 1 - \left(\frac{n-1}{n-p}\right)\left(\frac{SSE}{SSTO}\right) \tag{1.4}$$

"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).

In fact, there are so many data point available that almost every statistical factor proves statistically significant. However, by plotting the QYear parameters for each statistical model the convergence to a stable outcome can be confirmed graphically.

Table 7.1. The duration of each of the 8 periods within each quota year.
This is used instead of simple months to eliminate as many zero catch and effort months as possible.

Period	Months
1	March
2	April
3	May, June, July
4	August, September, October
5	November
6	December
7	January
8	February

Table 7.2. Definitions of the eight difference statistical models used in the standardization of the rock lobster catch rates for 1994/1995 to 2006/2007.
Cst was a constant, Qyear was quota year, Period was the 8 periods in each Qyear, BoatDM was vessel distinguishing mark, DayNight was whether a shot was overnight or during the day, DepCat was a series of 10 metre depth categories, Block was statistical block.

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

7.3 Results

Model 7 (including a Period x Depth category interaction term) was optimal in (Areas 1, 2, 6, and 8), elsewhere (Areas 3, 4, 7, and 5) Model 8 was optimal (including a Period x Block interaction term). The various factors described different amounts of variation in the catch rate data in different Areas (Table 7.3). The seasonality of the fishery is so marked that the factor *Period* accounted for most of the variation described by the statistical models in every Region except Region 6 where the vessel doing the fishing was most important. In Regions 1, 2, and 3 *Period* accounted for over 65% of all variation described while *Vessel* accounted for about 15% (Table 7.3). In Regions 4 and 5, *Period* accounted for between 43 and 50%, but only about 37 to 42 % in Region 6 and 7. *Vessel* accounted for between 13 and 29% except in Region 6 where it was 45.3%. In areas 2 and 7, the *daynight* factor described more variation than the *depthcategory* factor, in the other areas (1, 3, 4, 5, 6, and 8) the reverse occurred with depthcategory accounting for a maximum of 8.6% in area 4. In Region 7, *daynight* was as influential as *Vessel* (Table 7.3). These results are very similar to those obtained by a similar analysis last year except that last year Model 7 was optimal in area 7 rather than Model 8 as in this year.

The trends in the unstandardized catch rates (both the geometric mean and arithmetic mean catch rates (Figure 15), were similar to those exhibited by the standardized catch rates. The arithmetic mean closely followed the geometric mean catch rates in all assessment Areas.

Table 7.3. Contribution to total adjusted R^2 for each model for each assessment area. The models are described by adding each term down the left-hand size. QYear is quota year, DayNight is whether a shot was made during daylight hours or night, DepthCat were a set of 10 m depth categories, and block was the statistical block within each area, Period was one of the 8 assessment periods in each quota year. The bottom half of the table are the R^2 values converted to percent of the total.

Optimum	Model7	Model7	Model8	Model8	Model8	Model7	Model8	Model7
	Area1	**Area2**	**Area3**	**Area4**	**Area5**	**Area6**	**Area7**	**Area8**
Qyear	6.11	8.56	6.22	6.48	4.15	3.30	4.69	3.60
Period	32.81	38.56	32.29	18.42	19.85	14.01	16.65	23.12
Vessel	8.70	7.36	7.52	11.73	11.56	17.20	8.28	10.91
DayNight	0.22	2.37	0.42	1.37	1.69	1.48	8.19	0.36
DepthCat	1.15	0.37	0.52	3.70	1.82	1.05	1.69	1.01
Block	0.68	0.19	0.04	0.80	0.46	0.36	0.05	3.16
Period*Depth	0.45	0.17	0.19	0.26	0.24	0.56	0.62	0.97
Period*Block	0.33	0.06	0.30	0.49	0.64	0.46	0.71	0.58
Maximum R^2	50.12	57.58	47.31	42.98	40.19	37.96	40.25	43.12
Qyear	12.19	14.87	13.15	15.08	10.33	8.70	11.64	8.34
Period	65.46	66.96	68.26	42.86	49.40	36.91	41.37	53.63
Vessel	17.36	12.79	15.89	27.28	28.78	45.30	20.57	25.30
DayNight	0.45	4.11	0.89	3.18	4.21	3.91	20.35	0.84
DepthCat	2.30	0.64	1.11	8.60	4.53	2.78	4.19	2.33
Block	1.36	0.33	0.07	1.87	1.16	0.94	0.12	7.32
Period*Depth	0.89	0.30				1.47		2.24
Period*Block			0.63	1.13	1.60		1.76	
Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 7.4. Geometric mean catch rates along with the optimal statistical model for each assessment area.

The different models are described in Table 7.2. In the four northern areas (3, 4, 5, and 6) the standardization produces only relatively minor effects and catch rates are relatively flat. However. in the southern Areas all areas exhibit continued increases in catch rates with the standardization leading to larger increases than observed in the original geometric mean catch rates.

Qyear	Area1 Model1	Area1 Model7	Area2 Model1	Area2 Model7	Area3 Model1	Area3 Model8	Area4 Model1	Area4 Model8
94/95	1	1	1	1	1	1	1	1
95/96	1.2974	1.3990	1.1593	1.3617	1.2802	1.2608	1.0955	1.0936
96/97	1.4371	1.4671	1.2411	1.3847	1.3001	1.3247	1.3214	1.2951
97/98	1.1188	1.1682	1.0156	1.2117	1.1329	1.1883	1.2702	1.2197
98/99	1.2073	1.1999	0.9622	1.1546	1.1442	1.1918	1.3245	1.3493
99/00	1.2736	1.2894	1.2954	1.3709	1.3472	1.4607	1.6864	1.6689
00/01	1.4295	1.5457	1.3165	1.4749	1.2744	1.4250	1.6533	1.8069
01/02	1.5830	1.6983	1.5373	1.7407	1.7216	1.8343	1.8383	1.8613
02/03	1.6090	1.7655	1.9163	1.9074	1.9274	1.8701	1.9185	1.9080
03/04	1.6557	1.8643	1.7415	1.7280	1.7396	1.6081	1.6675	1.6358
04/05	1.8908	2.2436	1.8518	1.9907	1.8344	1.8046	1.8105	1.8963
05/06	2.2075	2.4675	1.9136	2.1349	1.7163	1.8079	1.7432	1.8038
06/07	1.9209	2.0281	1.7378	1.8806	1.9173	1.8929	1.7794	1.7838

	Area5 Model1	Area5 Model8	Area6 Model1	Area6 Model7	Area7 Model1	Area7 Model7	Area8 Model1	Area8 Model7
94/95	1	1	1	1	1	1	1	1
95/96	0.9195	0.9706	1.0000	1.0522	1.2160	1.3414	1.4275	1.3608
96/97	1.0016	1.0700	1.0363	1.0894	1.2313	1.3089	1.3439	1.3683
97/98	1.0757	1.1158	1.1292	1.1521	1.0097	1.1162	1.1172	1.1653
98/99	0.9975	1.1649	1.0914	1.2895	1.0670	1.2121	1.2442	1.3500
99/00	1.1682	1.3365	1.2835	1.4546	1.1819	1.2676	1.2358	1.3505
00/01	1.2252	1.3918	1.2250	1.3133	1.2234	1.3343	1.3892	1.5976
01/02	1.3471	1.5843	1.2209	1.3550	1.2499	1.3418	1.2571	1.4752
02/03	1.5878	1.7383	1.4295	1.3880	1.4631	1.5283	1.2311	1.4682
03/04	1.4724	1.5361	1.4438	1.3372	1.4974	1.5531	1.5250	1.8117
04/05	1.5026	1.5345	1.4391	1.4952	1.5795	1.8781	1.6740	2.1793
05/06	1.3105	1.4483	1.4700	1.3511	1.8580	2.2513	1.7626	2.3609
06/07	1.4317	1.5433	1.3744	1.2106	1.6220	3.0685	1.7959	2.3263

8 Appendix 2: 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.

9 Appendix 3: 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 remained 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 included 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.

10 Appendix 4: Previous Assessments

This report is the tenth assessment report since regular reporting commenced in the 1995 calendar year (Table 10.1). This report uses data available up until 28th February 2005. It includes data for the first seven years since ITQ implementation.

Table 10.1. Previous Tasmanian rock lobster fishery assessment reports.

Assessment Report No.	Last month of data used	Reference and quota year	Printing Date
1	December 1995	Frusher, 1997a	
2	December 1996	Frusher, 1997b	
3	February 1998	Frusher and Gardner, 1998	Mar 1999
4	February 1999	Gardner, 98/99	Dec 1999
5	February 2000	Gardner, Frusher and Eaton, 99/00	Jan 2001
6	February 2001	Gardner, Frusher, Eaton, Haddon and Mackinnon, 00/01	Jan 2002
7	February 2002	Frusher, Gardner, Mackinnon and Haddon, 01/02	Mar 2003
8	February 2003	Gardner, Mackinnon, Haddon and Frusher, 02/03	Mar 2004
9	February 2004	Gardner, Hirst and Haddon, 03/04	May 2005
10	February 2005	Semmens, Haddon, and Gardner 04/05	Jul 2006
10	February 2006	Haddon and Gardner, 05/06	Feb 2007

11 Appendix 5: 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.

12 Appendix 6: Present Performance Indicators and Trigger Point Strategies

12.1 Performance Indicators

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

12.1.1 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.

12.1.2 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.

12.1.3 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.

12.1.4 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.

12.1.5 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.

12.1.6 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.

12.1.7 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.

12.2 Trigger Points

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

12.2.1 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.

12.2.2 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.

12.2.3 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.

12.2.4 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.[2]

12.2.5 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.

12.2.6 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.

12.2.7 The recreational catch

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

[2] 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.

13 Appendix 7: Summary of Rules

Table 13.1. Summary of rules for the Tasmanian Rock Lobster Fishery.

COMMERCIAL	
Management zone	one management zone for the State
Limited entry	314 licenses
Limited seasons	Males: season open from 15 November 2006 to 30 September 2007 inclusive. Females: season open from 15 November 2006 to 30 April 2007 inclusive.
Limits of pots on vessels	minimum of 15 pots, maximum of 50 pots
Quota	Total allowable catch of 1523 tonnes
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 lob
Daily limit	5 per recreational license holder
Limited seasons	Males: Saturday 4 November 2006 to 31 August 2007 inclusive. Females: Saturday 4 November 2006 to 30 April 2007 inclusive.
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.

14 Appendix 8. Catch History by Area

Appendix 8. details of catches in tonnes by assessment area by quota year.

Qyear	A1	A2	A3	A4	A5	A6	A7	A8	Grand Total
1970/71	181.758	154.619	182.028	295.438	218.722	179.572	118.831	214.768	1545.736
1971/72	306.031	141.208	195.398	248.148	223.274	146.853	160.980	170.886	1592.778
1972/73	386.085	161.903	218.928	284.031	240.921	33.876	80.356	62.165	1468.265
1973/74	141.947	133.726	101.399	295.420	190.478	57.873	97.246	266.134	1284.223
1974/75	184.166	170.773	142.012	303.587	246.963	96.192	78.167	293.037	1514.897
1975/76	123.813	146.462	121.035	347.690	319.607	88.973	92.931	181.984	1422.495
1976/77	101.010	155.951	113.025	319.820	363.557	88.340	106.609	187.106	1435.418
1977/78	126.418	200.104	131.466	267.240	344.686	60.121	99.838	170.379	1400.252
1978/79	161.022	225.148	121.889	307.849	331.357	97.745	117.412	268.411	1630.833
1979/80	177.252	191.760	119.392	296.462	263.012	59.350	124.808	303.268	1535.304
1980/81	191.204	189.968	106.327	337.509	342.098	117.947	160.890	436.444	1882.387
1981/82	151.246	147.467	97.098	380.032	277.523	121.277	161.891	276.066	1612.600
1982/83	207.357	171.811	106.519	359.000	452.946	160.965	174.459	387.117	2020.174
1983/84	188.343	153.132	113.098	347.744	432.907	190.571	177.040	412.928	2015.763
1984/85	176.486	164.422	142.516	342.622	493.585	215.852	260.353	376.391	2172.227
1985/86	180.850	147.717	136.368	456.349	466.857	192.219	194.158	315.526	2090.044
1986/87	153.038	146.616	136.382	465.896	380.796	125.504	122.841	217.042	1748.115
1987/88	161.349	129.677	121.600	441.354	452.712	147.012	136.475	272.856	1863.035
1988/89	172.163	111.388	106.707	325.132	388.911	228.555	185.030	461.737	1979.623
1989/90	151.421	143.710	138.381	304.552	396.092	231.494	150.823	308.079	1824.552
1990/91	175.445	103.052	101.141	251.089	416.521	215.167	140.606	319.499	1722.520
1991/92	214.968	106.662	78.336	197.966	427.655	224.068	171.719	406.841	1828.215
1992/93	144.915	87.611	88.580	196.619	367.823	306.033	213.837	432.868	1838.286
1993/94	116.793	69.162	59.775	150.933	366.843	247.193	196.906	305.715	1513.320
1994/95	92.781	68.005	58.620	135.199	400.366	225.699	145.920	308.078	1434.669
1995/96	122.591	105.396	97.167	167.437	323.364	196.474	215.162	409.307	1636.899
1996/97	138.436	107.062	105.583	232.049	327.557	213.628	238.719	436.109	1799.143
1997/98	111.844	84.469	80.684	212.957	365.907	231.765	151.493	372.356	1611.474
1998/99	96.746	68.354	70.777	187.505	323.059	205.259	152.364	383.449	1487.512
1999/00	93.371	82.217	73.201	208.987	317.852	261.151	126.500	322.305	1485.585
2000/01	102.114	81.460	72.943	236.700	316.336	244.140	111.041	327.255	1491.988
2001/02	124.605	109.678	87.035	256.280	327.600	193.191	119.228	280.721	1498.338
2002/03	124.759	131.327	104.818	249.059	365.838	197.499	114.743	222.556	1510.598
2003/04	142.672	128.684	92.960	197.901	323.972	179.050	115.980	301.506	1482.723
2004/05	164.761	130.258	84.712	180.524	299.099	190.723	123.602	342.985	1516.663
2005/06	240.016	115.662	61.842	153.054	230.420	158.857	157.972	390.960	1508.782
2006/07	189.852	103.231	75.235	156.435	222.692	155.569	205.862	428.458	1537.335