FISHERY ASSESSMENT REPORT

TASMANIAN ROCK LOBSTER FISHERY 2002/03

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

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Rock Lobster Fishery Assessment: 2002/03

Executive Summary

The economic value of the Tasmanian rock lobster fishery contributes significantly to the State's regional economy. The fishery has recreational and commercial components, the latter generating an estimated $184.5 million p.a. ($65 million directly from landed value) and 1350 full-time-equivalent jobs in the harvesting and processing sectors in 2002. Recreational fishing also has a significant impact on the economy of regional centres with a recent national survey estimating the direct economic impact of all recreational fishing in Tasmania at $50 million. The Tasmanian rock lobster fishing industry is a source of significant economic growth to the State, with an 24.1% and 16.3% increase in the value of landed product in 2001 and 2002 respectively. Annual rate of growth in revenue has been matched by an increase in capital value at a compound rate of 18% per annum over the last decade. This increase in economic benefit has come at a time when some other marine industries in Tasmania have exhibited stalled growth in profitability and a loss of capital value.

Opportunities for further growth exist through both increasing catches and increasing the value of product. However, in the commercial fishery trading conditions are currently difficult due to the impact of Severe Acute Respiratory Syndrome (SARS), adverse exchange rates and reduction of demand for small (<800 g) and large (>1500 g) lobsters; these factors are expected to impact on the next assessment. The basis of the industry is, of course, the resource and this report is part of the annual process of reviewing the health of the stocks to secure future harvests and to identify potential for growth.

The state of the resource is formally evaluated against a series of performance indicators. These were evaluated for the most recent quota year: March 2002 to February 2003. Although trends were generally positive with no trigger points activated, some aspects warrant scrutiny in discussion of ongoing management.

Statewide commercial catch-rates rose slightly to 1.1 kg per potlift with a sharp increase of 21% in area 6 on the NW coast. This is an encouraging development because this area has had declining catch-rates in previous assessments. A standardisation routine for catch-rates was developed this year to account, at least partially, for the influences of seasonal and spatial fishing patterns on catch-rates. This analysis indicated that the increase in catch-rates seen over the last 10 years is a true reflection of change in stock abundance, rather than an artefact of fishing patterns. The analysis indicated that commercial catch-rate data might have slightly under-estimated the rate of rebuilding of the stocks.

Area 1 in the SE had the lowest catch-rate in the State (0.74 kg/pot lift) and in 2002 catch-rate declined by 9% relative to 2001. This area experienced higher recreational

effort than any other area and there were indications that recreational effort had continued to climb with a rapid increase in licenses (doubling over the last 8 years). The increase in number of license holders since 2000/01 was used to scale-up previous estimates of recreational catch. This showed that the trigger point, “recreational catch exceeding 10% of commercial catch”, was around this limit in 2001/2002. A survey of recreational rock lobster fishing was conducted during 2002/03 and results are expected early in 2004, which should provide more precise information on this matter.

Commercial catch-rates in Area 8 (SW) fell this year by a small amount (3%) and this downward trend was also reflected in research catch-rates of both legal sized animals and undersized animals. The basis for this change was unclear and there was some concern that it may be associated with increased effort in the area during September around the time of the male moult.

The assessment presents information on both legal-sized biomass (the estimated total weight of legal-sized lobsters on the sea floor) and catch-rates (the average weight of lobsters captured per pot-lift). The trend in estimated legal-sized biomass was often contrary to the trend in commercial catch-rate. All southern areas (1 (SE) and 8 (SW)) showed an increase in legal sized biomass compared to declines or stability in northern areas (4 (NE), 5 (NW) and 6 (NW)). These differences between biomass and catch-rate trends were caused by the time of year when fishing occurs – catchability of lobsters having distinct intra-annual trends.

This assessment saw an end to the rise of biomass and egg production in these northern areas that had occurred in previous assessments. Egg production Statewide was very high for a lobster fishery with current production estimated at 31% of virgin production. However, in the northern areas (4, 5 and 6), egg-production was relatively low at 13-18% of virgin production and declined in 2002/03 by between 1 and 11% relative to the previous year.

Projections for the resource over the next few years at current levels of quota indicated that legal-sized biomass was likely to continue increasing. However, this increase was expected to be mainly in male lobsters as egg-production was projected to remain stable rather than increase with legal-sized biomass. The regional decline in both egg production and legal-sized biomass was expected to continue in the north of the State, although there was less confidence in regional projections this year due to recent trends in the behaviour of the fleet. This made forward projections more uncertain than in the past. The spatial spread of fishing effort was less predictable by catch-rate, area and time of year than it was previously. Presumably commercial fishers were choosing to distribute their effort based on factors external to the resource, such as weather and market value.

The structure of the commercial industry continued to change, with a steady decline over the last decade in the number of active licenses and the number of vessels involved in lobster fishing (there were 330 active licenses in 1993 compared to 242 in 2002).

In summary, the continued rebuilding of the stock was encouraging, but the rate of rebuilding was not rapid. Current levels of harvest appear to be sustainable, although attention should be given to the size and rate of increase of recreational catches (which may have breached the trigger point of 10% of commercial catch), and the spatial location of catches from both sectors (fleet dynamics). None of the performance indicators for the fishery are of concern although issues have been identified that may require management intervention to optimise usage of the resource. One spatial issue that is apparent is the stability/decline in egg production in the north, rather than increase as targeted in the management plan. Also of some concern for optimal management is the decreasing harvest in deeper water at the expense of shallow water areas. Recreational catch appears to be growing steadily and may require management review, although additional data to that presented here is expected early in 2004 through a specific recreational fishing survey.

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1. Introduction

Tasmania's rock lobster fishery is distributed around the coast with the exception of the central north coast bordering Bass Strait. The rock lobster resource provides the basis for important commercial and recreational fisheries that provide significant benefits to regional communities.

The resource has been harvested commercially since European settlement with fishing effort initially focused on the East Coast. Earliest records show 70,000 lobsters valued at $1,456 recorded at the Hobart fish markets in 1888. The present commercial catch is from a broader area, with around 1.5 million animals valued at approximately $65 million taken each year. Most of this catch is taken from the deep reefs off the exposed West Coast.

There are 243 licensed commercial vessels participating in the commercial fishery, with additional catch taken by the approximately 16,000 licensed recreational fishers. Commercial harvests have been capped by a quota management system since 1998, which has resulted in substantial and steady rebuilding of stocks in most areas. This rebuilding can be seen in the historical trends in the fishery (Figure 1).

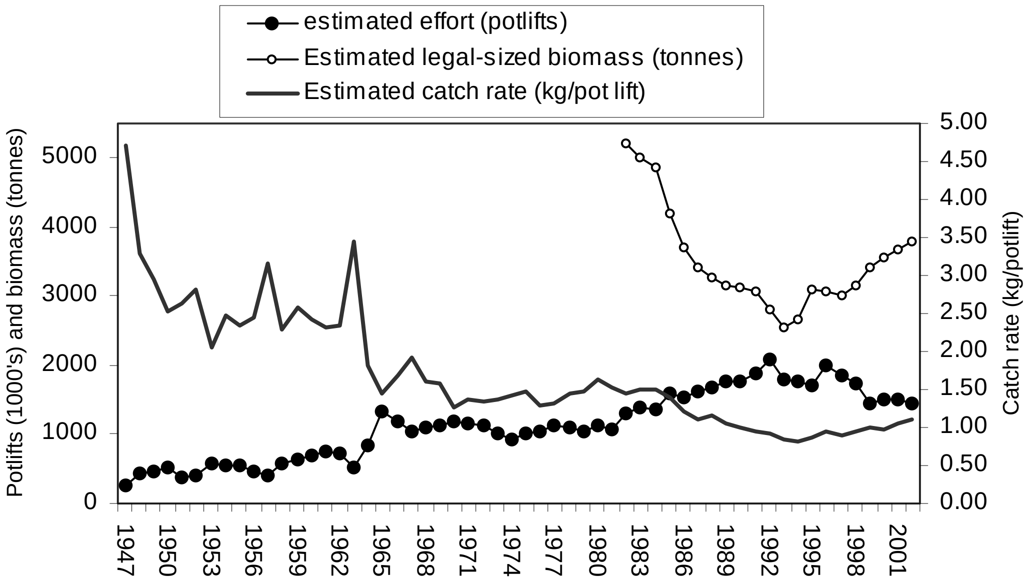


Figure 1. Historical trends in fishing effort (potlifts), catch-rate (kg/potlift) and estimated legal-sized biomass. Catch-rates after the 2nd world war and even before the 1960s were much greater those seen today. As fishing effort has risen, catch-rates have fallen. Legal sized biomass can only be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

Although biomass rebuilding has been substantial, catch-rate has picked up more slowly due to dynamics of the fishery (such as time of year when catch is taken). This is where historical records are valuable because they put the current increases in biomass into context. Based on catch rate, the biomass on coastal reefs around Tasmania generally appears well below that present even 20 years ago.

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 is considered to be a motivating factor for the steadily increasing recreational effort.

Although lobsters are harvested from all around the State, the patterns of commercial fishing vary considerably from region to region. Biological parameters also vary dramatically from region to region and this presents a major challenge for fishery management – trying to find management solutions for the whole State that function across such a diverse range of lobster populations. An important step towards meeting this challenge is assessing different regions separately. For this purpose the State is divided into eight different assessment regions, shown in Figure 2.

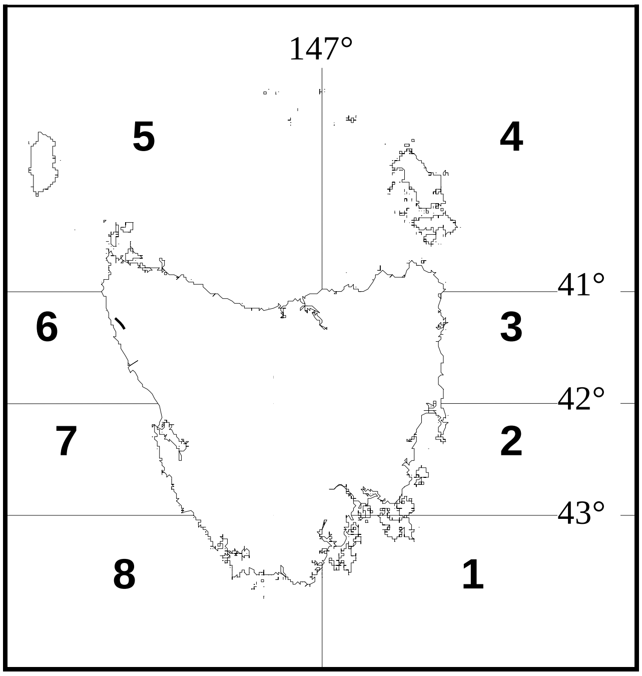


Figure 2. The boundaries of the eight stock assessment areas in Tasmania.

1.1 Management

Rock lobsters were an important source of food for coastal aboriginal tribes and this was also the case for the first European settlers, who arrived in Hobart from 1804. In 1882, a Royal Commission into the fisheries of Tasmania produced what was effectively the first Tasmanian rock lobster stock assessment report. Fishing in those days was concentrated around population centres but it was clearly possible to deplete stocks even then (Story, 1998).

The report led to the introduction of regulations in 1889, which included a minimum legal size, and a prohibition on taking soft shelled (recently moulted) lobsters or berried female lobsters. These input controls still play a role in management of the resource although soft-shelled lobsters are now protected by a seasonal closure.

Since the inception of catch records in the 1880's, the reported annual catch steadily increased in the rock lobster fishery to a high in 1984 of over 2,250 tonnes. During this time, concerns were expressed about overfishing in the commercial fishery, which resulted in government intervention. 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 high in 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.

Management of the commercial fishery has remained relatively stable since the introduction of quota. Quota was initially set at 1500 tonnes for the 1998/1999 fishing season. After three years of successive improvements in biomass, the quota was increased to 1523 tonnes for the 2001/2002 fishing season. In addition to increasing the quota, the length of the fishing season has increased. 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 old-shell lobsters that command a high price at this time of the year or fish for the lower priced soft new-shell lobsters that have a higher catchability after their moult. Timing of the September closure has changed regularly since 1998 with complete access in 2000. There remains some concern about fishing in September due to possible reduced survival of released soft-shelled animals and negative impacts on markets.

1.2 Economic and market status

While the commercial fishery is not the largest in Tasmania by value of landed product, it is the major contributing fishery to employment in Tasmania. This economic benefit is well distributed around the state, where an estimated 1,350 Tasmanian jobs are reliant on the rock lobster fishery (EconSearch 2003).

The fishery has recreational and commercial components and the economic value of these were assessed over the last 12 months. The analysis of the Tasmanian commercial industry was part of a national southern rock lobster economic assessment by EconoSearch™. That assessment estimated that the Tasmanian industry generated $184.5 million p.a. ($65 million directly from landed value) and 1350 full time equivalent jobs in the harvesting and processing sectors in 2002 (EconoSearch, 2003). Recreational Fishing also has a significant impact on the economy of regional centres with a recent national survey estimating the direct economic impact of all recreational fishing in Tasmania at $50 million (Lyle *et al*., 2003).

Research on public perceptions of fishing industries by Aslin and Byron (2003), included aspects on the economic value of fishing industries. That survey showed that there is a public perception that fishing industries are unlikely to contribute to economic growth, that is, they are seen as mature and stable industries. The Tasmanian rock lobster fishing industry has performed contrary to this perception as it is not only a source of economic impact, but also economic growth in the State with an 24.1% and 16.3% increase in the value of landed product in 2001 and 2002 respectively (ABARE, 2003).

Growth in revenue has been matched by an increase in capital value with growth at a compound rate of 18% per annum over the last decade (EconoSearch, 2003). This increase in economic benefit has come at a time when some other marine industries in Tasmania have exhibited stalled growth in profitability and a loss of capital value. The true capital value of the Tasmanian rock lobster fishery includes components that are difficult to quantify across the industry, such as vessel and gear value, and processing facilities. However, a large proportion of the capital value of the industry is linked to quota units, which are transferable and freely traded or leased. The commercial fishery is divided into 10500 quota units, each of which was valued at approximately $35,000 at the end of the 2002/2003 season. This implies a total capital value for quota units of $367 million.

Opportunities for further growth exist through both increasing catches and increasing the value of product. However, in the commercial fishery trading conditions are currently difficult due to the impact of Severe Acute Respiratory Syndrome (SARS), adverse exchange rates and reduction of demand for small (<800 g) and large (>1500 g) lobsters; these factors are expected to impact on the next assessment.

2. Previous Assessments

This report is the eighth assessment report since regular reporting commenced for the 1995 calendar year (Table 1). This report uses data available up until 1st March 2003. It includes data for the first five years since ITQ implementation.

Table 1. Previous Tasmanian rock lobster fishery assessment reports.

Assessment Report No.	Last month of data used	Reference
1	December 1995	Frusher, 1997a
2	December 1996	Frusher, 1997b
3	February 1998	Frusher and Gardner, 1999
4	February 1999	Gardner, 1999
5	February 2000	Gardner, Frusher and Eaton, 2001
6	February 2001	Gardner, Frusher, Eaton, Haddon and Mackinnon, 2002
7	February 2002	Frusher, Gardner, Mackinnon and Haddon, 2003

3. Recent Developments

3.1 The Fishery

In March 1998, management of the Tasmanian commercial rock lobster fishery changed from an input- to an output-controlled fishery. Controls based primarily on licence limitations and closed seasons were replaced with controls centred on individual transferable quotas (ITQs). In adopting the ITQ management system, several of the input controls were also retained, including the limitation of the maximum number of pots allowed in the fishery to 10500, maximum number of pots per vessel to 50, and the seasonal closures implemented to protect moulting lobsters (at varying dates from September to November).

The quota system of the commercial fishery has resulted in an increased focus on the value of the animals landed each season. Previous assessments have discussed the change in the dynamics of the fishing fleet since the change (Gardner *et al.*, 2001 and Frusher *et al.*, 2002), the key observation being a shift in effort towards winter fishing when prices are highest. An associated change includes an extension to the open season for males during September over the last three seasons.

From 1999 the use of recreational rock lobster rings was licensed. The distribution of recreational licence combinations in 2002/03 is shown in Table 2.

Table 2. Number of recreational licenses by category.

Licence combination	Number
Pot, dive and ring	964
Pot and ring	1774
Pot and dive	2686
Dive and ring	160
Pot only	6857
Ring only	352
Dive only	2787
Total recreational lobster licence holders	15580

3.2 Developments in stock assessment analyses

3.2.1 Standardisation of catch-rates

More detailed information on this area of development is presented in Appendix 1 (page 63).

The Tasmanian rock lobster fishery has a long history but useful data for stock assessment purposes is only available from the 1970s. The commercial fishery constitutes the major impact on the resource for the State as a whole and, as a result of the way in which it is managed, provides the most reliable source of information. The performance of the commercial fishery is used as a proxy for the performance of the whole fishery (which includes recreational and indigenous fishing for which data collection is more problematic). The quantity and detail of information provided by the commercial fishery has increased through time. These improvements have often been associated with changes to the management. Thus, from 1970 to the early 1980s, catch and effort data were available in monthly totals for the eight assessment regions around Tasmania. After 1983, monthly data was available at the resolution of one-degree statistical blocks. After 1992, fisheries data was available at a resolution of half-degree statistical blocks with daily records of catch and effort. From the mid-1980s depth information was available as a set of depth categories and after the early 1990s it was available as an estimate of the average depth of activity.

Quota Management was introduced into the Tasmanian rock lobster fishery in 1998/1999 (with a quota year running from March 1st to late February). Since then the behaviour and composition of the fishing fleet has altered significantly and this has had some effects upon the perception of the state of the fishery when such things as catch-rate data are considered.

It has been reported by the commercial industry, for example, that there is now far more effort in relatively shallow water in Area 6, and perhaps in Area 7, than in the past because the shallow water animals are of a higher value as a result of their deeper red colour. The problem for the assessment is that catch-rates are lower in shallower water, This gives the impression of decreased biomass when the change is really only one of fishing behaviour. The stock assessment model that is used to assess the status of the rock lobster stock around Tasmania is primarily driven by catch-rate data. The formal basis behind this problem of changes to fishing behaviour affecting the assessment is the assumption that catch-rates are an index of relative stock abundance. It is clear that there are important implications to the suggestion that fisher behaviour is altering catch-rates rather than changes to the stock biomass.

In fact, there are many factors that are likely to have an impact on observed catch-rates that have nothing to do with changes in the stock biomass. These factors would include the precise location where fishing occurred, who was doing the fishing, whether they were fishing at night or at day, and, of course, the depth of fishing. It is standard stock assessment practice to standardise 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 standardisation will be more closely related to what is happening to the stock biomass.

The most commonly used method of standardisation is to include the various factors thought to effect catch-rates into a general linear model (a standard statistical method) and to include year as a factor, in this way the parameters derived for each year become the indices of relative abundance. Any trends in these indices of relative abundance are assumed to relate more closely to changes in the stock biomass than the trends in the raw catch-rate data.

Detailed catch and effort data with associated vessel, depth, and location information is only available from 1993 onwards for the Tasmanian rock lobster fishery, so it was decided to provide a standardisation of data from that period to see if it were possible to detect and remove the effect of depth of fishing on catch-rates, amongst other things.

A detailed description of the methods and analysis of standardised catch-rates is given in Appendix 1(page 63). The standardising procedure included factors of year, month, fishing block, depth category, boat distinguishing mark and day/night.

Standardised catch-rates were compared with arithmetic catch-rates (total catch divided by total effort) and geometric catch-rates. Geometric means are the catch-rate from each shot for each fisher multiplied together and then taken to the nth root. For example the geometric mean of three catch-rates of 2, 3 and 4 kg/potlift equals the cube root of 2x3x4 (24) or 2.88 kg/potlift. Geometric catch-rates are more complex to compute than arithmetic catch-rates but they tend to be less susceptible to bias from a few extreme higher catches.

Standardised catch-rates were significantly different from non-standardised catch-rates although the magnitudes of these differences were rarely large (Figure 3). Encouragingly, standardised catch-rates tended to be higher than geometric and arithmetic catch-rates, which implies that changes in fishing patterns may be masking some increase in legal-sized biomass. Change in the depth of fishing over the last few years has been highlighted as an important issue to address through standardisation. Raw trends in depth data area shown in Figure 4 and Figure 5 and the impact on CPUE standardisation is discussed in more detail in Appendix 1(page 63).

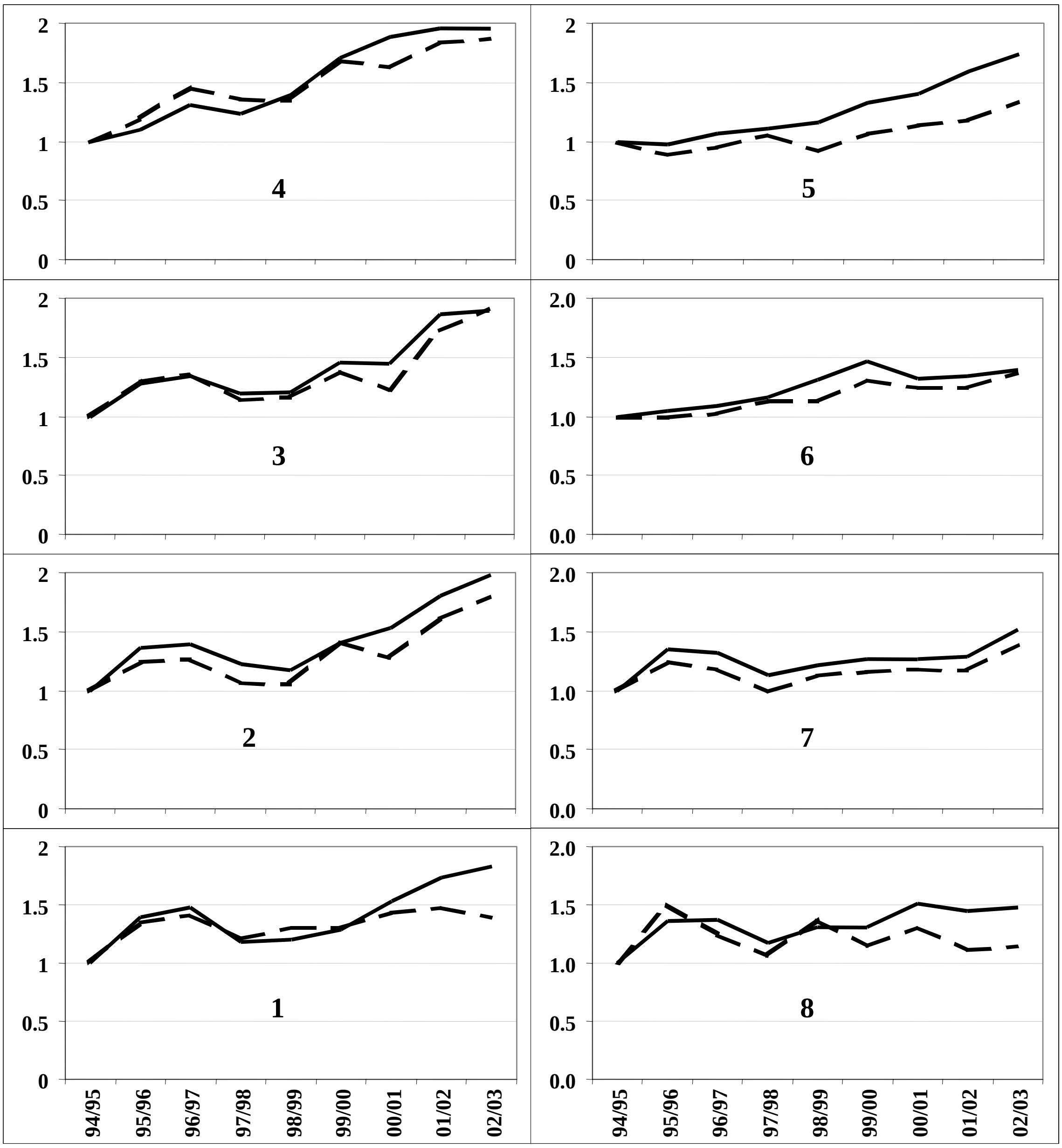


Figure 3. Regional rock lobster catch-rates standardised to the 94/95 quota year. Standardised catch rate (solid line) with the Totals catch rate (dashed line) for each of the eight regions across the quota years 94/95 to 02/03. Standardisation of catch rates produces an index of catch rate , which is scaled relative to a value of 1 for the 1994/95 year. That is, the y-axis cannot be read as kg per potlift. In all cases, the solid line (standardised catch-rate) tends to lie above the other two lines, although the perceived trend is not always increasing faster than the un-standardised catch-rates (see Regions 3, 4, and 6). Fortunately, in all regions the standardised catch-rates were all higher in 2002/2003 than in 2001/2002, although in some instances the increase was only minor.

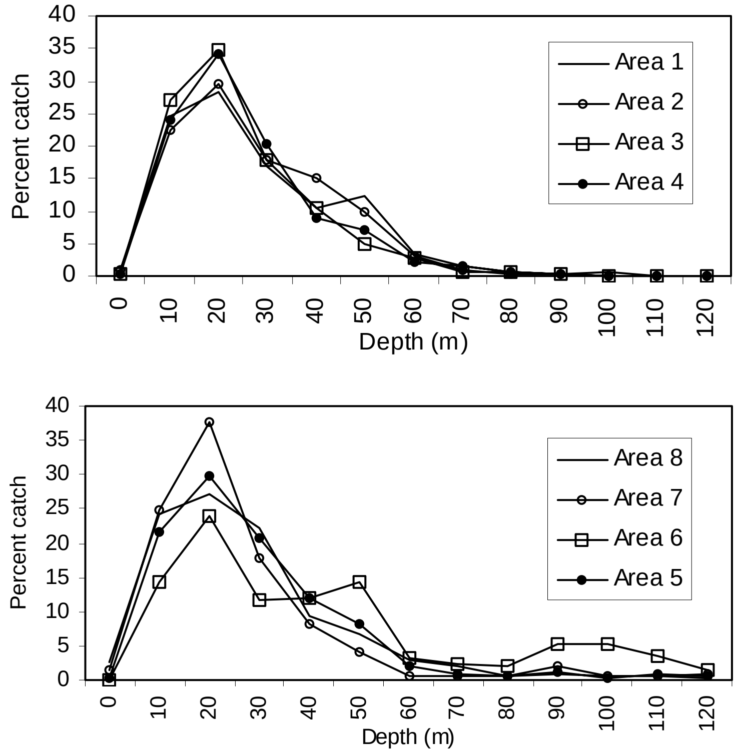


Figure 4. Distribution of catch in relation to depth for each area (east coast upper, west coast lower).

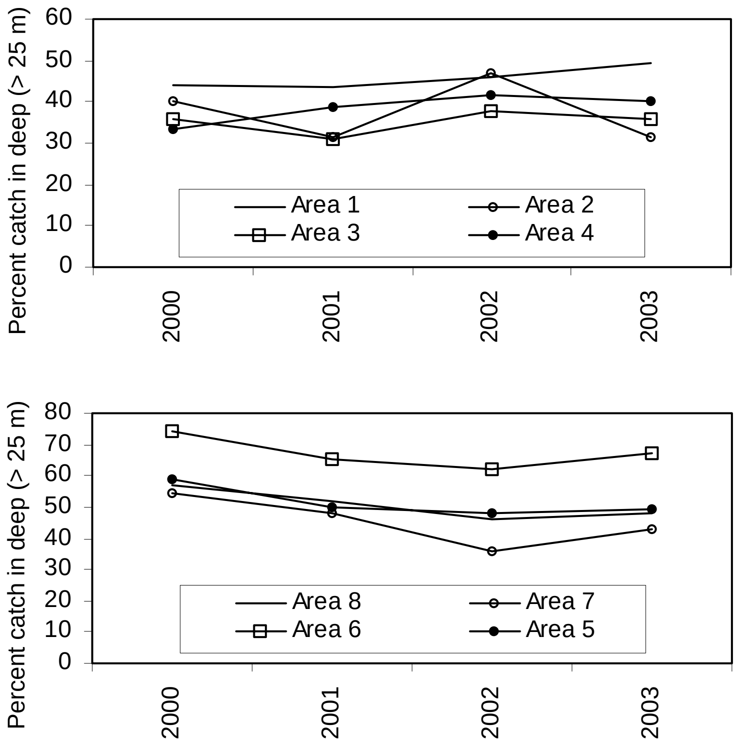


Figure 5. The proportion of the catch taken in deep water for each area, 2000-2003 (east coast upper, west coast lower). Data for 2003 is incomplete which may account for the apparent increase in the proportion of catch coming from deeper water in that year.

3.2.2 Data collection

A review of the rock lobster catch sampling project was conducted in May 2002. This review listed priority areas for future research and options available to meet these. Resource managers, researchers and stakeholders (commercial, recreational and community) all agreed that fisheries independent catch sampling was necessary as it provided crucial information for managing the fishery.

The priority areas of need indicated in the review were:

a) Fishery independent measures of fishing mortality,

b) increased regional coverage of size structure data,

c) growth/selectivity from all regions of the fishery - including depth stratification, and

d) maintenance of long-term sites.

An independent measure of fishing mortality was viewed as the most important need, especially if an estimate of natural mortality could also be obtained. As the change-in-ratio and index-removal methods were being continually compromised by the extended season opening, further development of tagging models developed by Frusher and Hoenig (2001) was seen as the best alternate option. The FRDC has funded a study to further develop these models. This project started in August 2003 and will look at gaining estimates from broad regions of the fishery.

In the past, we have been criticised for a lack of sampling in certain regions of the fishery, for sampling in regions considered to be unrepresentative of the commercial fishery, and for using a vessel that does not reflect a 'true' fishing operation. To obtain both estimates of fishing mortality (and possibly natural mortality) and increased size structure data from broader regions of the fishery it is planned to utilise commercial vessels this coming fishing season. This will allow us to increase our coverage of the State, without compromising the quality of the data. To offset the costs of chartering these vessels, we propose to reimburse fishers by the allocation of research quota. As a result, we see the use of the *FRV Challenger* as being restricted to maintaining our long-term study areas (South Coast – Maatsuyker Is. and Port Davey, East Coast – Sandstone Bluff).

Using commercial vessels, it is proposed to cover four of the eight stock assessment areas in this coming fishing season (2003/04). Proper coverage of all 8 areas was seen as financially and logistically impractical. Therefore, four areas have been highlighted by the review as being regions of greatest importance and/or concern within the fishery. Remaining areas will be targeted in subsequent surveys.

The areas chosen for catch-sampling surveys and reasons:

Area 1 – Due to the importance of the area to both commercial and recreational fishing in shallow waters.

Area 4– Northern fishing region that constitutes a high proportion of the overall catch, is an area with limited data available and represents a region with fast growth rates.

Area 6 – To assess the possible rebuilding of the offshore fishing grounds due to a recent shift to shallower waters, also an area of limited data.

Area 8 – Due to its importance to the fishery and to assess several concerns relating to recent declines in assessment performance indicators

It is also proposed to survey two depth categories (deep and shallow) within each of the selected assessment areas. Consultation with the commercial fishery has been conducted to determine appropriate depth categories for each area.

Table 3. Depth ranges selected by industry for shallow and deep categories in revised catch-sampling program.

	Shallow	Deep
Area 1	0-30 m	35-60 m
Area 4	10-35 m	40-70 m
Area 6	20-70 m	100-150 m
Area 8	5-35 m	40-80 m

The use of the tagging models requires two sampling periods. The first of these is a pre-season sample to be conducted in October. The second needs to be after the female closure as the longer the closed period the more robust the natural mortality estimate. However, the number of lobsters tagged is also important as a compromise between catch-rate and length of the closed season is required. Consultation with the commercial fishery is needed to determine the appropriate timing of this second sampling period but the months of June and July (varies between areas) appear to have better catch-rates.

3.2.3 Update of the commercial fleet dynamics model.

More detailed information on this area of development is presented in Appendix 2(page 68). The rock lobster stock assessment model (Punt & Kennedy, 1997) is used to assess the status of the rock lobster stocks in eight separate regions around Tasmania, each independent of the others. This is valid for assessment purposes because the amount of adult movement between regions is trivial (Gardner *et al*. in press), and recruitment levels are determined separately for each region within the assessment model. Once the assessment is complete the model is also used to project the stock forward under different harvest strategies (different TACC scenarios) so as to conduct a risk assessment and test the sustainability of the different possibilities under the assumption that recruitment patterns will be similar to those previously experienced.

The assessments are conducted separately in the eight assessment regions but all regions must be considered together for the forward projections making up the risk assessment. The risk assessment requires that the TACC be distributed across the eight regions in a realistic manner in each of the years of the projection. In effect, it becomes necessary to be able to predict where the fishers are going to distribute their effort and obtain their catch. For the projections to proceed it is essential to have a model of the fleet dynamics (the distribution of effort or catch). The only option for generating such a model that would interact effectively with the assessment model was to generate a statistical description of how the fishers distributed their effort through the year among the eight regions.

The original fleet dynamics model developed for the Tasmanian fishery by Punt and Kennedy (1997) used a relationship between the area, the month of fishing, and the expected catch-rates in each area in each month, to predict the harvest rate in the different regions in each month. The model used data from a short period prior to quota management - the years 1990 to 1995. As part of the FRDC funded project (1999/140) “Impact of Management Change to an ITQ System in the Tasmanian Rock Lobster Fishery” (Frusher *et al*., 2003) new alternatives were investigated so as to re-calibrate the fleet dynamics model to fleet behaviour since the introduction of the quota management system. At the time of those analyses there were only two complete years of data following the introduction of the ITQ system and it was questionable whether the fleet dynamics had stabilised within the new system. In 2003 there are now 5 years of data post-introduction of ITQs for the Tasmanian rock lobster fishery and a further attempt has been made to re-calibrate the fleet dynamics model.

The final statistical model selected was similar to that used originally except that the relative importance of different factors used to predict fleet movement had changed. These factors were the assessment area, month, month and catch rate interaction and area and catch rate interaction. This means the model is predicting where fishers will expend effort in relation to the time of year, the area and catch-rates.

One important development is that the interaction term between catch rate and area was estimated and included for the first time this year. This is intended to account for fishers responding differently to changes in catch-rate depending on the area.

4. Fishery Assessment

4.1 Evaluation of Trigger Points

The management plan contains performance indicators relating to:

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

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

The trigger points are often based on the 5-year period prior to the introduction of quota. For instance, regional catch-rates for the current year are compared with those from the 5 years before quota; if the current catch-rate falls below the lowest value from those 5 years, then the trigger is activated. Many of these trigger points have been in place for several years and were established at a time when the biomass was much lower than it is today. With the increase in biomass that has occurred since the late 1990, these trigger points will require review during the formulation of the next management plan. Although the criteria used for EPBC accreditation are assessed in this report, there may be value in incorporating these in future performance indicators.

4.1.1 Commercial catch-rates

Commercial catch-rates for 2002 were shown to have improved for the majority of assessment areas when compared to the previous year (Table 4). The only two areas of decline were from the southern-most Areas, 1 and 8. Despite the slightly lower catch-rates for Areas 1 and 8, they are still above the reference year and have not triggered the performance indicator. An encouraging trend was the reversal of the declining catch-rates indicated over the last two seasons for Area 6. Area 6 has rebounded with the largest increase of 21% when compared to the previous year. As mentioned in the previous assessment (Frusher *et al.*, 2003), there is a substantial shift in effort in Area 6 from deep to shallow water, where generally catch-rates are lower. This trend continued in 2002 (Figure 6), but improved catch-rates were recorded for both depth categories during this period resulting in the large improvement for the area (Figure 7).

Table 4. Change in annual commercial catch-rates. Negative values indicate a decline in the change. The reference year is defined as the year with lowest CPUE among 1993, 1994 and 1995. Included also are commercial catch statistics for 2002.

Region	**Reference Year**	**Commercial catch-rates (kg/potlift)**			**% change in 2002**		**Commercial catch 2002 (Jan-Dec)**	
		Ref. Year	**2001**	**2002**	**vs Ref. Year**	**vs 2001**	**Catch (t)**	**Effort (1000 potlifts)**
Statewide	1994	0.82	1.04	**1.11**	+35%	+7%	1437	1291
1	1994	0.52	0.81	**0.74**	+42%	-9%	119	166
2	1994	0.54	0.84	**0.97**	+80%	+15%	132	135
3	1994	0.44	0.68	**0.81**	+84%	+19%	102	123
4	1994	0.63	1.08	**1.17**	+86%	+8%	240	206
5	1995	0.90	1.19	**1.33**	+48%	+12%	339	255
6	1995	1.21	1.49	**1.80**	+49%	+21%	188	105
7	1994	1.11	1.31	**1.54**	+39%	+18%	106	69
8	1993	0.77	0.93	**0.90**	+17%	-3%	212	236

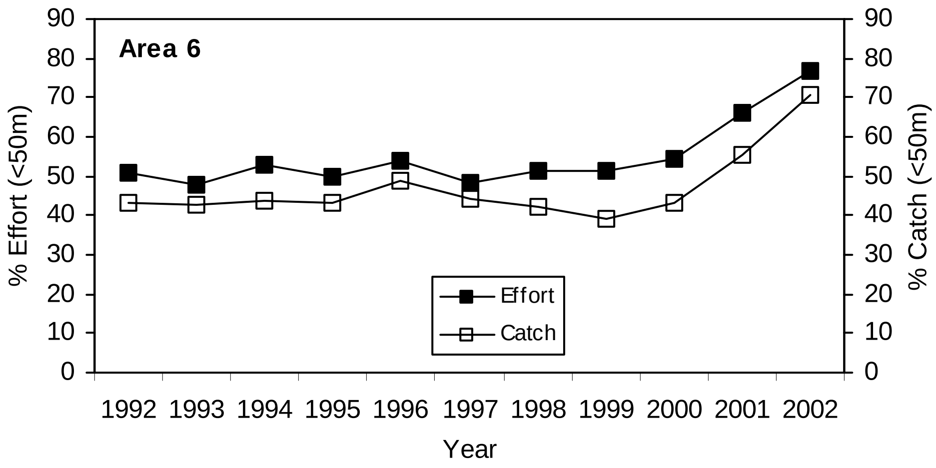


Figure 6. The percentage of effort and catch from shallow water grounds (<50m) from Area 6 since 1992.

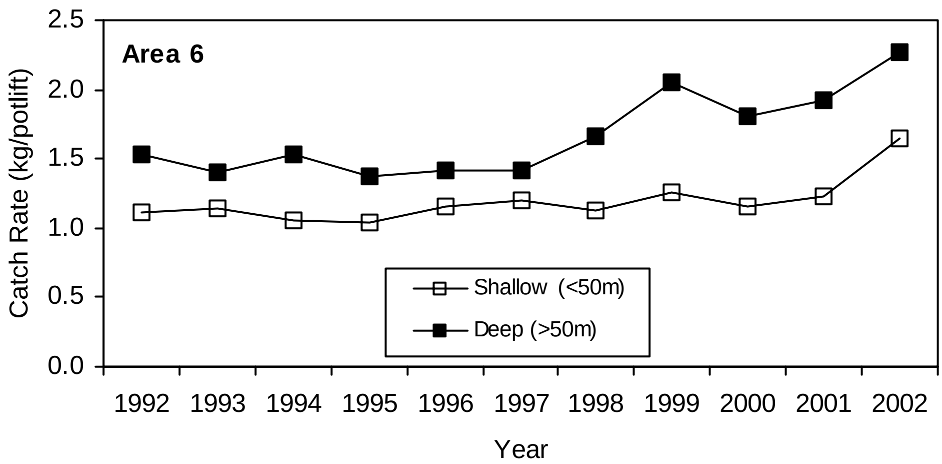


Figure 7. Comparison of catch-rates from shallow (<50m) and deep (>50m) water from Area 6 since 1992.

Monthly commercial catch-rates within each area continue to remain higher or equal to the representative catch-rates of the reference year (Figure 8). When monthly catch-rates for 2002 are compared to the previous year (2001), the improvement shown for the yearly estimate for most areas is a result of higher catch-rates recorded in late summer, early autumn (January-April). The exception was Area 8, which consistently yielded lower monthly catch-rates. Monthly catch-rate data for Area 1, the other region to record a decline in catch-rates for 2002, indicate the declines were restricted to the months of November and December.

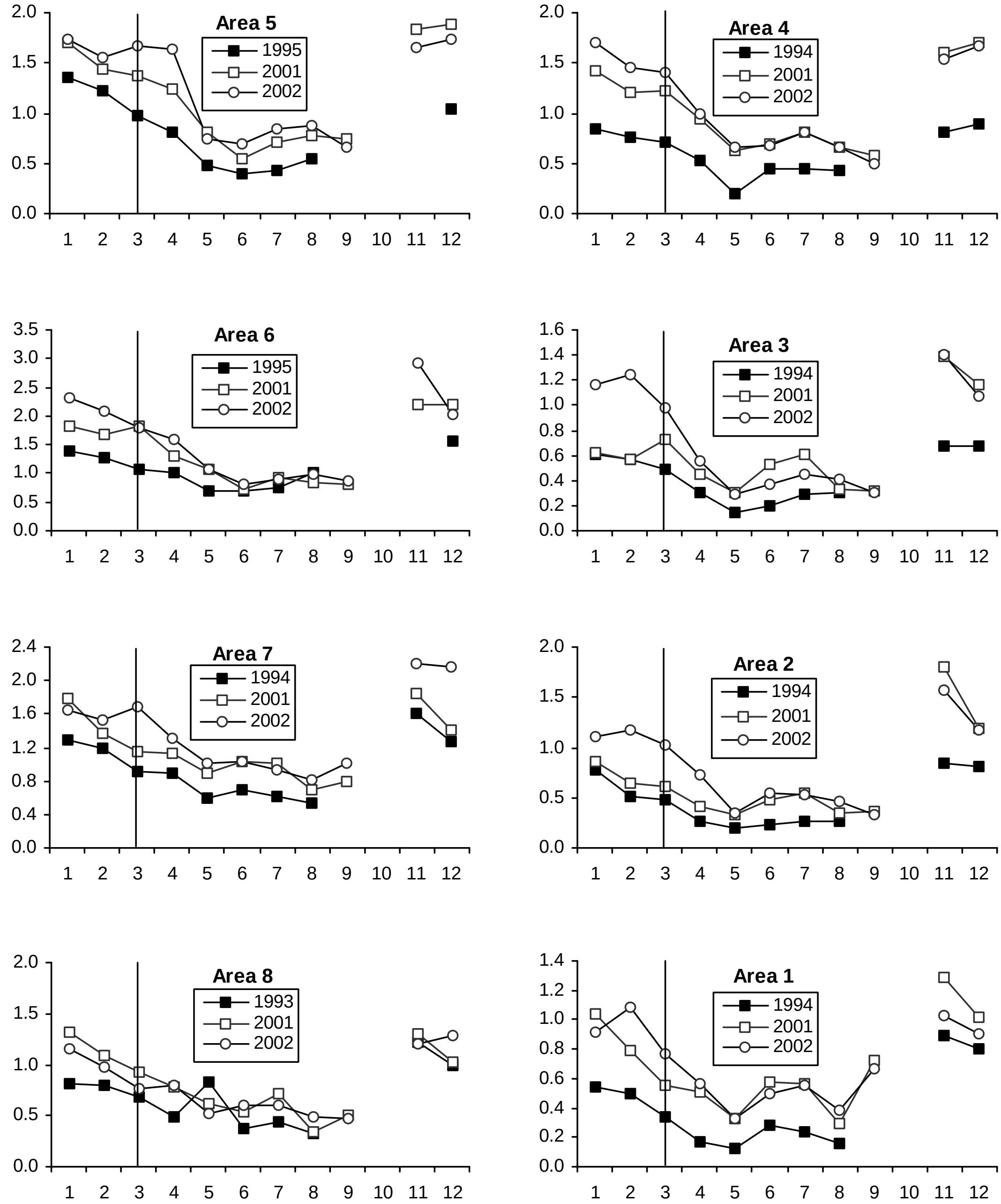


Figure 8. Change in catch-rate (Y-axis; CPUE, kg/pot lift) between months (X-axis) for 2002, 2001 and for reference year for each respective assessment area. Vertical line in each plot indicates the start of the quota season. Note the vertical axis depicted catch-rates changes scale for different regions. Catch rate summaries for the whole year (Table 6 and Table 7) can be affected by the time of year when fishing occurs. This figure illustrates that catch rates have improved across the year, in each area, relative to reference year.

With the shift to an ITQ managed fishery, it is perhaps more appropriate to examine commercial catch-rates based on a quota season and not a calendar year. When catch-rates based on a quota year (i.e. March to February) (Figure 9 and Table 5) are compared with those based on a calendar year (Table 4), differences are apparent. This three-month shift in the catch-rate analysis has resulted in a reduction of the percentage increases in catch-rates in eastern regions of the fishery (Area's 2,3 and 4) and a slight improvement in southern regions (Area 1 and 8). This would suggest that the improved catches from eastern regions based on a calendar year (Table 4) are likely to decline into 2003. The increase in southern regions also suggests that catch-rates in these regions may be improving. This is particularly encouraging as Area 8 contributes substantially to the overall Tasmanian catch (Table 5).

Catch-rates from SE areas 1, 2 and 3 are the lowest for the State and area 1 was the only area to record a declining catch-rate from 2001/02 to 2002/03. Exploitation rates in this region are maintained at high levels due to several factors including the large recreational catch and the more sheltered coast line.

Table 5. Comparison of highest and lowest commercial catch-rates (kg/pot lift) regionally around Tasmania from 1970. Comparisons are between years on a quota year basis (i.e. March to February). Included is the regional catch (tonnes) for the 2002/03 season.

Area	Highest Catch-rate		Lowest Catch-rate		% Difference in Catch-rate	2001/02 Catch-rate	% Difference 2000/01 to 2001/02	Catch 2002/03 (t)
	Year	Catch-rate	Year	Catch-rate				
State	1981/82	1.66	1995/96	0.82	+51%	1.11	+7%	1508
1	1971/72	1.30	1994/95	0.54	+58%	0.76	-6%	124
2	1974/75	1.47	1994/95	0.54	+63%	0.97	+11%	131
3	1974/75	1.40	1994/95	0.43	+69%	0.81	+9%	105
4	1980/81	1.72	1994/95	0.61	+65%	1.14	+1%	248
5	1982/83	1.92	1995/96	0.89	+54%	1.33	+13%	366
6	1984/85	2.43	1972/73	1.14	+53%	1.68	+9%	197
7	1980/81	2.03	1997/98	1.09	+46%	1.53	+19%	115
8	1980/81	1.80	1993/94	0.77	+57%	0.92	+2%	222

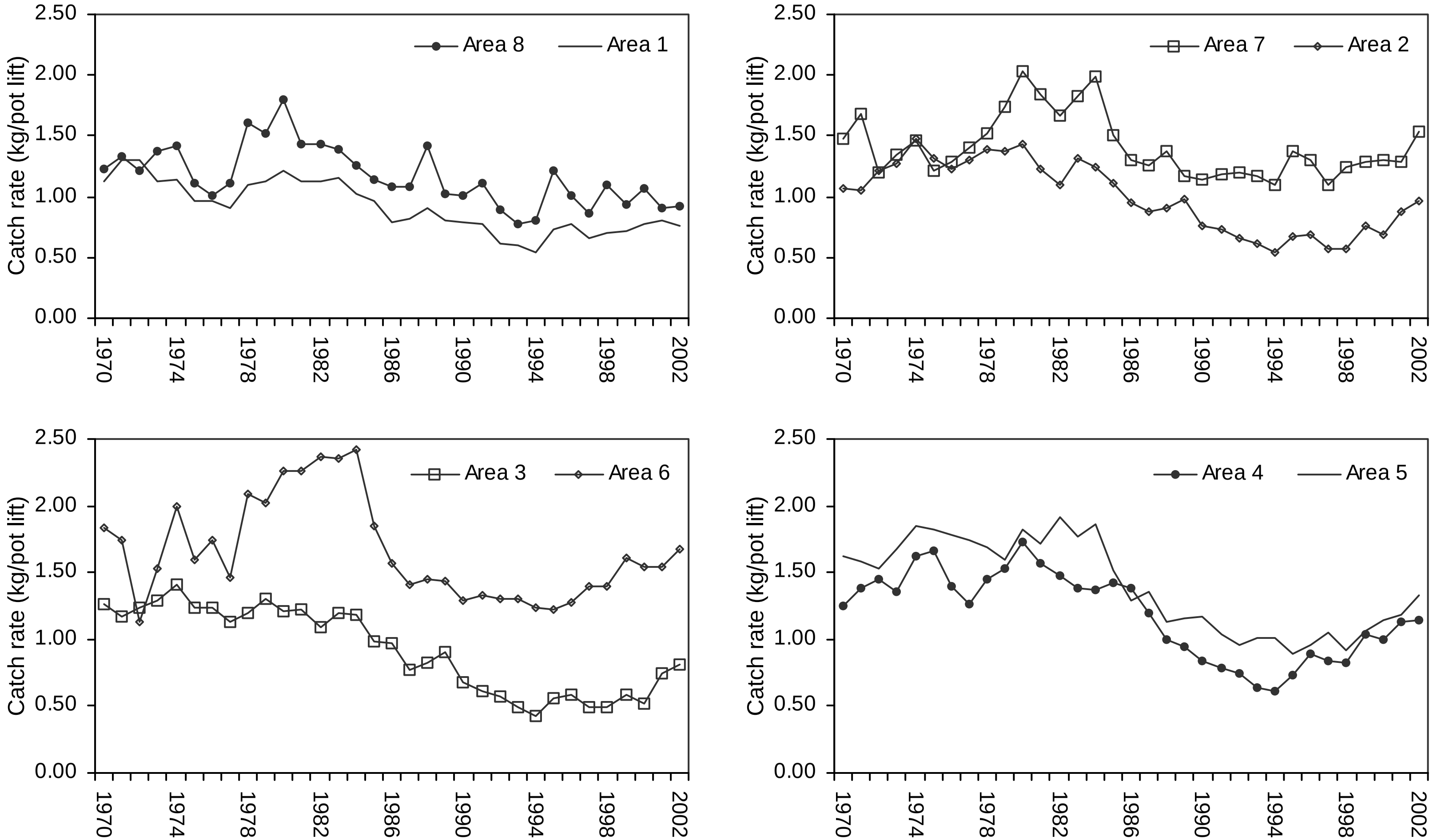


Figure 9. Regional catch-rates from southern and northern Tasmania since 1970. Data is presented on a quota year basis (i.e. March to February) so the last data point is for March 2002 to February 2003 inclusive.

4.1.2 Research catch-rates

With the resumption of research catch sampling during the 2002/03 fishing season, pre-season catch-rates (October/November) are available for comparison to previous estimates (Table 6). Large increases in research catch-rates were recorded in Area 2 for shallow and medium /deep waters, when compared to both the previous sampling period and the reference year. This is encouraging as it mirrors the increased commercial catch-rates recorded for this region (see Section 4.1.1).

Deep-water research sites in Area 8 indicated a large reduction in catch-rates when compared to both the previous sampling period and the reference year (Table 6). This reduction would suggest the performance indicator has been triggered for this area. However, we believe the research survey conducted in November 2002 was affected by catchability problems due to poor weather, based on similar observations from the Crayfish Point MPA sampling project. Research catch-rates for this region are typically volatile and the sample reported here is from a single survey, rather than the more extensive 3 annual surveys reported in previous reports. Thus we believe this result is of limited concern when viewed in isolation. Pre-season research catch sampling is planned for this region for the coming fishing season (2003/04), which will provide an opportunity to investigate catch-rates further.

Table 6. Change in November catch-rates from research surveys on the East and South Coasts of Tasmania. Note no catch sampling survey was conducted in November 2001 so comparison is made with 2000, which was the previous research sampling year.

Region	Depth (m)	Commercial Catch-rate 2002	Reference Year	Catch-rates (kg/ pot lift)			% change	
				Ref. Year	2000	2002	vs Ref. Year	vs 2000
Area 8	45 - 100	1.46	Nov'93	0.97	1.73	0.51	-47%	-71%
Area 2	30 - 50	2.65	Nov'94	1.36	2.59	3.69	+171%	+42%
Area 2	< 30	2.27	Nov'94	1.06	1.21	1.40	+32%	+16%

4.1.3 Legal-sized biomass

The rock lobster assessment model indicates that there has been continued stock rebuilding during 2002 at a State level, albeit at only a moderate level (Table 7). At a regional level, legal sized biomass tends not to reflect the changes seen in commercial catch-rates. This may be due to changes independent of biomass occurring in these regions of the fishery that are driving model estimates. Both standardised and arithmetic mean commercial catch-rates in Area 6 increased last year, but the assessment model suggests biomass is decreasing. This apparent paradox is presumably driven by estimates of seasonal change in catchability. Nonetheless, our understanding of the trend in stocks in this area is unclear so this area was targeted for fisheries independent catch sampling surveys in October 2003.

Legal sized biomass estimates for Areas 2 and 3 tend to reflect the recent increases in the commercial catch-rates, and have continued the rebuilding indicated in the previous assessment (Frusher *et al.*, 2003). This continuation is encouraging, as this region of the fishery has historically had the highest exploitation rates. Although biomass has increased in all areas since the reference years of ’93, ’94 and ’95, biomass is still below the estimates for the early 1980s (Figure 10). This is most noticeable in the productive northern regions (Areas 4 and 5). Legal-sized biomass in these northern areas did not appear to increase over the last year.

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

Region	Reference	Sized biomass estimate (tonnes)			% change in 2002	
	Year	Ref. Year	2001	2002	vs Ref. year	vs 2001
Statewide	1993	2540	3681	3795	+49%	+3%
State (adj)	1993	1456	2010	2044	+40%	+2%
1	1993	245	460	498	+103%	+8%
2	1993	132	227	250	+89%	+10%
3	1994	74	135	141	+90%	+4%
4	1994	429	747	734	+71%	-2%
5	1993	698	950	945	+35%	+0%
6	1995	261	336	318	+22%	-6%
7	1994	294	361	390	+33%	+8%
8	1993	394	464	519	+32%	+12%

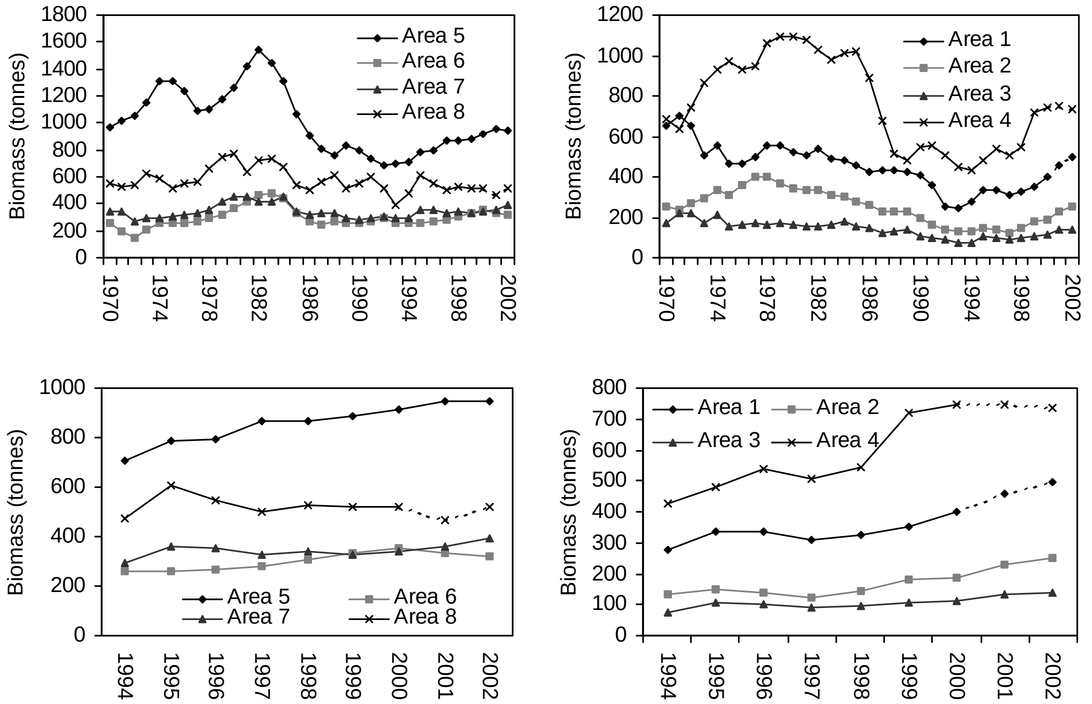


Figure 10. Regional legal-sized biomass estimates for the Tasmanian rock lobster fishery from (upper) 1970 to 2002 and (lower) from 1994 to 2002. All estimates are for October. Inter-annual changes, which are likely to be less accurate, are dashed.

4.1.4 Egg production

Egg production estimates are shown in Table 8. Egg production Statewide appears stable relative to recent years, rather than increasing as it was reported in previous assessments. The apparent lack of a Statewide increase in egg production is surprising given the trend in the commercial fishery to shift fishing effort into winter months when landing of females is prohibited.

The declines in egg production in northern areas 4, 5 and 6 over the last year is of some concern (although the extent of the decline in Area 6 is uncertain as estimates from this region are often biased; Gardner, 2000). Rebuilding of egg production in the northern areas is a goal of the current management plan, which gives a target of 25% of virgin.

The decline in egg production in Areas 1 and 7 is of limited concern as estimates of the percentage of the virgin egg production are exceptionally high for a lobster fishery at 59 and 45% respectively. Reflecting the increases in legal-sized biomass, egg production has increased in Areas 2 and 3. Despite the increase, egg production in Area 3 (along with other northern regions – Areas 4,5 and 6) is still below the management target of 25% of virgin production implying further improvement is required (Figure 12).

Estimates of egg production relative to virgin in area 8 exceed 100% due to difficulty in estimating egg production in this region because such a small proportion of females reach legal size. A value of greater than 100% is plausible if the harvesting of males has freed up resources to allow the population of females to increase above that in a virgin unfished state. While there is some uncertainty over the precise amount of egg production in area 8, it is clear that production in this area is massive and over double that of any other area. Density of females is extremely high with research trapping surveys averaging almost 50 animals per potlift.

Table 8. Change in relative egg production from the reference year to 2002, and the level of egg production in 2002 as a percentage of virgin egg production. Virgin egg production is the estimated egg production prior to commercial exploitation, assuming average recruitment is the same as that from 1970 to the present. Relative egg production is a numerical (linear) index of egg production so that a relative egg production of 200 implies twice as many eggs are being produced compared to a relative egg production of 100. Shaded lines are regions with greater uncertainty in egg production estimates. “State (adj)” is Statewide data excluding region 6, where egg production is estimated poorly for recent years.

Region	**Reference Year**	**Relative Egg Production**			**% change in 2002**		**% Virgin prodn. in 2002**
		Ref. Year	**2001**	**2002**	**vs Ref. year**	**vs 2001**	
Statewide	1993	938	1162	1160	+24%	+0%	30%
State (adj)	1993	870	1080	1087	+25%	+1%	31%
1	1995	158	146	143	-9%	-2%	59%
2	1992	68	128	142	+109%	+11%	50%
3	1993	27	48	51	+88%	+6%	13%
4	1993	78	145	140	+80%	-3%	16%
5	1992	80	141	140	+75%	-1%	13%
6	1986	51	82	73	+43%	-11%	18%
7	1989	133	137	132	-1%	-3%	45%
8	1994	300	336	339	+13%	+1%	114%

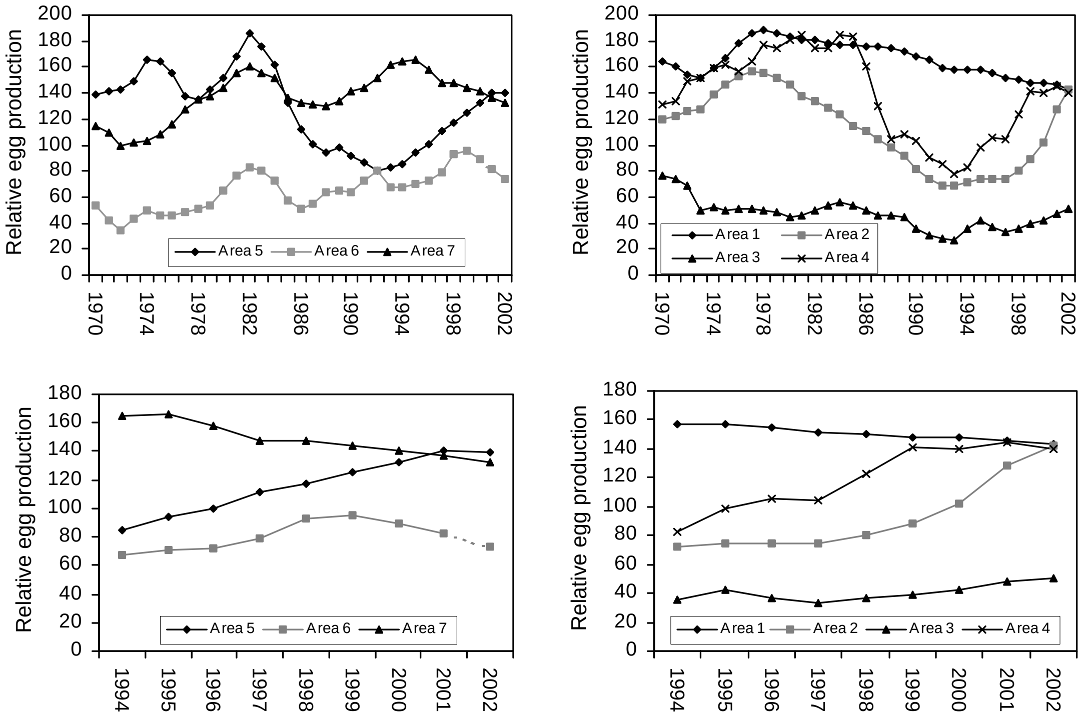


Figure 11. Relative egg production from 7 Areas around Tasmania, western regions to the left, eastern regions to the right. Area 8 is not included due to problems mentioned in the text. Interannual changes, which are likely to be less accurate, are dashed.

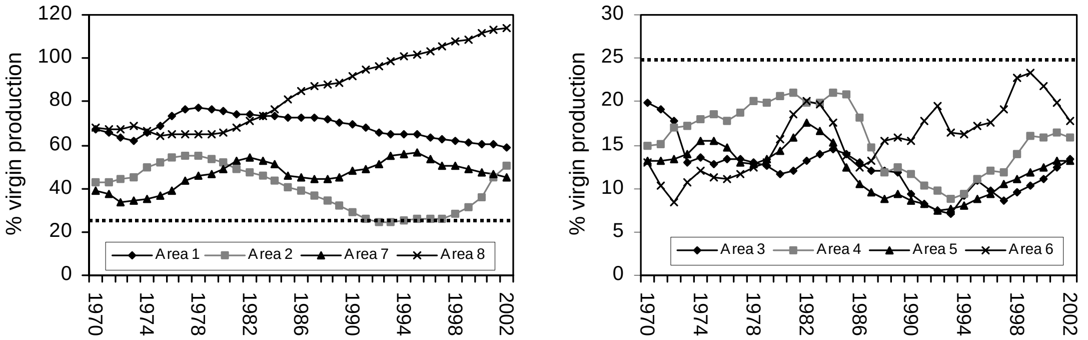


Figure 12. Percentage of virgin egg production from eight Areas around Tasmania, southern Areas to the left, northern Areas to the right. The horizontal bar in each plot represents the management target of 25%. The last year of the plot for Area 6 should be accepted cautiously.

4.1.5 Relative abundance of undersized lobster

Research estimates

For the abundance of pre-recruit lobsters (undersized lobster equivalent to one growth increment below legal size) to be relevant as a performance indicator, a relationship between the catch-rate of pre-recruits and the catch-rate of newly recruited lobster in the following year needs to be established. A link between the abundance of undersize and subsequent catch-rates has only been defined on the south coast where catch-rates of undersize males of greater than 105 mm CL provide an index of the number of animals moulting to legal size in the following season.

With the continuation of research sampling in 2002 after a years break, undersized catch-rates of lobsters caught during preseason surveys (October/November) at Maatsuyker Island (South Coast – Area 8) could again be compared. Preseason sampling in 2002 indicated a large decrease in undersized catch-rates of lobsters at Maatsuyker Island when compared to both the reference year and the last year of sampling 2000 (Table 9). The previous lowest catch-rate of undersized lobsters (1.43kg/pot lift) was achieved in the pre-season survey in 1995 (reference year). Sampling in 2002 indicated undersized catch-rates decreased to 0.47kg/pot lift or a 67% drop on the reference year (Table 9). As discussed in Section 4.1.2, catchability problems influenced the catch-rates during this survey, in particular at Maatsuyker Island. Therefore, despite being substantially below the reference year and thus activating the undersize trigger, caution should be shown in regards to undersized catch-rates from this region.

From 1996, research sites at Port Davey were included to increase the number of sites sampled in Area 8. The catch-rates of pre-recruits from the Maatsuyker sites and the combined sites (Maatsuyker and Port Davey) are different and thus the combined catch-rates cannot be compared to the 1995 reference year. We have included last year's catch-rates for the combined sites in Table 9 to determine if the trends in Maatsuyker are reflected in the more extensive data. Both the Maatsuyker and the combined dataset show a negative trend in fishery independent catch-rates of undersized lobsters. The percentage change in catch-rate was greater in the more southerly Maatsuyker sites, which tended to be more affected by catchability problems.

Although links between undersize catch rates and subsequent catch rate of legal size animals in the following year has only been shown for Maatsuyker and Port Davey, long term data-series are available for other sites. Total catch of undersize lobsters per pot lift are shown in Figure 13. Although there appear to be long term trends in some of these series, samples are often drawn from different projects with different sampling regimes. These different sampling regimes can causes biases in catch rate data, especially when samples were collected from different times of the year.

Table 9. Comparison of fishery independent preseason (Oct/Nov) catch-rates of undersized male lobsters (105-110 mm) sampled from waters adjacent to Maatsuyker Island (Maat) and these sites combined with sites at Port Davey (Maat + PD) in similar depths. No catch sampling survey was conducted in November 2001 so comparison is made with 2000, which was the previous sampling year. For Maatsuyker Island, 390 pot lifts were undertaken in the reference year compared to 100 in 2000 and 150 in 2002. Samples from Port Davey are based on 100 pot lifts in both 2000 and 2002. No sampling was undertaken at Port Davey in the reference year of November 1995.

Region	Reference Year	Catch-rates (kg/pot lift)			Actual Change (kg/pot lift)		% change	
		Ref. Year	2000	2002	vs Ref. Year	vs 2000	vs Ref. Year	vs 2000
Maat	Nov'95	1.43	3.94	0.47	-0.96	-3.47	-67%	-88%
Maat + PD			4.72	2.42		-2.30		-49%

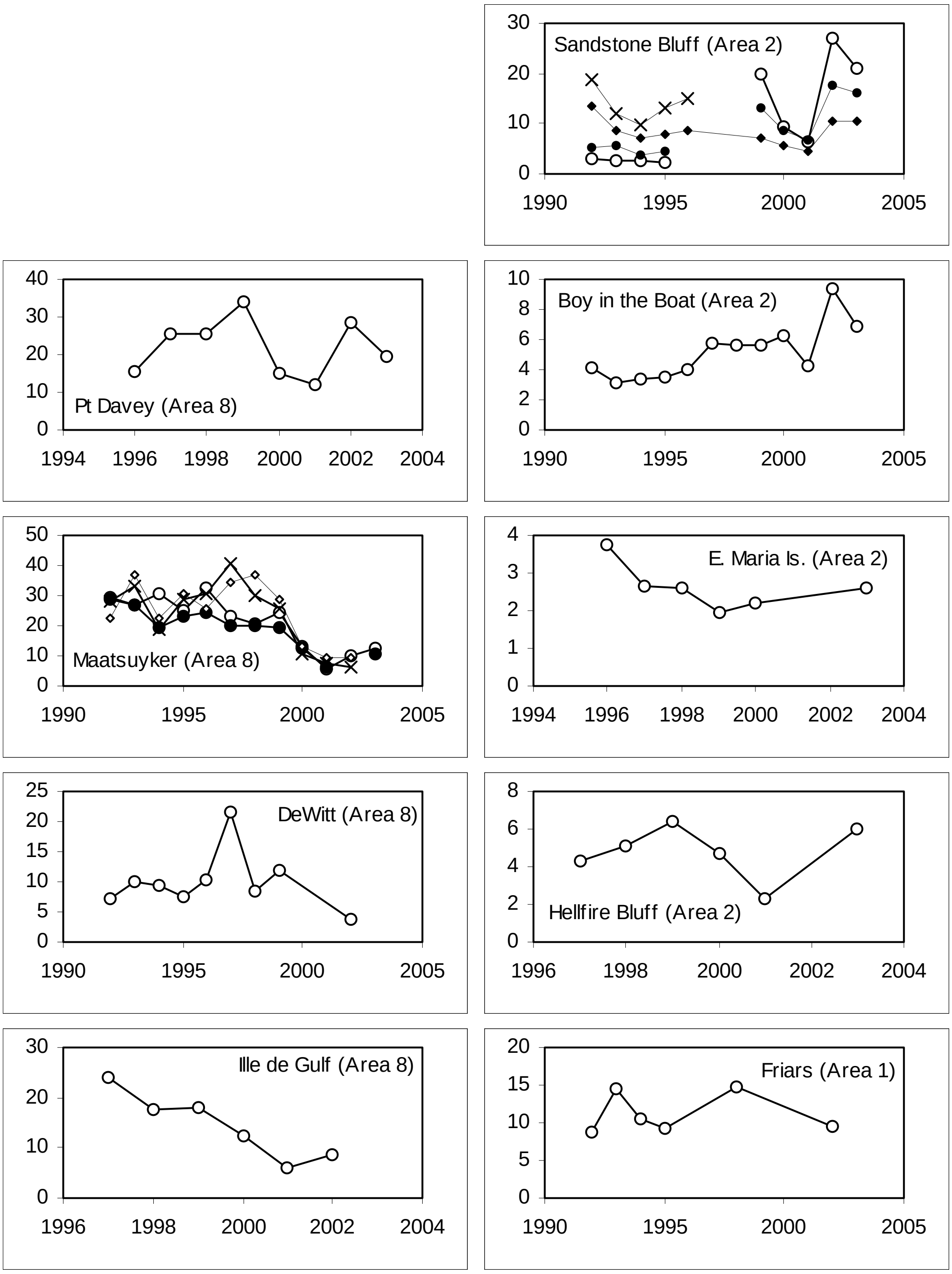


Figure 13. Catch rate of undersize lobsters (total lobsters per potlift) from research sites with extended sampling history. Sampling has occurred at different times of the year, which can affect interpretation of these charts. Time series from Maatsuyker Island were affected by change in timing of sampling from 2000-2003.

4.1.6 The total annual catch

The total annual commercial catch (TACC) is constrained by output controls on the fishery. A TACC of 1502 tonnes was introduced for the first time in March 1998 and was increased to 1523 tonnes in March 2002. A management trigger is set at a catch of 95% or less of this amount (2002/03 = 1447 tonnes). The total catch for the period March 2002 to February 2003 (inclusive) was 1520 tonnes, which is greater than the trigger. Several fishers have reported that they retained a small amount of quota unfished, as it was not economically viable to return to sea for this small amount of catch. This implies that the TACC shortfall is not a function of lobster abundance.

4.1.7 The size of the rock lobster fleet

The number of active licenses and vessels in the lobster fishery has declined steadily over the last 10 years (Figure 14). A trend of reduction in the size of the fleet was evident prior to quota. With the introduction of quota there was an immediate decrease in the number of active vessels and licences as several licences were aggregated on to a single vessel (Table 10). Since this redistribution, the rate of contraction has continued at a similar rate to that prior to the introduction of the Quota Management System (QMS). Note that the number of active vessels is influenced by several factors including the fishing of more than one license from a single vessel and the replacement of vessels so that more than one vessel is active under a single license.

Table 10. Changes in the number of licences and vessels in the Tasmanian rock lobster fishery in calendar years from 1993 to 2002. Licenses cannot be created so the 2001 value cannot change although it is based on partial year data. Active licenses are those that recorded catch. It is possible that the number of active licenses in 2002 is an underestimate as it is based on partial year data.

Year	Number of licences	% change	Number of active licenses	% change	Number of active Vessels	% change
1993	337	-	330	-	353	-
1994	334	-0.9	329	-0.3	342	-3
1995	331	-0.9	326	-0.9	348	2
1996	321	-3.0	315	-3.4	332	-5
1997	316	-1.5	309	-1.9	330	-1
1998	314	-0.6	304	-1.6	314	-5
1999	314	0	269	-11.5	270	-14
2000	314	0	259	-3.7	254	-6
2001	314	0	250	-2.4	246	-3
2002	314	0	242	-1.2	247	+0.5
2003 (part)	314	0	234	-3.3	227	-8.1

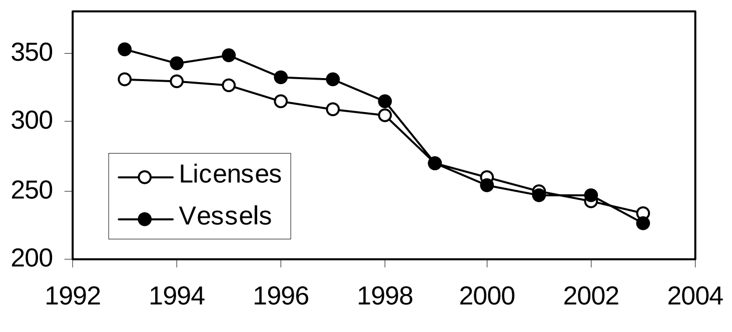


Figure 14. Trends in number of active licenses and vessels in the Tasmanian rock lobster fishery over the last 10 years. Data for 2003 is incomplete.

4.1.8 The recreational catch

A recent national survey of recreational fisheries estimated the fishing expenditure attributable to recreational fishers in Tasmania at $416 per person, and the total recreational fishing industry at around $50 million (Lyle *et al.*, 2003).

In comparison to the commercial fishery, frequent and precise estimates of the recreational fishery are relatively difficult. Reliable estimates for the amount of lobsters harvested by recreational fishers are typically based on surveys. In recent years there has been a growing commitment by resource management agencies to regular surveys of recreational fishers. These surveys are typically less frequent than annual.

Although we have scaled previous recreational catches by the number of license holders between 2000/01 and 2002/03 in Figure 17, it is overly simplistic to consider the number of licences or license entitlements to be a proxy for catches for earlier periods. This is because licensing arrangements have changed considerably since 1995. Prior to 1995 recreational fishers could freely use rock lobster ring but were required to have a licence for potting. If they wished to take rock lobster by diving, they could apply for a general dive licence that also provided access to abalone and scallops. In 1995 the diving entitlement was split into separate licences for rock lobster, abalone and scallop. In 1999 a licence was introduced for the use of rock lobster rings. As a result of these changes, the number of entitlements is a poor indicator of changing levels of access. The total number of individuals fishers involved in the fishery (independent of methods used) has increased by around 83% since the introduction of the present licensing system in 1995 (Figure 15). The changes to licensing systems in 1999 to separate licenses for ring, pot and dive methods has resulted in a more rapid increase in the total number of licences than total number of licensed recreational fishers (132% since 1995; Figure 16).

The rapid rise in licence numbers and apparent increase in catch taken from some regions of the fishery has caused concern for both recreational and commercial lobster fishers. Although biomass and catch-rates are increasing in most stock assessment areas, there is concern that this may be restricted to the offshore or deep water fishing regions where recreationals can't reach. It is possible that the combined commercial and recreational effort inshore in shallow waters may be resulting in declines in these areas. Fishery independent surveys of both inshore and offshore fishing waters commenced in October 2003 to improve our understanding of this issue. Area 1 (south-east) where the recreational catch for the 2000/01 season accounted for at least 45% of the total inshore catch (Forward and Lyle, 2002) was one area of the fishery that was surveyed independently.

The current management trigger point in regard to recreational catch is that recreational catch should not exceed 10% of the TACC in a year. The most recent survey estimate (2000/01 fishing season) of the recreational fishery estimated catch at 8.5% or lying between 95% confidence limits of 5.9% and 11.5% of the TACC (Gardner *et al.*, 2002), 2002). Since that time, the numbers of recreational licences and license holders have increased (Figure 16). If recreational catch estimates from the 2000/01 survey are scaled-up by the increased number of license holders, then it appears that recreational catch is around 10% or lying between 95% confidence limits of 6.9 and 13.4% (Figure 17). Thus there is a high probability that the trigger point has been activated.

It is anticipated that a survey of recreational rock lobster licence-holders held during the 2002/03 recreational rock lobster fishing season (November 2002 – August 2003) will provide an estimate of recreational catch with improved precision to those shown here. The results of this survey will be available for discussion in next assessment report (2003/04).

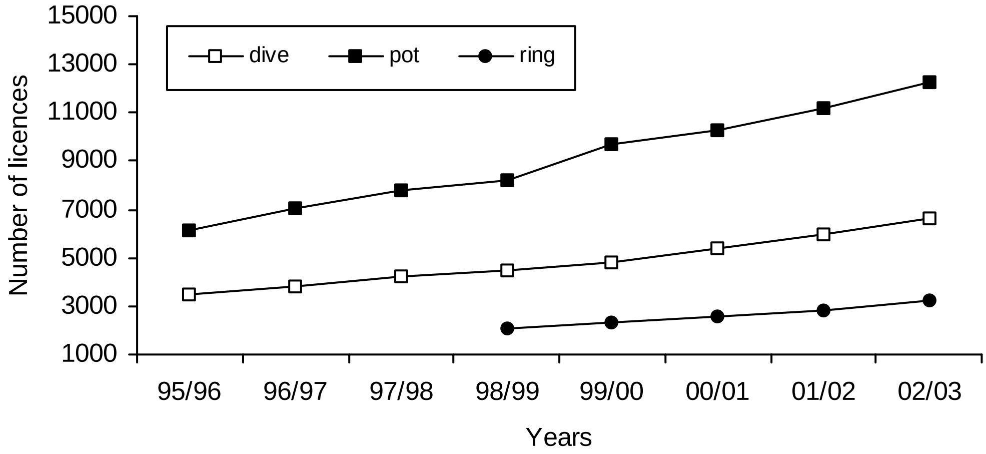


Figure 15. Number of recreational pot, dive and ring licences issued from 1995 to 2003.

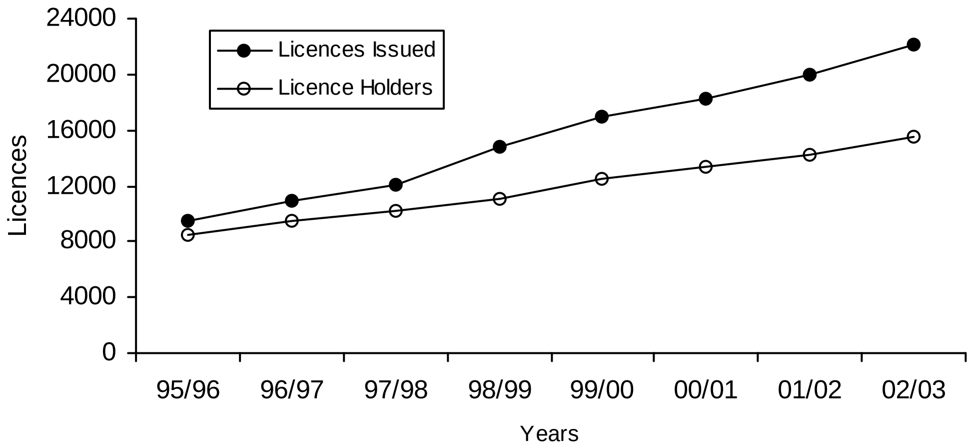


Figure 16. Comparison between the total number of recreational rock lobster licences issued (pots, dive and rings; solid circles) and the number of licence holders (open circles) from 1995/1996 to 2002/2003 recreational fishing season.

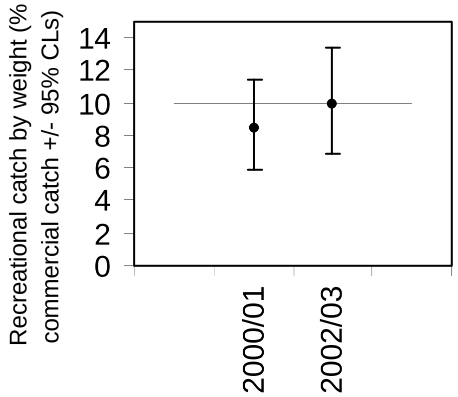


Figure 17. Estimated recreational catch as a percent of commercial catch in relation to the trigger point of 10% (+/- 95% confidence limits). Catch is based on weight, rather than numbers. The 2002/03 value is scaled up from the 2000/01 estimate based on the number of license holders and thus assumes that: (i) the spatial distribution of recreational effort is the same, (ii) the split between dive and pot/ring catch is the same, (iii) the difference in weight between dive caught and pot/ring caught is the same. Given these assumptions, there is high probability that the trigger point on recreational catch has been breached.

4.2 Trends in fisheries-independent abundance indices

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

4.2.1 East Coast – Shallow Depth

Commercial and research legal-sized catch-rates for shallow depths (<35m) were relatively similar for the first three years of sampling, after which commercial catch-rates tended to be much higher (Figure 18). This change probably reflected the large amount of effort expended in this area during the first few years of research sampling. Since then commercial catch-rates tends to show greater between year fluctuations than the research catch-rates. Research catch-rates would be expected to be less variable as they are obtained from the same site whereas commercial catch-rates will reflect the commercial distribution of the fishing fleet in this region during November of each year. While research catch-rates are variable, it is encouraging that mean catch-rate for 2002 was among the highest recorded for the last 10 years.

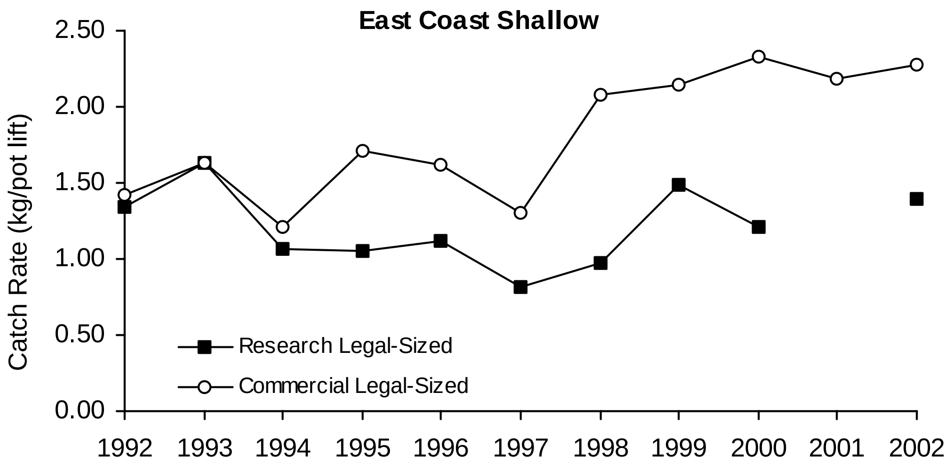


Figure 18. Shallow water catch-rates (<35m) from the east coast of legal-sized lobsters from research surveys and commercial fishing.

The relationship between the catch-rates of pre-recruits (males between 102 and 110 mm CL; females between 98 and 105 mm CL) and legal-sized lobsters prior to commencement of the following year is weak (Figure 19). This is primarily due to the large catch-rate of pre-recruits in November 1997 and 2003. With the exception of these two years, the eight remaining years show a relatively flat trend in research catch-rates of both pre-recruits and legal-sized lobsters. Catch-rates of pre-recruit lobsters in shallow water off the east coast were over double the previous highest which is a positive indicator.

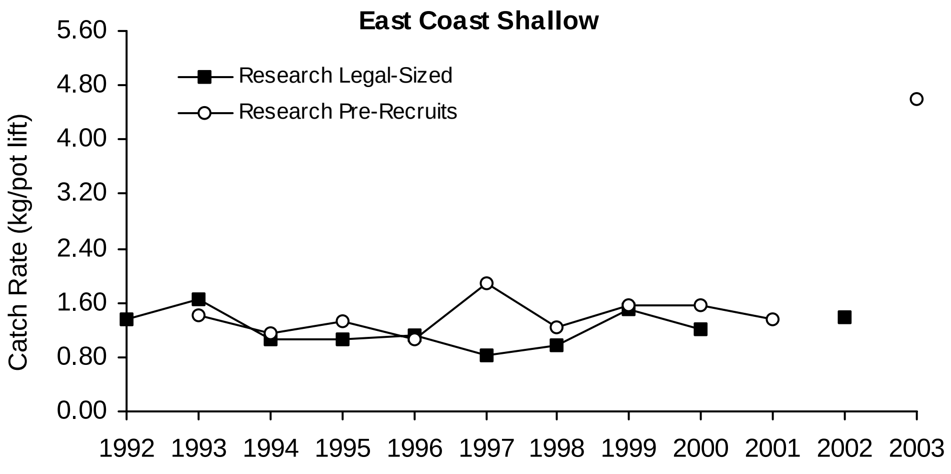


Figure 19. Shallow water catch-rates (<35 m) from the east coast of legal-sized and pre-recruit lobsters from 1992 to 2000 survey periods. The pre-recruit lobsters (males between 102 and 110 mm CL; females between 98 and 105 mm CL) have been advanced by 1 year to simulate growth of undersized lobsters to legal size.

4.2.2 East Coast – Medium Depth

Catch-rates on the East Coast in medium water depths (35-50 m) show an increasing trend for both commercial and research legal-sized lobsters (Figure 20). The relationship between both catch-rates was close until November 1998. Unlike in shallow water, the commercial catch-rate from medium depth water tends to be more stable than the research catch-rate. There appears to be no relationship between pre-recruit catch-rates and catch-rates of legal sized lobsters in the following year (Figure 21), although once again, a record high catch-rate of pre-recruits was recorded.

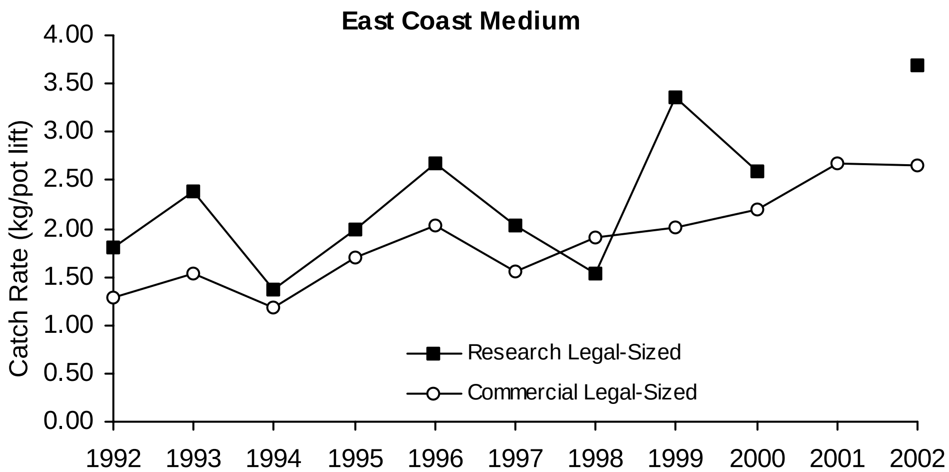


Figure 20. Medium depth (35-50 m) catch-rates for the east coast of legal-sized lobsters from research surveys and commercial fishing for the start of the fishing season.

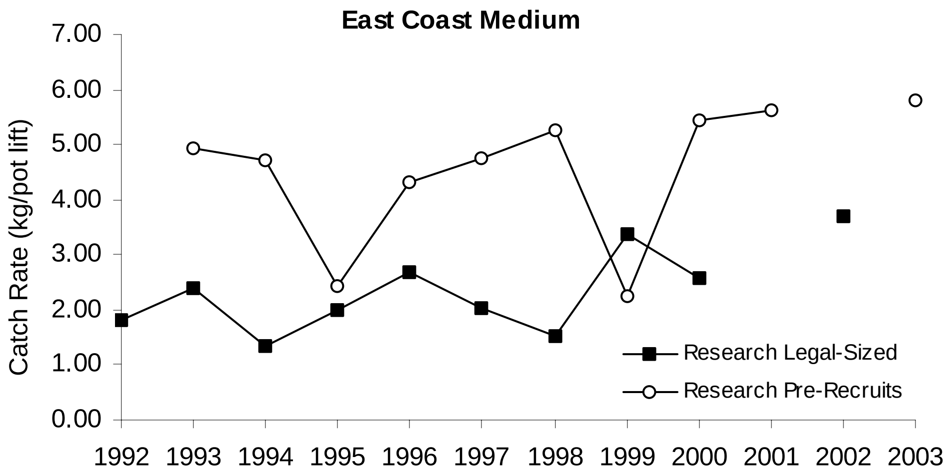


Figure 21. Medium depth (35-50 m) catch-rates from the east coast of legal-sized and pre-recruit (males between 102 and 110 mm CL; females between 98 and 105 mm CL) lobsters for the 1992 to 2000 survey periods. The pre-recruit lobsters have been advanced by 1 year to simulate growth of undersized lobsters to legal size.

4.2.3 South Coast - Medium to Deep Depths

When legal sized commercial and research catch-rates are compared for medium and deep-water depths (45-100m) on the south coast, substantial fluctuations are seen for the 10 years of data collection (Figure 22). Trends are broadly similar although commercial catch-rates tend to be higher.

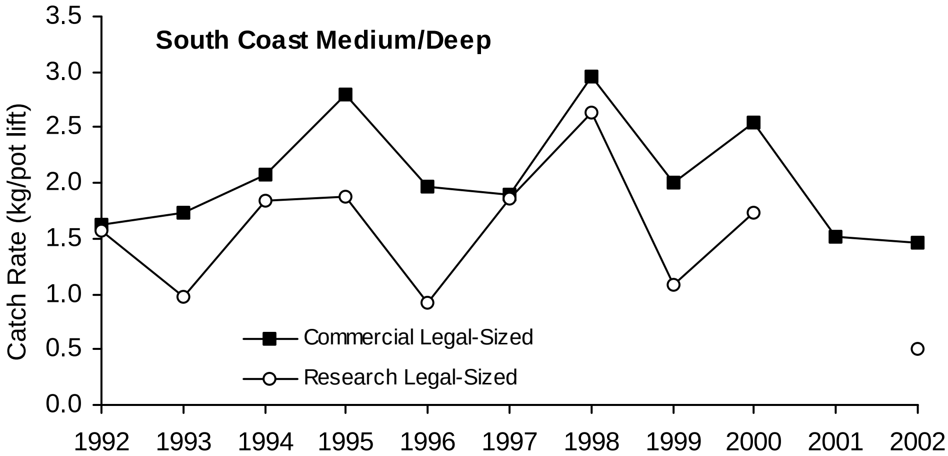


Figure 22. Comparison of medium to deep water (45-100 m) catch-rates for the south coast of legal-sized lobsters from pre-season research surveys (October/November) and commercial fishing for the start of the fishing season.

There appeared to be general agreement between the pre-recruits (males between 106 and 110 mm CL) and the one-year lagged legal-sized catch-rates for the first 6 years (Figure 23). Since this time, pre-recruit catch-rates have increased while the legal-sized catch-rates have shown considerable inter-annual variation with no pronounced trend. As discussed previously, we believe that catch-rates for the last year of sampling (both legal and pre-recruits) were suppressed because of poor weather, rather than necessarily lobster abundance.

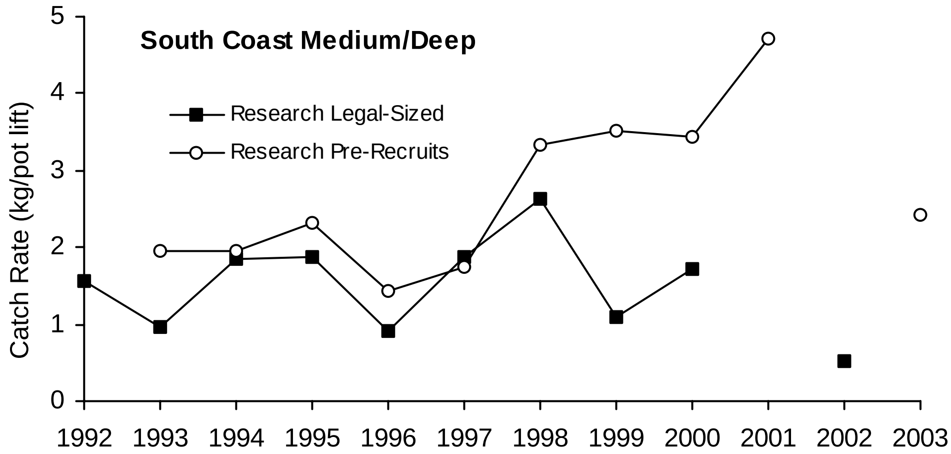


Figure 23. Medium to deep water (45-100 m) catch-rates from the south coast of legal-sized and pre-recruit lobsters (males between 106 and 110 mm CL) for the 1992 to 2002 Pre-season survey periods (October/November). The pre-recruit lobsters have been advanced by 1 year to simulate growth of undersized lobsters to legal size. Note no research survey was conducted for 2001.

4.3 Other analyses including risk assessments

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

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

The scenarios tested were:

- TACC of 1500 tonnes (142.7kg/pot);
- the status-quo of 1523 tonnes (145 kg/pot);
- TACC of 1550 tonnes (147.5 kg/pot).

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

4.3.1 Biomass

Legal sized biomass projections for the next three years show a rapid increase in the TACC for all scenarios. 95% confidence limits around these estimates are shown in Figure 25 and are based on the range of inter-annual fluctuations in recruitment that have been observed since 1970. An important point with these confidence limits is that it’s quite possible that catches over the next 3 years may be driven by recruitment outside the bounds experienced over the last 3 decades.

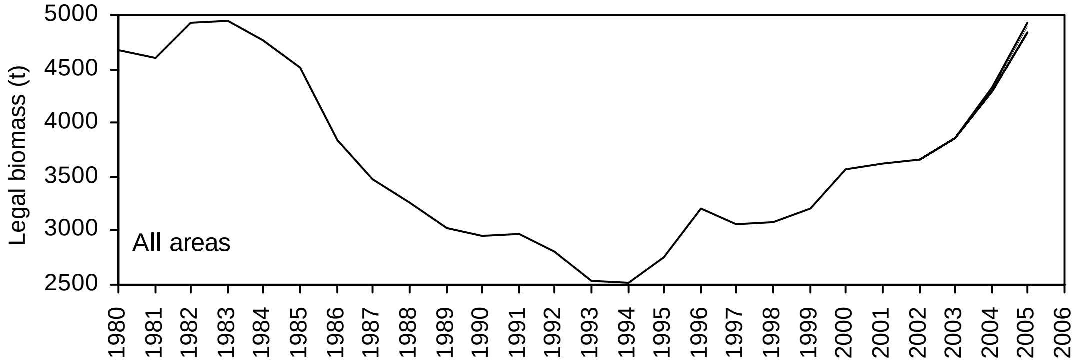


Figure 24. Statewide legal-sized biomass estimates from November 1970 to November 2002 with averaged trajectories to 2005 of biomass for TACCs of 1500 (upper line), 1523 (middle line) and 1550 (lower line). Biomass estimates are for the month of March.

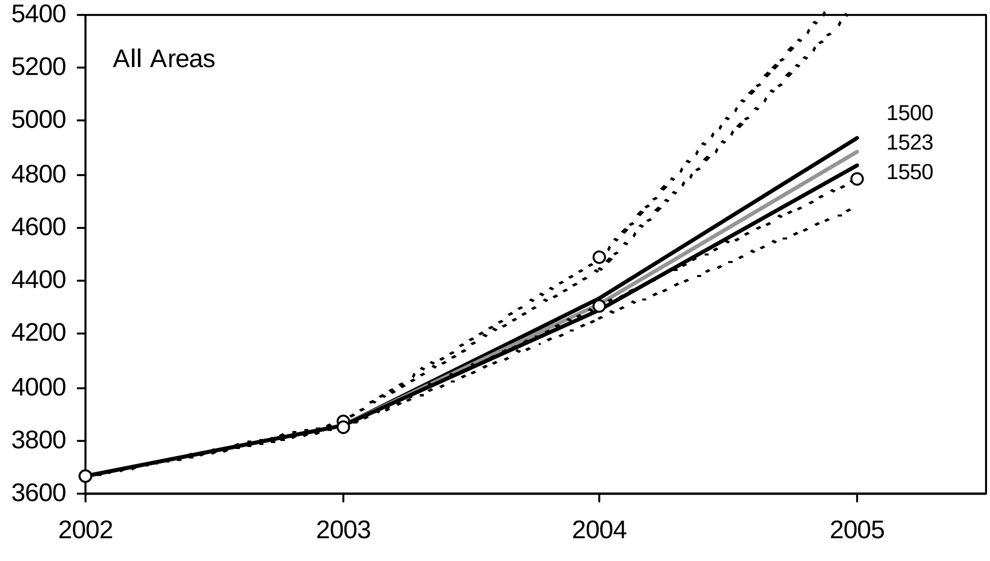


Figure 25. Statewide legal sized biomass projections showing the same data presented in the previous graph (Figure 24) but focused on projections for the next 3 years. Biomass estimates are for March. Maximum and minimum ranges of the 100 simulations are shown for the 1500 and 1550 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

Gardner (2000) found model estimates to have a greater bias in southern regions (Area 1 and 8) with actual changes in biomass typically falling short of that predicted. Excluding these regions (Figure 26 and Figure 27), the trend of increasing biomass is consistent, although the increase is not as great. The TACC scenario of 1550 tonnes in fact results in a slight decrease in biomass for 2004.

The model tends to perform best in projection of biomass in northern areas 4 and 5 (Gardner 2000) so these are shown separately (Figure 28 and Figure 29). These projections indicate a substantial decline in 2004 under all scenarios tested with only a very slight recovery of the median trajectory in 2005.

A caveat on projections from areas 4 and 5 combined is that these represent a region of the fishery, so the assessment model must predict what proportion of the total catch will come from this region. This process of apportioning catch was unusually difficult in 2002/03 with the spatial spread of fishing effort poorly predicted. The reason for this difficulty in modelling the behaviour of the fishing fleet which behaved in an unusual manner in 2002/03; fishers reduced effort in areas with high catch-rate and shifted to areas with low catch-rate. This shift was presumably due to some other factor such as market forces or weather that cannot be captured by the assessment model.

Due to lack of confidence in the ability of the model to predict fleet dynamics in a meaningful manner this year, the predictions of regional trends in biomass are not displayed this year. Investigation of this problem is described in Section 3.2.3, page 11.

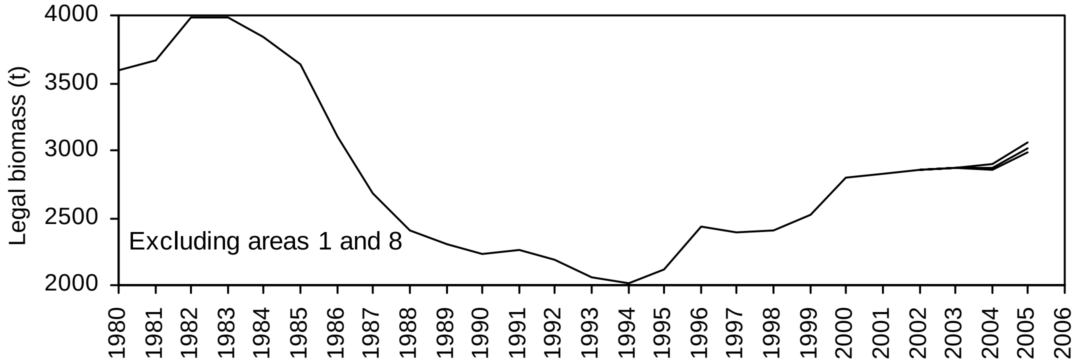


Figure 26. Legal-sized biomass estimates from November 1970 to November 2002 with averaged trajectories to 2005 of biomass for TACCs of 1500 (upper line), 1523 (middle line) and 1550 (lower line) for Areas 2 to 7 (that is, with Areas 1 and 8 excluded). Biomass estimates are for the month of March. Biomass projections from Areas 1 and 8 are typically most positively biased.

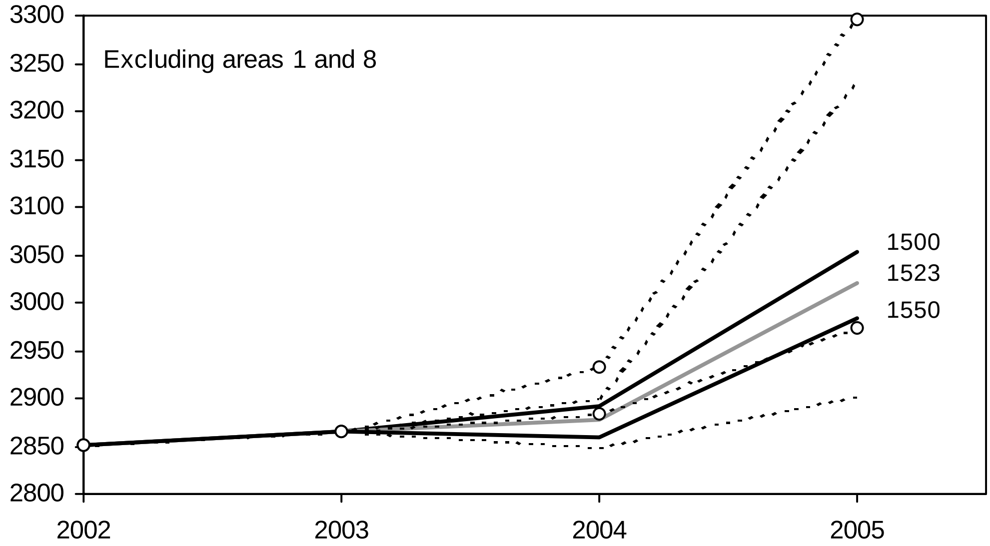


Figure 27. Legal sized biomass projections with Areas 1 and 8 excluded showing the same data presented in the previous graph (Figure 26) but focused on projections for the next 3 years. Biomass estimates are for March. Maximum and minimum ranges of the 100 simulations are shown for the 1500 and 1550 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

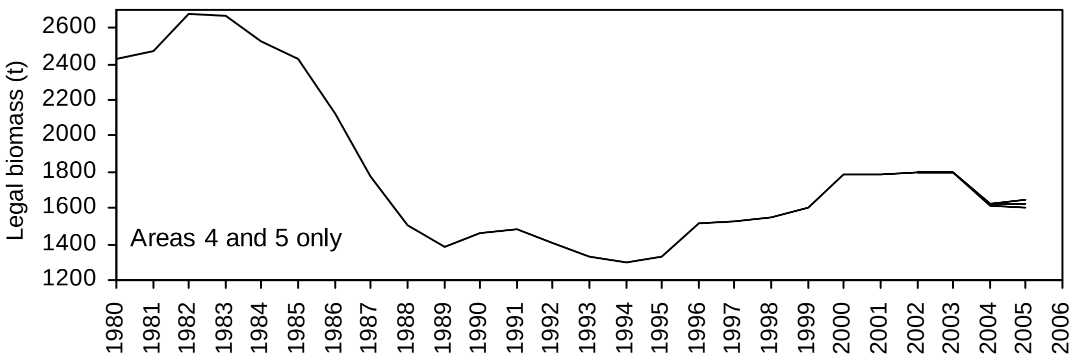


Figure 28. Legal-sized biomass estimates from November 1970 to November 2002 with averaged trajectories to 2005 of biomass for TACCs of 1500 (upper line), 1523 (middle line) and 1550 (lower line) for Areas 4 and 5 only (Northern areas). Biomass estimates are for the month of March. Biomass projections from Areas 4 and 5 are typically least biased.

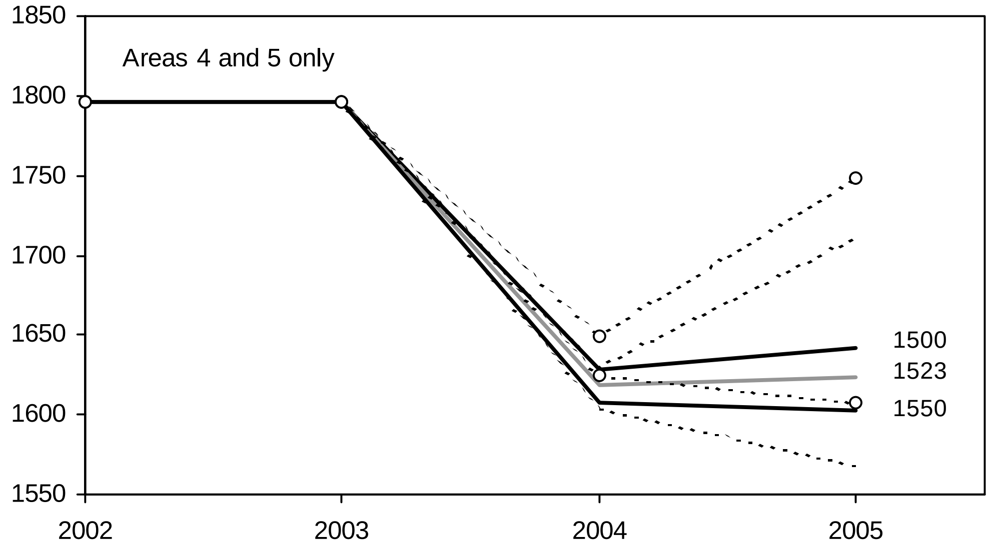


Figure 29. Legal sized biomass projections for Areas 4 and 5 only showing the same data presented in the previous graph (Figure 28) but focused on projections for the next 3 years. Biomass estimates are for March. Maximum and minimum ranges of the 100 simulations are shown for the 1500 and 1550 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

4.3.2 Egg Production

Model estimates of Statewide egg production over the last two years have shown a turn around of the rapid increases of the late 1990's (Figure 30). Projections indicate a possible continuation of this downward trend for 2003 (approximately 1%), before a marked increase in 2004 and 2005 (Figure 31). The northern region of the fishery (Areas 4 and 5), where there is greater certainty with the model outputs, demonstrates a slightly different trend (Figure 32 and Figure 33). Projections suggest egg production will decrease by approximately 2% over the next two years before a slight increase in 2005.

As with biomass, we are concerned that the model is failing to predict the probable regional distribution of fishing effort that will occur over the next few years. For this reason we have less confidence in the projections for areas 4 and 5 combined than in previous assessments. As with biomass, the regional projections are not presented.

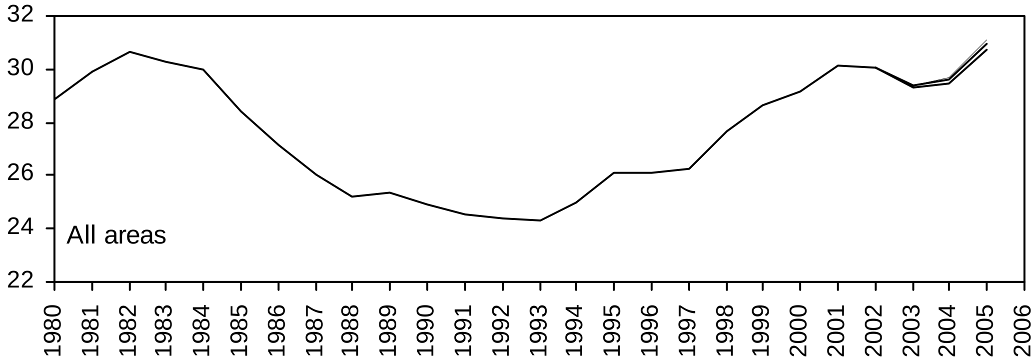


Figure 30. Averaged Statewide egg production as percent of virgin under 3 TACC scenarios: 1500 (upper line), 1523 (middle line) and 1550 (lower line). All trajectories are the average of 100 simulations.

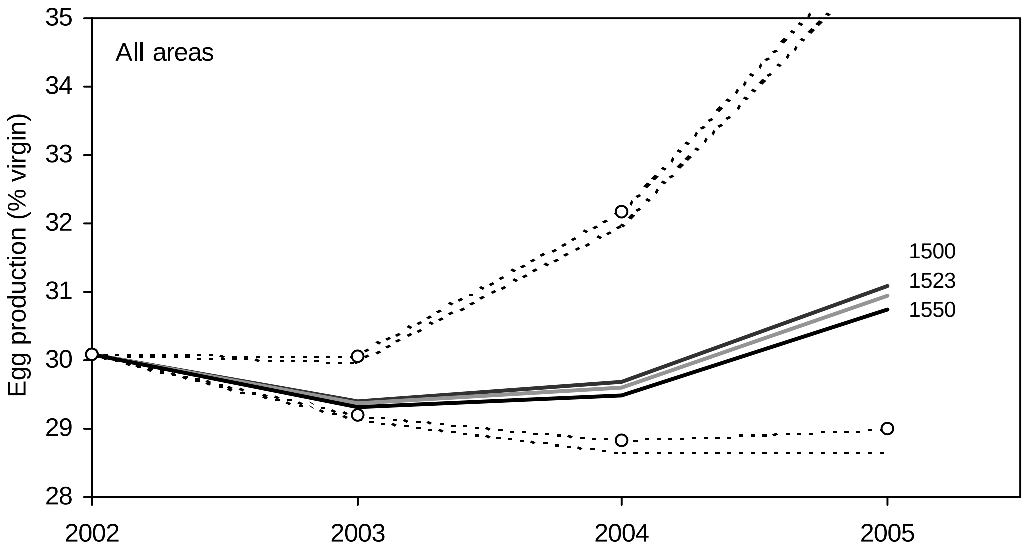


Figure 31. Statewide egg production projections (as % of virgin) showing the same data presented in the previous graph (Figure 30) but focused on projections for the next 3 years. Maximum and minimum ranges of the 100 simulations are shown for the 1500 and 1550 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

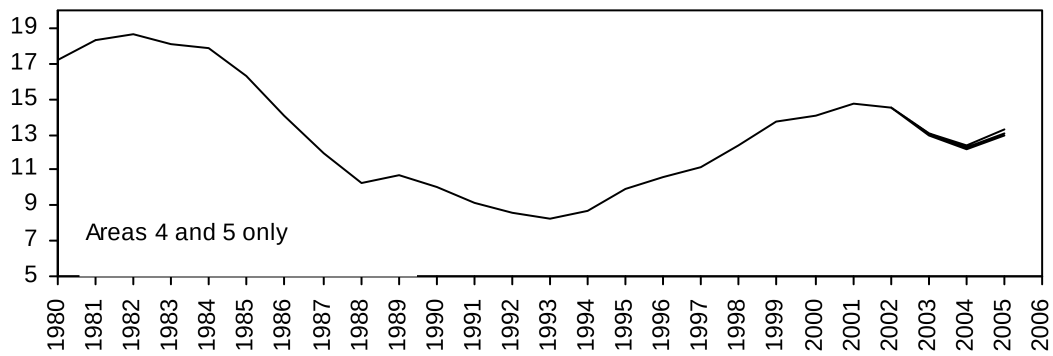


Figure 32. Mean egg production as percent of virgin in the north of the State (Areas 4 and 5) under 3 TACC scenarios: 1500 (upper line), 1523 (middle line) and 1550 (lower line). Means are drawn from 100 simulations.

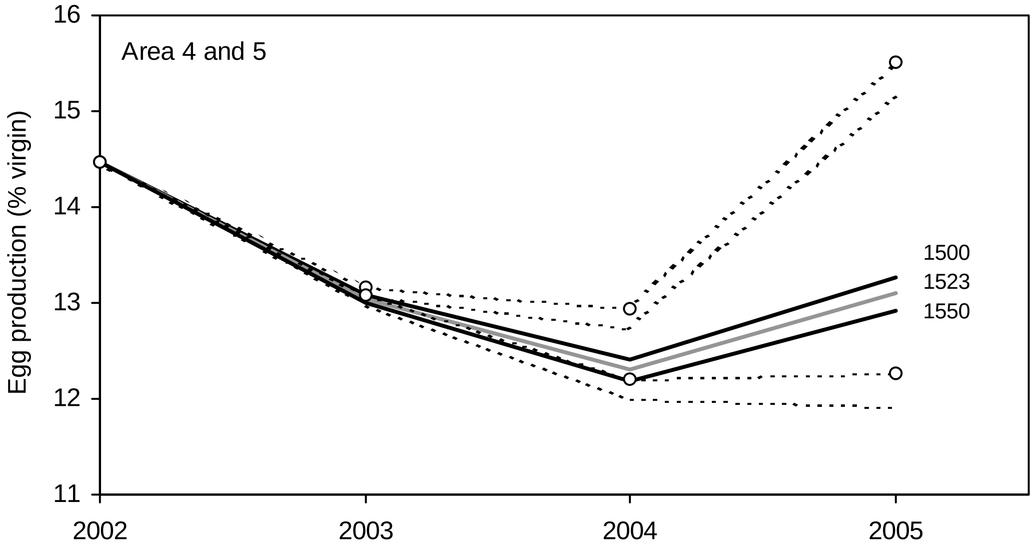


Figure 33. Egg production projections (as % of virgin) from Areas 4 and 5 combined showing the same data presented in the previous graph (Figure 32) but focused on projections for the next 3 years. Maximum and minimum ranges of the 100 simulations are shown for the 1500 and 1550 tonne TACC scenarios (shown respectively by the dashed lines with circles and plain dashed lines).

5. Temporal trends in the spatial distribution of commercial catch

Since the introduction of quota, there has been much discussion about the impact of the management change on the distribution effort. Any effect of QMS on the location of effort and catch is difficult to assess as there are other factors influencing distribution. Some of these other factors controlling the distribution of catch and effort include the response of the fleet to weather, and regional differences in catch rate driven by recruitment and catchability. Frusher *et al*., 2003 examined this issue of spatial change in effort in relation to QMS and concluded that there was limited evidence of any change in location of effort between blocks. That analysis also examined possible shift in effort to different depths.

The issue was re-examined in 2003 by Justin Welch from the School of Geomatics, University of Tasmania using a different approach and his results are shown here. Catch data is recorded in commercial logbooks at the fairly coarse spatial resolution of ½ degree blocks. Depth of shots is also recorded and this provides additional clues about the location of catch. For instance, if 2/3 of the seabed in a block is known to lie deeper than 50 m then a reported catch in 10 m must have come from the remaining 1/3rd of the block. Reported catch from commercial logbooks was mapped in this way by combining catch at depth data with bathymetry data from around Tasmania.

Data from different months were grouped to cover the period of high catch-rates from November to January, the subsequent lower catch-rate period from February to April, and the male-only period from May to September. Maps produced by the analysis are shown in Figure 34. The analysis concluded that:

- This method of using depth information to refine spatial location of catch appears effective in improving resolution. This process may be of value for other spatial management issues, such as evaluating the impact of proposed MPAs.

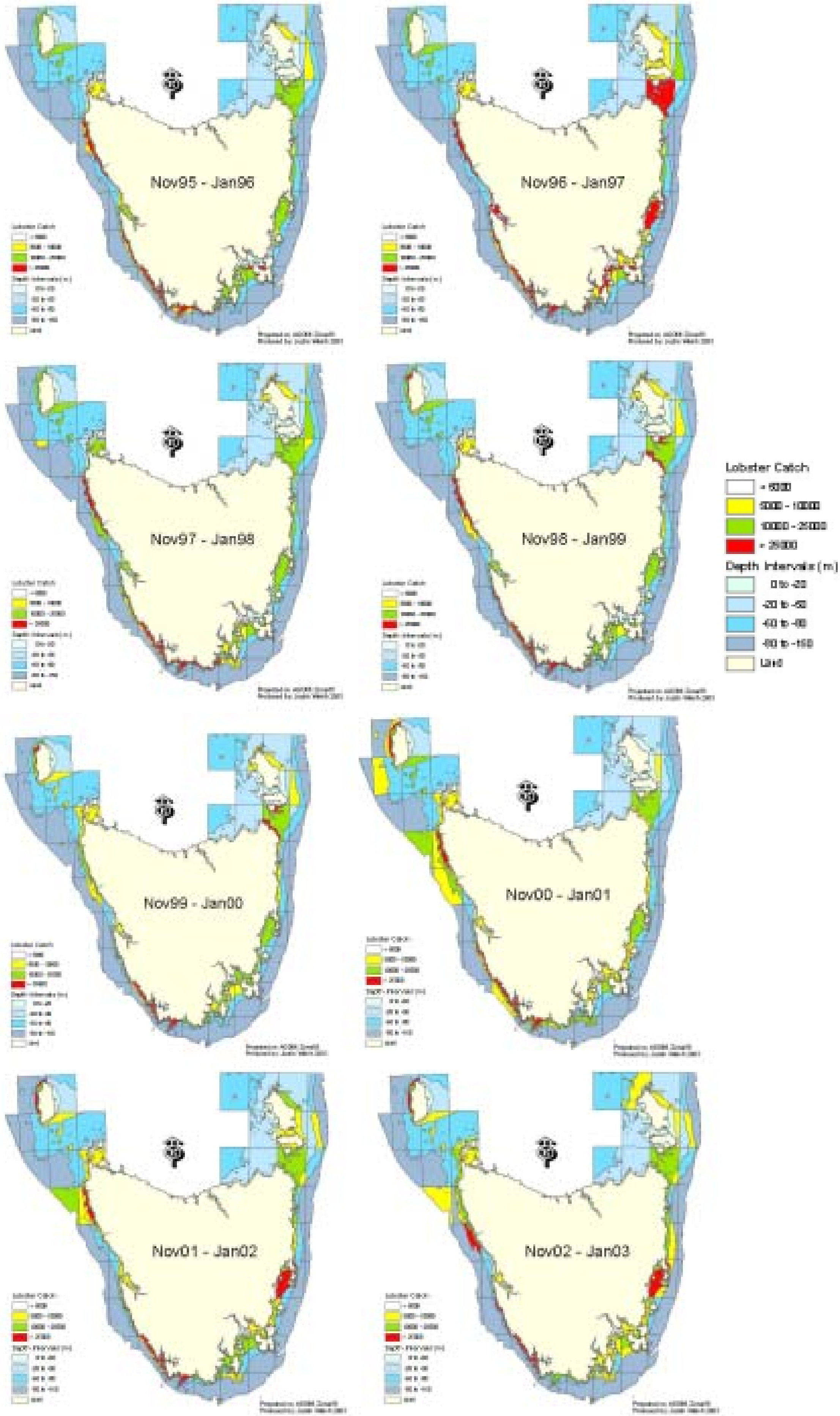
- Large numbers of lobsters are harvested from the south west of Tasmania throughout the year although less so in 2002/03.

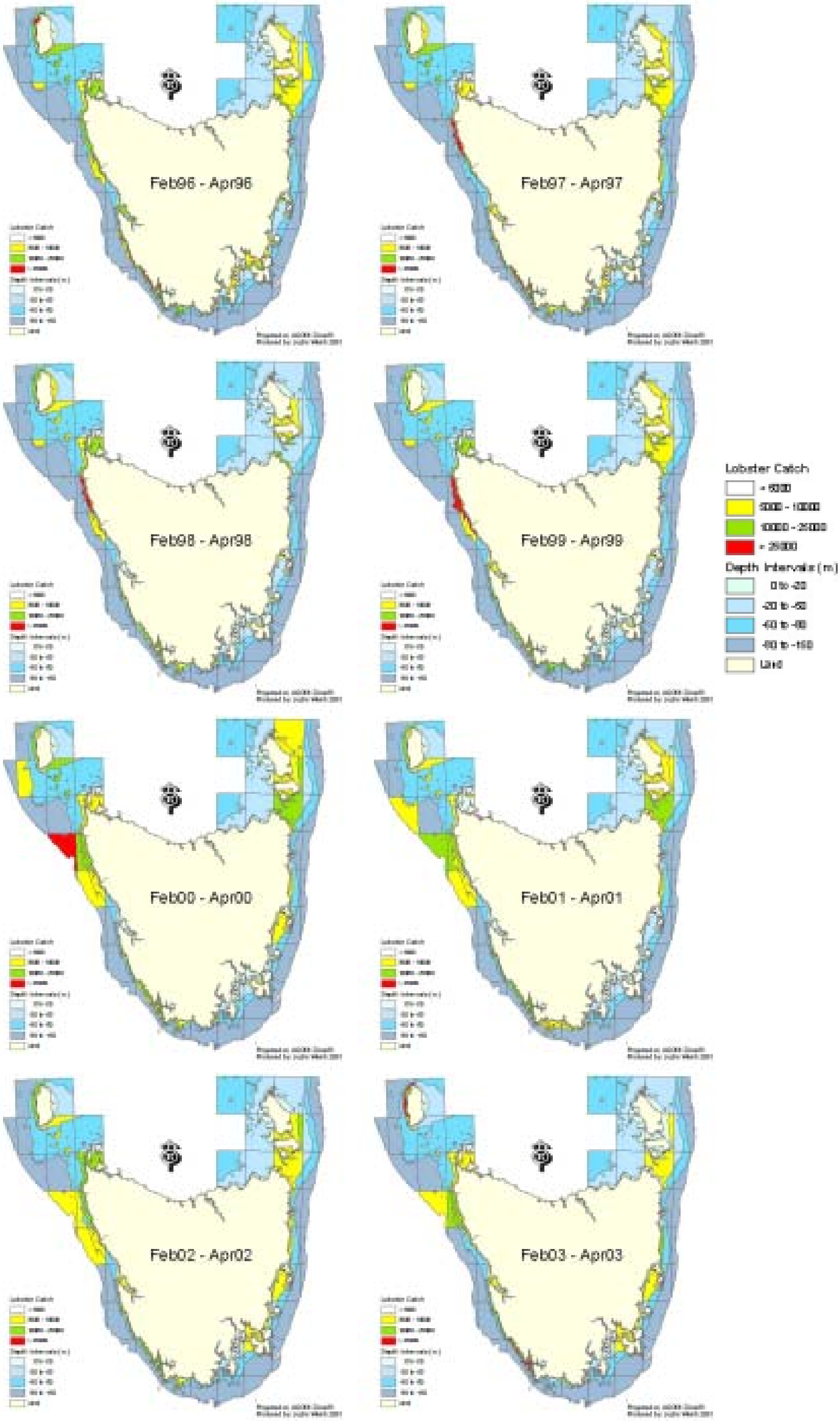
- Early season catches from King Island have been relatively larger over the last 3 years.

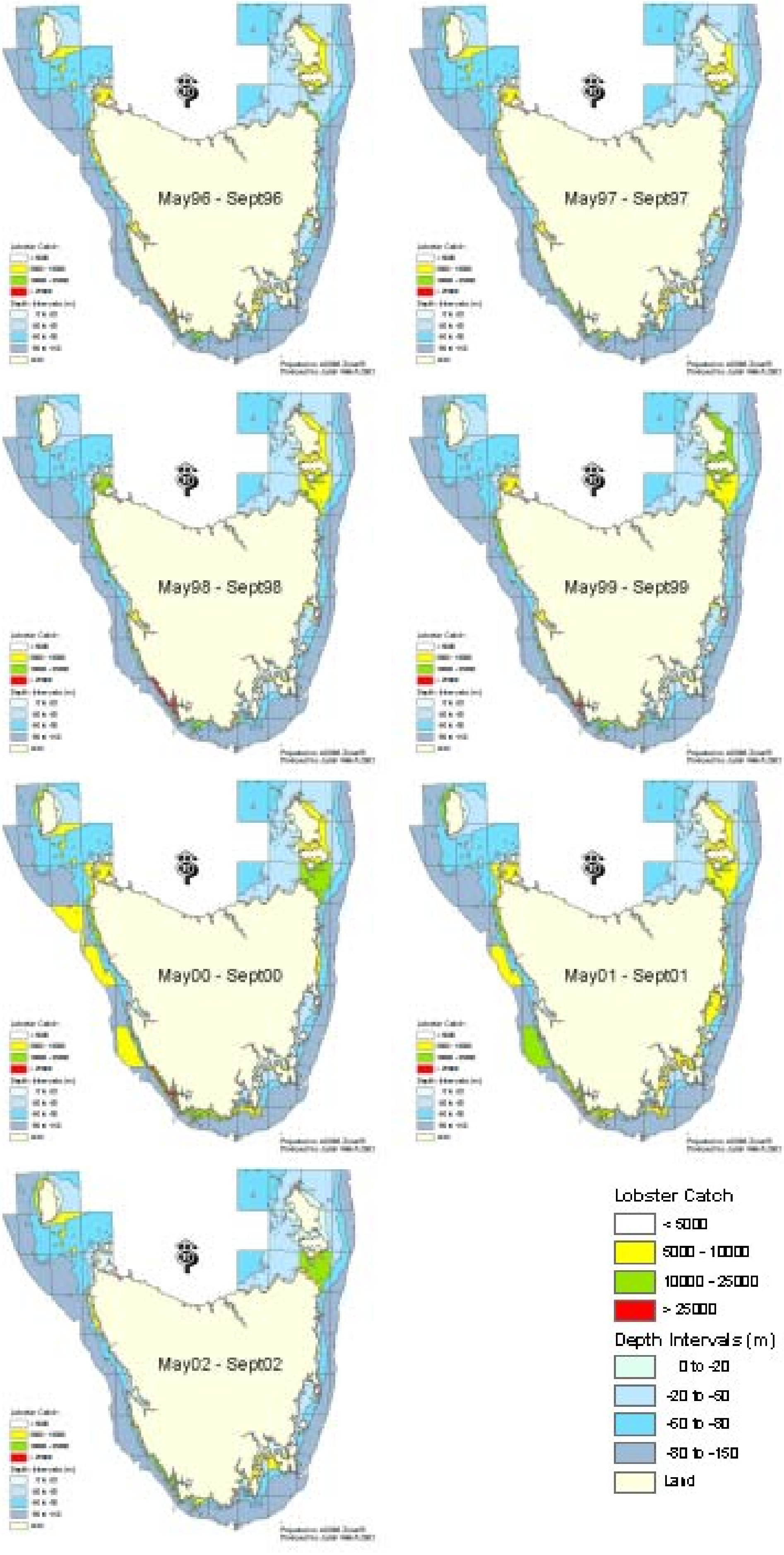
- There appears to be some evidence of increased lobster harvesting on the east and northwest coasts in recent years.

- Catch appears to be taken further out to sea in recent years during months after the initial high catch period from November to January (note this does not imply that total catch from deeper waters is increasing).

Figure 34. (following pages) Spatial distribution of commercial catch (kg) around the Tasmanian coast from 1996 to 2003 for three temporal periods: Nov-Jan; Feb-Apr; and May-Sept. Location of catch is inferred from logbook records based on reported block and depth.


Nov95 - Jan96
Nov96 - Jan97
Nov97 - Jan98
Nov98 - Jan99
Nov99 - Jan00
Nov00 - Jan01
Nov01 - Jan02
Nov02 - Jan03
Lobster Catch
Depth Intervals (m)
Land


Feb96 - Apr96
Feb97 - Apr97
Feb98 - Apr98
Feb99 - Apr99
Feb00 - Apr00
Feb01 - Apr01
Feb02 - Apr02
Feb03 - Apr03
Lobster Catch
5000 - 10000
10000 - 25000
Depth Intervals (m)
Land


May96 - Sept96
May97 - Sept97
May98 - Sept98
May99 - Sept99
May00 - Sept00
May01 - Sept01
May02 - Sept02
Lobster Catch
< 5000
5000 - 10000
10000 - 25000
> 25000
Depth Intervals (m)
0 to -20
-20 to -60
-60 to -80
-80 to -150
Land

6. Recruitment

Recruitment of rock lobsters is monitored at several sites around the Tasmanian coast as part of TAFI's puerulus monitoring program. Puerulus collectors are designed to mimic natural rocky reef with crevices that provide shelter for puerulus swimming in to shore from oceanic areas (Figure 35). Arrays of these collectors have been deployed at Recherche Bay (Area 1), South Arm (Area 2), Bicheno (Area 3), Flinders Island (Area 4) and King Island (Area 5). Several attempts have been made to establish sites in the remaining areas on the west coast, however, all of these attempts have failed due to low catch rates. Most recently, 3 sites were tested near Woolnorth in 2002/2003 but almost no puerulus were captured.

The objectives of the puerulus monitoring project are to provide a measure of actual recruitment of juveniles into the population. This information has a number of practical benefits including early warning of large increases or declines in settlement, improved basis for future projections of the assessment model, and contributing to an improved understanding larval sources. Analyses are presented below that compare estimated larval recruitment from the stock assessment model with observed larval recruitment from the puerulus-monitoring project.

The estimates of larval recruitment from the stock assessment model are derived from commercial catch and effort data and research catch-sampling data. Estimates of recruitment are hindcast based on a model of growth. This means that catch and effort data from 2003 are used to estimate larval recruitment from some years previous, say 1997. We have contrasted these model estimates with actual observed puerulus catches; where the pattern between the two indices is close it implies that puerulus catches will be of value as a model input for future projections of the fishery.

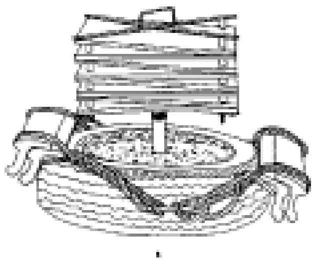



Figure 35. Crevice style puerulus collector (left) and a newly settled puerulus (right).

For the purposes of contrasting model estimated recruitment and puerulus catches, the annual puerulus catch was fitted to the recruitment data by standard least squares regression of the simple linear model:

Recruitment = $a + b$ puerulus catch.

6.1 South East Coast (Area 1)

Model estimates of recruitment and puerulus catches from area 1 show close similarity, however, there is little signal in the data (ie no extremes of high or low estimates) so this relationship is difficult to evaluate.

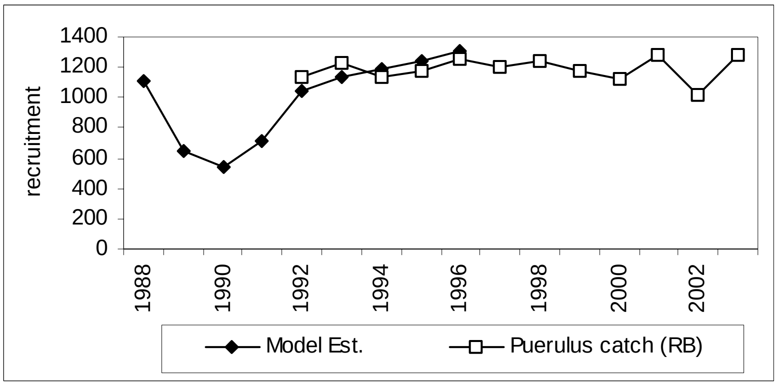
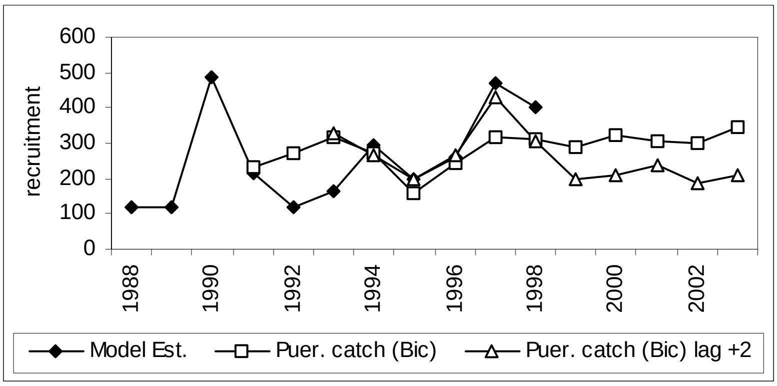


Figure 36. Puerulus catches from Recherche Bay (RB) contrasted with estimated recruitment from the stock assessment model. The consistent pattern between the two indices suggests that the puerulus monitoring program is predicting future recruitment to the fishery with reasonable accuracy, however, there is little variation in the signal. The subsequent years of puerulus catch indicte that recruitment to the fishery in Area 1is likely to remain stable.

6.2 East Coast (Area 2 and 3)

The Bicheno puerulus monitoring site lies close to the boundary between Areas 2 and 3 and puerulus catches from this site were contrasted with model estimates from both areas (Figure 37). Pueurlus catches appear to contribute to quantifying future recruitment to both these areas.



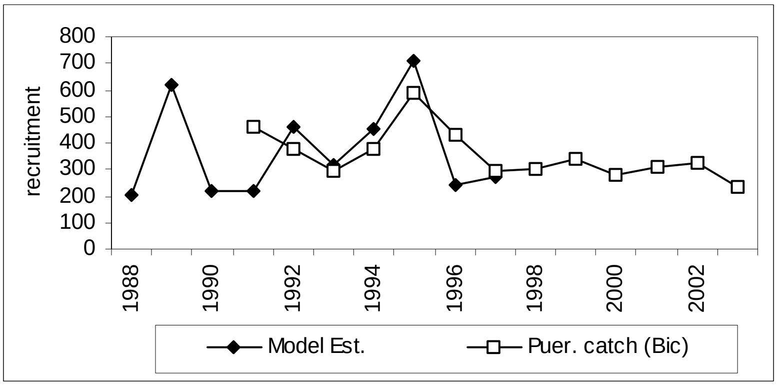


Figure 37. Puerulus catches from Bicheno (Bic) contrasted with estimated recruitment from the stock assessment model for Area 3 (upper) and Area 2 (lower). A second pueurlus model is shown for Area 3 with a lag of 2 years. The consistent pattern between the puerulus and model recruitment indices suggests that the puerulus monitoring program is predicting future recruitment to the fishery. The subsequent years of puerulus catch indicte that recruitment to the fishery in Areas 2 and 3 are likely to remain stable.

6.3 North East Coast (Area 4)

Puerulus catch data from Area 4 has only been collected since 1996 so there is less data than at other sites. The three years of overlap between model estimated recruitment and puerulus catches exhibit a close fit, however, this comparison is not robust as it is based on such a short time series (Figure 38).

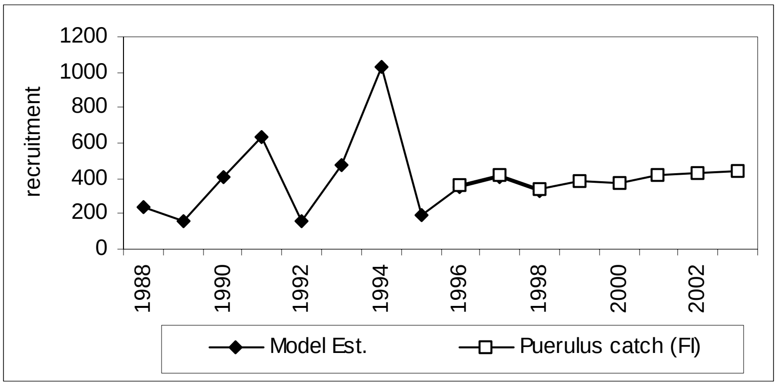


Figure 38. Puerulus catches from Flinders Island (FI) contrasted with estimated recruitment from the stock assessment model for Area 4. The consistent pattern between the puerulus and model recruitment indices suggests that the puerulus monitoring program is predicting future recruitment to the fishery, however, there are very few years of overlap (3) so the comparison is not robust.

6.4 North West Coast (Area 5)

Puerulus monitoring at King Island has been irregular with missing months in all years sampled except one. For this reason, comparisons between model estimated recruitment and puerulus catch are less likely to be close than for other Areas. Nonetheless, puerulus catch broadly followed the same trend as model estimated recruitment, with the exception of data for 1992.

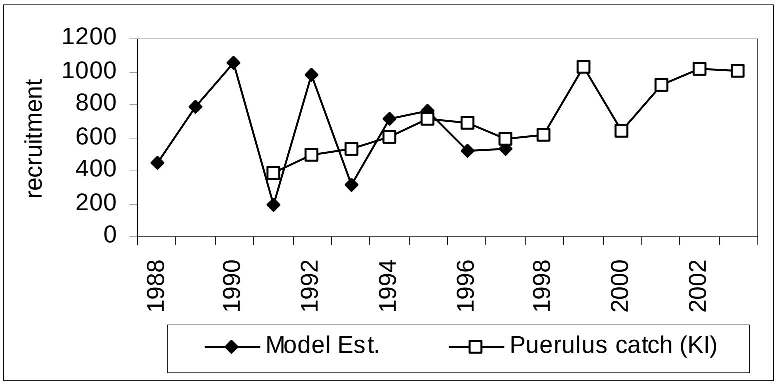


Figure 39. Puerulus catches from King Island (KI) contrasted with estimated recruitment from the stock assessment model for Area 5. The pattern between the puerulus and model recruitment indices was reasonably consistent, although with a notable exception in 1992.

6.5 West Coast (Area 6-8)

Three puerulus monitoring sites were established in area 5 at Woolnorth Point in late 2001 in an attempt to extend coverage of the puerulus-monitoring program down the west coast. Unfortunately the catches were too low to be of value. Since 1989, 10 sites along the west coast have been monitored for various periods and all have failed to detect significant levels of puerulus settlement.

7. Aquaculture

In July 2001, 7 permits were issued to allow Rock Lobster ongrowing trials to be conducted using puerulus and early-stage juveniles harvested from the wild. Each permit was for the harvest of 50,000 puerulus. Of the 7 permits issued, only 4 submitted harvest plans and were eligible to collect puerulus.

The permits were issued through the *Living Marine Resources Management Act 1995* and it was envisaged that animals would be on-grown to a marketable small size (eg 200-300 g). Issue of permits followed four years of discussions with the original intent to develop an industry based on puerulus harvest and ongrowing. However, this aim was later modified to the development of grow-out methodologies to complement hatchery production of puerulus.

Research on the production of puerulus from eggs has been underway since 2000 and has been directed at a broad range of issues including broodstock manipulation, larval health, nutrition and system design. No puerulus have been reared to date although some larvae have survived for over 12 months and grown through to stage 11.

After year one, three of the four eligible permits collected only 1408, around 1% of their quota. Collection by these three permit holders was mainly as bycatch of existing gear. Only two of these three permits were renewed in the next year and again only low numbers (316) were collected opportunistically.

One of the permit holders deployed large numbers of collectors and evaluated sites. This operation evaluated the potential to collect large numbers of puerulus. Over 5000 animals were collected in the two years of the trial. Over 2000 of these were collected from a trial with only 200 collectors hauled twice. Scaling up this operation to obtain the quota of 50,000 puerulus thus appears feasible.

Despite the initial interest in the trialing of rock lobster growout through the collection of puerulus, most permit holders have found the collection of puerulus problematic. It appears that the cost of the trials, the limited success in harvesting puerulus, the lack of financial return and the realisation that closure of the life cycle of the rock lobster is unlikely in the foreseeable future has diminished enthusiasm of permit holders.

Two permit holders remain active and it appears probable that these will be extended to 2006.

8. By-Product

By-product differs from by-catch as animals are retained for sale rather than discarded at sea. Most by-catch species in the Tasmanian rock lobster fishery are released unharmed or with unknown discard mortality wheras by-product catch involves defined fishing mortality. By-product of species captured in lobster traps has been reported through the general fish logbook system since 1995 so that catch of these species in lobster pots is included in separate assessments. Seventeen types of by-product have been reported although these groupings may have overlap with others (eg “morwong other” with “jackass” and “banded morwong”), or include several species (eg “shark”, “octopus”, “flathead”, “mullet”, “whiting”, “leatherjacket” and “gurnard/latchet”). Some records appear spurious, such as a reported 20 kg catch of tuna, but are included here for completeness. These records that appear spurious represent very small catches and are insignificant to the assessment of overall by-product catches. Total reported by-product of most fish types was small; only two types of fish had reported annual catches for the fleet of greater than 1 tonne - cod and octopus (Figure 40). Catches of cod have declined since 1996/97 while no clear pattern is apparent in octopus catches.

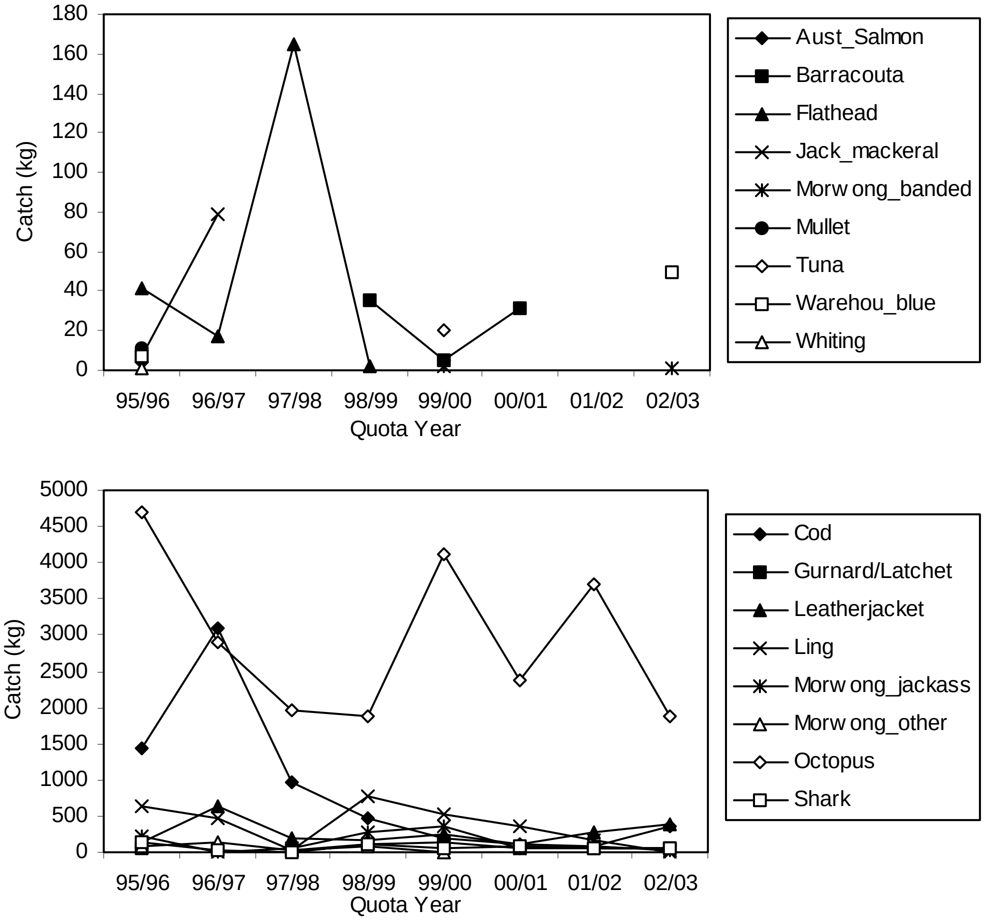


Figure 40. Reported by-product from rock lobster pots, January 1995 to August 2002. Data is grouped into quota years (March to February) so annual catches are incomplete for the 1995/96 and the 2002/03 quota years. Catches of minor species are shown in upper plot, those with greater catch are shown in the lower. Values for catches of octopus are shown on the right-hand axis of the lower plot.

9. By-Catch

Results on research on the bycatch of the lobster fishery have been published in previous assessment reports (Frusher and Gibson 1998; Gardner *et al.*, 2001). General conclusions were that although bycatch enters lobster pots, the majority is released alive or escapes through mandatory escape gaps. Although this research is extensive it has relied largely on bycatch data collected on research fishing voyages. Traps used on these voyages are similar, but not identical to those used by commercial and recreational fishers (Figure 41). A study of by-catch in the Tasmanian rock lobster fishery is underway and is directed at assessing the impact of escape gaps in lobster traps and value of research by-catch data for assessing the impact of the fishery. In October 2003, sampling was conducted with four commercial vessels, and one research vessel.

Areas 1, 4, 6 and 8 are sampled in the study. In each of the areas a commercial vessel carried out 8- 24 shots on suitable lobster habitat, each in which 10-50 pots were set with bait over a day or night. In each shot, approximately half of the traps were set with escape gaps open and the other half closed. Each vessel had an observer recording identity and quantity of species caught in each trap. The research vessel sampled an area in the southwest. All research traps had their escape gaps closed and were set over night. Identity and quantity of species caught in each trap were recorded.

A total of 2320 traps were set in the study, including 200 traps set by the research vessel. 3102 by-catch individuals were recorded, 207 of which were found in research traps. Of the recorded by-catch from the commercial vessels:

- 1751 individual by-catch specimens were collected in the traps with closed escape gaps and 1144 in traps with open escape gaps. Thus, approximately 60% of the by-catch was found in traps with closed escape gaps.

- A total of 25 species were recorded as by-catch. Hermit crabs were the most frequent by-catch species, followed by rough rock crabs and draughtboard sharks. The finfish species caught in the greatest number were bearded rock cod, red gurnard perch, blue-throated leatherjacket, and Degan's leatherjacket. The by-catch species composition varied between the different areas sampled.

- The data collected will be further analysed for differences between open and closed escape gaps on different by-catch species, trap types or areas. Calibration between research traps and commercial traps will be attempted to improve the extrapolation of bycatch in research traps to the whole fishery.

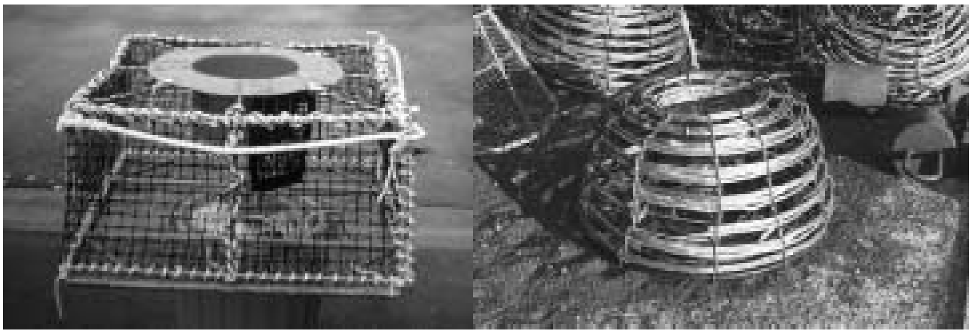


Figure 41. Steel research trap (left) and standard "beehive" trap (right) used in the commercial and recreational fisheries. Note that some fishers also use steel traps although designs differ from the research trap shown here.

10. Protected species

Detailed reporting of trends in protected species interactions were reported in previous assessments. No interactions with protected species were reported this year although numerous sightings of protected vertebrate species clearly occurred.

Improved reporting of interactions with protected species commenced at end of the 2002/03 assessment year. Each fisher is now equipped with logbook containing a protected species interaction section to improve reporting. Data collected through this new logbook will be reported in the next assessment report.

11. Marine Protected Areas

Research focused on marine protected areas or MPAs has been conducted through the FRDC project "The use of marine protected areas as a fisheries management tool" (FRDC 1999/162; C. Buxton, M. Haddon, N. Barrett, G. Edgar and C. Gardner). The project investigated two issues in relation to the Tasmanian rock lobster fishery and results are summarised here. First, the effect of MPAs on lobster stocks was examined by modelling the implementation of MPAs in different regions around the coast. Secondly, the community structure in existing no-take MPAs has been monitored to evaluate possible ecological effects of harvest of exploited species, including rock lobsters. Summaries are presented here with detailed results to be presented in the final report to the project, due in 2004.

11.1 Evaluation of MPAs as a Fisheries Management Tool

The effect of introducing a large MPA into a managed commercial fishery was investigated using a spatially explicit, size-structured model. The stock dynamics approximated the biology of Tasmanian rock lobsters in that adult movement was very limited while larval dispersal was widespread. The strategy used to explore the effects of MPAs involved:

- Initiating a stock of numerous populations in an equilibrium, unfished state.
- Harvesting to deplete the model populations to a known level using selective fishing mortality.
- Introducing the maximum sustainable harvest rate for the given level of depletion either with or without a large MPA.

If introducing an MPA displaced a significant amount of fishing effort into the area that remained open to fishing, then fishing mortality (*F*) was observed to rise in the open area. There was an asymmetry to the effect of this increase in *F* depending on the level of stock depletion, with three main outcomes:

1) If the population was only lightly depleted and was above the B_{MSY} level then fishing the open areas harder increased the level of depletion that, at the same time, rendered the stock more productive. Depending on the exact level of depletion and the degree of increase in *F*, a new equilibrium was produced.

2) If the depletion level was high and the population was below B_{MSY} then fishing the stock harder merely depleted it further, making it even less productive. If the excess harvest rate was maintained this led to a fishery collapse.

3) If the stock was already depleted to such an extent that the fishery was close to collapse, then the displaced effort was so ineffective that the MPA could act to increase recruitment levels and make the whole stock relatively more productive.

Of these, outcome 2 seem most probable in the Tasmanian lobster fishery, that is, large MPAs are expected to lead to increased depletion of stocks.

The model suggested that:

- The introduction of large MPAs may not be beneficial if there is no reduction in catch at least equivalent to that displaced from the MPA.

- An MPA with no concomitant catch reduction could lead to further stock depletion in the open regions. This further depletion could in turn lead to a new equilibrium or fishery collapse, which would depend on the level of stock depletion when the MPA was introduced.

- If the fishery was close to or already collapsed an MPA was likely to be beneficial to stock recovery because of its contribution to recruitment.

Although MPAs in most areas are predicted to lead to depletion of stocks and resultant declines in overall egg-production, they may have some positive roles for managing regional issues in the fishery. For example, MPAs placed in northern areas would tend to raise egg production in those areas, albeit at the expense of egg production across the rest of the State (Gardner *et al.*, 2000). This would help address the current management target of egg production greater than 25% of virgin in each stock assessment area. Note that MPAs are only one of several management tools that could be used to address this issue, with alternative options including split regional size limits, translocation of lobsters, maximum size limits or restriction on the harvest of legal but immature females.

Other possible positive uses of MPAs in reference to the rock lobster fishery include management of recreational catch, which is not constrained by a quota, and as sites for research. Areas closed to rock lobster fishing for research purposes ideally should be small so that the negative impacts of MPAs predicted by modelling are minimised.

11.2 Fished and unfished areas monitoring program

Tasmania's first 'no-take' MPAs were established a decade ago. At this time a monitoring program was initiated to document changes occurring in the MPAs and to compare these with changes at external (fished) reference locations. By surveying reef fishes, invertebrates and plants on an annual basis, a comprehensive database has been established allowing some understanding of natural variability at this temporal scale and the extent that fishing, introduced species and range-extensions of habitat modifying species can influence this.

Changes within the MPAs over this period indicate that fishing has had a substantial influence on the demographic structure of many species, particularly those targeted by fishers, although the magnitude of change detected depends on the susceptibility of species to capture, the remoteness of protected locations and MPA design. Changes within the remote Maria Island MPA (the largest) relative to reference sites have included increases in the abundance of lobsters and net-susceptible fish (eg bastard trumpeter *Latridopsis forsteri*), increases in the mean size of rock lobsters and a decrease in the abundance of prey species such as urchins and abalone.

A 30% decline in the abundance of common urchins (*Heliocidaris erythrogramma)* within the Maria Island reserve may be the first Tasmanian evidence of cascading ecosystem effects related to protection from fishing, while a strong decline in abalone numbers suggests an inverse relationship between exploited predatory species (presumably lobsters) and abalone (Figure 42). These results show MPAs at the Maria Island scale (7km) can be effective reference areas for determining and understanding the effects of fishing in the absence of historical baseline data.

These findings highlight the value of small MPAs for research on the impacts of fishing. Observations of future changes within the Tasmanian reserves provide the only real opportunity of quantifying the extent of these and placing them in perspective with the natural variability of coastal systems. This highlights the important role that reserves have as a reference for conservation based management.

Increased fishing effort and reduction of lobster biomass should clearly be avoided given the apparent relationship between lobsters, urchins (*Heliocidaris erythrogramma)* and other invertebrates and algal species. These findings support the current management policy of stock rebuilding that was initiated in the early 1990's through changes to closed seasons and has been driven by QMS since 1998. Although MPAs provide a valuable resource for reference sites on the effects of fishing, they appear counter-productive as a management tool to reduce the impact of lobster fishing on ecosystems, at least in terms of commercial fishing. This is due to the displacement of fishing effort and subsequent decline in total lobster biomass.

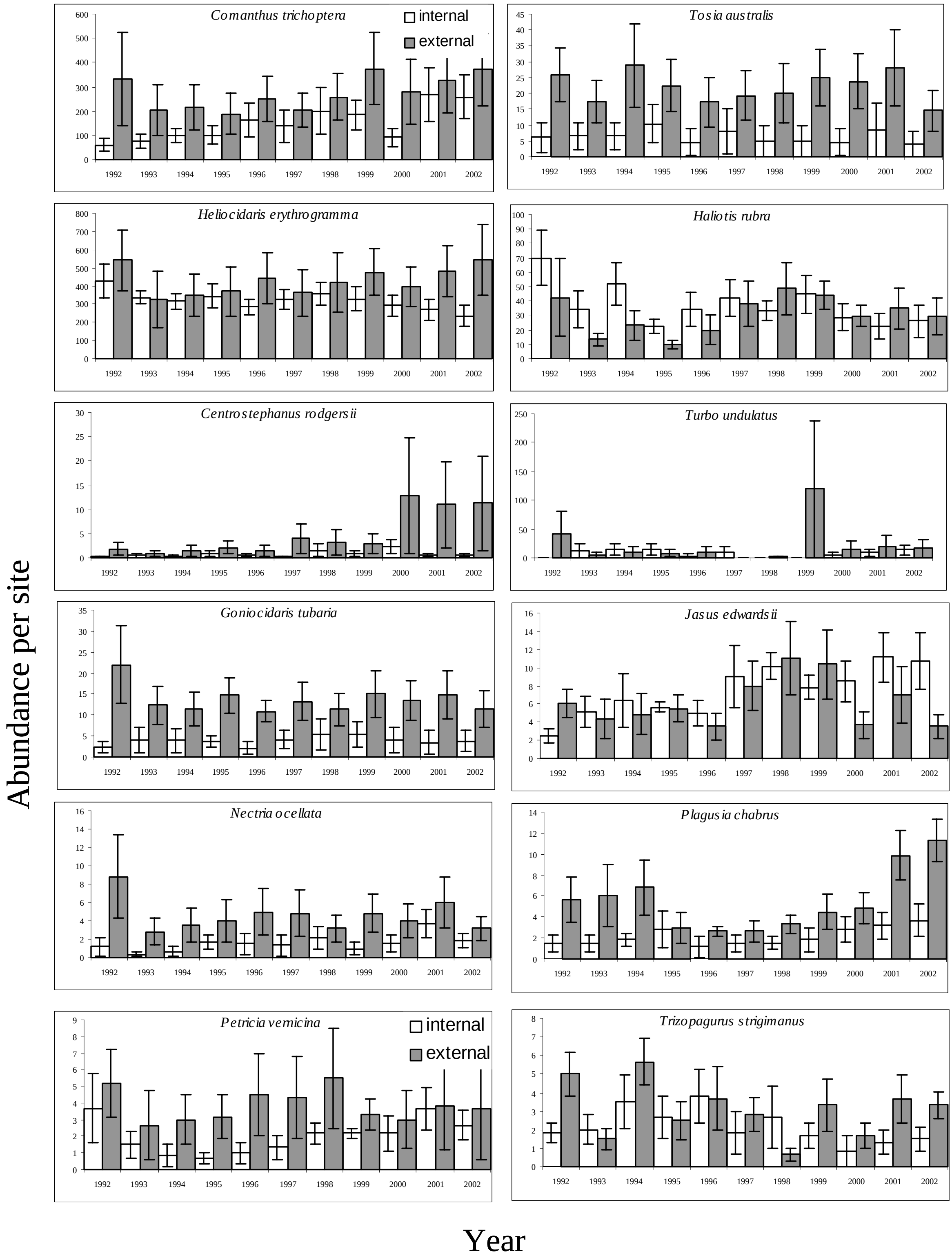


Figure 42. Mean abundance per site of mobile megafaunal invertebrates within the Maria Island marine reserve and at external reference sites during autumn surveys between 1992 and 2002. Abundances are number per site (N/200 m^2 +/- se). *Comanthus trichoptera* (common featherstar), *Heliocidaris erythrogramma* (common urchin), *Haliotis rubra* (abalone), *Turbo undulatus* (large turbo), *Goniocidaris tuberia* (pencil urchin), *Jasus edwardsii* (rock lobster), *Nectria ocellata* (ocellate seastar), *Petricia vernicina* (velvet star), *Tosia australis* (biscuit star), *Plagusia chabrus* (red bait crab) and *Trizopagurus strigimanus* (red hermit crab).

12. Maturation of Female Lobsters

A feature of the Tasmanian lobster fishery is the large spatial variation in growth rates with moult increments of females from northern areas around 5 mm across a range of sizes, while those in the south have moult increments of 1 mm and perhaps less (Punt *et al*., 1997). Indeed, females in the south rarely reach the minimum legal size of 105 mm CL. Information on size at onset of maturity (SOM) is fundamental for many aspects of fisheries management as it influences analyses of size limits and estimation or prediction of the reproductive output of stocks. In the context of Tasmania, where there is such large spatial variation in growth, information on spatial variation in SOM has added importance for managers charged with the task of managing sustainable harvests.

Size at onset of maturity was reviewed in 2003 using catch sampling data collected from 1963 to 2002. A total of 141685 female rock lobsters were sampled during this period using baited traps set from commercial and research vessels. Data were collected for general stock assessment purposes rather than research targeted at collecting maturity data. Sites for sampling were distributed around the Tasmanian coast covering most areas important to lobster fishing. All sites were sampled on more than 2 occasions, usually over a period of several years.

Females were classified as mature based on the development of ovigerous setae on the endopodite of pleopods. In some cases, pleopods had slight development of setae and observers classed these animals as "partially setose"; these were classed as immature for analyses conducted here (Gardner and Mills, unpublished). The latitude, longitude and depth from each site was based on the midpoint of all trap locations recorded at the site.

12.1 Statistical analyses

Sample sizes were variable and ranged between 119 and 34028 females at a single site. Data were analysed from 81 sites although it was not possible to obtain reliable estimates of SOM from 31 of these. Problems with data included small sample sizes; also, some of the samples from southern sites contained few immature animals due to their slower growth rates and selectivity of traps used for sampling. Hence, despite large samples of several hundred animals, poor model fits were obtained on occasion as samples contained mainly mature females. Those analyses were excluded from results presented here.

The proportion of females that were classed mature (P) was modelled for each site with a logistic function of the form: $P = e^{(a+bx)} / \left(1 + e^{(a+bx)}\right)$, maximising the Log likelihood derived from using the logit transformation (Neter *et al*., 1990). These models were then used to estimate the size at which 50% and 95% of the population were mature (L50% and L95%). Estimation of uncertainty around these estimates followed the method of Turner *et al*. (2002). Briefly, 95% confidence limits around model fits were estimated from 1000 simulations for each area in a bootstrapping routine where data were randomly sampled with replacement from each of the 5 mm size bins (Haddon, 2001). The middle 95% of the bootstrap replicates constituted the confidence interval. Confidence limits derived by this method reflect the uneven distribution of certainty around estimates of SOM; we typically had less certainty towards the lower bound due to smaller sample sizes of individuals classed as immature than those classed as mature.

The effects of latitude, longitude, depth and second degree interactions on SOM was analysed using standard least square regression on the estimates of SOM of each of the 50 sites.

12.2 Results

Standard least squares regression indicated that the factors of depth, depth x latitude, depth x longitude, depth x density and longitude x density did not significantly affect L50% ($P>0.12$). These factors were subsequently removed from the full model and the effect of remaining factors examined. Of these, latitude, longitude and their interaction appeared to have most significant and substantial influence on L50% (F-ratio and probability respectively: 99.8,<0.0001; 13.4,<0.001; 13.5,<0.001).

Given the apparent importance of latitude, longitude and their interaction, a linear model based solely on these factors was used to estimate parameters that describe the spatial pattern of L50% around Tasmania (L50% = 112.422 – 10.266Lat + 2.733Long + (-41.876Lat x –146.406Long)). This model is shown in Figure 43.

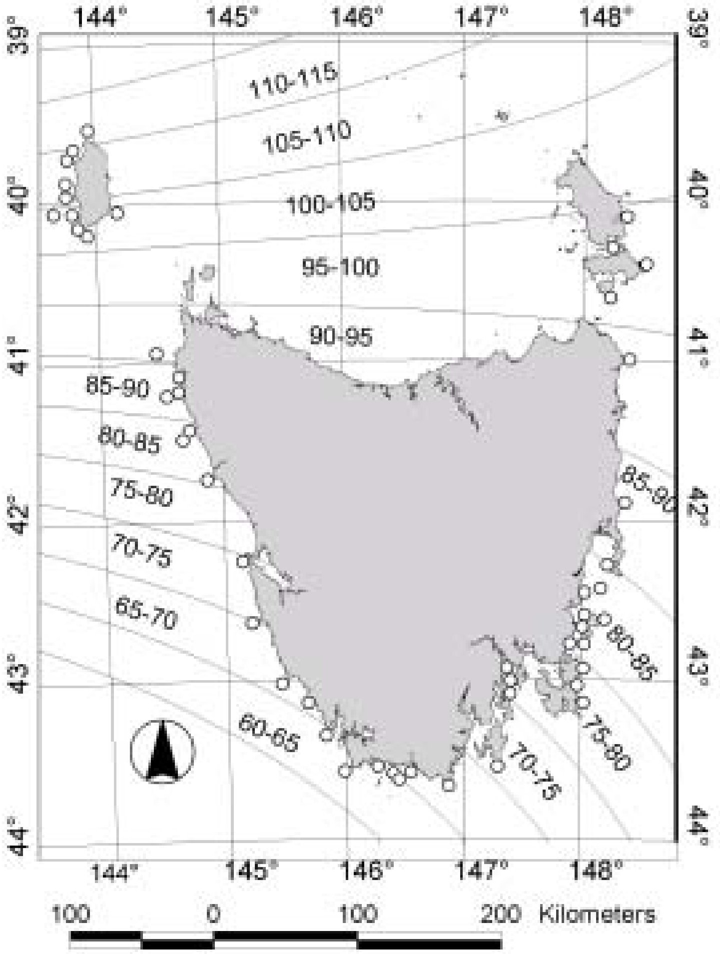


Figure 43. Spatial variation in L50% for female southern rock lobsters *Jasus edwardsii* around Tasmania. The 50 sample sites where real estimates of L50% were collected are shown by points. Contour lines indicate the continuum of changing SOM with latitude and longitude as estimated from the sites shown.

13. Trends in population fertility

Estimates of regional egg production given in Section 4.1.4 assume that all females that reach mature size will produce eggs each year. However, recent tank-based research has indicated that there is potential for sperm limitation and subsequent infertility in lobster populations (MacDiarmid and Butler, 1999). If sperm limitation, caused by lack of males, was impacting on Tasmanian lobster populations then we would expect to see increasing incidence of infertility in lobsters collected during catch-sampling.

Patterns in change in sex ratio through time are unclear due to a sharp decline in the number of females in the catch in 2000 and 2001 (Figure 44). This pattern appears to be caused by a change in catchability of females rather than a change in the population structure because the decline occurred across all sites in area 8 and then recovered in 2002. Nonetheless, the general trends in both areas appears to be that sex ratios are shifting towards the more natural distribution of 1:1, which would be expected with the current trend of stock rebuilding.

When females fail to mate with a male the ovaries are resorbed which produces marked change in pigmentation of the haemolymph so that the underside of the tail appears bright red (MacDiarmid and Butler, 1999). The presence of females with this condition has been monitored in research sampling since 1992 but is observed only rarely. Of those sites where infertility has been recorded, the incidence remains very low (Figure 45).

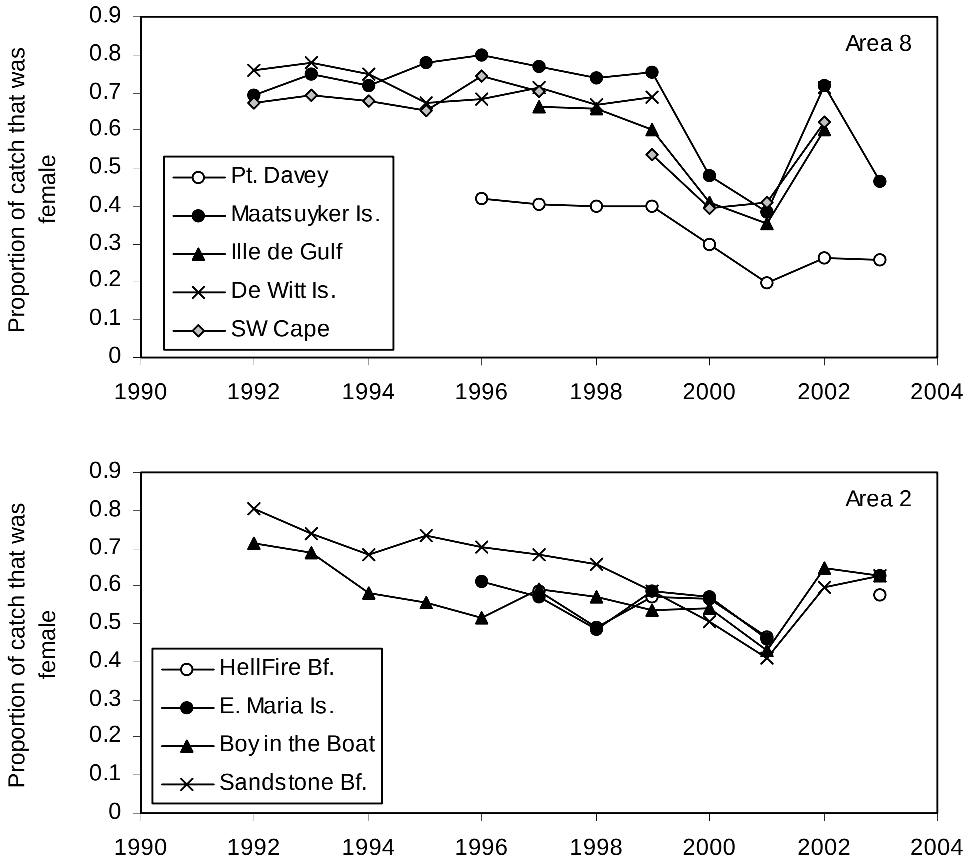


Figure 44. The proportion of lobsters in research catches that were female. A proportion of 0.5 equates to a ratio of 1:1 while a proportion of 0.7 equates to a ratio of 7 females : 3 males.

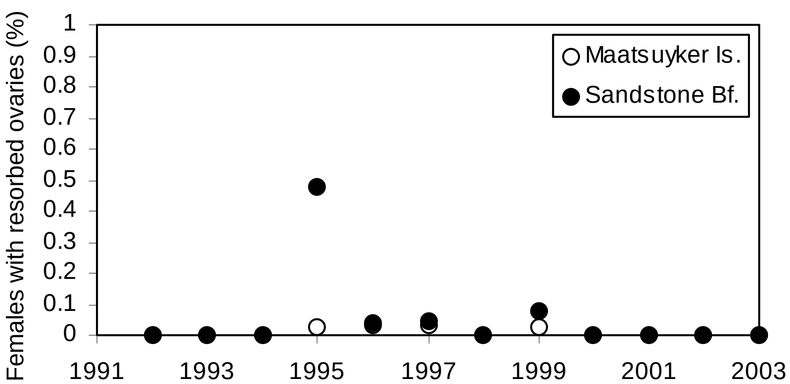


Figure 45. Proportion of females in research catch sampling with evidence of resorption of ovaries. Sites where no observations of females with resorbed ovaries were recorded are not shown.

In summary, the risk of infertility in the population caused by lack of males appears low. However, MacDiarmid and Butler (1999) noted that fertility can also be affected by reduced brood size, rather than complete failure of females to produce eggs. This could be assessed in Tasmanian populations by conducting a survey to determine current fecundity:size relationships and comparison with data collected in 1989.

14. Species interaction - predators

14.1 Predation of pot caught rock lobsters by the Maori octopus (*Octopus maorum*)

This section reports on aspects of octopus-lobster interaction research conducted by Dr Jayson Semmens and Julian Harrington with support from ARC.

Data from research fishing conducted by TAFI between January 1993 and December 2001 was examined to determine if the number of octopus caught and the number of lobsters killed by octopus in rock lobster pots varies over a range of spatial and temporal scales. Lobsters and octopus were caught in baited commercial cane pots or meshed steel pots, with 67% of all pots having the escape gaps closed. To measure spatial variations, data from four broad locations (fishing grids 2, 5 and 8 and Crayfish Point Reserve) were compared, while within each location data were analysed to examine temporal variation annually, seasonally and with moon phase. The effect of lobster density on the catch rates of octopus and lobster mortality was also examined over these spatial and temporal scales.

A brief summary of the results of this study is presented here. The analysis of the scientific fishing data provides rates of lobster mortality and octopus catches, with a maximum value for any spatial or temporal parameter being one dead lobster or captured octopus per 100 pot lifts. If this ratio of octopus kills per unit effort is applied to the commercial fishery data, it estimates 12 910 lobsters were killed by octopus in 2002 (using the figure of 1 291 000 pot lifts in 2002). This equates to 0.8% of the total commercial catch (1 546 130 lobsters) for that year.

Significant differences in catches of octopus between locations and years were evident in this study; however, no significant differences in lobster mortality were evident at these scales. Although differences in octopus and lobster mortality rates varied with season and moon phase, no trends were evident when comparing between locations. The hypothesis that locations or times of the year that demonstrate higher lobster catch rates would have corresponding higher catch rates of octopus and lobster mortality was not proven correct in this study. However, although significant differences were not evident, lobster mortality rates did roughly parallel lobster catch rates.

To test if differences in estimates of mortality rate from octopus predation occur between scientifically collected data and commercial catch return data, data for research pots with escape gaps open (to allow a more direct comparison) was collated for a small subset of the total data set. This data was then compared to matching commercial data. Estimates of percent of the catch killed (total kills divided by total lobsters caught per year) was more than double, and kills per pot (total pots set divided by lobster kills per year) substantially higher in the commercial data compared to the research data from the same areas and time periods.

14.2 Predation of rock lobsters by draughtboard sharks

This section summarises research on lobster-draughtboard shark interaction conducted by Cynthia Awruch.

Over the last few years, the population status of many bycatch species in the rock lobster fishery has grown in importance to assessments. The draughtboard shark (*Cephalloscyllium laticeps*) is commonly caught in the rock lobster pots and, unlike most species; do not escape through escape gaps due to its size (Frusher and Gibson, 1999).

A recent change in assessment of the Tasmanian rock lobster fishery has been the increased focus of an environmentally sustainable management. For proper ecosystem assessment of fisheries there is a need to understand the ecology of the major components. To build our knowledge on these issues relating to rock lobster, a research was developed in 2000 to look at the interaction between lobsters and draughtboard sharks.

The draughtboard shark is an upper trophic level predator in southern temperature reefs. In many ecosystems these types of species have been lost through increased fishing pressure, which has resulted in a cascading effect in the ecosystem (Pauly *et al*., 1998).

During the period June 2002 to August 2003, 918 draughtboard sharks were collected as bycatch from lobster pots or gillnets. The gut contents of 516 of these sharks were analysed.

As can be seen in the Figure 46, nearly a quarter (23%) of the sharks analysed had rock lobster in their gut contents. The proportion of the lobster in the gut of female sharks was higher than in males, 25% and 19% respectively. Lobsters from small sizes up to very large animals of 181 mm tail length were recorded.

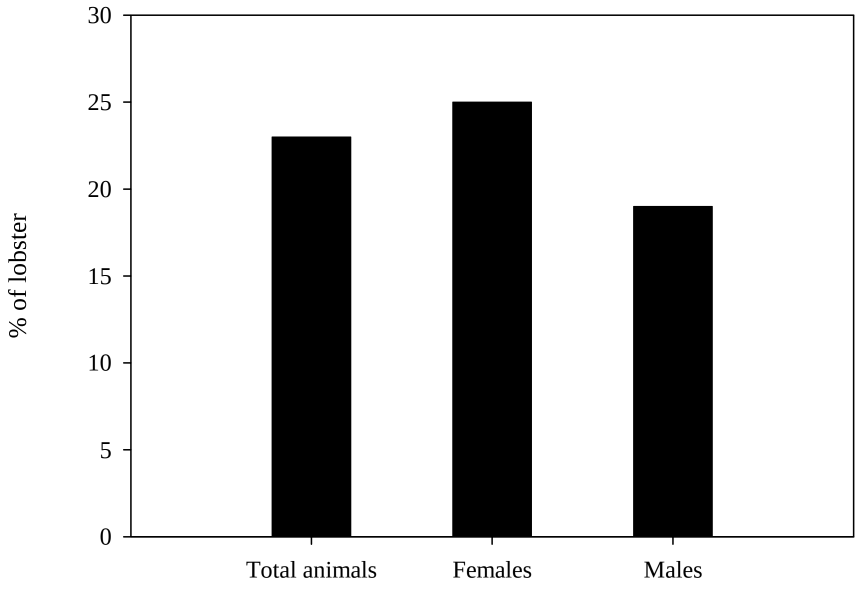


Figure 46. Percentage of draughtboard sharks with lobsters in stomachs.

To determine if there is any specific time of the year when the draughtboard sharks eat lobsters, the presence of the lobsters as part of the stomach contents of the sharks was plotted for each month. For females, January, April and July were the months with greatest proportion of lobster. Peak periods for males were in December, January, April and July. Neither female nor male sharks were found with lobsters in June, July, September and October 2002 (Figure 47). These periods of greatest predation did not appear to correspond to periods of moulting in lobsters when lobsters would be expected to be most vulnerable.

Other components of draughtboard shark diets include finfish and also octopus, which are also lobster predators. Clearly the ecosystem interactions between lobsters and these natural predators are complex and much remains to be investigated.

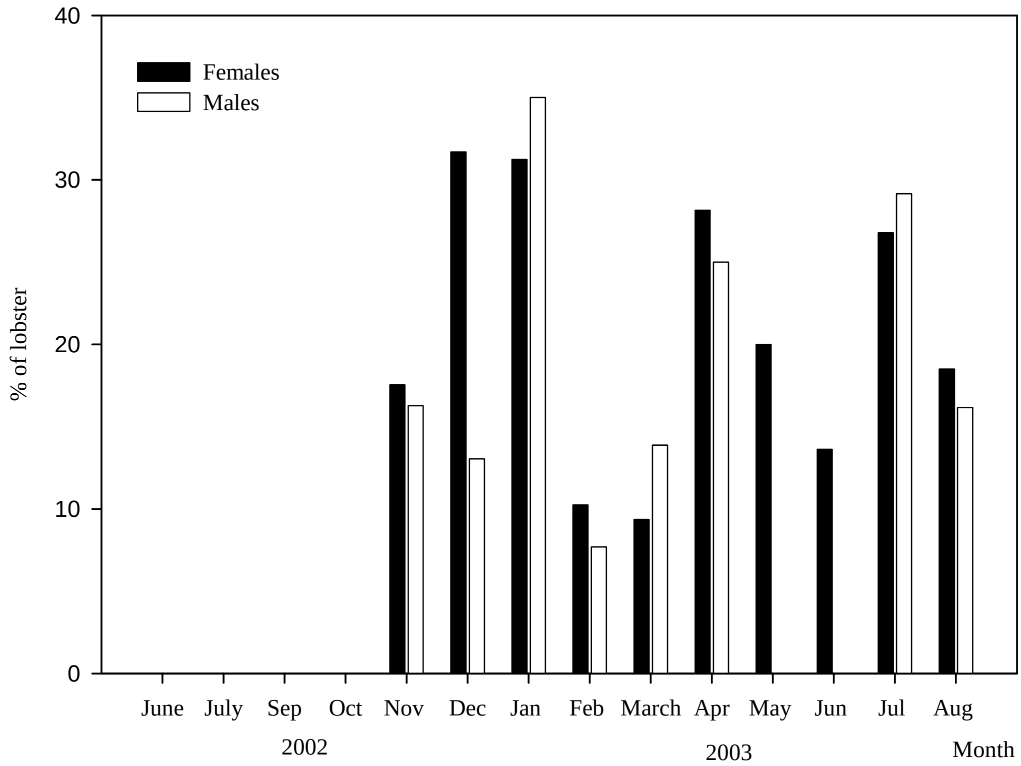


Figure 47. The percentage of individual male and female draftboard sharks with lobsters in their gut contents for each month sampled.

15. Commercial Fishery Industry Issues

Since the last stock assessment, several new issues that are of concern to industry have emerged. These include the expansion of effort in the trawl component of the South-East Fishery (SEF) from the deeper waters off the continental slope to the sallower waters of the upper shelf break and a further encroachment into waters < 30 fathoms. The primary concern of industry is the potential damage to ‘light’, mainly coralline, benthic habitats. The removal of habitat permanently lost to the fishery would have long-term consequences for the sustainability of the fishery in these waters.

The Stock Assessment Working Group noted the decline in catch-rates at King Island. The trend in catch rates, particularly in statistical blocks 3C4, 4C2 and 4D1 need to be closely monitored as these blocks make a significant contribution to the fishery.

Industry have expressed their concern in regard to the potential impacts of any ‘no-take’ MPAs that may be established as part of the South-East regional Marine Planning Process (EA 2003). The Tasmanian rock lobster fishery operates in six of the Broad Areas of Interest (BOAI) in which it is planned MPAs will be established. These are the Apollo, Bass Basin, Zeehan, Tasman Fracture, Huon and Banks Strait BAOI. The catch from the statistical blocks that lie within the BAOI contributed approximately 967 tonnes to fishery (63.3% of the TAC) in 2001-2002. The creation of any substantial ‘no-take’ MPAs in the South-East Marine Region that prohibit rock lobster fishing could necessitate a reduction in the TAC.

The continued low egg production in the north of the state, assessment areas three, four, five and six are still of some concern, particularly given the projected decline in egg production in areas three and five. Industry is conscious of the need to obtain a target level of egg production 25% of virgin in all assessment areas. The continued uncertainty in relation to 'source – sink' dynamics within the fishery and the need to adopt a precautionary approach to management highlights the need increase egg production in the north of the state. Further measures to enhance egg production in the north of the state may have to be considered.

Industry notes two of the trigger points attached to performance indictors for the fishery are close to being activated. After period of stabilisation the number of vessels operating in the fishery appears to be declining. Industry still believes that the size of the fleet should be maintained at approximately 220 vessels if possible. The continued increase in the recreational catch particularly in Area 1, the south-east which has the lowest catch rate of all the assessment areas should concern not only commercial fishers but recreational fishers and fisheries managers as well. The need to develop a cost-efficient methodology to monitor the recreational catch should be given a higher priority particularly as the recreational catch moves closer to the trigger point every season.

An emerging issue for industry is the price differential between the different size classes of rock lobster. High grading of catch is likely to increase in order to maximize returns, mainly in relation to the lower value smaller < 800gm and larger, > 2kg. As a result, fleet dynamics and catch rates may be affected. A careful analysis of any decline in catch rates will be required as catch rates (CPUE) remains one of the primary drivers of the stock assessment.

Industry acknowledges two specific refinements to the assessment process. First, as mentioned in the previous assessment, there is a need to incorporate depth stratification into assessments. In addition to improving the accuracy of the assessment, depth stratification will help identify which areas make a more important contribution than others to the fishery, and will assist in identify any changes to fisher behaviour. Second the incorporation of weather into the standardization process for the assessment model. This is an important development as fishers have long maintained that changes in weather patterns greatly influences both catch rates and catchability, which are important drivers in the assessment process.

16. Appendix 1: Standardisation of Catch-rates

16.1 Background

The Tasmanian rock lobster fishery has a long history stretching back to the 19th century. Fisheries data useful for stock assessment purposes is available from the 1970s. The commercial fishery constitutes the major impact on the resource for the State as a whole and as a result of the way in which it is managed, provides the most reliable source of timely information. The performance of the commercial fishery is used as a proxy for the performance of the whole fishery (including recreational and indigenous fishing for which data collection is more problematic). The quantity and detail of information provided by the commercial fishery has increased through time. These improvements have often been associated with changes to the management. Thus, from 1970 to the early 1980s, catch and effort data are available in monthly totals for the eight assessment regions around Tasmania. After 1983, monthly data is available at the resolution of one-degree statistical blocks. After 1992, fisheries data is available at a resolution of half-degree statistical blocks with daily records of catch and effort. From the mid-1980s depth information is available as a set of depth categories and after the early 1990s it is available as an estimate of the average depth of activity.

Quota Management was introduced into the Tasmanian rock lobster fishery in 1998/1999 (with a quota year running from March 1st to late February). Since then the behaviour and composition of the fishing fleet has altered significantly and this has had some effects upon the perception of the state of the fishery when such things as catch-rate data are considered. It has been reported by the commercial industry, for example, that there is now far more effort in relatively shallow water in Area 6, and perhaps in Area 7, than in the past because the shallow water animals are of a higher value as a result of their deeper colour. The problem for the assessment is that catch-rates are lower in shallower water and this gives the impression of decreased biomass when the change is really only one of fishing behaviour. The stock assessment model that is used to assess the status of the rock lobster stock around Tasmania is primarily driven by catch-rate data. The formal basis behind this problem of changes to fishing behaviour affecting the assessment is the assumption that catch-rates are an index of relative stock abundance. It is clear that there are important implications to the suggestion that fisher behaviour is altering catch-rates rather than changes to the stock biomass.

In fact, there are many factors that are likely to have an impact on observed catch-rates that have nothing to do with changes in the stock biomass. These factors would include the precise location where fishing occurred, who was doing the fishing, whether they were fishing at night or at day, and, of course, the depth of fishing. It is standard stock assessment practice to standardise 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 standardisation will be more closely related to what is happening to the stock biomass.

The most commonly used method of standardisation is to include the various factors thought to effect catch-rates into a general linear model (a standard statistical method) and to include year as a factor, in this way the parameters derived for each year become the indices of relative abundance. Any trends in these indices of relative abundance are assumed to relate more closely to changes in the stock biomass than the trends in the raw catch-rate data.

Detailed catch and effort data with associated vessel, depth, and location information is only available from 1993 onwards for the Tasmanian rock lobster fishery, so it was decided to provide a standardisation of data from that period to see if it were possible to detect and remove the effect of depth of fishing, among other things, on catch-rates.

16.2 Methods

First, the behaviour of the fishing fleet was characterised in terms of depth of fishing in the different Areas. This permitted the development of a set of depth categories that satisfactorily represent the depths over which fishing occurs.

The General Linear Models (GLMs) were all conducted using SAS version 8.02 (Proc GLM). The analysis was conducted to provide standardised catch-rates for each month of the fishery; this was necessary because of the enormous differences in catch-rate exhibited through the yearly cycle. The factors available for analysis included vessel distinguishing mark, depth-category, half-degree statistical block, and the day/night flag. By including Year*Month as a dummy variable into the statistical model, the parameter estimates for each Year*Month combination 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 with the affects of the factors of vessel, depth-category, statistical block, and day/night accounted for.

It should be noted that the output from a GLM does not guarantee that a relation exists between stock size and standardised catch per unit effort. It is possible that factors not included in the GLM (through no other information being available) may still be obscuring any effects of changes in stock biomass.

It is possible to define the so-called 'full statistical 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. However, there is no doubt that the more terms 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 simply by having the same number of explanatory variables 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 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:

$$AIC = nLn\left(\hat{\sigma}^2\right) + 2K$$

where

$$\hat{\sigma}^2 = \frac{\sum \varepsilon^2}{n}$$

is the maximum likelihood estimator of the variance, σ^2, ε^2 is the estimated sum of squared residuals for the candidate model, K is the total number of estimated parameters, including the intercept and σ^2, and n is the total number of observations (Burnham & Anderson, 1998). The optimum statistical model is the one that gives rise to the smallest AIC.

16.3 Results and Discussion

A set of general linear models were generated, one for each of the eight assessment areas. The statistical models used a number of factors including the quota year, months within those years, a set of 10-fathom depth categories, the statistical blocks within the eight Areas, the vessels (vessel distinguishing marks), and the day/night flag. Thus, the statistical model fitted to the raw data was:

Ln(CE) = Qyear + Month + DepthCategory + Block + BoatDM + DayNight

A similar set of models were also generated for year x month combinations, permitting the trends to be considered on a monthly time-scale. The patterns observed were very similar to those seen in the annual analyses. Depth categories deeper than 100 fathoms were left out of the analysis because of the very small number of observations present in any of the areas. The GLM invariably accounted for a much greater proportion of the available variation than the simple geometric means (Table 11). However, the difference between the standardised trend and the geometric mean catch-rate was rarely large (Figure 48).

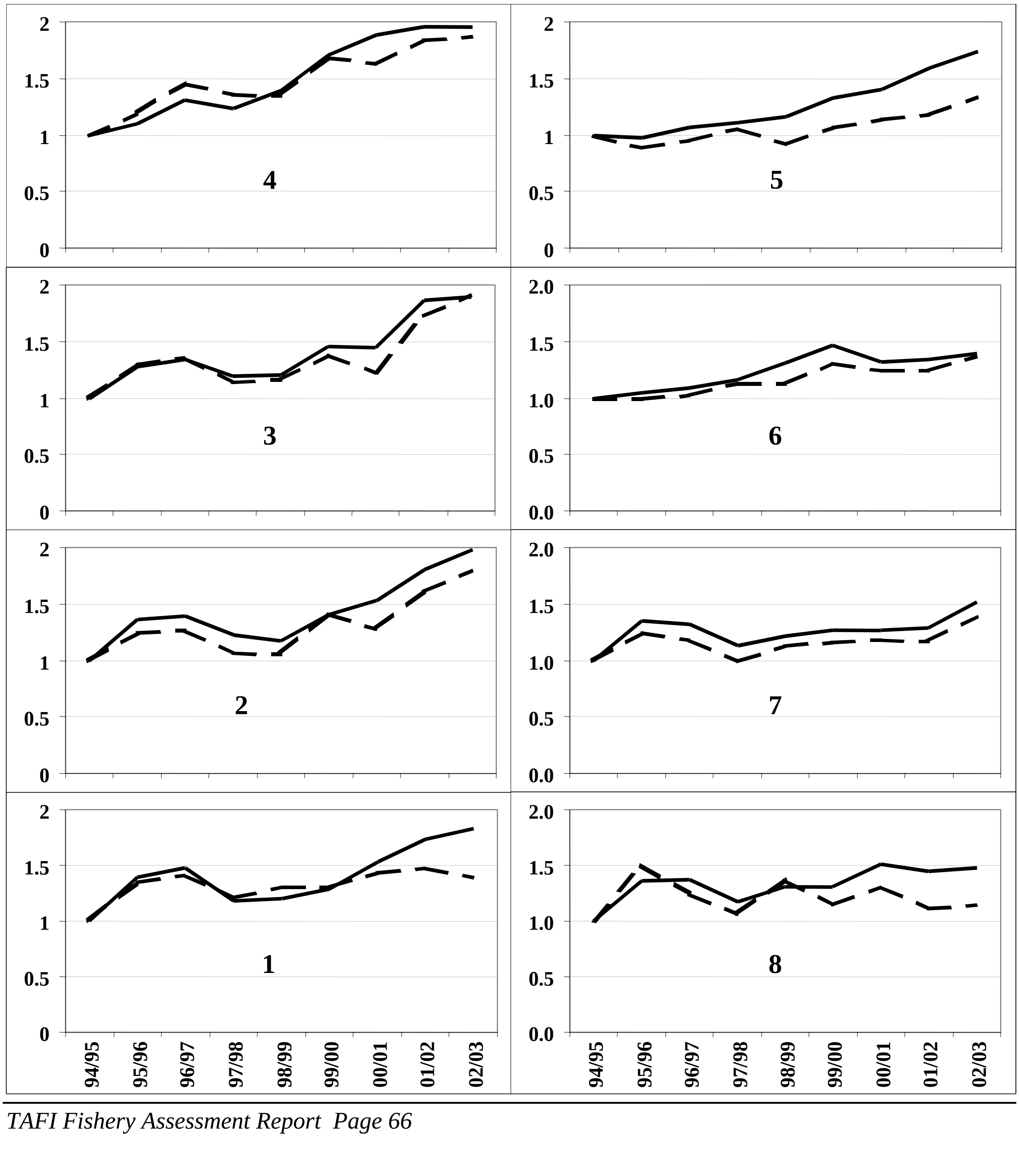


Figure 48. Regional rock lobster catch-rates standardised to the 94/95 quota year. Standardised catch rate (solid line) with the Totals catch rate (dashed line) for each of the eight regions across the quota years 94/95 to 02/03. In all cases, the solid line (standardised catch-rate) tends to lie above the other two lines, although the perceived trend is not always increasing faster than the un-standardised catch-rates (see Regions 3, 4, and 6). Fortunately, in all regions the standardised catch-rates were all higher in 2002/2003 than in 2001/2002, although in some instances the increase was only minor.

Table 11. A comparison of the percent of available variability in the catch-rate data accounted for first by the simple geometric mean catch-rate and then by the optimal general linear model used to standardize the catch-rates. The number of records relates to how many catch-rate records were available from the 94/95 quota year to the 02/03 quota year. Depth categories greater than 100 fathoms were omitted from consideration because of low numbers of records at those depths.

Area	GeoMean % Variation	% Variation	Records
1	2.44	48.99	44393
2	5.68	57.13	38767
3	4.55	47.85	41534
4	6.48	43.09	58624
5	3.05	40.03	75303
6	2.17	37.12	38517
7	1.57	38.3	28017
8	1.57	43.66	85338

The effect of depth on catch-rates in Area 6 is of special interest. To investigate this we compared the geometric mean catch-rates for Area 6 with those obtained from the standardisation both with and without depth as a factor (Figure 49). When the effects of depth are factored into the standardisation the catch-rates do indeed increase, although not as much as the simple geometric mean catch-rates. It can, therefore be concluded that while there is an effect of changing depths through the last few years it has only been minor.

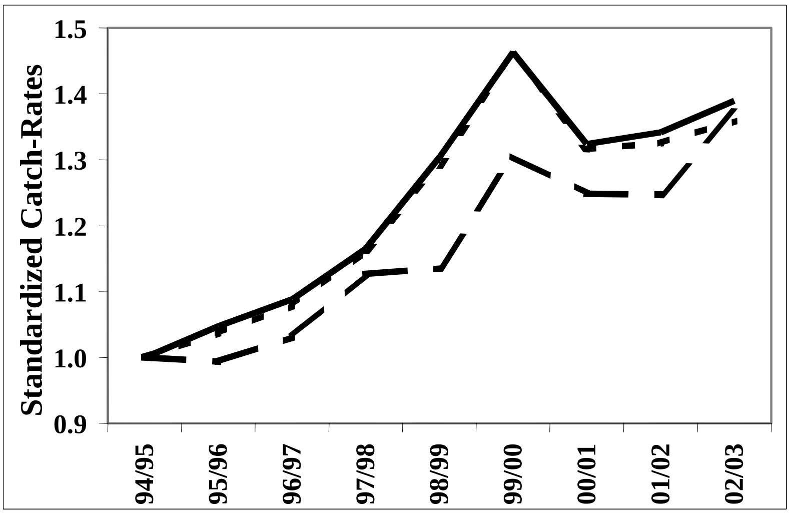


Figure 49. The standardized catch rates with depth included (solid line), depth excluded (dotted line), and the arithmetic mean catch rates (dashed line) for Region 6. Note the left-hand axis, the y-axis, has a different scale to that in Fig. 2. This is a relative scale and does not equate to kg/potlift.

The major factors in the analysis were those of month and vessel, though depth accounted for significant variation in some Areas (Table 12). Because there are so many data points, virtually every factor that is included provides a statistically significant contribution. However, the impact that each makes on the final standardised catch-rate trends can become sufficiently minor as to be insignificant to the fishery statistics. In the data presented, four trends are compared.

Table 12. A comparison of the components of variation accounted for by different model factors. Statistical models were built in the descending order illustrated. Thus, Quota year accounted for 2.42 % of variation in Area 1 but 6.47% in Area 4. Month accounted for 39.25% in Area 2, vessel accounted for 8.13 % in Area 7 and depth accounted from 2.93% in Area 7. The lower half of the table transforms the amounts of variation accounted for by the various factors into proportional contributions to the total variation accounted for in the model. The bolded cells relate to those that accounted for more than 10% of the total described.

Factor	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8
Qyear	2.42	5.66	4.53	6.47	3.04	2.15	1.54	1.56
Month	36.81	39.25	33.42	18.45	20.58	15.17	17.14	26.98
Block	2.21	0.35	1.68	2.40	4.25	5.39	0.57	5.12
Depth	0.20	0.95	0.47	1.38	1.54	1.78	2.93	0.88
Vessel	5.59	8.35	6.76	10.12	7.61	10.06	8.13	7.39
DayNight	1.40	2.27	0.70	3.99	2.79	2.17	7.47	1.51
Month*Depth	0.79	0.28	0.27	0.30	0.29	0.92	1.35	0.84
Total R^2	49.43	57.11	47.83	43.12	40.10	37.64	39.12	44.29
Qyear	4.90	9.92	9.46	**15.00**	7.57	5.71	3.94	3.51
Month	**74.47**	**68.74**	**69.87**	**42.79**	**51.32**	**40.30**	**43.80**	**60.92**
Block	4.47	0.61	3.52	5.57	**10.61**	**14.33**	1.46	**11.56**
Depth	0.41	1.67	0.99	3.21	3.85	4.73	7.48	2.00
Vessel	**11.31**	**14.61**	**14.14**	**23.46**	**18.97**	**26.73**	**20.77**	**16.70**
DayNight	2.83	3.97	1.46	9.26	6.95	5.76	**19.09**	3.42
Month*Depth	1.61	0.48	0.56	0.71	0.72	2.44	3.45	1.89
Total R^2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

17. Appendix 2: Update of the Commercial Fleet Dynamics Model

17.1 Background

The original fleet dynamics model developed for the Tasmanian fishery by Punt and Kennedy (1997) used a relationship between the area, the month of fishing, and the expected catch-rates in each area in each month, to predict the harvest rate in the different regions in each month. Without the catch-rate information this would have been equivalent to the geometric mean harvest rate expected in each area in each month. Because the fishers usually respond very effectively to changing catch-rates it appeared to be a sensible strategy to include the expected catch-rates (as indicative of the available biomass) in the statistical description. When this is done there is a clear improvement in the ability to predict where fishing will occur.

The fleet dynamics model originally defined in the assessment model Fortran 77 code was:

Ln(H) = Area + Month + Area*CPUE + Month*CPUE.

In practice, the model parameters for the Area*CPUE components were all set to zero so the simpler model using just the first two terms and the last term was used.

Ln(H) is the natural log of predicted harvest rate, Area and Region are dummy variables designating the 12 months and 8 assessment regions. CPUE was the expected catch-rates, in kgs per pot, from the assessment model fit to the fishery data. The harvest rate definition used was idiosyncratic to the particular assessment model code because it was not the usual proportion of the available biomass that is taken as catch but, rather, was that amount multiplied by 1,000. This was because the predicted catch from the model is in kilograms while the predicted available biomass is presented as tonnes, thus:

$$H = \text{Catch in kg / Biomass in tonnes}$$

The original fleet dynamics model used data generated by the model for the years 1990 to 1995. As part of the FRDC funded project “Impact of Management Change to an ITQ System in the Tasmanian Rock Lobster Fishery” (1999/140; Frusher *et al*., 2003) the various current models along with new alternatives were investigated so as to re-calibrate the fleet dynamics to more closely match fleet behaviour since the introduction of the quota management system. At the time of those analyses there were only two complete years of data following the introduction of the ITQ system and it was questionable whether the fleet dynamics had stabilised within the new system.

Frusher *et al*. (2003) were able to show that there were a number of trends in the data relating to both spatial and temporal fishing patterns. Fishing inshore to target better quality red coloured lobsters and increased fishing effort into the winter months when prices are highest were two of the major changes identified. The winter fishing trend had commenced prior to the introduction of quota whereas the increased effort in inshore waters appears to be a more recent trend. In some cases it was uncertain whether there had been a qualitative change in how the trends were proceeding following ITQ introduction but it remained clear that fleet dynamics were not stable or stabilising.

In 2003 there are now 5 years of data post-introduction of ITQs for the Tasmanian rock lobster fishery and a further attempt has been made to re-calibrate the fleet dynamics model.

17.2 Methods

Similar to the attempts made by Frusher *et al.* (2003), a data set was developed consisting of 13 years (1990/1991 to 2002/2003) with the required predicted harvest rates, for each month and area, along with the predicted catch-rates for each of the combinations. This was used as the basis for generating various statistical descriptions of the fleet dynamics, and the best model, as determined by the amount of variability described and the AIC (see Section 16).

The final statistical model selected was the same as used originally, i.e:

$$\mathrm{Ln}(H) = \mathrm{Area} + \mathrm{Month} + \mathrm{Area*CPUE} + \mathrm{Month*CPUE}$$

this time, parameters were also estimated for the Area*CPUE interaction term. While these new parameter estimates were included in this year's assessment there are problems developing for this approach deriving from how the fleet dynamics has been changing since the introduction of quota. These were investigated using autocorrelation at a one-year time lag.

17.3 Results and Discussion

Since the introduction of quota, various trends have developed in how the fishers behave that were not expressed to the same extent prior to quota. These trends are most apparent in regions 2, 3, 4, and 8, but other regions also show steady increases, decreases or stability in a manner different to that prior to quota (Figure 50).

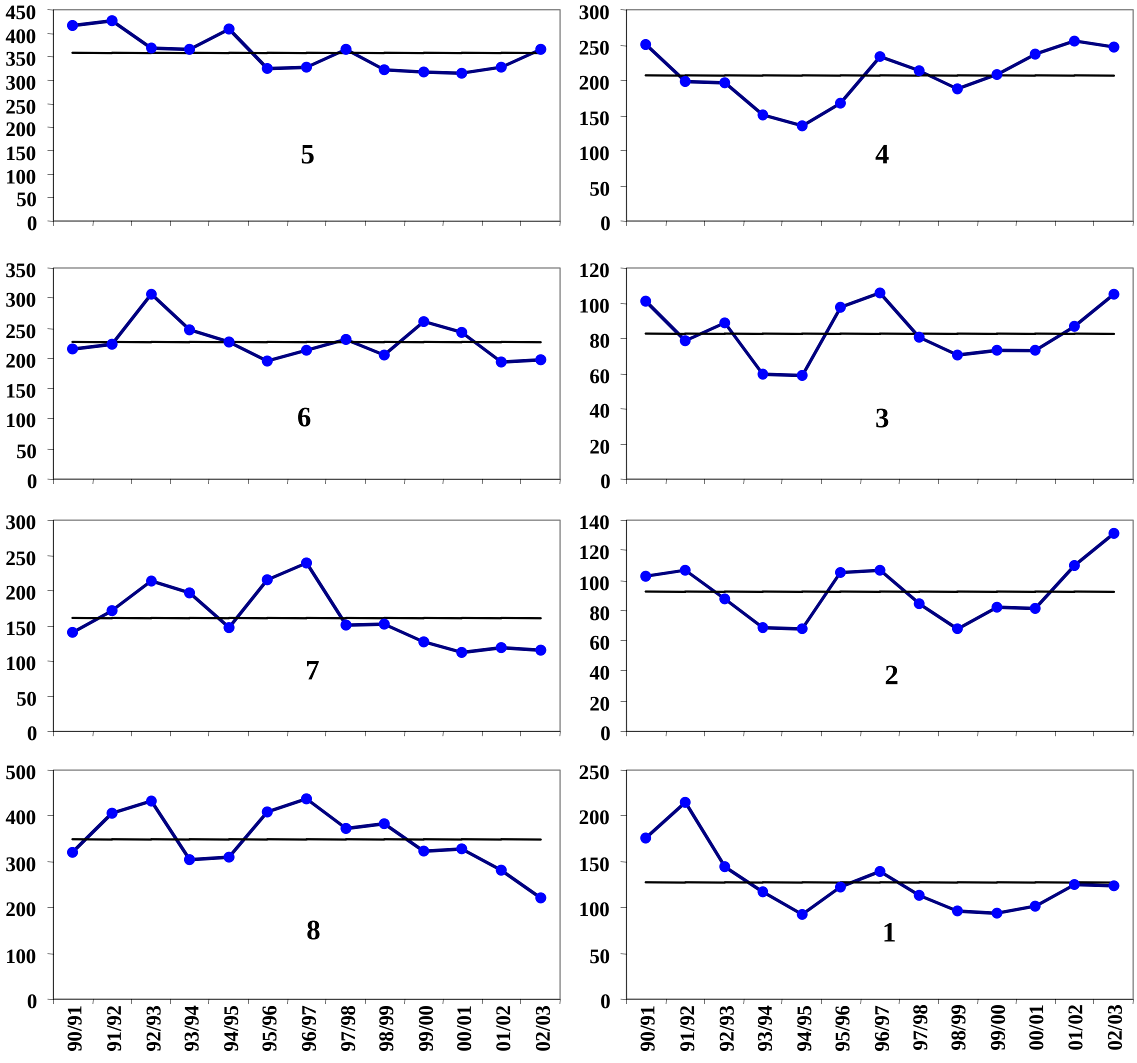


Figure 50. Catches, in tonnes, for each of the 8 assessment regions against the quota years March 1st to Feb 28th/29th. In each case the horizontal line is the average catch taken in each region through the 13 year time-period. The quota system was introduced in the 1998/1999 quota year.

One way of describing such trends is by considering the autocorrelation that exists within the time-series of catches in each region. That is, how much does a high catch in one year signal a high catch the next? If there is a trend present then one would expect the autocorrelation to be large, whereas if there is variation without a general pattern then the autocorrelation (time lagged one year) would be expected to be small.

In the earlier period, used to describe the fleet dynamics in the original model, only regions 1 and 4 show indications of trends in the catches taken each year. Since the introduction of quota management relatively high autocorrelation levels corresponding to trends are seen in all regions except region 6 (Table 13, Figure 51).

Table 13. Autocorrelation coefficient for two different sets of five years, calculated as the correlation between the first four years with the last four years i.e. a time-lag of 1 year. The 90/95 period is for the 1990/1991 to 1995/1996 seasons, while the 98/03 is for the period 1998/1999 to 2002/2003.

Region	90/95	98/03
1	0.5458	0.6967
2	0.2247	0.8654
3	-0.1650	0.9144
4	0.6515	0.8671
5	-0.1353	0.7358
6	0.0428	0.0760
7	-0.2175	0.6313
8	-0.1280	0.7775

The trends that have developed since the introduction of quotas, in how catches are being distributed around the State, may become exaggerated in the projections of the model into the future and may confuse the statistical fleet dynamics model. Instead of describing the variation inherent in the fleet dynamics, the presence of trends can introduce biased predicted levels of effort in particular regions.

While the predictions for the whole fishery will remain useful, the particular predictions by assessment region may become biased if the projections are pushed too far into the future. Ways of avoiding this problem should be investigated by attempting to develop alternative fleet dynamics models that are less affected by recent trends.

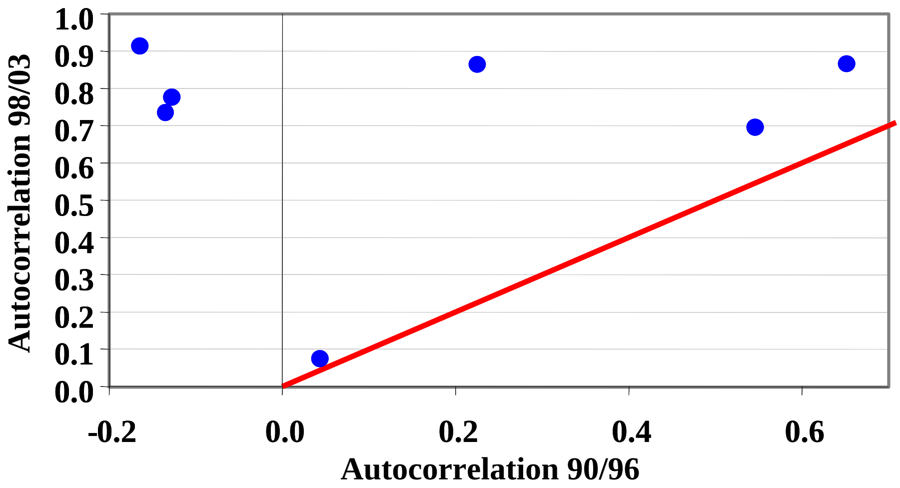


Figure 51. The autocorrelation in each assessment area for the years since the introduction of quota on the y-axis and the early years, 90/91 to 95/96, on the x-axis. The low point near the origin represents area 6. In all the other areas the level of autocorrelation has increased, in some cases markedly. The diagonal line represents the line of equality.

18. Appendix 3: List of Management Objectives and Strategies

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

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

The proposed policy objectives listed in the draft plan are:

- The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range and within acceptable levels of probability.

- Where the fishery assessment suggests that the fish stock is below defined reference points, then the fishery will be managed to promote recovery to ecologically viable levels within a nominated timeframe.

- An appropriate compliance strategy that minimises the opportunity for illegal activity through monitoring, compliance and enforcement measures that are supported and aided by industry.

- Optimise the economic value of the fishery within the constraints of objective 1.

- Recover a financial contribution from both commercial and recreational rock lobster fishers to contribute to the real costs of management, compliance and research.

- Ensure that the rock lobster fishing fleet continues to provide employment and an economic return to Tasmanian coastal communities.

- The fishery is conducted in a manner, which minimises the effect on by-catch or by-product species.

- The fishery is conducted in a manner, which minimises mortality of, or injuries to, endangered threatened or protected species and avoids or minimises impacts on threatened ecological communities.

- The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.

- Maintain a fishery that is conducted in an orderly manner recognising different participants need to access shared fishing grounds.

- Provide reasonable recreational access to the fishery.

- Provide access to the fishery for Aboriginal people to undertake cultural activities.

- To promote and maintain handling and processing practices that attempt to ensure the highest quality rock lobster product.

19. Appendix 4: List of Performance Indicators and Trigger Point Strategies

19.1 Performance Indicators

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

19.1.1 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.

19.1.2 Biomass

- While CPUE can provide a relative index of abundance, it does not provide an actual estimate of biomass. For the purpose of the Management Plan, biomass will be defined as the estimated tonnage of legal-sized lobster on the bottom at a stated point in time. Changes in the biomass are important because this will affect the catch-rate, productivity, sustainable harvest level and egg production of the fishery.

- Biomass will be estimated by two different techniques. The first will be a length structured, spatial stock assessment model of the rock lobster fishery and the second method will be through independent research surveys in selected regions of the fishery. While these two techniques are different, the stock assessment model incorporates research data, which implies that the two sources of biomass estimates are not completely independent.

19.1.3 Egg production

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

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

19.1.4 Relative abundance of undersized lobster

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

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

19.1.5 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.

19.1.6 The size of the commercial rock lobster fishing fleet

- As the restructuring process occurs 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.

19.1.7 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.

19.2 Trigger Points

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

19.2.1 Catch per unit effort (CPUE)

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

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

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

19.2.2 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 region falls below 75% of that estimated for the reference year with the lowest biomass in the related region.
- Legal-sized biomass estimates from research surveys in available regions declines significantly from one survey year to the next (technique being developed). Biomass specific research surveys will not commence till the 1997/98 season, hence it is not possible to use a past reference year in the trigger point. An exception to this trigger can be invoked if the stock assessment model or other models can adequately demonstrate that the decline in biomass seen through research surveys results in a biomass that remains higher than that which existed in the reference years.

19.2.3 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 regions have egg production levels which exceed 40% of that of the estimated unfished stock.
- For regions in which the estimated value of Egg_{low} is less than 10% of that of the estimated unfished stock, no reduction in egg production below that of Egg_{low} is permissible.

19.2.4 Relative abundance of undersized lobster

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

19.2.5 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.

19.2.6 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.

19.2.7 The recreational catch

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

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

20. Appendix 5: Summary of Rules

Table 14. Summary of rules for the Tasmanian Rock Lobster Fishery.

COMMERCIAL

Management zone	one management zone for the State
Limited entry	314 licenses
Limited seasons	In 2001: closed season 24-28 February (both sexes); 1st October – 2nd November (both sexes); 1st May-1st October (females).
Limits of pots on vessels	minimum of 15 pots, maximum of 50 pots
Quota	Total allowable catch of 1523 tonnes
Restrictions on setting pots	pots cannot be set, or pulled, between two hours after sunset and two hours before sunrise
	pots must be hauled no longer than 48 hours after being set
Restrictions on pot size	maximum size of 1250 mm x 1250 mm x 750 mm.
Escape gaps	one escape gap at least 57 mm high and 400 mm wide and not more than 150 mm from the inside lower edge of the pot, or two escape gaps at least 57 mm high and 200 mm wide and not more than 150 mm from the inside lower edge of the pot
Minimum size limits	105 mm CL for females, 110 mm CL for males
Berried females	taking of berried females prohibited

RECREATIONAL

License requirements	rock lobster potting licence - 1 recreational pot per person, rock lobster diving licence, rock lobster ring license – 4 rings per person.
Daily limit	5 per recreational license holder
Possession limit	10 for holders of recreational licenses, 5 for those without a rec. license (a receipt of purchase is required if more are held). No possession on state waters without a recreational license.
Limited seasons	In 2001: closed season 1st May-2nd November (females); 1st September-2nd November (males).
Restrictions on setting pots	as per commercial fishers
Restrictions on gear	Pots as per commercial fishers, rings no more than 1 m in diameter, capture by glove only when diving.
Escape gaps	as per commercial fishers
Minimum size limits	as per commercial fishers
Berried females	as per commercial fishers
Sale or barter of lobsters	prohibited
Marking	All recreational lobsters must be tail clipped within 5 minutes of landing. No tail-clipped lobsters to be sold.

21. Acknowledgments

Membership of the RLAWG:

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

This report includes contributions from a range of sources:

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Aquaculture - Carl Waterworth (DPIWE) and Dr Arthur Ritar (TAFI).

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Recruitment – Pip Cohen (TAFI).

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Industry summary - Neil Stump (TRLFA).

Mapping of catch - Justin Welch (School of Geomatics, University of Tasmania).

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