FISHERY ASSESSMENT REPORT

TASMANIAN ROCK LOBSTER FISHERY 1999/2000

Compiled by C. Gardner, S. D. Frusher and L. Eaton

January 2001

Tasmanian Aquaculture
& Fisheries Institute
University of Tasmania

This assessment of the rock lobster resource is the fifth in the series and the third to be produced by the Tasmanian Aquaculture and Fisheries Institute (TAFI) and uses input from the Rock Lobster Fishery Assessment Working Group (RLAWG).

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The fishery description was obtained from the Fish Policy Document (Anon,1997).

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Rock Lobster Fisheries Assessment: 1999/2000

Summary

This document reports on the state of the Tasmanian rock lobster resource and fishery for the period March 1999-February 2000.

The Tasmanian Rock Lobster Fisheries Assessment 1999/00 showed that performance indicators were not triggered with two exceptions. These were declines relative to reference years in: (i) catch rate of legal sized animals from research sampling in Area 8, and (ii) abundance of undersize lobsters in southern areas (Areas 1 and 8). The decline in catch rate from research fishing in Area 8 was not consistent with commercial data indicating that this was due to a factor other than a change in abundance. Abundance of undersize lobsters was estimated with low precision and is not thought to be influenced by fishing. Consequently, apparent changes in abundance of undersize lobsters is of limited concern and this performance indicator may be adjusted in the next management plan.

Data from 1999/2000 indicate an increase in statewide catch rate, legal sized biomass, and egg production relative to the previous year and relative to the reference years. Increases in egg production, legal sized biomass and catch rates were due in part to unusually high levels of recruitment in the north east of the State. Model projections that assume more average patterns of recruitment indicate that further stock-rebuilding is likely to occur with a Total Allowable Commercial Catch (TACC) of 1500 tonnes, but not with TACCs of 1600 and 1700 tonnes.

Egg production in northern regions appears to have increased substantially in the last two years but remains below the target of 25% of virgin egg production.

Puerulus settlement data collected from the East Coast from 1990 onwards appear to provide an accurate prediction of future catch rates. These data indicate a decline in recruitment in that region for the next few years.

Uncertainty levels in the stock assessment model have been clarified and progress towards the inclusion of post-quota management system (QMS) fleet dynamics has been made. While the distribution of effort between regions appears relatively unaffected by the introduction of quota, there has been a shift in the seasonal timing of effort – with less expended during summer months and more in winter.

A socio-economic assessment of the impact of change to QMS is underway and a significant impact on the operations and livelihoods of many participants has been noted.

Current information on ecosystem interactions from lobster fishing activities indicates that impacts are small. Bycatch effects were considered insignificant based on the analysis of 18,000 potlifts. The use of mandatory escape gaps reduces bycatch by greater than 80%. Of the remaining bycatch, most individuals are returned alive and apparently unharmed. No effect of ecosystem change in response to rock lobster fishing was detectable in research in marine reserves. No interaction with listed threatened species or protected species was reported in 1999/2000, although occasional reports of entanglement in buoy lines or capture in pots have been reported in the past.

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1. Introduction

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

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

The commercial fishing fleet comprises approximately 240 vessels, which are licensed to use between 15 and 50 pots. Additionally, the rock lobster resource supports an active recreational fishery with over 8500 pot and 4500 dive licenses issued annually.

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

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

1.1 Management

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

Since the inception of catch records in the 1880’s, catch steadily increased in the rock lobster fishery to a high in 1984 of over 2,250 tonnes. During this time concerns of overfishing were expressed by industry, and resulted in government intervention. The most important changes were the restriction of the number of licenses in 1951 and a ceiling on the number of pots in the fishery at 10,000 in 1967.

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

2. Previous Assessments

The first stock assessment of the fishery was produced in July 1997 (Frusher, 1997a). This report used data available up until December 1995. An update to the first assessment was produced in December 1997 (Frusher,1997b). That report included an application of the rock lobster assessment model with data to December 1996 and a description of the 1996/97 fishing season up to July 1997.

This report is the fifth assessment report and uses data available up until the 1st March 2000. It includes data for the first two years since ITQ implementation.

Assessment Report No	Last month of data used	Reference
1	December 1995	Frusher, 1997a
2	December 1996	Frusher, 1997b
3	February 1998	Frusher and Gardner, 1999
4	February 1999	Gardner, 1999

3. Recent Developments

3.1 The Fishery

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

3.2 Developments in stock assessment reporting

This Stock Assessment Report sees major changes in the format and content, which will provide a more thorough assessment of the rock lobster resource. This report for the first time addresses the management objective of ecologically sustainable development (ESD).

The National Strategy for Ecologically Sustainable Development released in 1992 defines ESD as: 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased' Assessments that address ESD principles are considered important for industry accreditation (e.g, Marine Stewardship Council) and marketing. Additionally, an increased understanding of the marine ecosystem and the effect of sustainable ecological fishing activities should improve community perceptions of the fishing industry.

Although ESD is a significant issue that will require a large and sometimes new research investment, past research has made a contribution to ESD management.

Past research has focused on species specific biological issues such as lobster size at maturity, growth rates, fecundity, and fishery specific issues such as exploitation rate and biomass. Under the ESD principles, socio-economic and environmental aspects need to be more fully integrated with current knowledge.

As a starting point, this 1999/2000 Assessment Report will maintain the normal assessment approach based on species specific knowledge, adding to these chapters on socio-economic and environmental/ecosystem issues. Future assessment reports will build on these areas as knowledge becomes available.

3.3 Assessment Model

During 2000, we had the opportunity to test the forward projection capabilities of the model (Gardner, 2000). Results demonstrated that increases in estimates of biomass in the latest year were often overestimated (Figure 1). Errors in estimation of egg production in the final year were also detected but were small in magnitude (Figure 2). The overestimation of biomass occurred only for the final year's estimate and stabilised (corrected) once an extra year of data was added. The consequence is that although rebuilding is occurring, it is more conservative than estimated in the previous assessment report (eg statewide increase in legal sized biomass from 1997/98 to 1998/99 was closer to 6% than 11%). This implies that caution needs to be used when interpreting estimates from the final year's data. Throughout this report we have highlighted estimates where we believe precision may be low.

Work is currently in progress to improve the model to overcome this error in the forward projections, however, it must be emphasised that fisheries estimates are not precise measures.

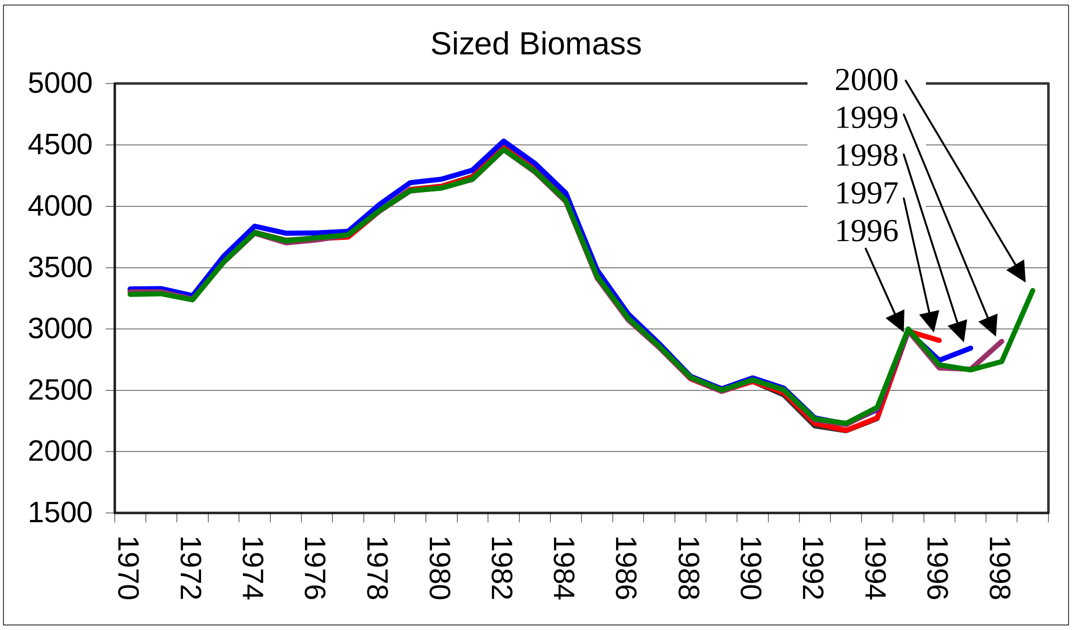

Figure 1. Model estimated statewide legal-sized biomass (tonnes) using 5 different model fits from 1996 to 2000. It can be seen that model estimates of biomass tend to be slightly optimistic in the final year of estimation. This has occurred for all model fits except the first (1996) which is completely overlayed by later model estimates of biomass. The reason for this consistent error in the final year is that there is less data for the model to estimate biomass, relative to estimates two or more years in the past. The implication of this observation is that biomass estimates from the most recent year need to be treated with a degree of caution – a more reliable indicator is a trend in biomass that occurs over several years.

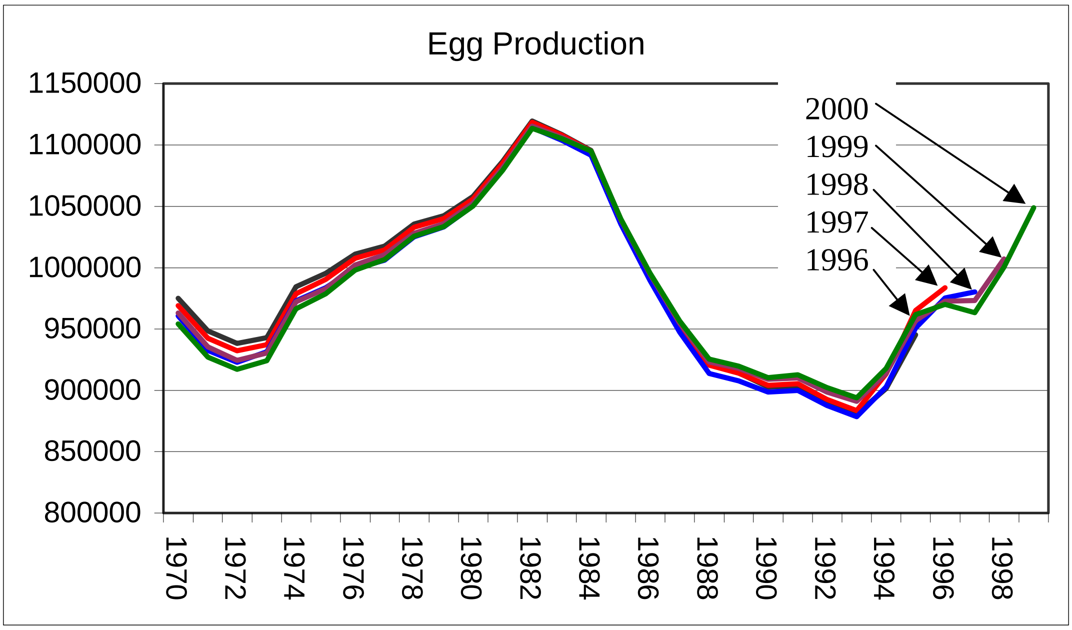

Figure 2. Model estimated statewide relative egg production using 5 different model fits from 1996 to 2000. It can be seen that model estimates can be slightly optimistic depending on the year of estimation. The implication of this observation is that egg production estimates from the most recent year need to be treated with a degree of caution – a more reliable indicator is a trend in egg production that occurs over several years.

Work on improving the model to incorporate standardised effort is underway through FRDC funding and this is considered especially important after introduction of ITQ management. Standardisation will enable us to directly compare catch rates of fishers today with those from the 1970's, even though there has been improvement in technology during this period. Associated with this work is revision of the fleet dynamics component of the model. The fleet dynamics component is used to predict movement of fishers when conducting projections. We expect that the decision-making processes that fishers use when choosing to shift to another area will be different under ITQ management. This is discussed in more detail in Section 6.

4. Fishery Assessment

4.1 Evaluation of Trigger Points

4.1.1 Catch per unit effort (CPUE)

Standardisation procedures are currently being investigated as part of a project to evaluate the changes in CPUE due to the implementation of quota. This report does not contain standardised CPUE data. Standardisation of CPUE data is an important step in overcoming the bias from technology change although the extent of this bias is unknown for the Tasmanian fishery. We expect this problem to be significant as Fernandez (1997) found that technologies such as colour echo sounders and global positioning systems had increased the efficiency of effort by 35% over the last 25 years for the deeper water lobster stocks in Western Australia. Fishing efficiency increases would lower the CPUE figures and thus declines in CPUE since 1970 would be steeper than shown.

There are significant seasonal trends in catches with over 80% of the catch currently being caught by the end of March. In general, the majority of the fleet commences fishing in southern regions prior to dispersing to fishing zones closer to their home port. Towards the end of the fishing season there is often an increase in effort around the Bass Strait Islands. With a change to an ITQ management system in March 1998, fishers are tending to change their fishing behaviour so as to increase their profits by harvesting their portion of the catch when prices are high (July to September). Previously increased catches were a major influence on fisher's behaviour.

To assist in comparison of spatial trends, regional catch rates are presented for the reference year and for 1999 (Table 1).

4.1.2 Commercial catch rates

All changes in the commercial catch rates both Statewide and at a regional level show an increase in catch rates since the reference year of lowest catch rate (Table 1). Relative to 1998, catch rates have increased in all areas except Area 8. However, the statewide catch rate was marginally higher, mainly due to much higher catch rates in

Areas 2, 3 and 4 on the east coast and Area 6 on the west coast. The improvement in east coast catch rates is attributable to the improved recruitment for this area (see recruitment section).

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

Region	Reference Year	Commercial catch rates (kg/potlift)			% change in 1999	
		Ref. Year	1998	1999	vs Ref. Year	vs 1998
Statewide	1994	0.82	0.94	**1.00**	22	6
1	1994	0.52	0.70	**0.73**	40	4
2	1994	0.54	0.55	**0.73**	35	33
3	1994	0.44	0.48	**0.57**	30	19
4	1994	0.63	0.81	**0.98**	56	21
5	1995	0.90	1.0	**1.02**	13	2
6	1995	1.21	1.36	**1.64**	36	21
7	1994	1.11	1.21	**1.30**	17	7
8	1993	0.77	1.05	**0.98**	27	-6

Monthly comparisons between the reference year and 1999 show that catch rates had improved for most months in all Areas (Figure 3). The only notable exception was during May in Area 8 where an uncharacteristic catch rate occurred. The magnitude of any difference between 1999 and the reference years was generally small except for the months of November and December. These months were the first months of fishing when new recruits for the following season are present (ie animals captured in Jan-August 1998 had already been legal sized and subjected to fishing pressure under input control only management).

The higher catch rates in November may be a combination of several events. More lobsters could be available due to either good recruitment or the rebuilding biomass or a combination of both. High catch rates in November to February may also reflect the quota process as the quota year ends in February. Fishers with remaining quota after September are focusing their efforts when prices are higher such as the Australian Christmas/New year and the Chinese New Year periods. Since the introduction of quota there has been a reduction in the number of fishing days by nearly 30% (Ford, in prep.). This implies that fishers now have greater flexibility in deciding where and when they want to fish and thus enables them to target areas and times to maximise their returns.

With the rapid reduction in the number of vessels operating (Figure 30, page 35), and the ability of operators to upgrade their pot holdings by 10%, the improved catch rates may reflect a shift in potting efficiency. As already mentioned, standardisation of the catch rate data is required before definitive conclusion can be made. For instance, improved catch rates may also have resulted from the following:

1) transfer of pots from less efficient operators to more efficient operators

2) transfer of pots from fishers operating in regions of lower catch rates (e.g., east coast) to fisher operating in regions of higher catch rates (west coast).

A substantial redistribution of pots occurred with the introduction of quota and the impact of this redistribution on catch rates is currently being investigated (see section 6.3, page 43).

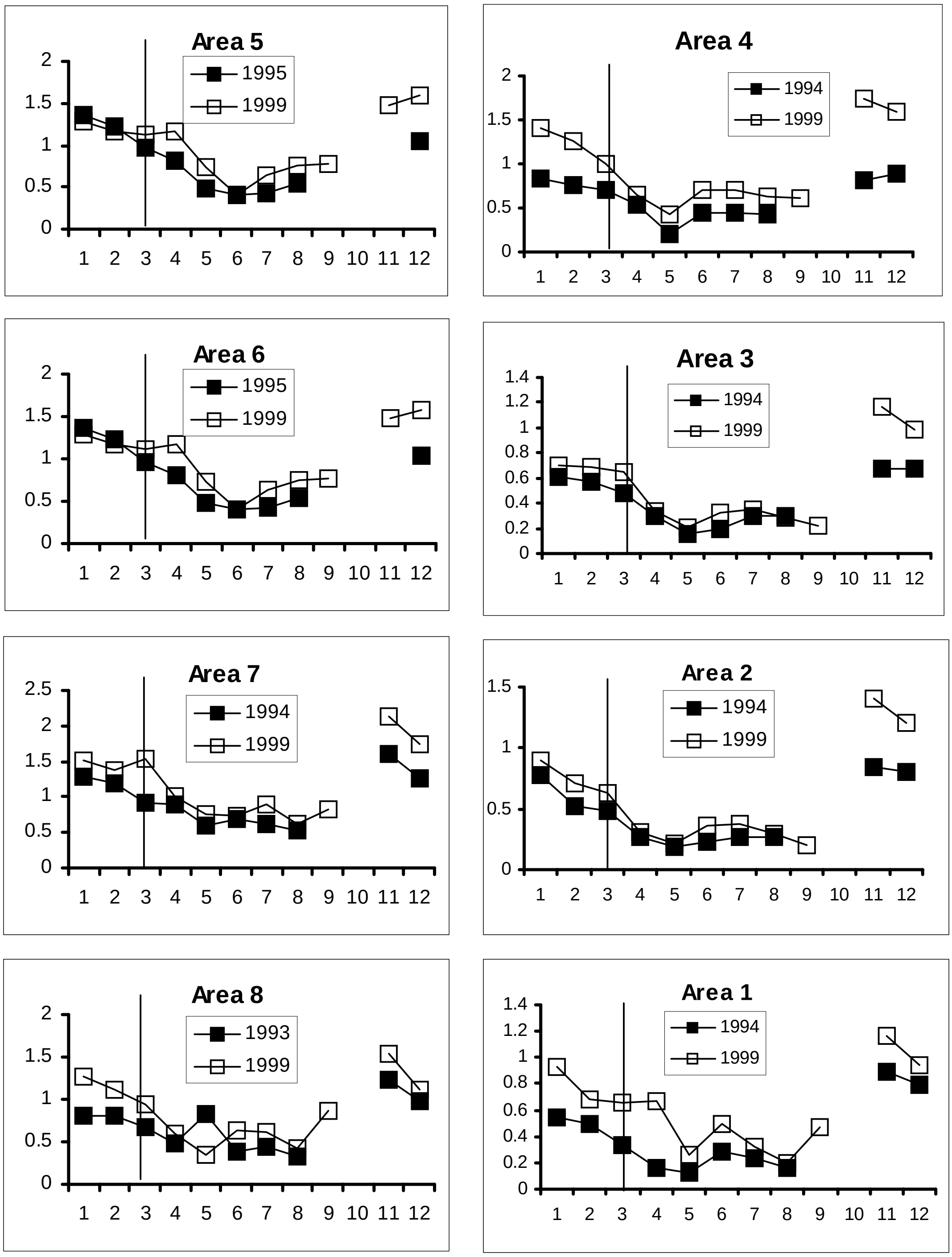

Figure 3. Change in catch-rate (CPUE, kg/pot lift) between months for 1999 and for reference year.

4.1.3 Research catch rates

Catch rates from research surveys showed an increase from the reference year to 1999 in the east coast sites (Area 2). These increases reflect the positive recruitment peak associated with the 1995 record puerulus index (Section 5, page 31). However, there was a decline in catch rates in south coast (Table 2). This decline is consistent with the commercial catch rate data (Table 1) which also found Area 8 to be the only Area where catch rates had declined. The extent of the decline in research catch rates of legal sized lobsters in Area 8 is probably an overestimate as the first two weeks in September were open for fishing. An early moult was recorded in the fishery during September and considerable numbers of recruits that are normally available for the start of the fishing season in November were harvested in September.

Fishers and processors report that this occurred primarily in the southern regions of the fishery. This is supported by the rapid rise in catch rates in Areas 1 and 2 for September 1999 (Figure 3). The extent to which the decline in catch rate for November 1999 is due to a portion of the catch being taken in September or a decline in the abundance of lobsters in this Area is uncertain.

Table 2 Change in catch rates from research surveys on the East and South Coasts of Tasmania.

Region	Depth	Reference	Catch Rates			% change	
	(metres)	Year	Ref. Year	1998	1999	vs Ref. Year	vs 1998
Area 8	45 - 100	Nov'93	1.18	2.35	0.91	-23	-61
Area 2	30 - 50	Nov'94	1.36	1.43	3.36	147	135
Area 2	< 30	Nov'94	1.35	1.30	2.17	61	67

The south coast region is the only region where there is concern about the trigger point. For the reasons mentioned above, caution needs to be used in interpreting this figure, especially as the catch rates in other regions are positive. However, the importance of Area 8 to the fishery should not be underestimated and future research needs to evaluate ways of interpreting the impact, which the extended September opening has on the November catch rates.

Catch rates from research surveys are limited by spatial coverage although they are valuable due to the fact that surveys are conducted in the same region with the same gear. The fact that catch rates are consistently higher in research sampling than in the commercial industry is partially a reflection of the ability to sample before the season opens in November.

4.1.4 Legal - sized biomass

Biomass estimates refer to the legal sized biomass in October of each year. This month was chosen as it is at the first month of the future fishing season after the spring closure when the assessment model has accounted for the annual moult. Thus, the legal-sized biomass is at its peak for the year. This is because it includes animals that moulted into legal size during closed periods in the preceding months. Biomass estimates from

October also permit comparisons with estimates derived from research sampling, which commences in October/November prior to the opening of the fishery.

Legal sized biomass has shown a positive increase compared to the reference years both Statewide and for the eight individual Areas (Table 3). Relative to the previous year (1998), there was a general trend of increasing legal sized biomass with the exception of Area 7, which was unchanged.

Table 3. 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 those regions where biomass is estimated poorly for recent years.

Region	Reference	Sized biomass estimate (tonnes)			% change in 1999	
	Year	Ref. Year	1998	1999	vs Ref. year	vs 1998
Statewide	1993	2508	3063	3612	44	18
Areas 2,3,5,6,7 only	1993	1461	1668	1806	24	8
1	1993	244	342	412	69	20
2	1993	182	224	256	41	14
3	1994	78	96	103	32	7
4	1994	386	524	796	106	52
5	1993	647	738	793	23	7
6	1995	250	263	307	23	17
7	1994	301	345	344	14	0
8	1993	400	528	597	49	13

A recent appraisal of the assessment models performance found that biomass was often overestimated for the final year. The last year's biomass was overestimated by about 5 to 6 percent and this was primarily in Areas 1, 4 and 8. These Areas normally account for the largest change in biomass and thus need to be treated cautiously. In contrast, regions 2, 3, 5, 6 and 7 have shown limited change from the biomass estimated in the last year. Excluding the biomass estimates from Areas 1, 5 and 8 we see that there is still an improvement in biomass but that it is only 8% rather than 18%. Importantly, biomass is still rebuilding although at a slower rate than indicated in previous assessments. Part of the biomass rebuilding in 1999 can be attributed to the improved recruitment on the east coast derived from the 1995 peak puerulus settlement (see recruitment section). This also explains the exceptionally large increase in biomass recorded in Area 4.

Table 4. Comparison of deviation in estimates of biomass in the final year of the model fit, from that estimated for the same period but using a model fitted to an additional year of data. (eg. biomass in 1995 was estimated with a model fitted to 1996, and again with a model fitted to 1997 – the deviance is the percentage difference between the two estimates).

Deviation in final year (%)	Model fitted to: 1996	1997	1998	1999	**Mean**
All Areas	0.4	5.6	6.0	5.7	**4.4**
Areas 2,3,5,6,7.	-3.4	0.8	-1.0	-2.8	**-1.6**

Trends in regional biomass estimates since 1970 are shown in Figure 4. In most regions there has been a decline from the early eighties to the early nineties. Importantly, recent trends have been positive, particularly over the last 3 years. However, the extent to which this is due to actual biomass rebuilding or a change in the effectiveness of effort needs to be determined. As previously mentioned, this is currently under investigation.

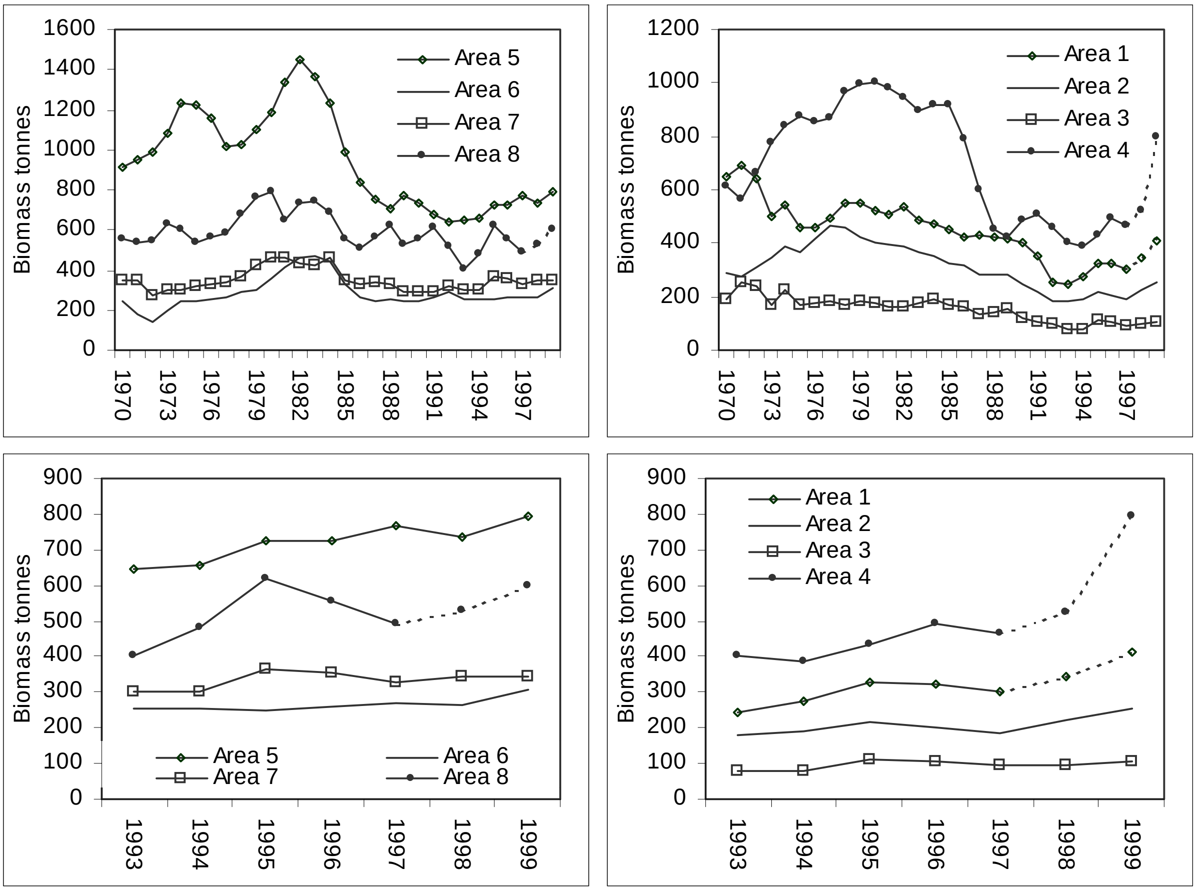

Figure 4. Regional legal-sized biomass estimates for the Tasmanian rock lobster fishery from (upper) 1970 to 1999 and (lower) from 1993 to 1999. All estimates are for October. Interannual changes, which are likely to be less accurate, are dashed.

All Areas have shown an improvement in legal sized biomass since the reference year, although this is marginal for Areas 3 and 7 (Figure 4).

Biomass estimates are derived from the model and also from data collected during research surveys. These data are used to estimate exploitation rate, which is a measure of the proportion of legal sized lobsters available at the beginning of the season that are actually captured. A biomass estimate is obtained by dividing the commercial catch by the exploitation rate (eg 1000 tonnes caught / exploitation rate of 0.5 = initial biomass of 2000 tonnes). Since 1992, fisheries independent research has tested techniques for determining exploitation rates in the south (Area 8) and east coast (Area 2) regions of the fishery (Frusher *et al*., 1998; Frusher *et al*., 1997). The techniques are still being evaluated for the east coast and no east coast data is presented.

Biomass estimates for Area 8 using south coast exploitation rates derived from change-in-ratio (CIR) and index removal (IR) are presented in Figure 5. Biomass estimates derived from the commercial catch data using the Leslie depletion method (DEP) (Leslie, 1945), biomass estimates from the model and, the commercial catch are also included in Figure 5.

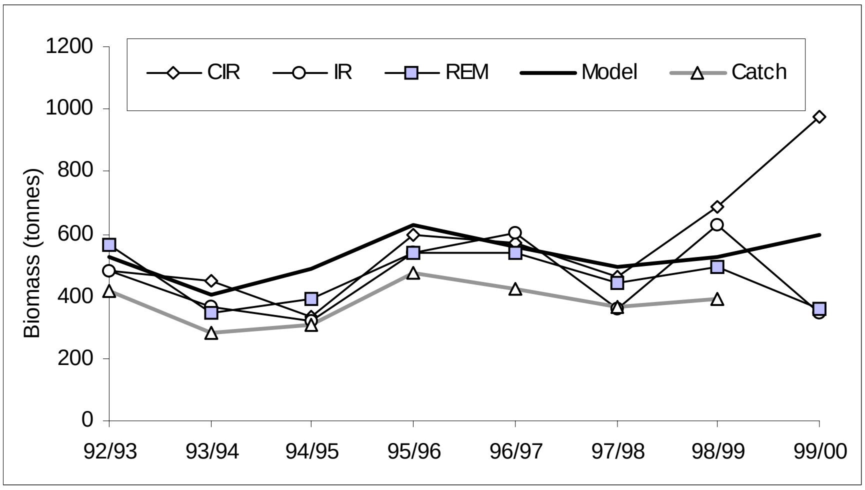

Figure 5. Estimates of legal sized biomass in Area 8 using change-in-ratio (CIR), index removal (IR), depletion (REM) techniques and from the rock lobster assessment model (Model). The commercial catch (Catch) is also shown. All biomass estimates are at the beginning of the open season in November and catch is for the period from that November until the following August. Estimates for 99/00 are based on partial year sampling to March 2000.

There is close agreement between the trends for all estimates until the 1998/99 season. Whether the lack of agreement between estimates is an artefact of quota implementation is being investigated. The impact of the extended season and the decline in fishing effort and catch from November to March would be expected to impact on the CIR and IR techniques. Both methods are more robust when exploitation rates are high. The 99/00 CIR, IR and REM figures are only for the period from November to end of February. The full year's exploitation is expected to improve these estimates. As mentioned in section 4.1.3, the impact of the harvesting of newly recruited lobsters in September 1999 on the exploitation rate estimates needs to be investigated.

Legal sized biomass estimates from the 1999/00 fishing season from research surveys are higher than the lowest estimate which occurred in the 1994/95 fishing season. The downward trend in biomass from 98/99 to 99/00 for the IR and REM methods is of concern although for the reasons mentioned above, these figures need to be used cautiously.

It is noteworthy that Area 8 was the only Area that showed a decline in catch rates. Although catch rates are not precise indicators of abundance (Section 4.1.2, page 5) the decline in this Area is of concern and suggests that Area 8 needs to be monitored closely over the next year.

4.1.5 Egg production

The increase in egg production above the virgin level for Area 8 is currently unexplained . This was also noted by Kennedy (1998), who concluded that further modelling work was required to sort out this problem. Possible causes of the estimates of egg production in Area 8 being above virgin levels include: i) expansion of fishing grounds, and ii) changes in growth and abundance of females due increased food availability through harvest of males. Due to the slow growth rate and small size at maturity of females in Area 8, egg production is high and not of concern.

Table 5. Change in relative egg production from the reference year to 1999, and the level of egg production in 1999 as a percentage of virgin egg production. Virgin egg production is the estimated egg production prior to commercial exploitation, assuming average recruitment the same as that from 1970 to the present. Relative egg production is a numerical (linear) index of egg production so that 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 those regions where egg production is estimated poorly for recent years.

Region	**Reference Year**	**Relative Egg Production**			**% change in 1999**		**% Virgin prodn. in 1999**
		Ref. Year	**1998**	**1999**	**vs Ref. year**	**vs 1998**	
Statewide	1993	894	1001	1049	17	5	29
State (adj)	1993	825	911	951	15	4	30
1	1995	157	150	149	-5	-1	61
2	1992	79	83	80	1	-4	29
3	1993	24	30	35	46	17	9
4	1993	63	99	135	114	36	17
5	1992	61	88	98	61	11	10
6	1986	52	90	99	90	10	25
7	1989	112	131	122	9	-7	44
8	1994	308	330	332	8	1	110

Table 6. Comparison of deviation in estimates of egg production in the final year of the model fit, from that estimated for the same period but using a model fitted to an additional year of data. (eg. egg production in 1995 was estimated with a model fitted to 1996, and again with a model fitted to 1997 – the deviance is the percentage difference between the two estimates).

	Model fitted to:				
Error in final year	1996	1997	1998	1999	**Mean**
All Areas	-2.1	0.9	0.7	0.7	**0.0**
All Areas (adj.)	-2.6	1.0	-0.9	-1.2	**-0.9**

The only decline in egg production compared to the reference year was from Area 1 where egg production compared to virgin production is high and not of concern (Table 5). With the exception of Areas 6 and 7 in the south-west, egg production has declined since the late 1970’s to the early 1990’s (Figure 6).

As with biomass, the assessment model was evaluated for bias in estimates of relative egg production. Although biases did exist they were minimal, mainly in the final year, and not consistently in one direction (Table 6).

Substantial increases in relative egg production have been achieved in the northern regions (Figure 6), although they are still low compared to virgin stocks and below the recommended level of 25% (Figure 7) (Frusher, 1997a). Although Areas 4 and 5 still provide reasonable numbers of eggs compared to other regions (Figure 6), the low percentage of egg production compared to the virgin (unharvested) production indicates the large contribution Areas 4 and 5 would have made to overall egg supply prior to exploitation.

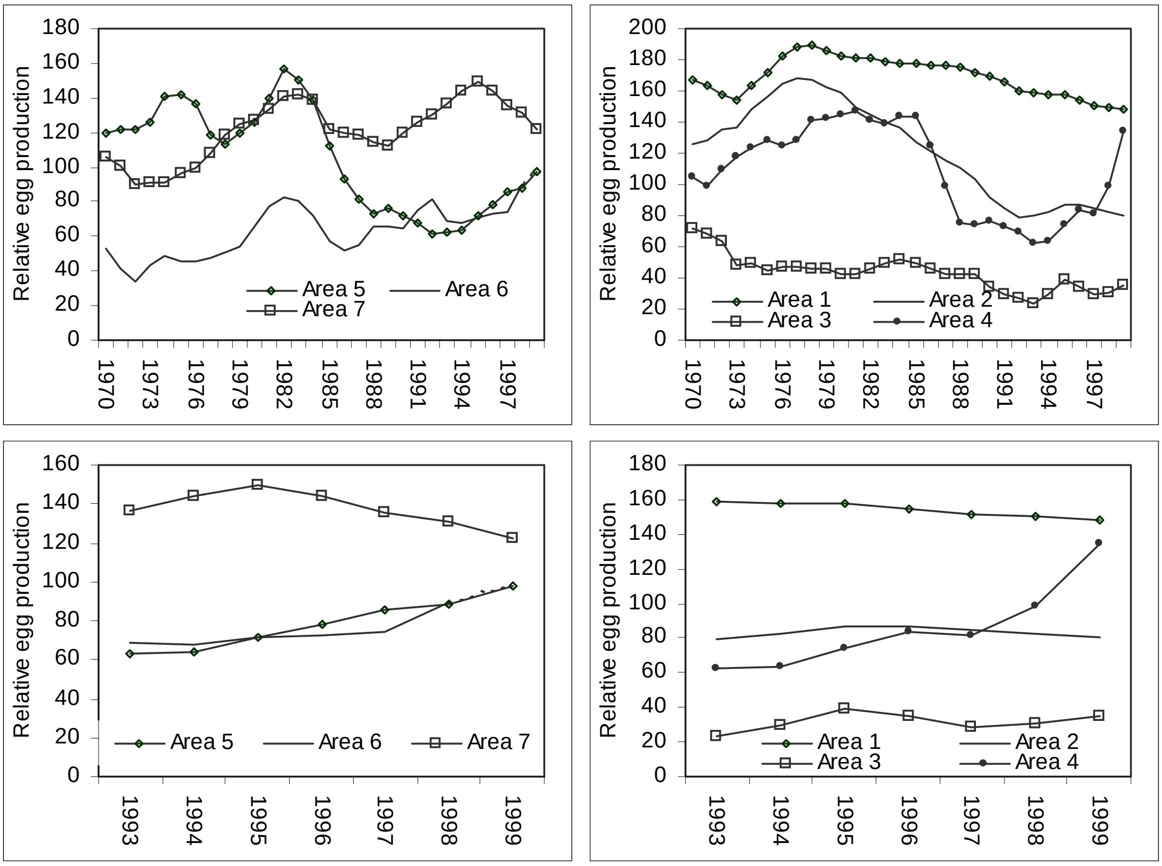

Figure 6. Relative egg production from 7 Areas around Tasmania, western regions to the left, eastern regions to the right. Area 8 is not included due to problems mentioned in the text. Interannual changes, which are likely to be less accurate, are dashed.

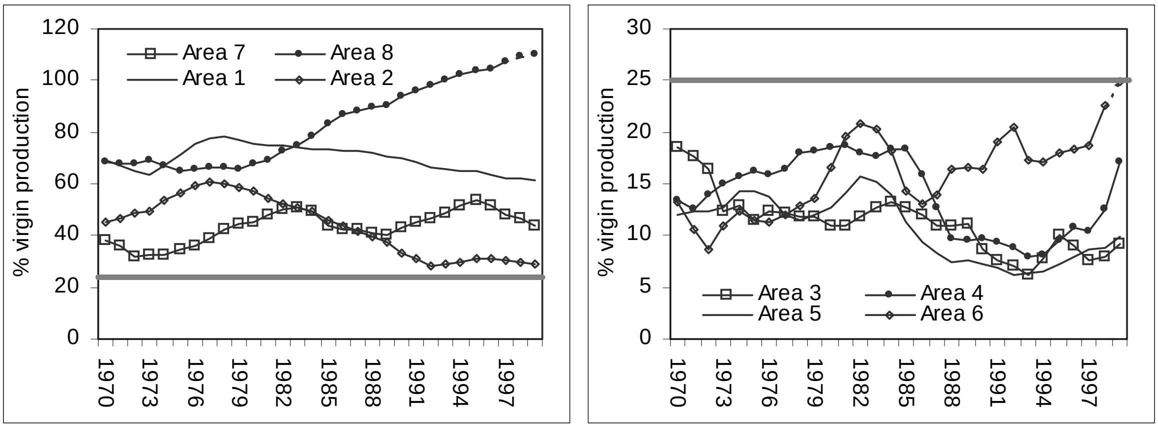

Figure 7. Percentage of virgin egg production from eight Areas around Tasmania, southern Areas to the left, northern Areas to the right. The horizontal bar in each plot represents the management target of 25%. The dashed portion of the plot for Area 6 should be accepted cautiously.

4.1.6 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 (see section on trends in catch rates) where undersize males of greater than 105 mm CL are assumed to moult to legal size in the following season.

The lowest catch rate of undersized achieved in the pre-season surveys undertaken in October/November was in 1995. The catch rate of 1.45 undersized lobsters per pot lift in 1995 increased to 2.51 in 1998 and declined to 2.18 in 1999. The 1999 catch rate of undersize is still substantially higher than the reference year so the undersize trigger gives no cause for concern.

Model Estimates

Undersized biomass estimates obtained from the model reflect undersized lobsters from 80mmCL to the legal size limit (Figure 8 and Figure 9).

Biomass estimates are derived from catch and effort data. This data relates only to the Area being fished at the time and does not take into account non-fished or unknown fishing grounds. Thus as new grounds were being developed on the west coast during the seventies and eighties, apparent increases in biomass occur. This explains the observed increase in undersize biomass in Areas 5, 6 and 7. The rapid increase in undersize biomass in Area 6 during the 1980’s is considered an artefact of the discovery and then exploitation of a new and productive ‘patch’ of fishing grounds which fishers often refer to as the ‘Golden Mile’ patch.

As mentioned in the sections on biomass and egg production, there is uncertainty in the model estimates for Area 8. Interpretation of undersize biomass trends in this Area needs to be treated with caution.

In Areas 2,4,6, and 7 undersized biomass has declined for both sexes in recent years and is at or below 95% of the reference years in Areas: 1 (females only); 2 (both sexes); 7 (both sexes); and 8 (males only). Although undersized biomass is not a trigger, these trends are of some concern and require monitoring. Undersize biomass is a volatile index and there has also been sharp increases in some Areas, particularly in Area 5.

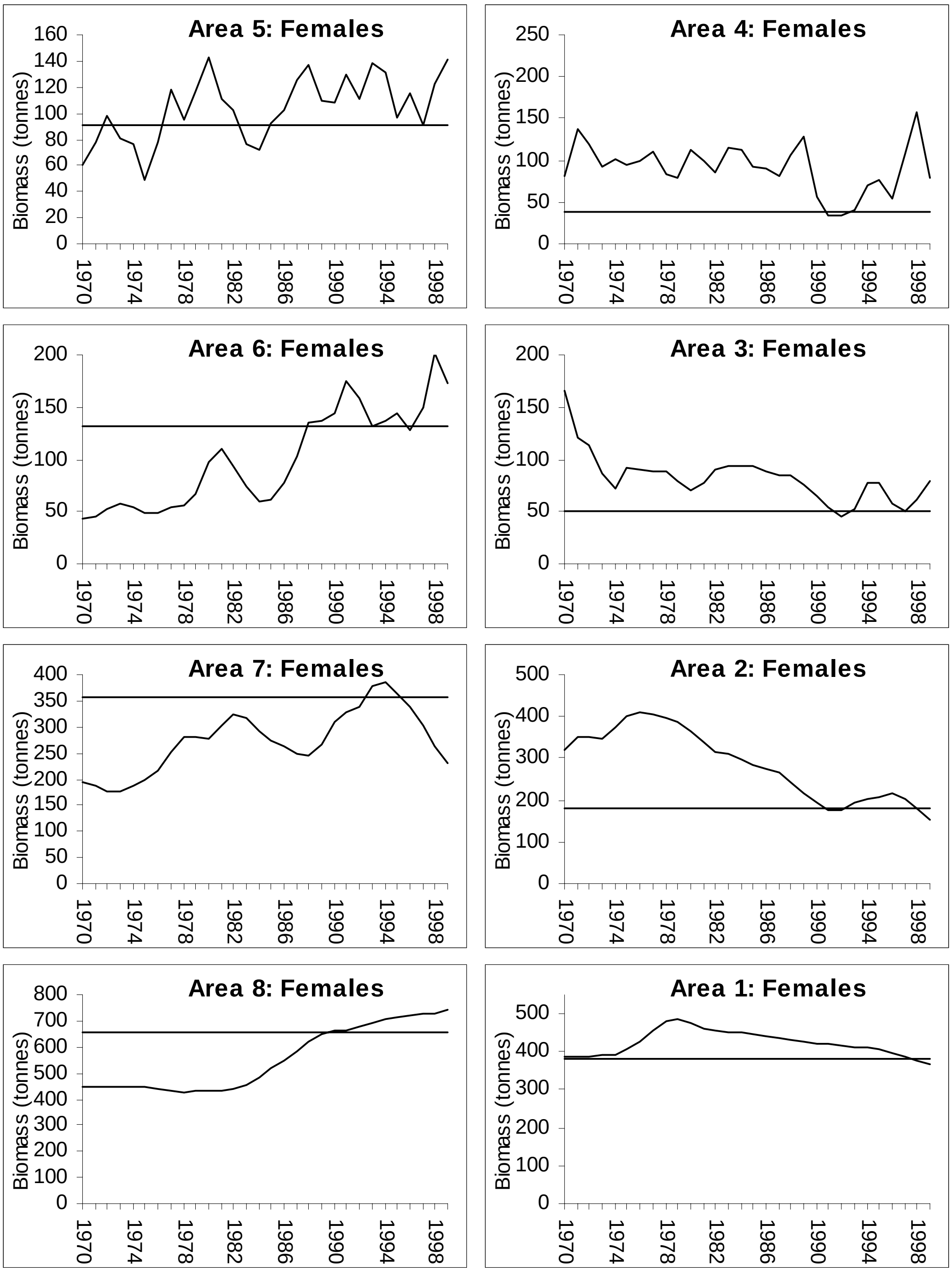

Figure 8. Undersized biomass estimates female lobsters from 80mmCL to 104mmCL. The horizontal line represents the value of 95% of the reference year. These estimates are back calculated from recruitment estimates of the model.

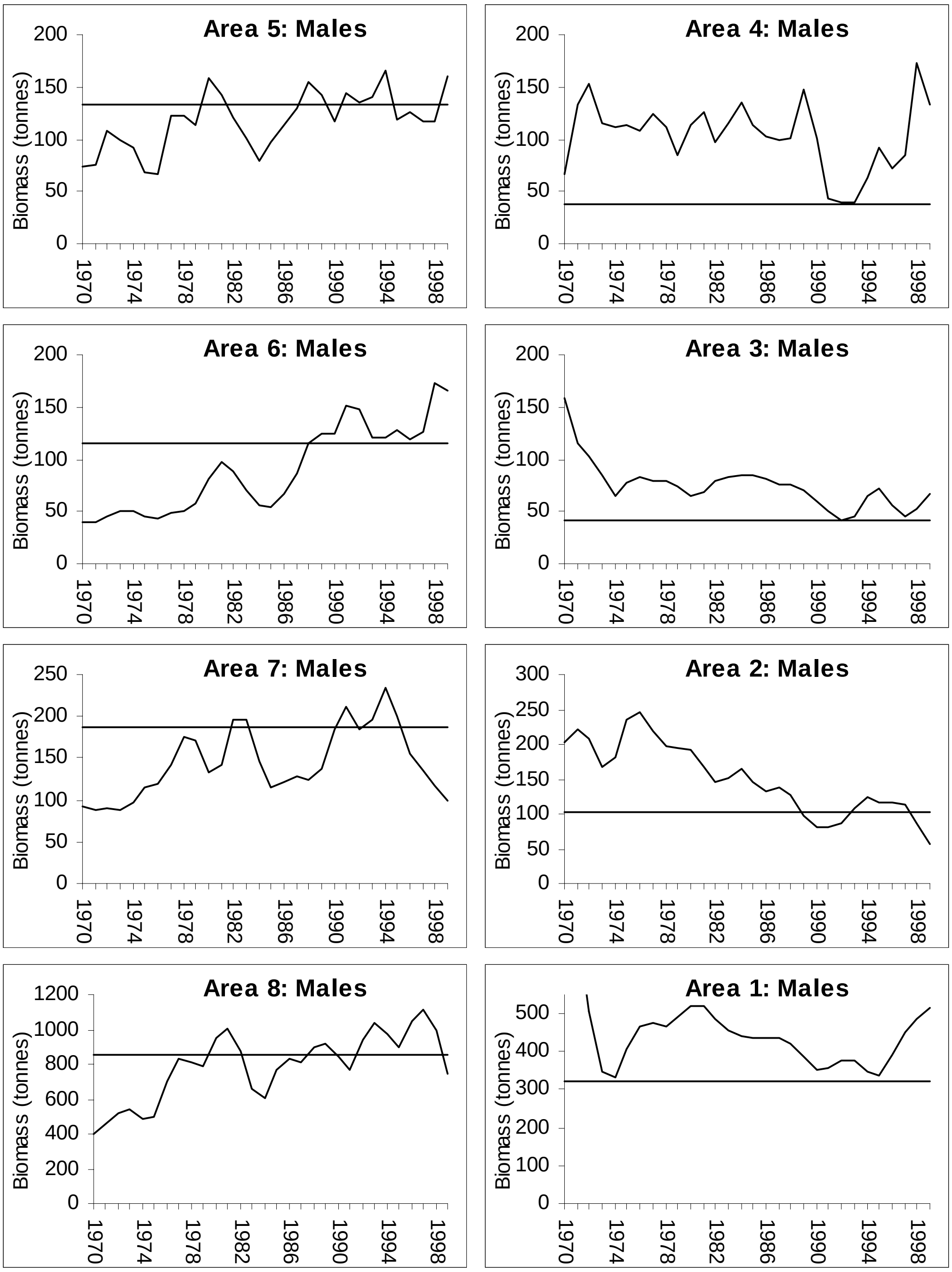

Figure 9. Undersized biomass estimates of male lobsters from 80mmCL to 110mmCL. The horizontal line represents the value of 95% of the reference year. These estimates are back calculated from recruitment estimates of the model.

4.1.7 The total annual catch

The total annual commercial catch (TACC) is constrained by output controls on the fishery. A TACC of 1500 tonnes was introduced for the first time in March 1998 and the management trigger is 95% of this amount (=1425 tonnes). The total catch for the period March 1999 to February 2000 (inclusive) was 1476 tonnes which is greater than the trigger. Several fishers have reported that they retained a small amount of quota unfished, as it was not economically viable to return to sea for this small catch. This implies the TACC shortfall is not a function of lobster abundance.

4.1.8 The size of the rock lobster fleet

The average number of licenses in the fishery can be determined by the number of returns processed. It is mandatory for each license holder to submit a monthly catch return irrespective of whether the person was fishing or not. The average annual number of licenses in the fishery since 1993 has declined marginally each year with 314 licenses operating in the fishery in 1999 (Table 7). The proportion of these licenses that were active (that is, they recorded a catch) has decreased at a more rapid rate. It appears that the introduction of QMS has reduced the number of active licenses with a partial year decrease of 14.8% from 1998 to 1999. This would be expected as a consequence of the increase in the allowable maximum number of pots from 40 to 50 and the ability to aggregate quota from two licences onto one.

The number of operators is still above the trigger of 220 for this performance indicator.

Table 7. Changes in the number of operators in the Tasmanian rock lobster fishery in calender years from 1993 to 1999. Licenses cannot be created so the 1999 value cannot change although it is based on partial year data. Active licenses are those that recorded catch. It possible that the number of active licenses in 1999 is an underestimate as it is based on partial year data.

Year	Number of operators	% change	Number of active licenses	% change
1993	337	-	330	-
1994	334	-0.9	329	-0.3
1995	331	-0.9	326	-0.9
1996	321	-3.0	315	-3.4
1997	316	-1.5	309	-1.9
1998	314	-0.6	304	-1.6
1999	314	0	259	-14.8
2000	314	0	254	-1.9

4.1.9 The recreational catch

Recreational catches of rock lobster are taken by potting, diving and with rings. Divers are permitted to use surface supply, scuba, and snorkel. Most recreational rock lobsters are taken by potting (Figure 10) and effort is concentrated in shallow water of less than 18 m due to the constraints of safe diving and the ability to pull pots by hand.

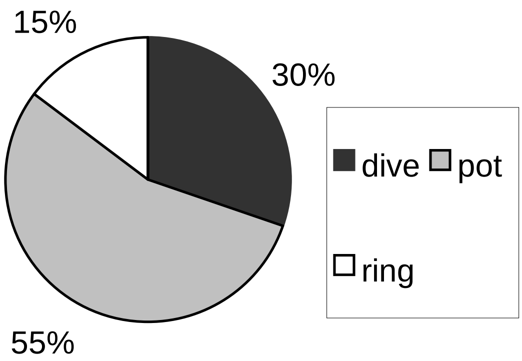

Figure 10. Proportion of recreation catch taken by different gear types**.**

No further estimates of the recreational catch are available since the 1998/99 assessment. A targeted rock lobster recreational survey for 2000/01 is underway.

There has been a substantial and steady increase in the number of licences issued over the last 5 years (Figure 11). Since 1996 pot and dive licences have increased by 40 and 43% respectively. This escalation in licenses issued is of concern and the survey to be undertaken over the next 12 months will determine if the increased number of licences is reflected in an increased catch. Reasons for the increase in licenses include improved public awareness for the need for licences together with increased police surveillance, the option to buy a second licence for a minimal amount, and improved catch rates of recreational fishers. Note that the use of rings did not require a license prior to 1999.

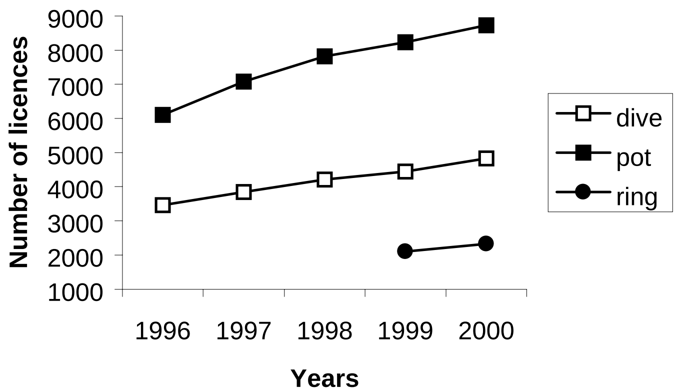

Figure 11. Trends in the number of recreational licenses issued annually.

4.2 Trends in Commercial Catch, Effort and Catch Rate Data

Catch rates in Tasmania remained relatively constant or increased during the 1970’s and early 1980’s prior to a decline to record lows in the mid 1990’s (Figure 12). This has been followed by minor recovery. While this trend is reflected in all regions of the fishery, there are differences that are worth noting.

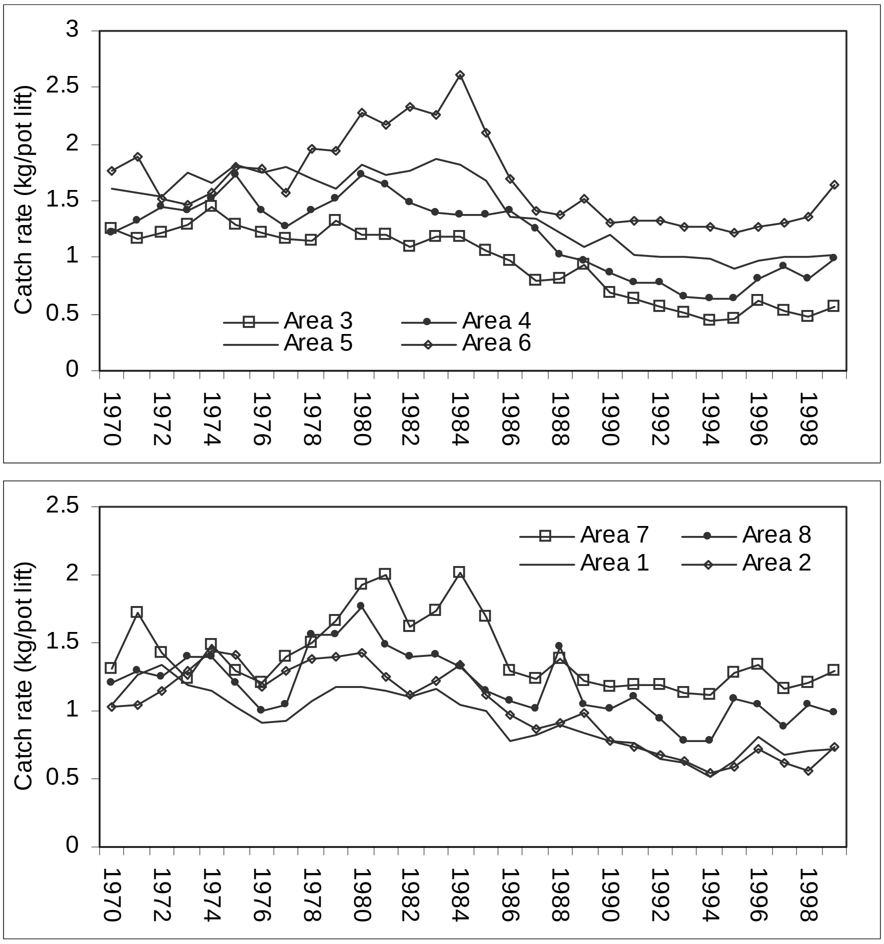

Figure 12. Regional catch rates from southern and northern Tasmania since 1970. Data is presented on a quota year basis (ie March to February) so the last data point is for March 1998 to February 1999 inclusive.

East coast regions recorded their highest catch rates in the early to mid seventies, whereas the west coast regions were developed later with highest catches occurring in the early to mid 1980's (Table 8). An exception to this is Area 4 (NE) which recorded its highest catch rate later than the other East Coast Areas.

The rapid increase and subsequent decrease in Area 6 resulted from the discovery of relatively virgin ground during the early 1980's. In almost all regions catch rates have halved since the eighties.

The extent of decline, and the timing of peaks in catch rates reflect the nature of the east and west coast operations. The East Coast, which has greater infrastructure and population combined with more settled weather, was developed and exploited earlier. In contrast, fishing on the more weather dependent west coast grounds was stimulated by the declining east coast catch rates, improved technology including 'bottom lock' echo sounders, and availability of larger vessels.

Table 8. Comparison of highest and lowest commercial catch rates regionally around Tasmania from 1970. Comparisons are between years on a quota year basis (ie March to February).

Area	Highest Catch Rate		Lowest Catch Rate		% difference in Catch Rate	1999/00 Catch Rate	% difference 1998/99 to 1999/00
	Year	Catch Rate	Year	Catch Rate			
All	1981/82	1.66	1995/96	0.82	51	1.04	+12
1	1971/72	1.31	1994/95	0.54	58	0.70	-1
2	1974/75	1.47	1994/95	0.54	63	0.76	+33
3	1974/75	1.40	1994/95	0.43	69	0.60	+22
4	1980/81	1.72	1994/95	0.61	65	1.06	+29
5	1982/83	1.92	1995/96	0.89	54	1.08	+19
6	1984/85	2.43	1972/73	1.14	53	1.65	+20
7	1980/81	2.03	1997/98	1.09	46	1.32	+6
8	1980/81	1.80	1993/94	0.77	57	0.98	-11

Since the lows of the mid-1990's, last year's catch rates are showing considerable improvement with the exception of Area 1 which has remained static and Area 8 which has shown a decline. These southern Areas may be influenced by the extended seasonal openings as discussed in section 4.1.3 (page 8). It is important to understand that these are non-standardised annual CPUE values so they will be influenced by the change to quota management. This change will affect the timing and spatial distribution of commercial effort so annual comparisons of CPUE may be affected. For this reason, the biomass trends (Table 3) and monthly CPUE data (Figure 3) are a more useful indicator of stock abundance. Research is underway though FRDC funding to overcome this effect of management change on stock assessment.

4.3 Trends in fisheries independent abundance indices

A fishery independent catch sampling project has been conducted at a number of sites around the southern half of the State since 1992. Three groups of sites have been surveyed on all occasions and thus provide a time series of data. The groups correspond to shallow (<30 metres) and medium (35 to 45 metres) regions around southern Maria Island and south west Schouten Island respectively on the east coast, and medium to deep (45 to 100 metres) sites south of Maatsuyker Island on the south coast.

4.3.1 East Coast Shallow

Pre-season research catch rates of sized lobsters declined from 1992 to 1997 but recovered in 1998 and 1999 (Figure 13). The commercial catch rate for the months of November in the same Area remained relatively stable until 1998 after which there has been an increase. In general there is good agreement between the trends in the commercial catch rates and the research catch rates, particularly for the last 4 years.

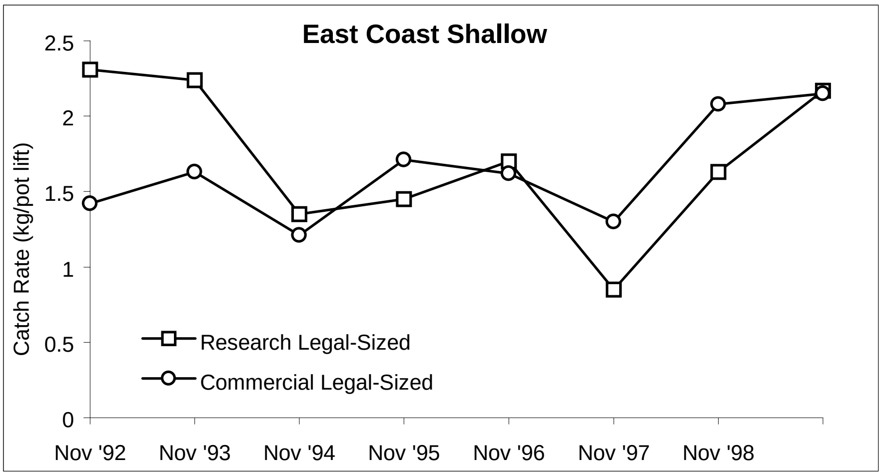

Figure 13. Shallow water catch rates from the east coast of legal sized lobsters from research surveys and commercial fishing.

Research data may have the potential to predict catches as the abundance of undersize lobsters is recorded. To evaluate this, the catch rates of sized and undersized lobster were compared by shifting the undersize data forwards one year (ie we compare catch rate of sized lobsters this year with catch rate of undersize last year). Undersize classes used for this analysis were restricted to those considered likely to moult in the next 12 months: 6mm CL for females and 8mm CL for males below the legal size limit (Figure 14).

The catch rate of under sized lobsters was a good predictor of catch rates of legal sized lobsters except for one sample taken of undersize lobsters in 1996 (Figure 14). Given the large deviation in this one year, pre-recruits from research surveys can not be used in this region to predict future catches with the method used here. However the method does appear to predict catches on most occasions and warrants further investigation - the divergence in 1996/97 may be due to atypical moult timing or increment which could be assessed with tag-recapture data.

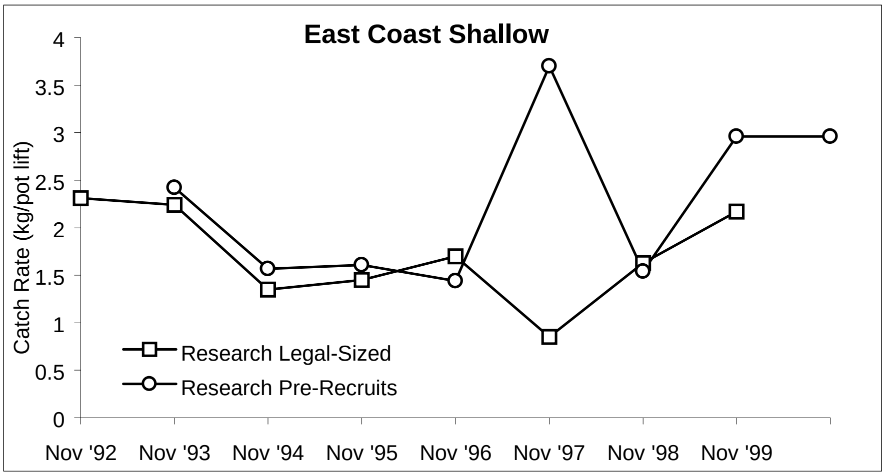

Figure 14. Shallow water catch rates from the east coast of legal-sized and pre-recruit lobsters from 1992 to 1999 survey periods. The pre-recruit lobsters have been advanced by 1 year to simulate growth of undersized lobsters to legal size. Undersize catch rate has been a reasonable predictor of catch rate of legal sized lobsters the following year, apart from 1996/97. The reason for this deviation is unclear but may have been due to atypical moult timing.

4.3.2 East Coast - Medium

There has been a substantial increase in the medium depth research catch rates in Area 2 over the last year and this reflects the expected recruitment pulse from the 1995 puerulus index (Section 5, page 31)(Figure 15). Commercial catch rates have also increased since 1992 in this Area although the magnitude of this trend is small and not significantly different from 0 ($P>0.10$). Both the commercial and research catch rates show substantial annual variation, although trends are broadly similar with the exception of the last year. The catch rate of pre-recruits is a poor predictor of catch rate of legal size lobsters the following season in this region (Figure 16 and Figure 17). There appears to be a better relationship if pre-recruits are not advanced by 1 year. This would suggest that the catch rates are being driven more by catchability factors than by recruitment variation. The use of pre-recruits to predict the following years catch is not appropriate in this region.

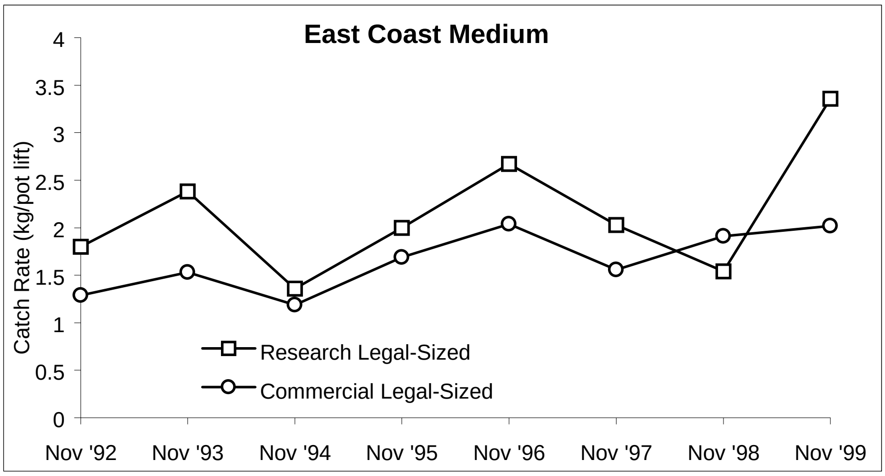

Figure 15. Medium depth catch rates for the east coast of legal sized lobsters from research surveys and commercial fishing for the start of the fishing season.

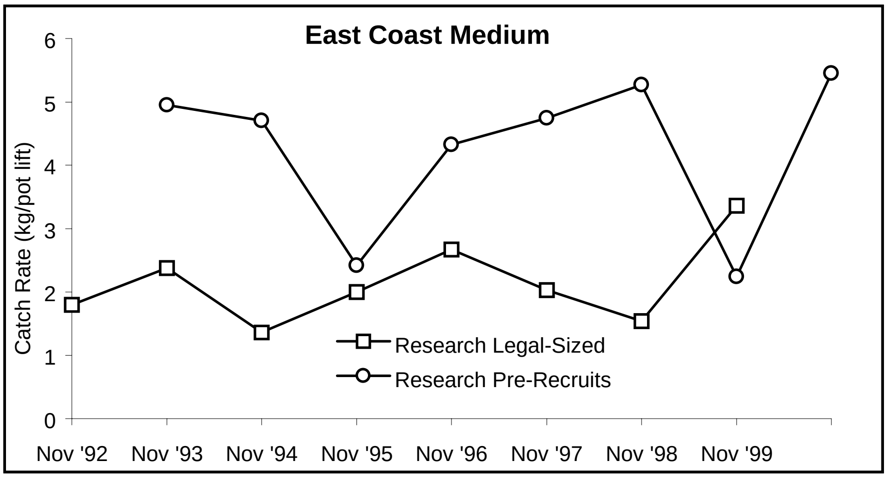

Figure 16. Medium depth catch rates from the east coast of legal-sized and pre-recruit lobsters for the 1992 to 1999 survey periods. The pre-recruit lobsters have been advanced by 1 year to simulate growth of undersized lobsters to legal size.

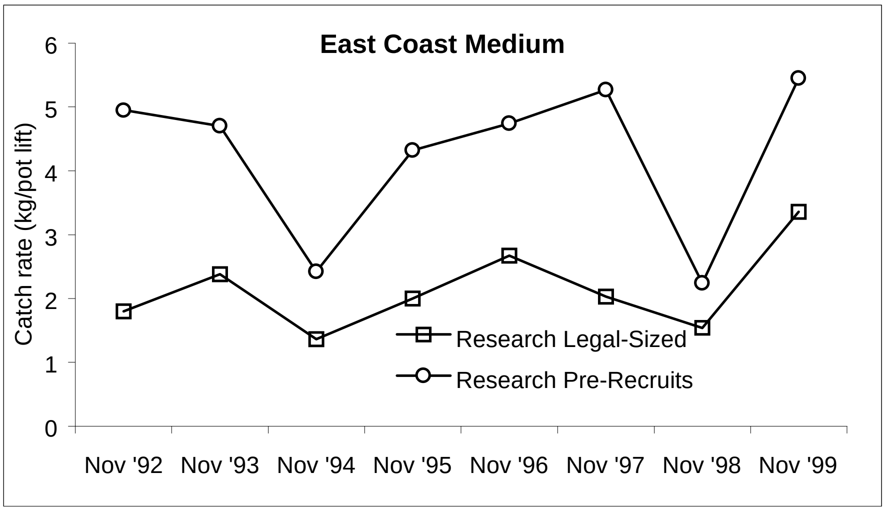

Figure 17. Medium depth catch rates from the East Coast of legal-sized and pre-recruit lobsters for the 1992 to 1999 survey periods. The pre-recruit and legal sized lobsters have been plotted on the same time series. The similarity in trends of these separate size classes suggests that the inter-annual fluctuation is more an effect of catchability than recruitment (compare with Figure 16, which shows the same data, only with a time lag of 1 year).

4.3.3 South Coast - Medium to Deep

The catch rates in Area 8 of sized lobsters from commercial fishing and research surveys have similar patterns although there is a lack of correlation over all years (pairwise correlation = 0.57, P > 0.10)(Figure 18). As catch rates from research sites south of Maatsuyker Island were not reflecting regional trends in commercial catch rates in 1997, new sites around Port Davey in the south west were established in 1998. This appears to be successful with both data sets showing a similar trend since 1997.

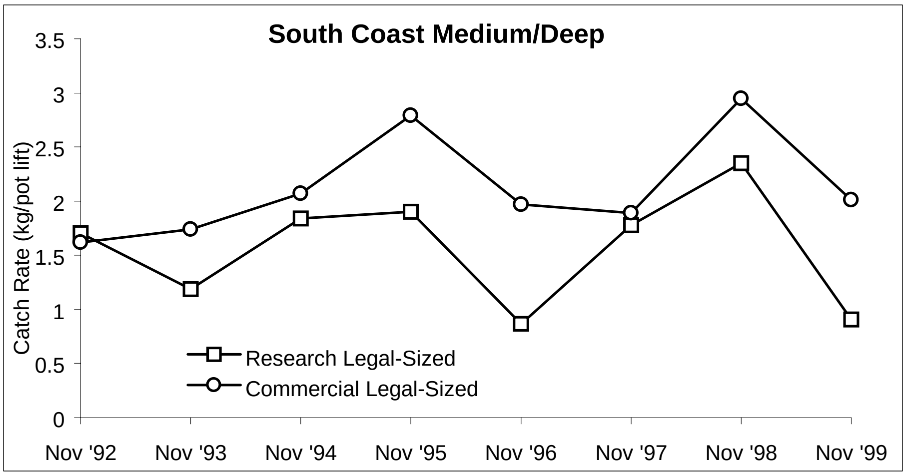

Figure 18. Medium to deep water catch rates for the south coast of legal sized lobsters from research surveys and commercial fishing for the start of the fishing season.

Up until 1998 there are indications of an approximate link between the undersized catch rates and sized catch rates in the following year from research sampling (Figure 19). In 1999 the catch rate of legal sized lobsters shows a substantially different trend to the pre-recruits. A reason for this may be the impact that the extended seasonal opening in September had on the following November's catch rates. The November catch rates are normally the highest for the fishing season as they target recent recruits to the fishery. Moulting normally occurs during September and October, when the season is closed. However, during September 1999 fishers landed a substantial number of newly moulted lobsters. The actual magnitude of recruits landed is unknown although it was sufficient to cause processors to drop the price for 'soft' (recently moulted) lobsters and request the Government to review the decision to open the fishery in forthcoming seasons. The apparent similarity of trends in Figure 19 indicates that the use of undersize index may have value in predicting catch when recruits have not been influenced by previous fishing activity. However, it is clearly influenced by other factors such as interannual variation in growth and behaviour. As noted for the East Coast shallow samples (Section 4.3.1, page 20), incorporation of tagging data may improve the value of this index.

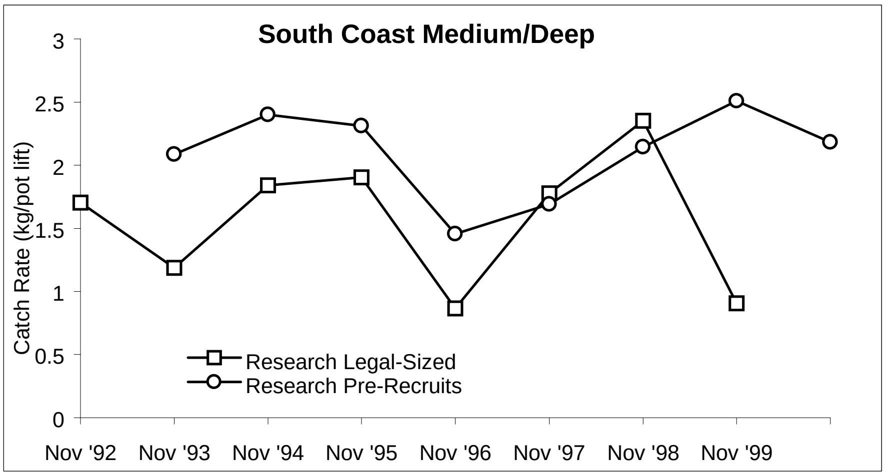

Figure 19. Medium to deep water catch rates from the south coast of legal-sized and pre-recruit lobsters for the 1992 to 1997 survey periods. The pre-recruit lobsters have been advanced by 1 year to simulate growth of undersized lobsters to legal size. Undersize catch rate has been a reasonable predictor of catch rate of legal sized lobsters the following year, apart from in 1999/00. The reason for this deviation is unclear but may have been due to atypical moult timing.

4.4 Other analyses including risk assessments

4.4.1 Biomass

Projections of legal sized biomass in the month of October are presented in Figure 20, Figure 21 and Figure 22 under 3 scenarios - 100 tonne increase, 200 tonne increase and maintaining the current TACC of 1500 tonnes. The most important observation from this assessment is that only the 1500 tonne scenario maintains biomass rebuilding.

The increase in biomass estimates from 1970 to the early 1980s is considered to be an artefact of expansion of effort into new grounds, rather than an actual increase in statewide legal sized biomass.

Biomass levels in the first year prior to quota management (QMS, 1997) are well below the levels of the early 1980's (Figure 20). Maintaining the current 1500 tonne TACC should result in an improvement in legal sized biomass during the current management plan with further improvement during the next management plan.

The projections indicate that an increase in quota to 1600 tonnes will initially lower the biomass before it begins to increase. In 5 years time the biomass is likely to be approximately equivalent to what it is currently.

Like the final years biomass estimates, biomass projections also have been found to have an amount of bias (Gardner, 2000). However, the bias appears to be regional and greatest in southern regions. For this reason projections have also been plotted with Areas 1 and 8 excluded (Figure 21), and for Areas 4 and 5 separately (Figure 22). Projections for the northern Areas 4 and 5 are typically the most accurate for all regions. Note that although rebuilding of biomass in these regions appear probable under a TACC of 1500 tonnes, the range of the 100 simulations undertaken is broad – and thus a decline in biomass is not improbable (Figure 23).

The biomass projections suggests that, on average, biomass rebuilding will be slow with a possible minor decline in biomass over the next two years. The range of each years biomass projection is based on recruitment patterns that have been observed since 1970 and we have been surprised previously by recruitment that was outside that observed previously (Frusher, 1997). Given that egg production during the early 1990's was at a historic low and there has been a decline in puerulus settlement rates since 1995 on the East Coast, there is a risk of lower recruitment during the projected years than we have seen previously. Poor recruitment will result in biomass simulations that fall below the average trajectory.

The change to QMS can be expected to influence fisher behaviour and thus the meaning of effort in terms of estimating biomass. The implications of this impact on current projections are unknown and work is currently in progress (Section 6). Until this study is completed the projections need to be treated cautiously.

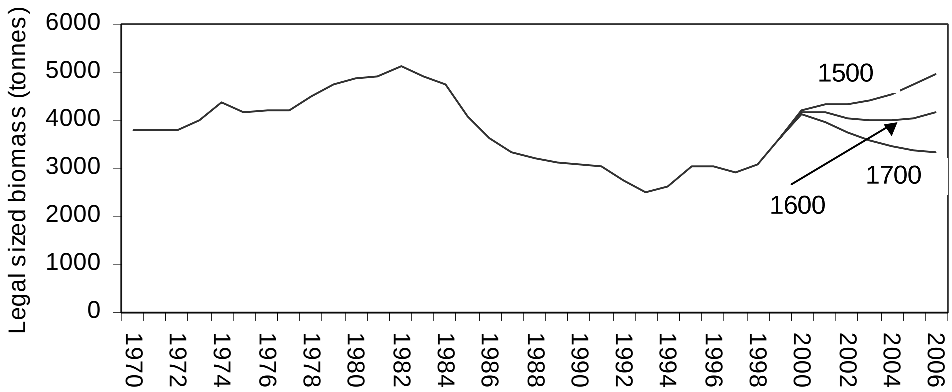

Figure 20. Statewide biomass estimates from November 1970 to November 1999 with averaged trajectories to 2006 of biomass for 1500 (upper line), 1600 (medium line) and 1700 (lower line) tonnes TACC's.

Figure 21. Mean biomass projections for TACs of 1500, 1600, and 1700 tonnes with Areas 1 and 8 excluded. Biomass projections from Areas 1 and 8 are typically most positively biased. Estimates are for the month of October.

Figure 22. Mean biomass projections for TACs of 1500, 1600, and 1700 tonnes for Areas 4 and 5 only. Projections from these Areas are typically the most accurate. Estimates are for the month of October.

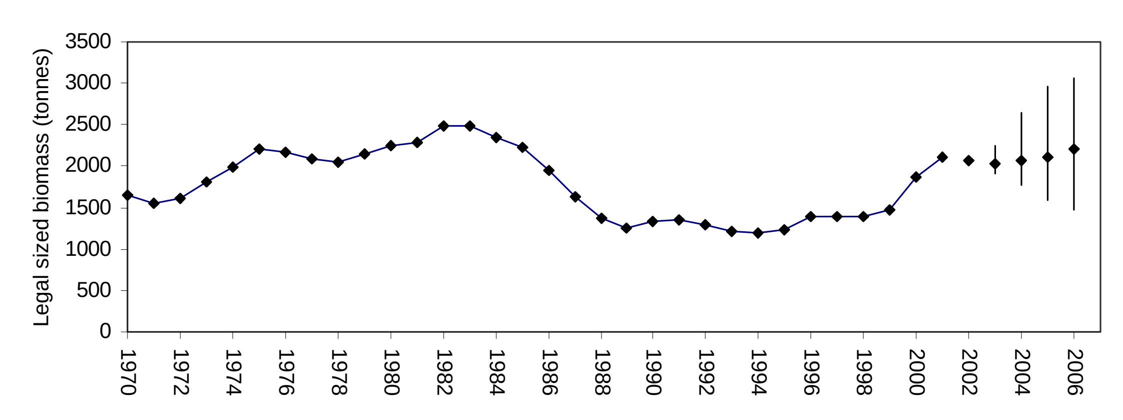

Figure 23. Biomass projection for Areas 4 and 5 with a TACC of 1500 tonnes. Bars indicate the range of outputs from the 100 simulation runs. Note that these ranges indicate that a rebuilding in biomass is not assured under a TACC of 1500 tonnes.

An objective of the current management plan is that ‘biomass levels are increased over time to a level required for producing the maximum yield from the fishery’. To evaluate if biomass trends are meeting this objective, November 1997, the year prior to quota implementation, is the reference point for the term of this Management Plan. Thus a less than 50% probability of decline in biomass by 2000, the last year of the current management plan, would approach the management objective.

The probability of decline in biomass in 2000 to below that of 1997 is estimated to be zero for the 1500 tonne scenario. The problems in applying these projection scenarios listed above also apply to the estimates of probability - clearly biomass could decline below that of 1997 if recruitment was exceptionally low so the zero probability estimate is unrealistic. The main conclusion from these estimates of probability is that given typical recruitment over the next few years, a decline in legal size biomass to that estimated in 1997 is unlikely. This is mainly a function of the increase in the estimate of legal sized biomass after the first two years of QMS.

4.4.2 Egg Production

Projections of statewide egg production indicate that egg production is likely to increase under current management (Figure 24). Total statewide egg production is currently around 30% of virgin (Table 5) which is high relative to most rock lobster fisheries so this increasing trend only strengthens egg production. While statewide egg production is high, it is concentrated in southern Areas with northern Areas at relatively low levels of virgin egg production (Table 5).

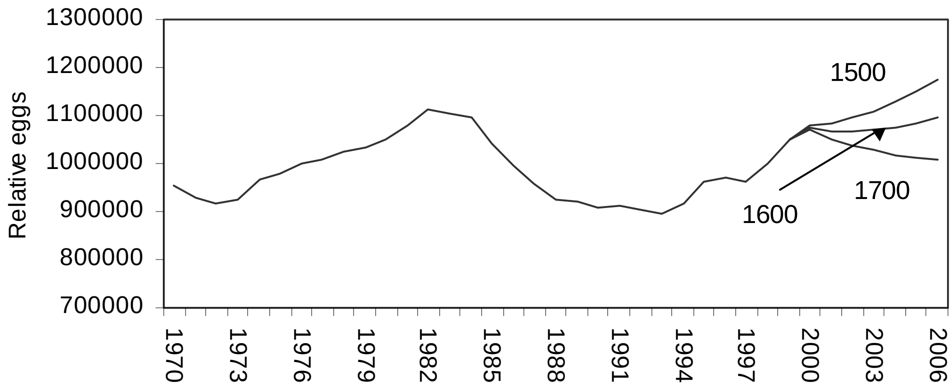

Figure 24. Averaged relative statewide egg production under 3 TACC scenarios: 1500 tonnes (upper); 1600 tonnes (middle); and 1700 tonnes (lower). All trajectories are the average of 100 simulations.

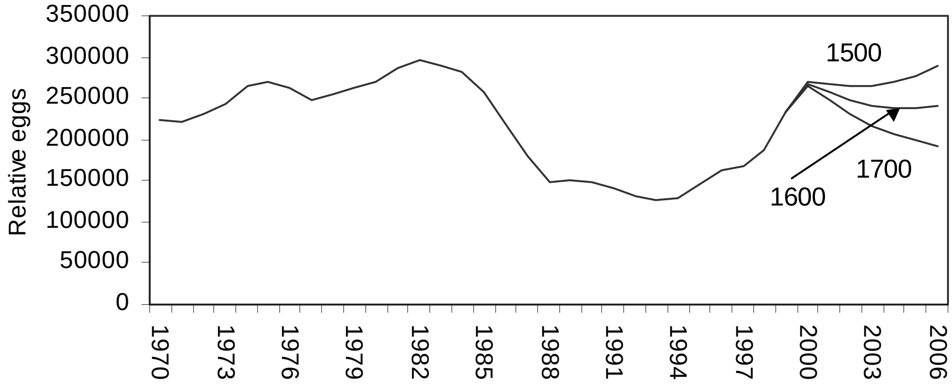

Figure 25. Mean relative egg production in the north of the state (Areas 4 and 5) under TACC scenarios of 1500, 1600 and 1700 tonnes. Means are drawn from 100 simulations.

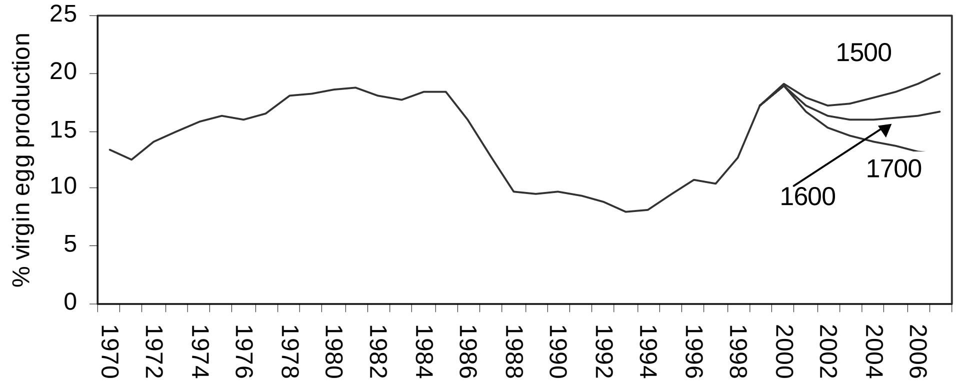

Figure 26. Mean virgin egg production in Area 4 under 3 TACC scenarios.

Figure 27. Mean virgin egg production in Area 5 under 3 TACC scenarios.

The forward projections of legal sized biomass estimates indicate that under the current 1500 tonne TACC there is a high probability that biomass will increase. While QMS is likely to be effective at rebuilding biomass in the north of the state, it appears less effective at rebuilding egg production.

Projections of biomass from Areas 4 and 5 appear to be relatively unaffected by bias (Gardner, 2000) whereas Areas 3 and 6 displayed considerable bias. Consequently, projections presented in this report focus on other regions. The forward projections of egg production indicate that Area 4 will see a decline in egg production over the next few years prior to improving egg production again. (Figure 26). A decline in egg production in this region is also expected from the puerulus index forecasts. Although these are preliminary, they do indicate poorer recruitment to the fishery over the next 5 years. The model projections suggest that egg production will start to improve after three years. This may be due to the fleet dynamics component of the model, which may shift effort away from Area 4 as catch rates in this Area decline due to several years of poor recruitment. However, this is speculative as the fleet dynamics component of the model was constructed prior to implementation of quota using data from 1992 to 1995. The fleet dynamics is expected to change with the change to an ITQ management system and, as stated earlier, caution is required in interpreting these projections.

Area 5 also shows an increase in egg production but the pattern of this increase is different from that of Area 4. In Area 5 there is no expectation of a period of declining egg production over the next few years (Figure 27).

Although egg production in the northern Areas (4 and 5) is expected to increase under a 1500 tonne TACC scenario, the magnitude of these increases is small. To boost egg production to the 25% of virgin production as suggested by Frusher (1997), additional measures to increase egg production need to be implemented in northern regions of Tasmania. It should be noted that improving egg production in the north of the state does not need to be achieved at the expense of the TACC. Work is planned for 2001/2002 to investigate options for increasing egg production in northern regions.

5. Recruitment

Prediction of the magnitude of future recruitment to the fishery is a desirable tool for management and business alike as it reduces risk in decision making. Research on the development of predictive capacity through monitoring of puerulus catch has been underway in Tasmania since 1989 although the original, more conservative, aim was to develop the ability to detect periods of prolonged low or declining puerulus settlement (Kennedy, 1991; Kennedy *et al*., 1994). In addition to this aim of predicting trends in future catch, the data collected through puerulus monitoring was expected to provide insights into the biology of early settlement stages. Impetus for the research came from success in similar work with *Panulirus cygnus* in Western Australia (Phillips, 1986), and progress towards the prediction of recruitment of *Jasus edwardsii* in New Zealand (Booth and Bowring, 1988; Breen and Booth, 1989).

An index of puerulus settlement is obtained by measuring the number of puerulus captured on artificial collectors that mimic natural reef. Detail on the design and layout of Tasmanian puerulus monitoring sites is described in detail elsewhere, although it is important to note that monitoring is conducted in 5 sites around the state (Kennedy *et al.*, 1994; Gardner *et al*., 1998). Puerulus captured are generally those of the southern rock lobster *Jasus edwardsii* although individuals of the eastern rock lobster *Jasus verreauxi* are also collected occasionally.

Within the last 12 months it has been shown that indices of puerulus settlement from eastern Tasmania indicates future recruitment to the fishery. Correlation between puerulus index and commercial catch rates, model estimates of recruitment, and change in size structure of research sampling have demonstrated this relationship (Gardner *et al.*, in press).

Figure 28 shows the remarkably close correlation between puerulus index from Bicheno and commercial catch rates from the surrounding region. An interesting aspect is the high catch rates for the 1999/00 year, which was predicted by the puerulus index 5 years ago.

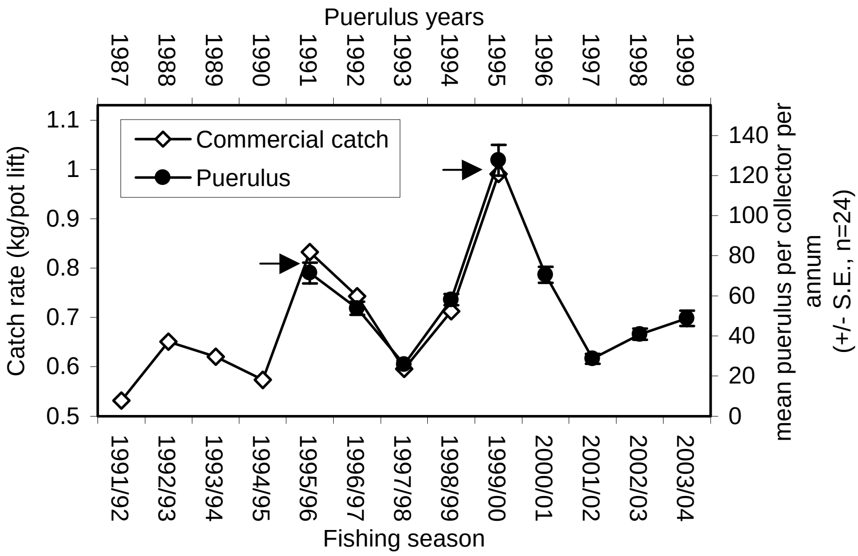

Figure 28. Correlation between interannual change in commercial catch rates for eastern Tasmania (regions 2 and 3) and puerulus index from Bicheno. Puerulus index has been shifted forwards 5 years to simulate growth from settlement to legal size. Arrows indicate the extent of the current overlap which is 5 years ($r=0.974$; $P<0.01$).

The puerulus index from Bicheno predicts reduced recruitment to the East Coast region for the next few years. The extent to which catch rates actually fall may be an interesting test of quota management for this region. Under quota management we would expect that catch rates would become more stable as the fishery becomes less reliant on annual recruits. However, this increased stability may not be observed on the East Coast due to relatively high exploitation rates. These high exploitation rates are a result of more sheltered conditions and also higher recreational catches.

Patterns in puerulus index from other regions of the coast are shown in Figure 29. Currently, a relationship between puerulus index and recruitment to the fishery has only been demonstrated for the Bicheno region, although King Island puerulus data also appears to correlate with catch rates. We remain cautious with the interpretation of data from King Island due to missing data from some years. An important test of the King Island data set will be in 2003 when a recruitment spike is predicted.

Insufficient data has been collected from the remaining sites to test correlation with catch-rates (ie at Recherche Bay, South Arm and Flinders Island). This is because growth from puerulus to recruitment is slower in southern regions of the state, and because the Flinders Island site was only established a few years ago.

Recent collaborative research between CSIRO and TAFI has indicated that puerulus settlement in the southern regions of the state is likely to be relatively consistent from year to year, while occasional spikes in settlement are expected in the north, particularly at Flinders Island (Bruce *et al*., 2000). This may account for the sharp increase in catch-rates from Flinders Island over the last 2 years. We expect collection of settlement data from Flinders Island to be particularly valuable for management in the future.

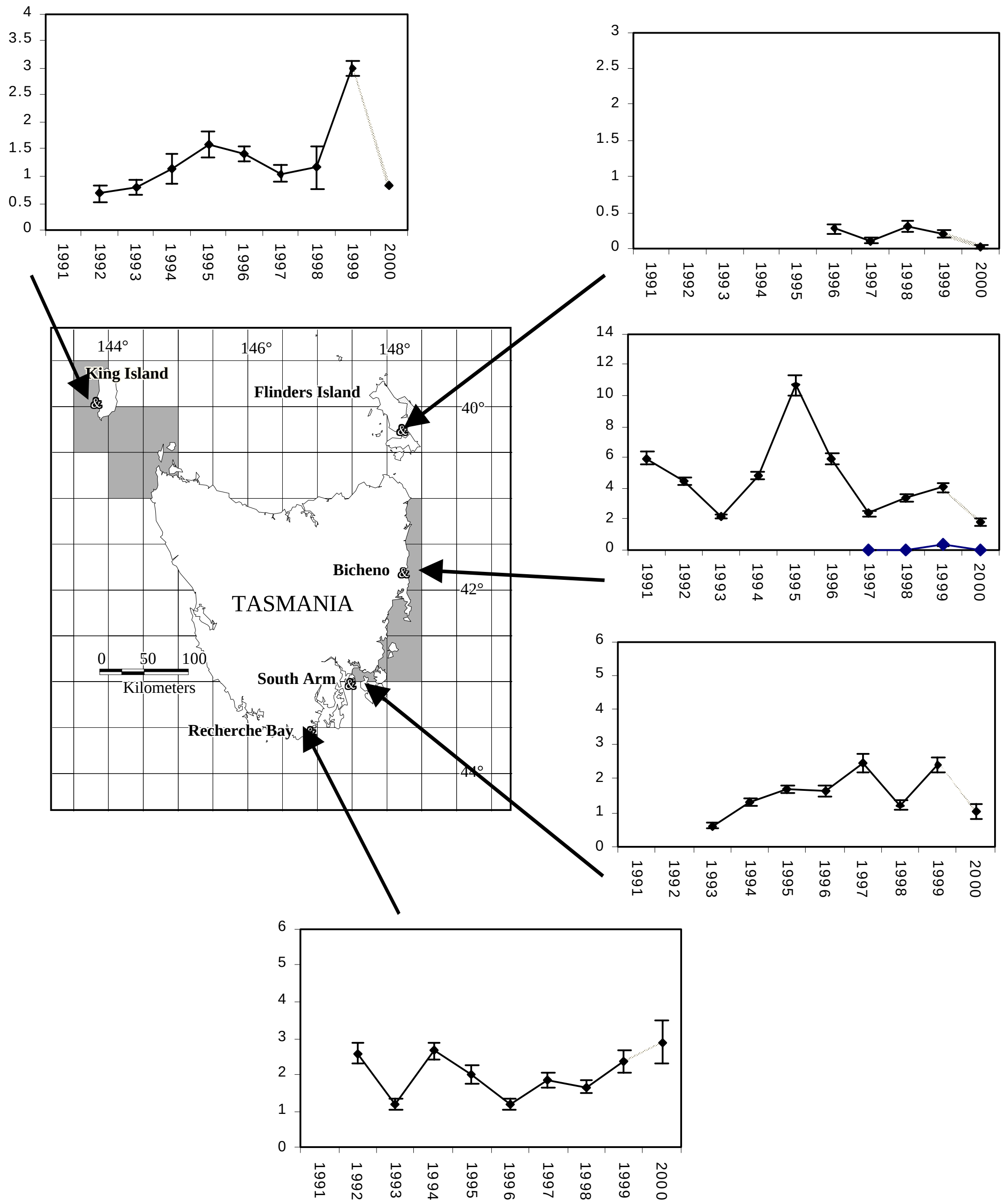

Figure 29. Interannual trends in puerulus index from monitoring sites around Tasmania. Scale on y-axis in all plots is the mean number of puerulus per collector per month (+/- S.E.). Quarter degree reporting blocks shaded in grey are those for which puerulus index is currently providing indication of future recruitment to the fishery. Data for 2000 is incomplete. Two lines are shown are on the plot for the Bicheno region; these relate to *Jasus edwardsii* (higher catch rates) and *J. verreauxi* (lower catch rates).

6. Changes in the Fleet Dynamics in Response to ITQ.

At the beginning of 2000, the Tasmanian Aquaculture and Fisheries Institute (TAFI) commenced a project funded by FRDC to investigate the impact of management change to an ITQ system in the Tasmanian rock lobster fishery. A component of this project is to develop a "fleet dynamics" model, which is intended to be incorporated into the assessment model to improve future projections and to monitor the impact quota has had on the fishery.

The current assessment model predicts effort distribution in the future based on the distribution of effort in the past using data from 1990-1995 . Although it provides an approximation of probable patterns in effort, it is based on only a few factors primarily catch rate and month (which is a proxy for price and weather). Most importantly, as it was created prior to the introduction of quota, we can no longer expect it to closely model fishers' behaviour now and in the future.

The "dynamical" model under construction will predict fishers' behaviour based on variables such as price and weather. One step in achieving such a goal is to understand the influence various factors have on fishers' behaviour in the past. Summarised within this section are some of the observations that have been made during this investigation with particular emphasis on changes found since the introduction of quota.

One of the main changes since quota has been the decrease in the number of license holders and vessels partaking in the fishery. The decrease in license holders began to take effect a number of years prior to quota but it is suspected that this decrease was a reaction to the proposed quota laws. A large proportion of the smaller vessels (under 10 metres) and of the larger vessels (over 20 metres) have left the fishery. However, as these vessels represent a small portion of the overall fleet the distribution of the sizes of vessels has not greatly changed.

There have been many speculations about how quota has and will affect the fishery (Bradshaw et. al. 2000). The preliminary study of catch and effort data presented in this section provides little evidence to support most of these claims. For instance, it has been suggested that since quota, fishers have less need to race to catch their quota. They now choose to fish in more convenient locations and in shallow inshore regions. However, from the raw data currently available, there is little evidence of increased fishing in shallower water, nor of a change in the average number of Areas a vessel fishes during the year. Furthermore, as their yearly catch is limited, it is expect that fishers will now fish harder in the winter months when the price of lobster is at a premium. Although there has been an increase in the amount of fishing that occurs in winter months, these changes are continuations of a trend that has occurred over the last decade. The only definite change that can be associated with the last two years, is a decrease in both the effort and the proportion of vessels fishing in the months of November and February.

This lack of supporting evidence does not mean that these changes will not occur in the future or are not already occurring. As catch and effort data is highly variable and influenced by many factors it is difficult to isolate changes that have occurred in the last two years and attribute them to quota alone.

6.1 Composition of the Fleet

6.1.1 Number of vessels

Since quota was introduced in 1998, there has been a decrease in the total number of vessels involved in the rock lobster fishery, that is, vessels that submitted a positive catch return (Figure 30). In the last two seasons there has been an 11% decrease per year. Before 1992 and the lead up to quota, the fleet was increasing at a steady rate of about 1% each year.

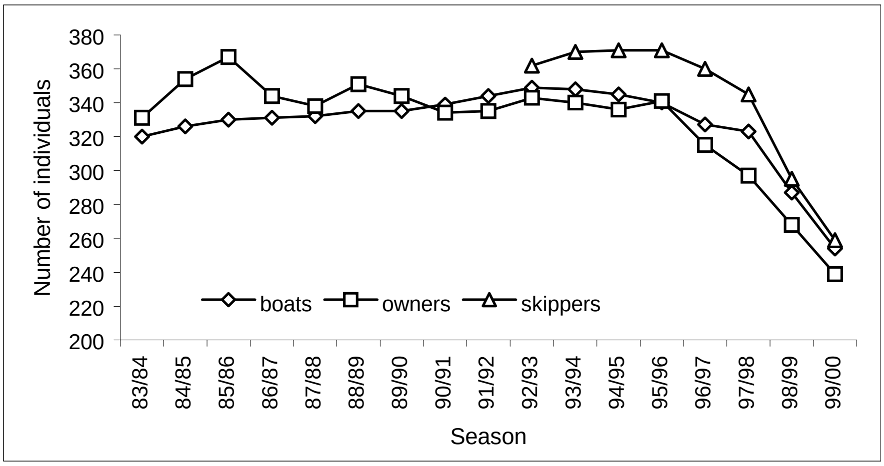

Figure 30. Numbers of Vessels, Skippers and Owners Fishing. Seasons are from Mar-Feb to make all seasons directly comparable with 98/99 and 99/00. There is no accurate data for the number of skippers before 1992. Only owners and vessels that caught lobster during the season were counted. Owners with different trading names are counted as different owners.

6.1.2 Total number of skippers employed

It is not surprising that the number of skippers employed in the fishery followed a similar trend to the number of vessels. Note that the number of skippers is always larger than the number of vessels. This occurs as the skipper on a vessel may change during the year.

6.1.3 Total number of entitlement owners

In contrast to the trends for the number of vessels, the number of entitlement holders in the fishery began to decrease in 1996. In the two seasons preceding quota there was a decrease of 8% and 6% respectively. The first two seasons of quota saw further decreases of 10% and 11%. It has been suggested that this was a reaction to the proposed quota laws. Speculating that quota may be equally divided among license holders, the larger fishers brought licenses from operators planning to leave the fishery and then leased them to vessel owners with no license. Once quota was introduced and divided they could then concentrate their holding on one vessel, continuing to fish the same quantity as they had prior to quota (Bradshaw et. al. 2000). Certainly this proposal would fit the apparent trends, however a more detailed analysis should be performed to be confident of these conclusions. For instance, the raw data used in Figure 30 overestimates the number of owners as some trade under different names. Therefore the changes apparent may in part be due to owners who have reshuffled their licenses amongst their trading names. To obtain a true measure of the number of owners who have left the fishery we must perform a detailed analysis of the ownership of each license to remove this uncertainty.

6.1.4 Number of owner operators

As a preliminary investigation into the number of vessels that were operated by the owner of the license, we have checked the names of the skipper against the owner of the entitlement. Again, for accurate figures a detailed analysis into the relationships of owners with differing names is required. As we do not have accurate details for skippers before 1992 we can only look at the last 8 years.

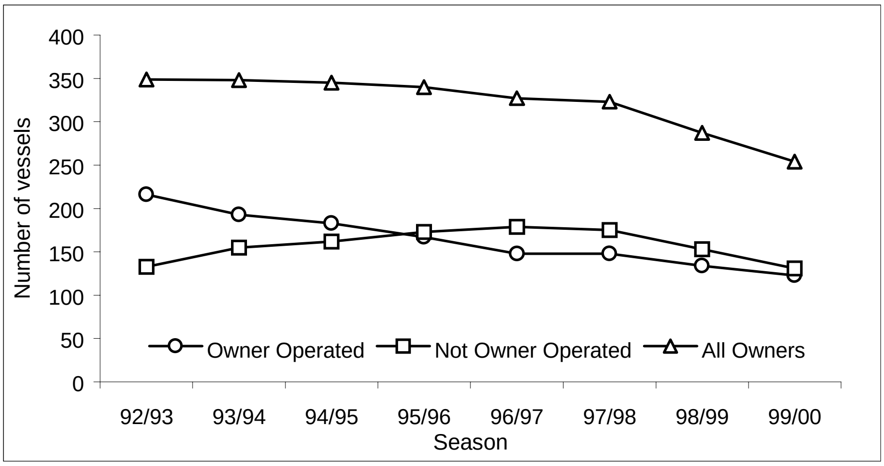

Figure 31. Number of vessels that were owner-operated 1992-2000.

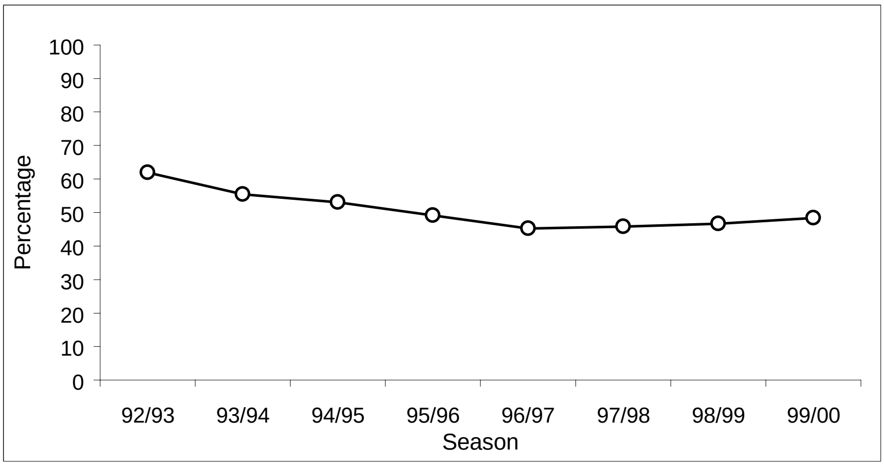

Figure 32. Percentage of vessels that were owner-operated 1992-2000.

Figure 31 and Figure 32 show that the number of vessels that were operated by their owner dropped from 1992 to 1995. In the two years since introduction of quota, however, the percentage that was owner operated increased. These trends seem to support the proposal above that several operators brought licenses from those leaving the fishery in the years prior to quota and then consolidated their holdings onto one vessel.

6.1.5 Length of vessel

Figure 33 shows the distribution of the lengths of the vessels in the fleet between 96 and 98 and between 98 and 00. As we can see there does not appear to be a great change in the overall distribution of the sizes of vessels in the fleet. However, Figure 34 displays the percentage of each size class that left the fishery. This demonstrates more clearly that 40% of the 8 metre vessels left the fishery, 36 % of 10 metre vessels, and 30% of 22 metre vessels. These do not greatly affect the overall distribution as the contribution of 8, 10 and 22 metre vessels to the fishery is low.

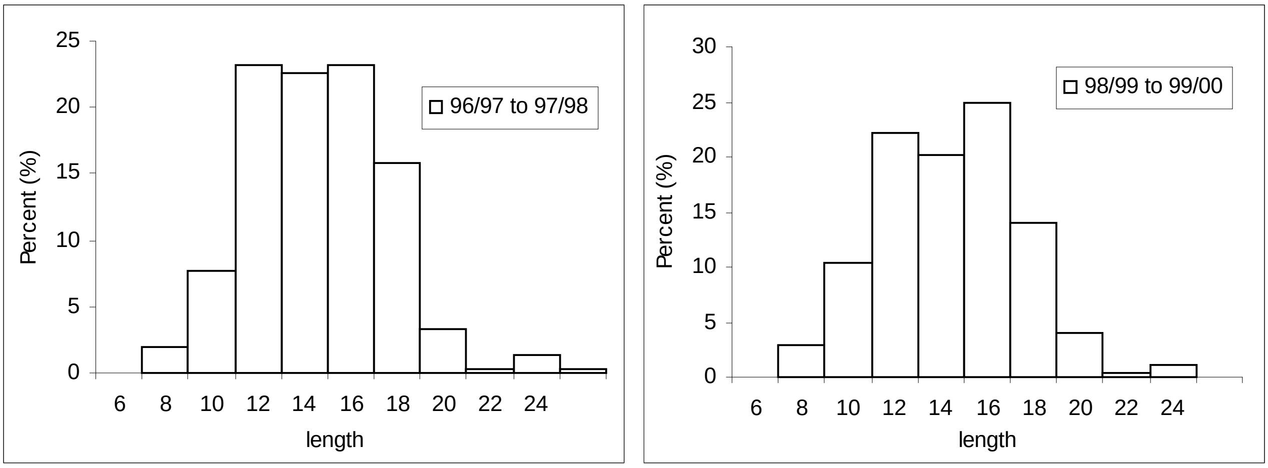

Figure 33. The distribution of the sizes of vessels that fished from March 1996-February 1998 and from March 1998-February 2000.

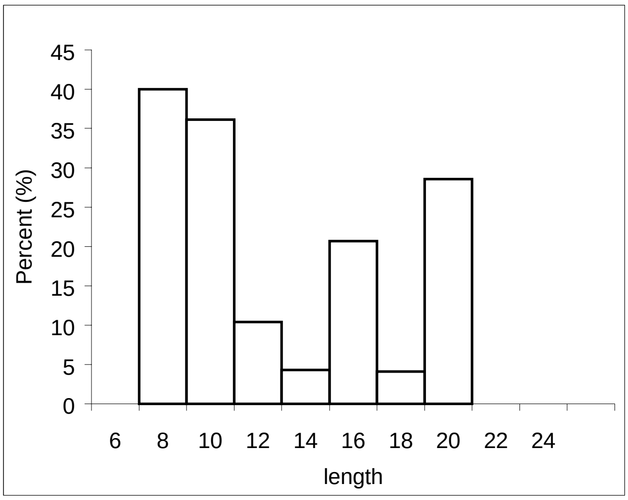

Figure 34. The percentage of each vessel size class that left the fishery between 1996 and 2000.

6.1.6 Mobility

"Mobility" describes how responsive the fleet is to changes in spatial composition of the stock and other spatial factors. Not only are we interested in the degree of mobility of the fleet but whether this mobility has changed over time. It has been suggested that an effect of quota is that fishers are now less mobile (Bradshaw et. at. 2000). As the fishery has become less competitive they have less need to travel large distances for their catch and choose to fish in more convenient locations.

A preliminary exploration of "mobility" is achieved by looking at the number of different regions a vessel fishes in over the year and how this has varied over time. The Tasmanian fishing region is broken up into 8 Areas, which have been chosen for their relevance to the stock and fishing regions. Each of these Areas is subdivided into half-degree blocks and fishers report their catches in terms of these blocks. For this preliminary analysis we have chosen to look at the movement of fishers amongst these 8 Areas as they demonstrate how willing the fleet is to move to different regions to follow higher catch rates or more favourable weather conditions. To perform a meaningful investigation at block level we would also need to incorporate distances travelled by vessels to obtain a realistic measure of the variation.

Figure 35 shows the expected number of Areas a vessel fishes in within a year. “Quota year” is from 1 Mar until 28 Feb to allow direct comparison in the time series before the introduction of the quota system with that after the introduction of quota.

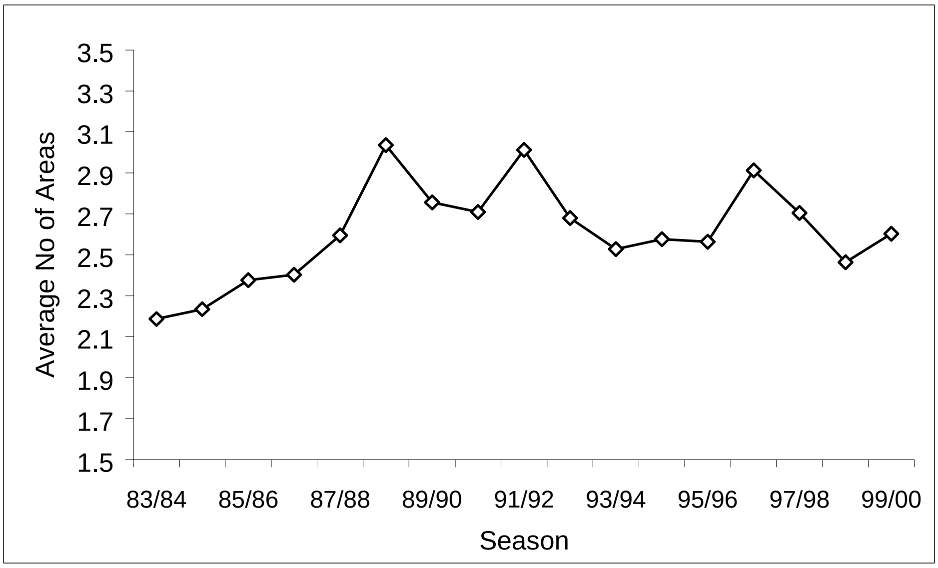

Figure 35. The average number of Areas fished by a vessel during a year.

On average a vessel will fish in between 2 and 3 of the 8 Areas during a year. This pattern has varied with time. From the 1983/84 season to the 1987/88 season there was a steady increase in the expected number of Areas fished. Since then it has stabilised at around 2.6 Areas with the exception of three peaks in the seasons 1988/89, 1991/92 and 1996/97, and a trough in 1998/99. Determining the factors that influence these peaks would be useful in understanding the nature of the fleet. Unusual catch rates in particular Areas or unusual weather patterns are two of the possible causes.

It is not possible to draw conclusions regarding whether the introduction of quota has affected mobility from this graph. Although there is a trough in 1998/99, there is no reason to infer that this was in response to quota. The last two years of the time series provides little evidence to identify a change in trend.

Figure 36 looks at mobility in slightly greater detail. Throughout the years we see that the majority of vessels have fished 3 Areas or less. Between the 1983/84 and the 1988/89 season there was a decline in these numbers as many vessels began fishing in more that 3 Areas each year. However, since then the proportions have remained roughly stable other than the peaks and troughs highlighted in Figure 36.

Although these graphs highlights the trends and identify exceptional years they give no clue to the cause. Whether the peaks are related to the CPUE in a given Area, the weather patterns or some other factor is to be explored. Collecting representative weather data is a major task that is yet to be achieved. Similarly a quick analysis against CPUE is not feasible as CPUE in different Areas and time must be standardised for a number of confounding factors. The fleet dynamics model, which is being developed, will be useful for this objective.

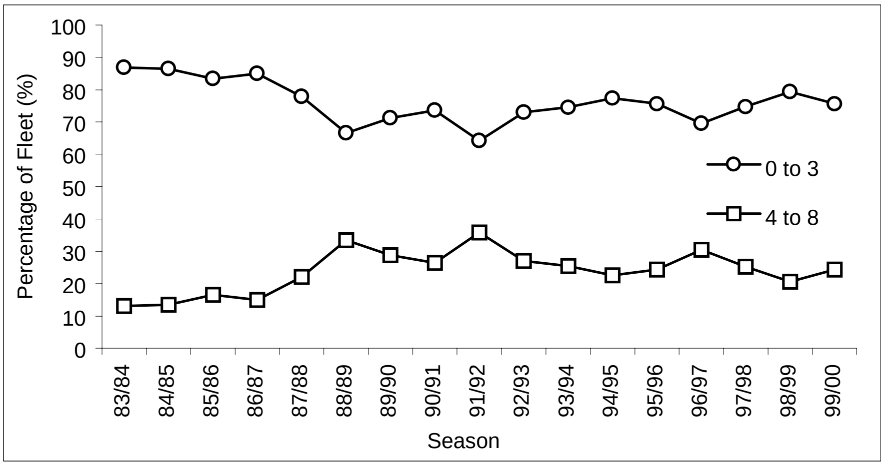

Figure 36. Percentage of vessels fishing in 0 to 3 Areas, or in 4 to 8 Areas during the quota year.

6.2 Analysis of the fishers who left the fishery with the introduction of QMS

In section 6.1 it was shown that the number of licenses (both active and total) declined with the introduction of QMS. This section looks at this change in more detail to see if those who left the industry (termed "leavers" thoughout this section) tended to have any common charactersitics.

Figure 37 shows the average number of pot lifts per month in 1996/97 and 1997/98 for the vessels that left the fishery in either 1998/99 or 1999/00 (the leavers) and compared it with the average for those vessels that remained. In both years a decrease occurred in the average for most months suggesting that the leavers tended to apply less effort. The end of this time series should be viewed with caution for many of the fishers planning to leave the fishery would have already left, so the averages are based on progressively fewer vessels. As we see in Figure 38, by November 1997 many of these vessels had already left the fishery and the "leavers" contributed a smaller proportion of the total effort.

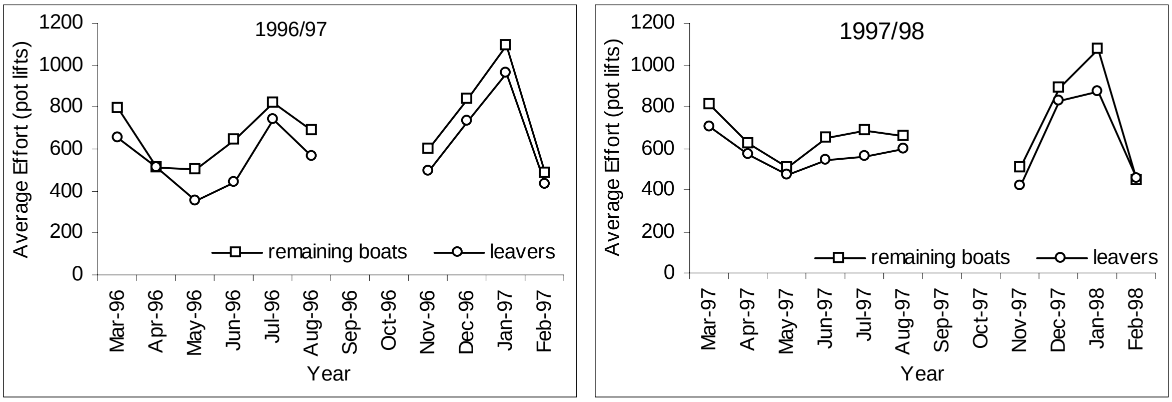

Figure 37. Average pot lifts per month in 96/97 and 97/98 for the boats that left the fishery in 98/99 or 99/00 and for those that did not leave.

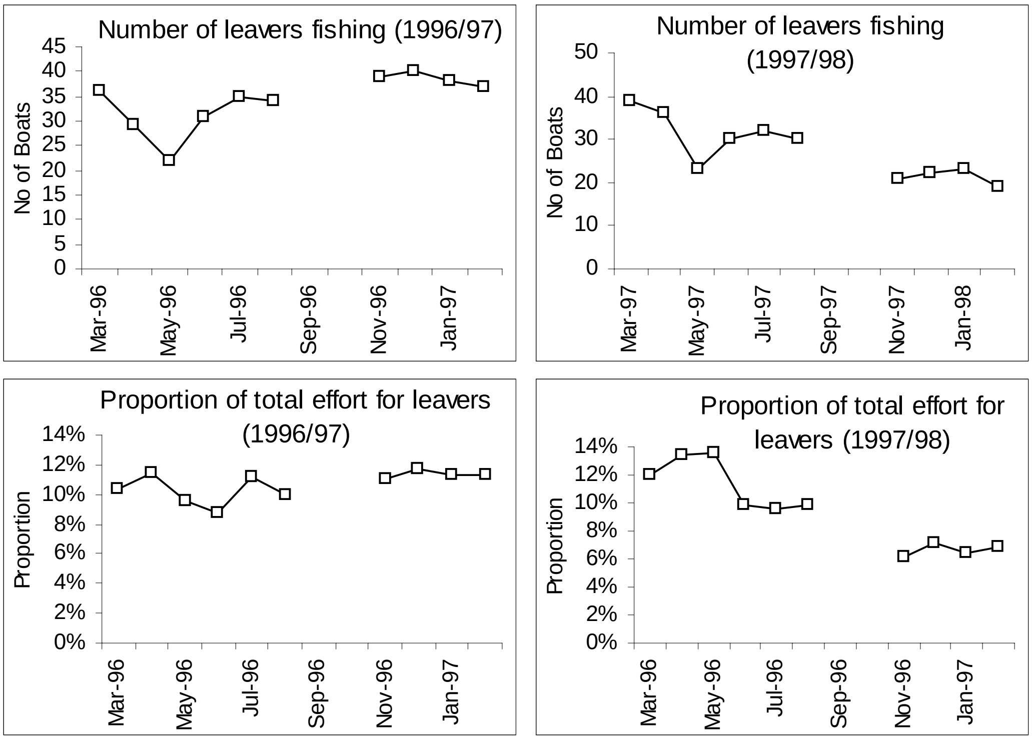

Figure 38. The number of "leavers" fishing and the proportion of their effort.

To test if the vessels that left had favoured particular fishing Areas, we compared the proportion of a vessel’s yearly effort applied to different Areas. The leavers seem to have applied a greater portion of their effort in Areas 2 and 6 but less in Area 3.

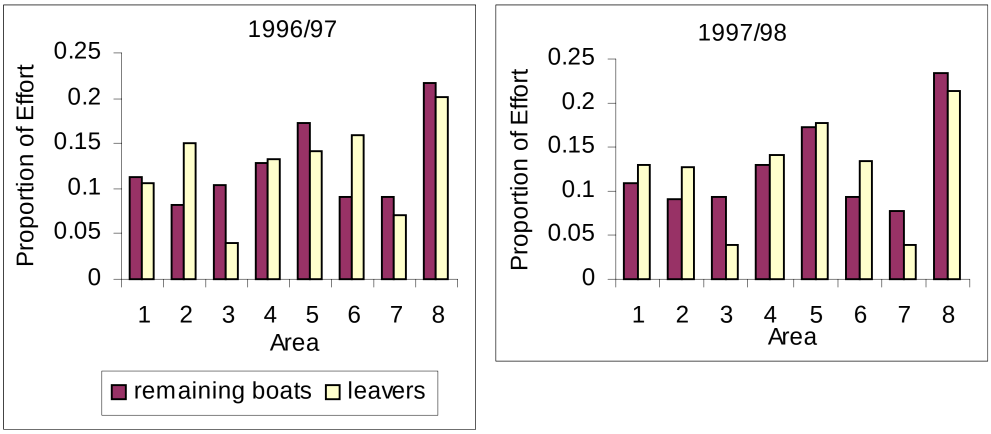

Figure 39. Average proportion of yearly effort in each Area amongst all boats and those that left the fishery in either 98/99 or 99/00

Should the vessels leaving the fishery represent less efficient operators we would expect their average CPUE to be less than those that remained. As we see in Figure 40 these vessels tended to have a lower CPUE in the high catching summer months. This has an important implication to the management of the fishery as the remaining vessels should have higher average CPUE in the following years which will lead to an increase in CPUE that is not connected to an increase in stock abundance. This demonstrates the effect a change in composition of the fleet has on CPUE and highlights the need to standardise catch rates so we can increase confidence in using them as a measure of abundance.

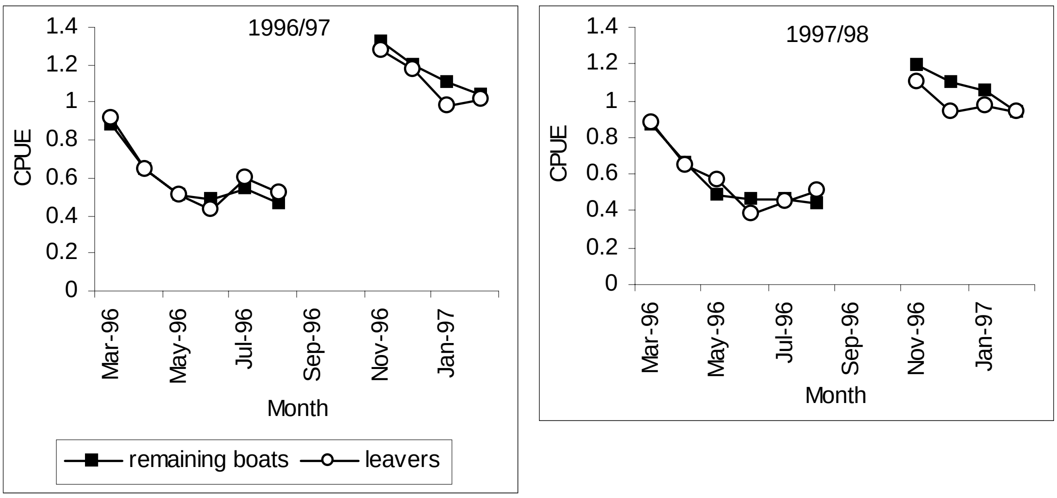

Figure 40. Average CPUE (kg/potlift) for "leavers" in comparison with those boats that remained in the fishery.

6.3 Distribution of Catch and Effort

6.3.1 Yearly trends

Figure 41 and Figure 42 show the effort and catch of the fleet over time. Before 1998, a fishing season was taken to be from November to October. In 1998, the fishing season was changed to begin in March and end in February. Figure 41 shows trends in catch and effort for a November-October fishing year, while Figure 42 shows trends for a March-February fishing year. From a long-term historical perspective, Figure 41 is useful, whereas to compare previous fishing years with the first two years of quota, Figure 42 becomes useful.

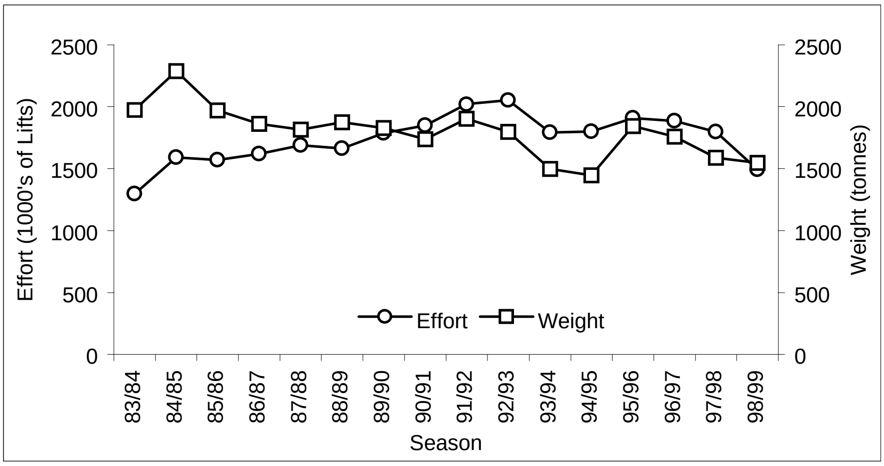

Figure 41. Catch and effort (Season = November-October)

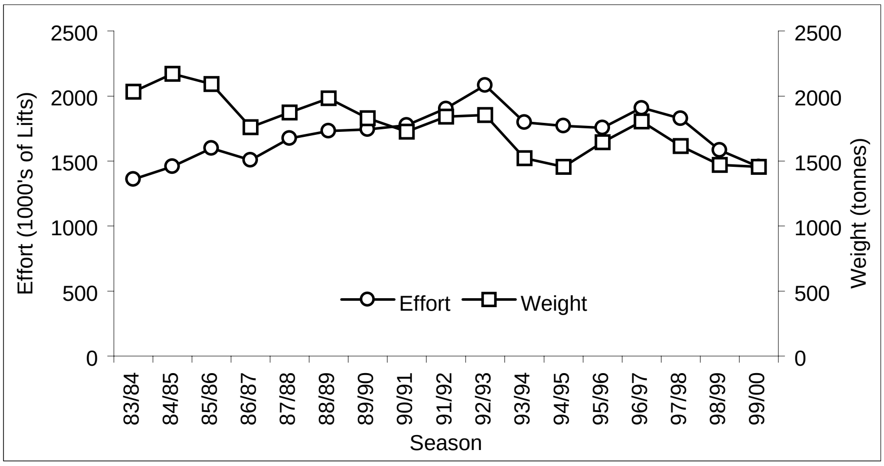

Figure 42. Catch and effort (Season = March-February)

Figure 41 shows that from the 1983/84 season until the 1992/93 season the total effort of the rock lobster fleet steadily increased from 1.2 million to around 2 million pot lifts per year. In 1993/94, season closures along with a period of poor weather caused a large decrease in the effort expended. There was a slight increase in 1995/96. In 1996/97 further season restrictions were implemented and the increase in effort seemed to be contained.

Figure 42 compares the first two years of quota with previous years, which shows that there has been a clear decrease in effort since quota was introduced. Effort is now reduced to around 1984/85 levels.

In contrast, the total catch decreased during the effort increases of the eighties and early nineties, which has been attributed to decreasing stock numbers. The season restrictions introduced in 1993/94 saw a corresponding decrease in the total catch, however in the 1995/96 season there was a large increase in catch, which has been linked to favourable recruitment (Frusher, 1997). Catches declined after the recruitment pulse despite continued seasonal closures. In 1998/99 and 1999/00 a TACC of 1500 tonnes was introduced.

6.3.2 Seasonal changes in catch and effort

In the last 10 years there has been a steady increase in the proportion of the yearly effort expended in the winter months of May to August and a decrease in the proportion expended in the summer months of November-February (Figure 43). There appears to be two reasons for these changes. Seasonal closures introduced during the summer months of the 1990s forced fishers to fish less in summer. At the same time the winter price of lobster increased making fishing in the low catch rate seasons more profitable. In the two years of quota there has been a continuation of this trend.

Figure 44 compares the total effort of the fleet (in terms of pot lifts) expended in summer and winter to the total effort per number of "available open days", as recorded in Table 9. Until 1992, the effort per open day in the summer months increased at a rate comparable to the increase in the total yearly effort. However once season closures where implemented the effort per open day continued to increase even though the yearly effort increases were contained. Since quota, season restrictions have been removed but there was clearly a large decrease in effort per open day in the first year of quota. Whether this is because fishers are choosing to fish less in the summer months or because those fishers who have left the fishery fish where traditionally "summer fishers" is yet to be explored. The answer to this question should become apparent once further investigation is undertaken. During the 1980's there was an increase in effort per open day during the winter months. The peak in 1989 and 1990 is due to the closure of May and June, the months when traditionally less effort is exerted. During the 1990's the effort per open day in winter increased more rapidly. In fact, between 1992 and 1996 it was increasing 9% faster than the summer rate of increase. In the last 4 years the effort/day has been decreasing in winter but this decrease is in line with the decreases in total effort.

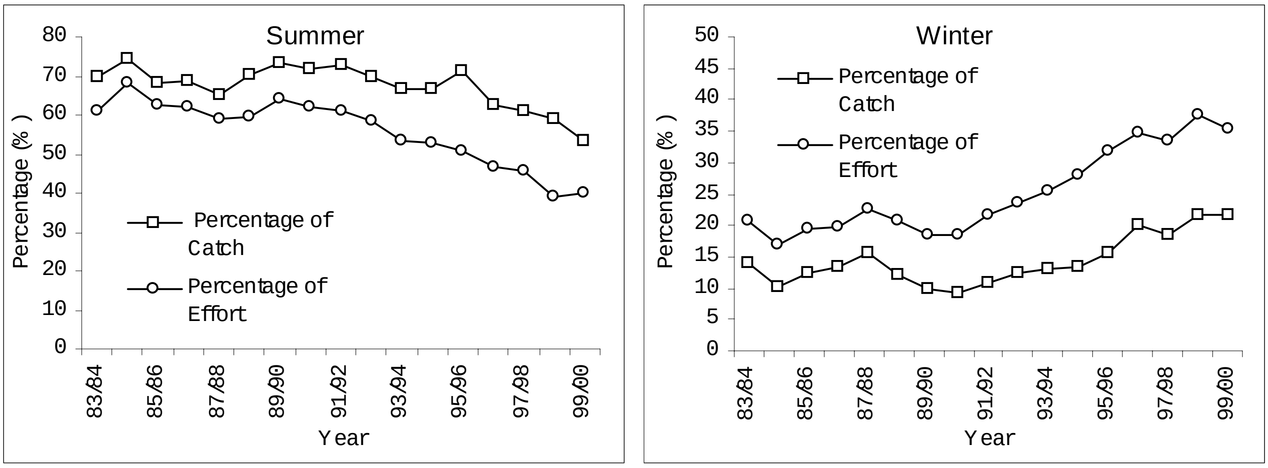

Figure 43. Summer and winter effort and catch

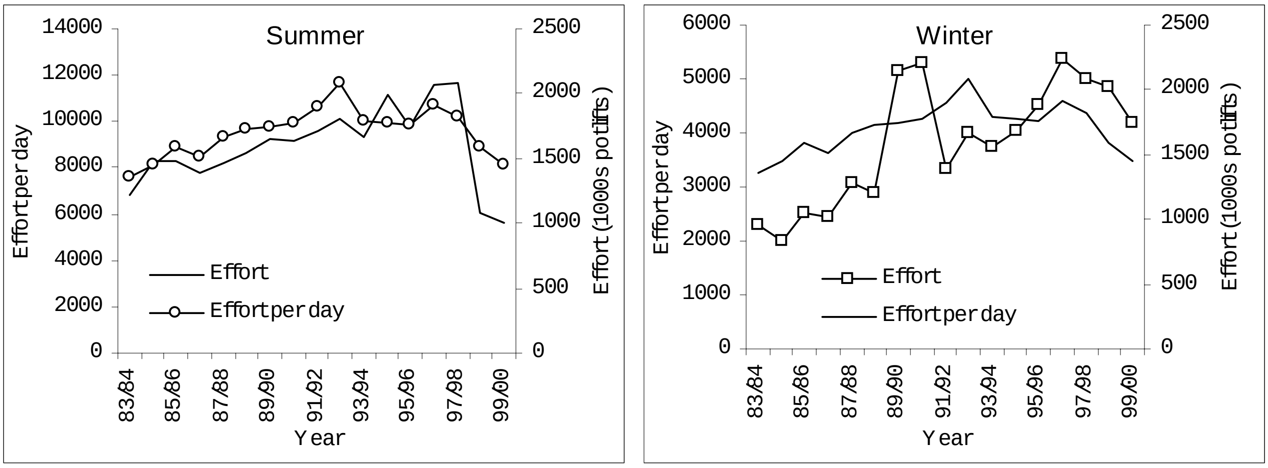

Figure 44. Summer and winter daily effort.

Table 9. Allowable Fishing Days

	Month											
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	31	28	31	30	31	30	31	31	30	0	30	31
1984	31	29	31	30	31	30	31	31	30	0	30	31
1985	31	28	31	30	31	30	31	31	30	0	30	31
1986	31	28	31	30	31	30	31	31	30	0	30	31
1987	31	28	31	30	31	30	31	31	30	0	30	31
1988	31	29	31	30	31	30	31	31	30	0	30	31
1989	31	28	31	30	0	0	31	31	0	0	30	31
1990	31	28	31	30	0	0	31	31	0	0	30	31
1991	31	28	31	30	31	30	31	31	0	0	30	31
1992	31	29	31	30	31	30	31	31	0	0	30	31
1993	31	28	31	30	31	30	31	31	0	0	13	31
1994	31	28	31	30	31	30	31	31	0	0	13	22
1995	21	28	31	30	31	30	31	31	0	0	0	31
1996	31	29	31	30	31	30	31	31	0	0	13	21
1997	29	14	31	30	31	30	31	31	0	0	9	21
1998	28	13	31	30	31	30	31	31	15	0	17	31
1999	31	23	31	30	31	30	31	31	15	0	18	31
2000	31	23										

Figure 45 and Figure 46 highlight the effect quota has had on the distribution of effort and the distribution of the catch amongst the months over the past 17 years. The proportion of the yearly effort exerted in the winter months has increased from 21% to 35% while the proportion of the catch caught in winter has increased from 14% to 22%.

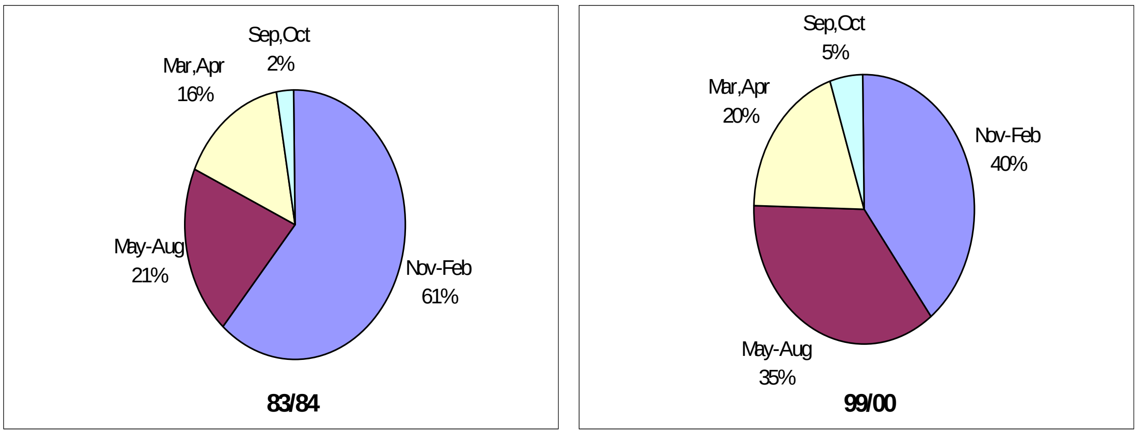

Figure 45. Distribution of Effort

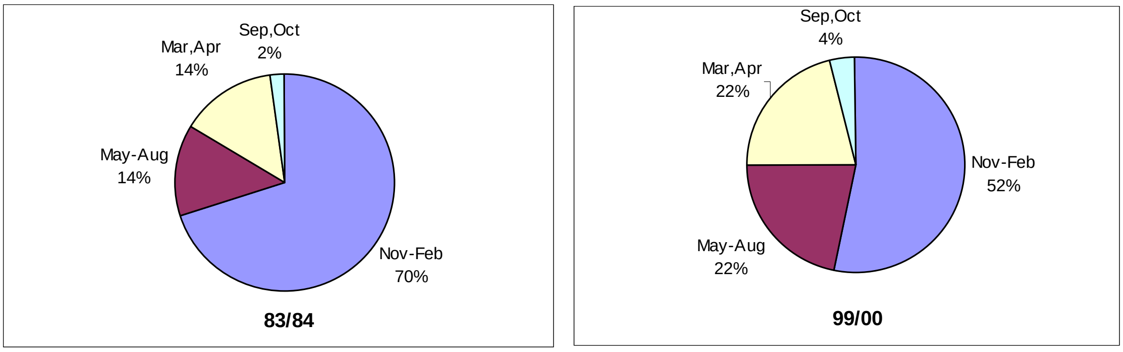

Figure 46. Distribution of Weight

The increasing trend for winter fishing is also apparent on a month by month analysis (see Figure 47). The only noticeable difference since the introduction of quota is an increase in fishing effort in Aug.

The decreasing trend in the summer months is not as apparent in the graphs of Figure 48 as effort between these months seemed to be linked and is probably connected to the length of the legal open season. In 1993/94, season closures in November were introduced for the first time and we see a corresponding decrease in the proportion of effort expended in November, which has continued through to present times. In the 1996/97 season there was a large decrease in effort expended in February. This corresponds to a shortening of the season with February closed for 14 days in 1996/97 and 15 days in 1997/98. This decrease in effort also continued through the first two years of QMS, which would be expected, as fishers would have taken their quota by this month. In January there was a sharp increase in effort in 1995/96 which continued through to 1997/98. This increase is possibly linked to the closure of November in 1995/96 and the shortening of the February season in the following two years. Since quota was introduced however there has been a decrease in the proportion of effort expended in January. Finally there has been a slight decrease in the proportion of effort in December over the past 4 years.

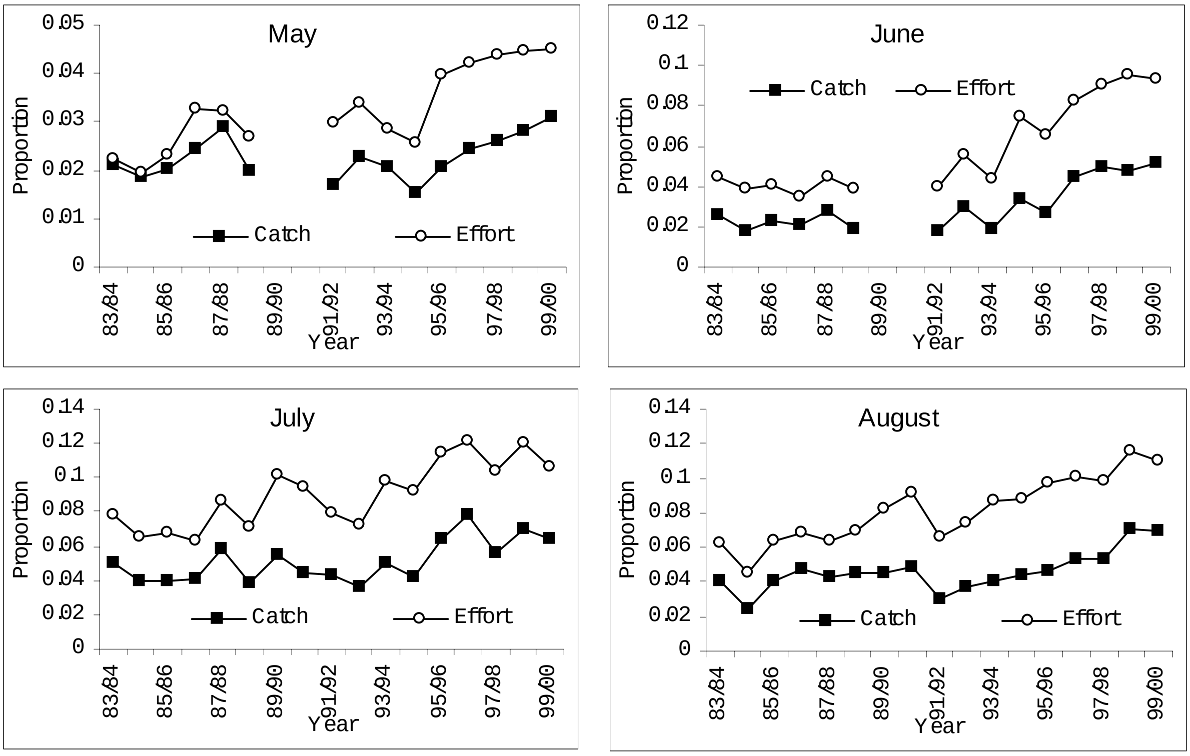

Figure 47. Distributions of catch and effort over individual months: winter distributions.

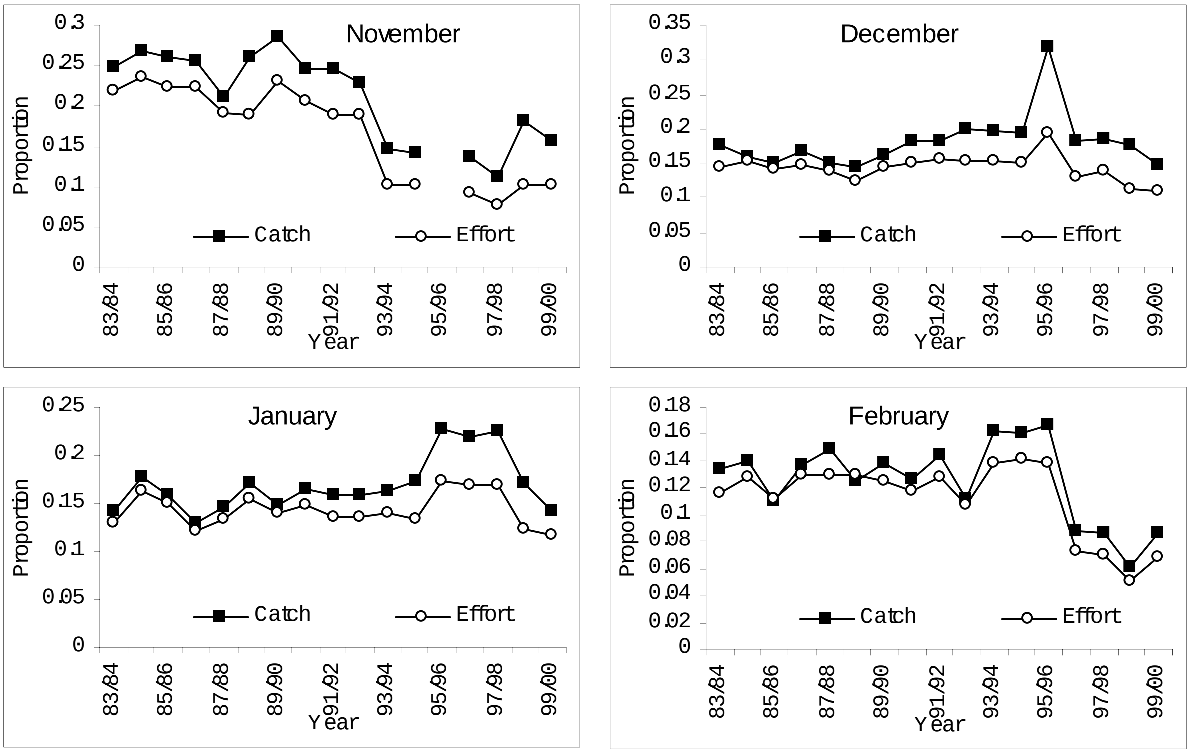

Figure 48. Distributions of catch and effort over individual months: summer distributions.

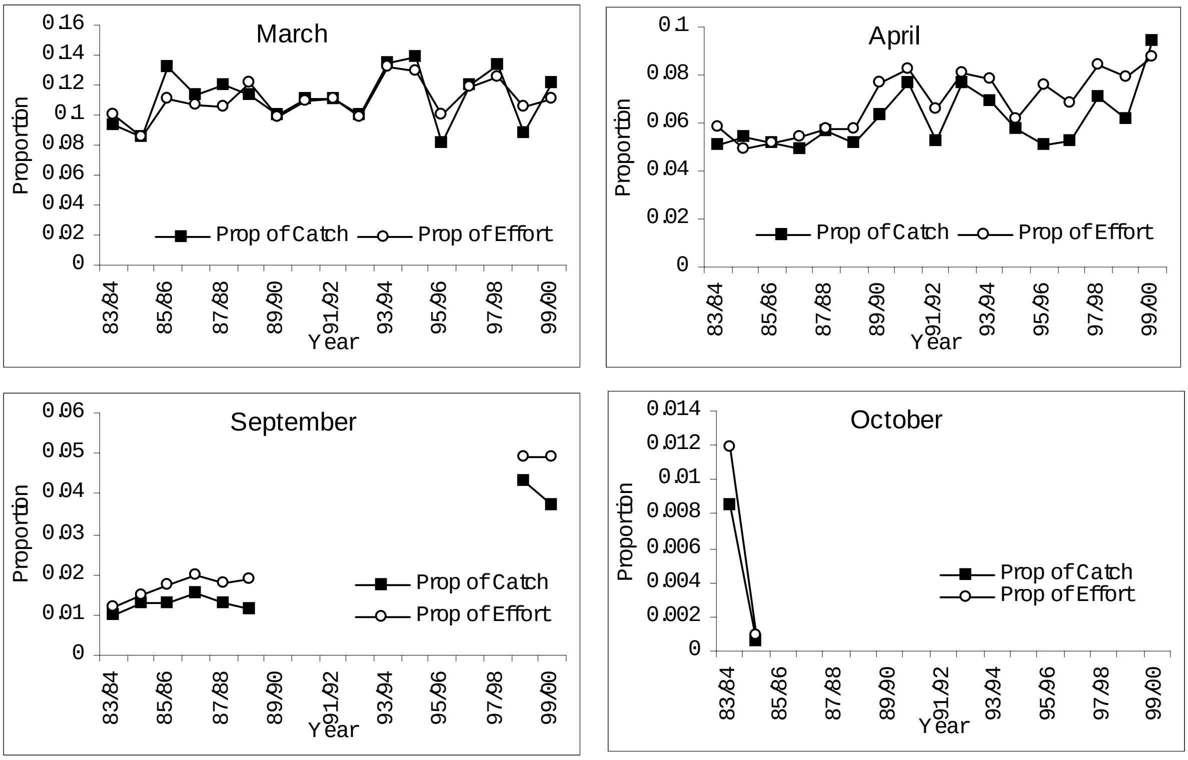

Figure 49. Distributions of catch and effort over individual months: other months.

6.3.3 Number of vessels fishing each month.

The number of vessels fishing at a particular time also gives us a measure of effort. In Figure 50, trends in effort are reflected in the number of vessels fishing at a given time. Summer is considered to run from November to February, winter from May-August and “other” to represent all other months. The proportion of the fleet that fished in summer has remained relatively constant with a slight decrease since 1996/97. In the winter months the proportion of the vessels fishing increased until 1996/97 when the proportion approached the summer months. Likewise there has been an increase in those fishing in the rest of the year. Whereas in the early 1980s we saw a large difference between the proportion of the fleet that fished in summer to those that fish in other times of the year, we now see that the number of vessels fishing in a particular period is roughly equal.

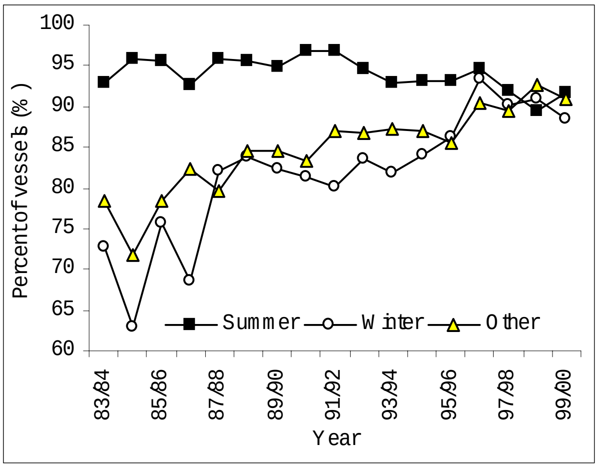

Figure 50. Proportion of vessels fishing.

Figure 51 shows the patterns in the number of boats fishing over the last 7 years, which was the period when changes were most apparent. In summer there has been a clear change in the fishing patterns since quota. From November to March, the number of vessels fishing stayed at the same level for the 5 years prior to quota, but since this time there has been a significant decrease in the proportion of the fleet fishing. The most substantial decreases have been seen in November and February. The February decrease is possibly due to those vessels who have already fished their quota being removed from the fishery leaving a smaller number of vessels who either lease up unused quota or are still fishing their remaining quota.

In each of the winter months there has been an increase in the proportion of vessels fishing. There has been no significant change in these patterns since quota although there has been a decrease in the proportion of vessels fishing in July and August in the last 3 years. We have not plotted the trends for the months of September and October as these months were closed in most years.

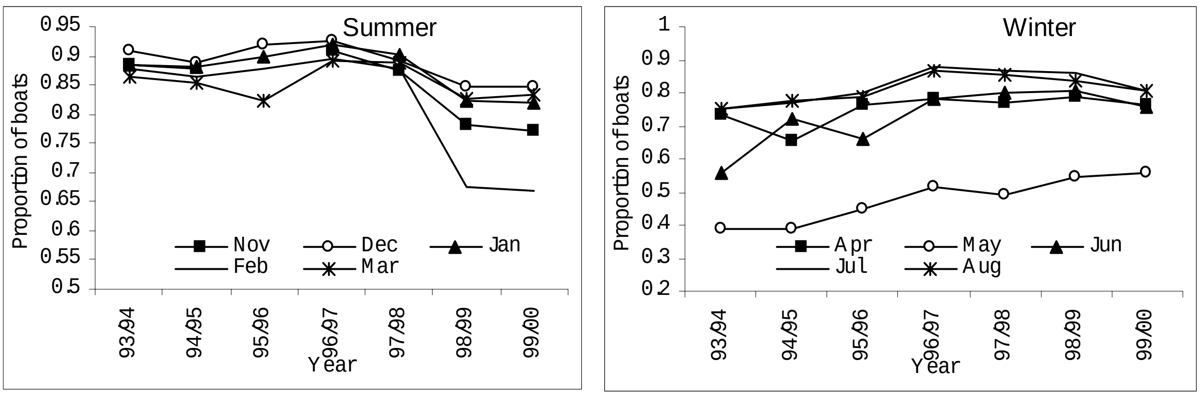

Figure 51. Proportion of Boats Fishing

It is interesting to compare Figure 51 to Figure 48. Although there has been a significant decrease in the number of boats fishing in November and February since quota, the proportion of the yearly effort exerted in these months has not decreased. We expect that the effort during a period should be related to the number of boats fishing and the number days available to fish. Therefore, a measure of fishing intensity can be achieved by dividing the effort during a period by the number boats multiplied by the number of available fishing days. In Figure 52 we plot this quantity for yearly periods and in Figure 53, Figure 54 and Figure 55 we look at this quantity on a monthly basis.

In Figure 52, it can be seen that fishing intensity [effort/(boat*day)] was increasing steadily during the 1980's and early 1990's but has level off at around 18 lifts/boat/day with the exception of two peaks. The peak in 1989/90 and 1990/91 is expected as during these years May and June where closed (See Table 9). As these are months of low fishing activity the yearly effort has not changed considerably even though 61 days have been removed from the allowable fishing days.

On the other hand, to understand the peak in 1996/97 and 1997/98 we refer to Figure 53 and Table 9. During these years we saw season closures in December and February in addition to those in November. In each of the summer months the level of fishing per open day has increased. So even though the season closure during February and December caused the total effort for these months to be reduced, the reduction was not in proportion to the reduction of allowable fishing days.

Figure 53, Figure 54 and Figure 55 show variation that was not apparent in Figure 52. In particular, since the introduction of quota there has been a decrease in fishing intensity from December through to February and an increase in fishing intensity during August. In the rest of the winter months, fishing intensity is following the trend seen prior to the introduction of quota. In particular there was a steady increase in fishing intensity in June and July during the 1990's.

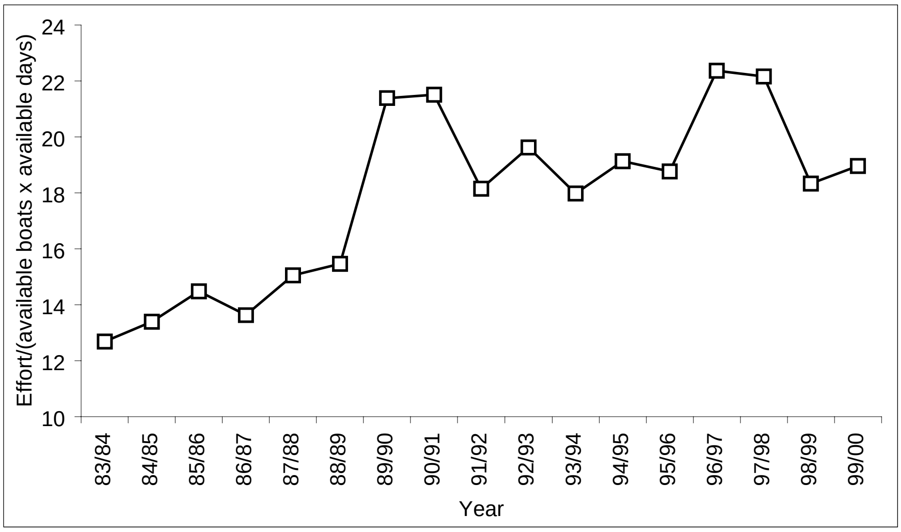

Figure 52. Interannual trend in "fishing intensity" which is: effort / (number of available boats x number of days open).

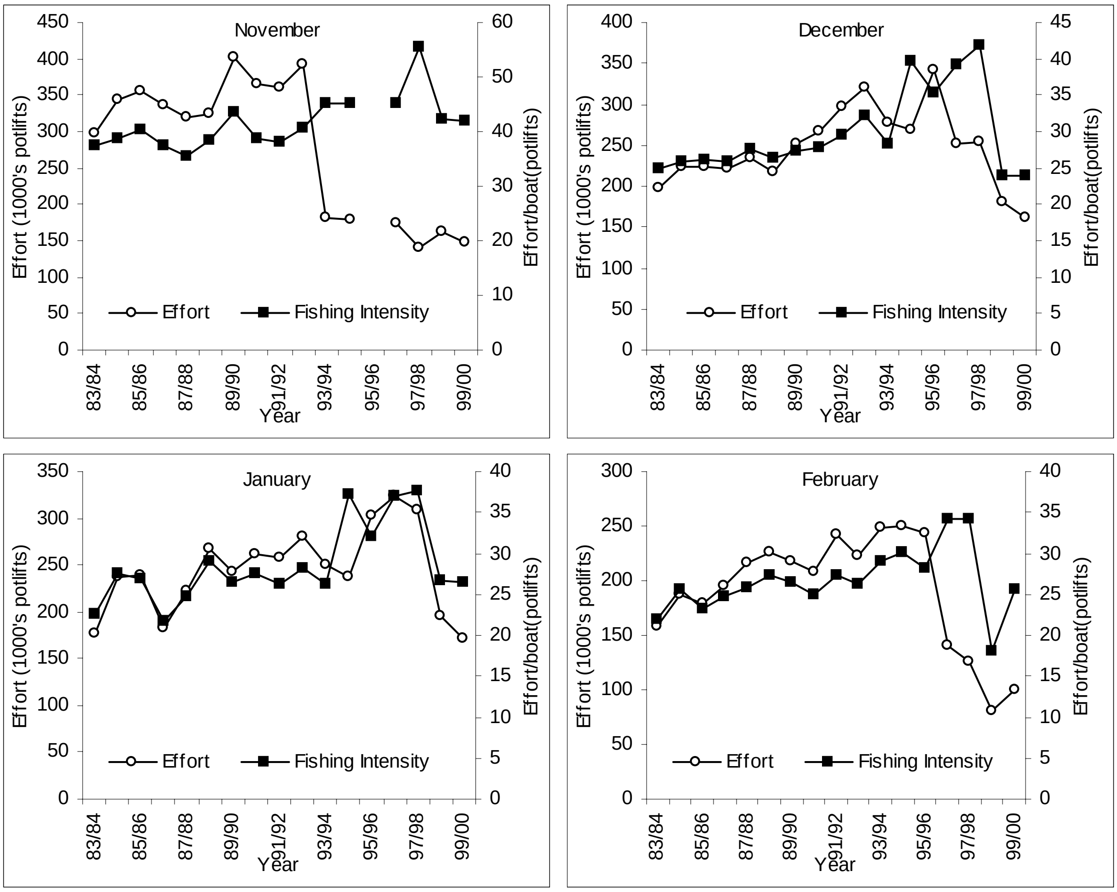

Figure 53. Interannual trend in "fishing intensity" during summer. "Fishing intensity" is: effort / (number of available boats x number of days open).

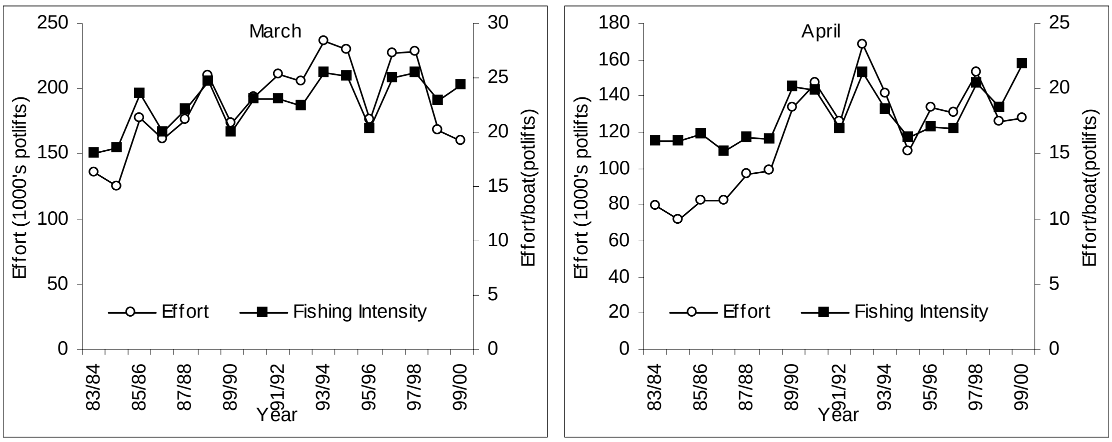

Figure 54. Interannual trend in "fishing intensity" during autumn. "Fishing intensity" is: effort / (number of available boats x number of days open).

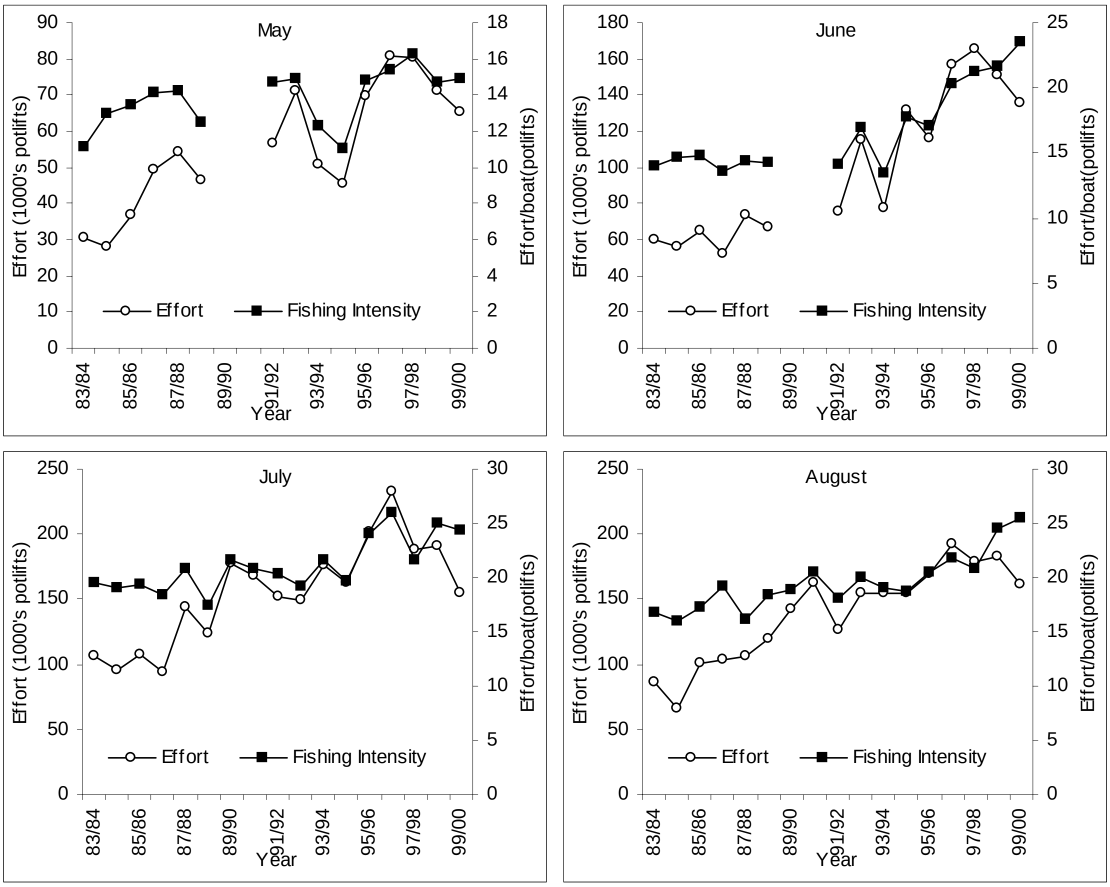

Figure 55. Interannual trend in "fishing intensity" during winter. "Fishing intensity" is: effort / (number of available boats x number of days open).

6.4 Returns on Effort and Catch

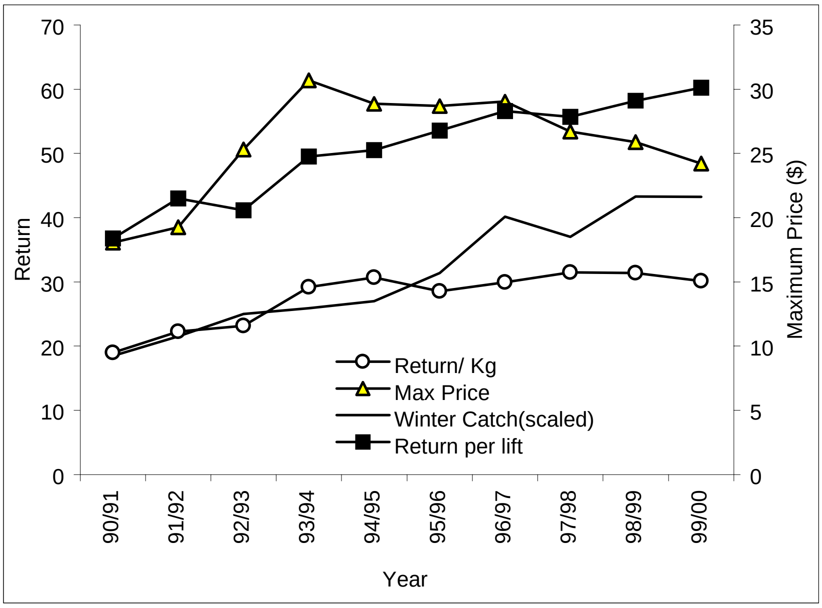

Figure 56. Estimates of the return paid per lift and per kg (adjusted with CPI) compared with the maximum and the average of the prices paid during the year, and the proportion of the catch caught between May and Aug. The return is a theoretical value only and is based on prices paid by processors as reported to DPIWE and the catch in kg each month. The proportion of the yearly catch caught in winter has been scaled to fit the graph (multiplied by 20). Prices have been adjusted by CPI and represent prices in $ as at Nov 99. Season has been taken from Mar-Feb each years to make the data comparable to the quota years.

In Figure 56 we see that the return per unit effort has been steadily increasing over the past 9 years with the greatest increase occurring in 93/94 at the same time that the maximum price paid increased considerably. This represents a shift in the market when high prices could be obtained during the winter months for live lobster. The return per kg also increased in this year. Whereas the return per unit effort has continued to increase the return per kg has not. Again this is linked to the changes in the Asian market which caused the CPI adjusted maximum price paid for lobster to decrease in the last few years.

6.5 Spatial Distribution of Effort

6.5.1 Distribution of effort over Area

The distribution of fishing effort in a particular Area for each of the seasons of the year has been plotted in Figure 57. It is not surprising that these graphs are highly variable and possibly cyclic in nature. Weather, fleet composition, and stock dynamics are some of the variables that will affect these graphs. Until a dynamical model is developed we cannot unfold these patterns to determine the causes of the variation. It is impossible to interpret any change that has occurred in the past two years as being due to the introduction of quota, and likewise changes that have occurred that are due to quota may be hidden by the variation caused by other factors. The only observations of note is that there has been a redistribution of effort in Areas 4,6,7 and 8 from the summer months to the rest of the year and in Area 3 there was a redistribution of effort from the winter months to the autumn months.

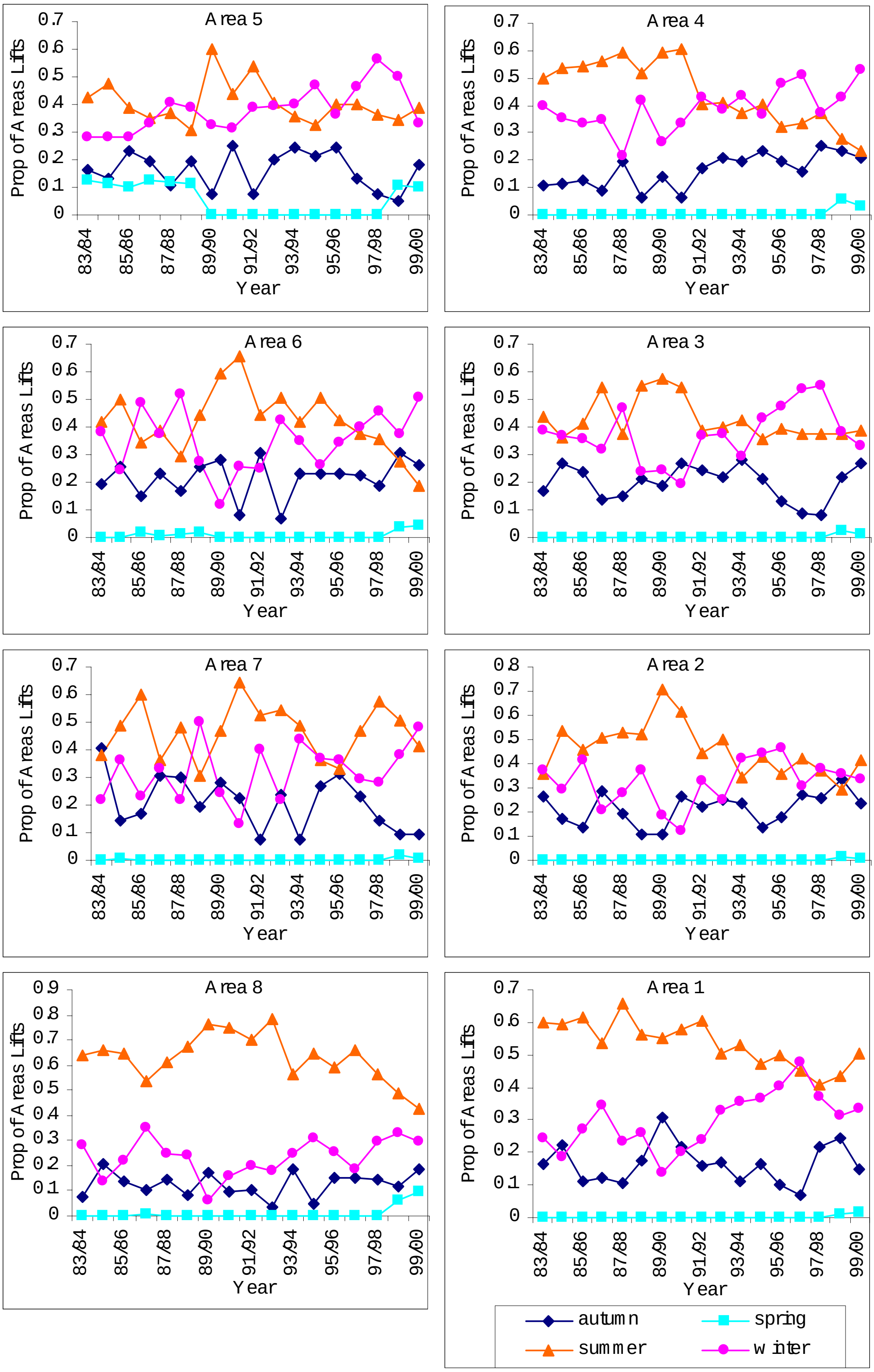

Figure 57. The distribution of seasonal effort within each assessment Area. (Summer = November-February, Winter = May-August, Autumn = March-April, Spring = September-October).

Plots of the distribution of seasonal effort in each of the 8 different Areas would demonstrate if there has been a change in where a fisher fishes at a particular time of the year. Although seasonal and temporal variation is apparent, there is little trend. To examine the extent of change in the distribution of effort, summer and winter effort is compared between Areas in the 1983/84 season and again in 1999/00.

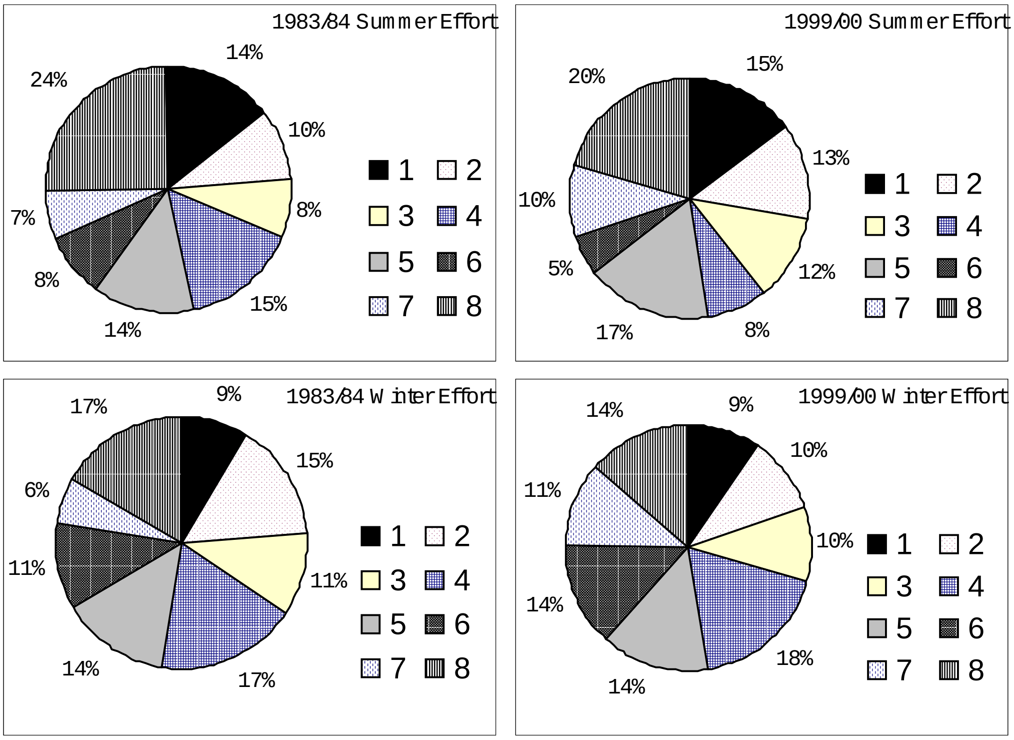

Figure 58. The Distribution of effort in winter and summer around the State in 1983/84 and 1999/00.

6.5.2 Distribution of Effort at Depth

One of the concerns that has been voiced is that since the introduction of quota many fishers have moved their fishing efforts into shallow waters. To investigate this proposition we look at the effort and catch distribution of the fleet amongst depths. As depth was not accurately recorded before 1992, data is not included before this date.

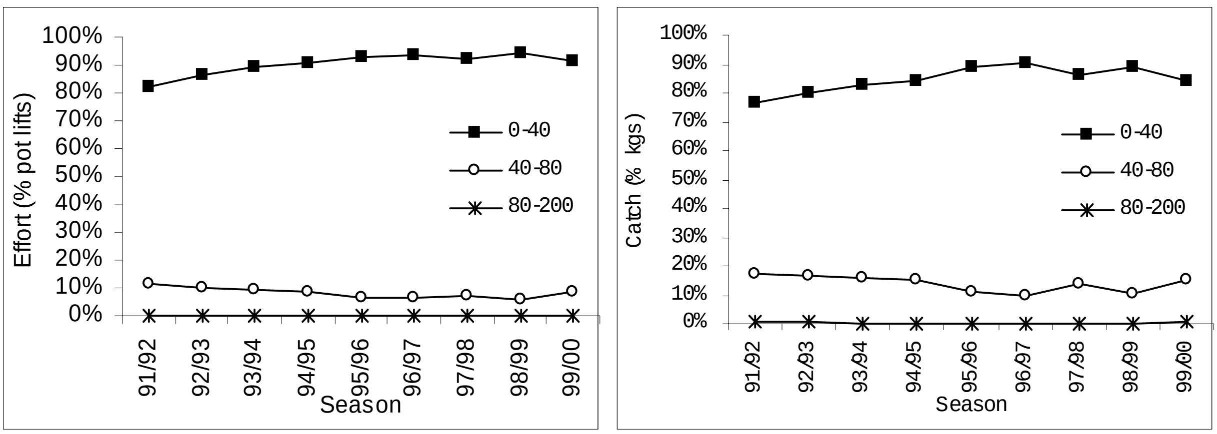

Figure 59. Catch and effort in relation to depth.

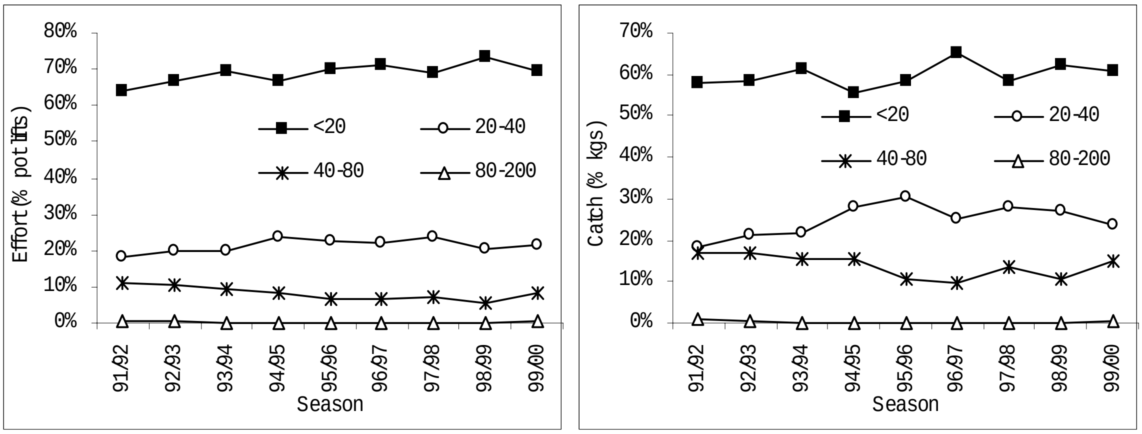

Figure 60. Catch and effort in relation to depth.

Figure 59 and Figure 60 show inter annual changes in catch and effort at different depths (using different scales in each figure). In Figure 59, shallow water data is grouped into 40 fathom categories while in Figure 60, 20 fathom categories are used.

As can be seen in Figure 59 there has been little change in the trend of effort in depths of 40 fathoms or less in the past two seasons. The "catch at depth" graph portrays greater variation which will be influenced by changes in catch rates at the various depths. A closer analysis is found in Figure 60. Here we see an increase in the effort in depths of less than 20 fathoms in the 1998/99 season followed by a decrease in the 1999/00 season. These changes are mirrored by a decrease followed by an increase in effort in the depth classes of 20-40 and 40-80 fathoms in the first two seasons. From these graphs it does not seem reasonable to infer that the introduction of quota has affected what depth fishers fish in.

This broad analysis only looks at fishing effort as an aggregate of the whole fleet. An analysis of the catch of individual vessels will be useful to see if there has been considerable variation in the pattern of individual fishers.

6.5.3 Effort at Depth and Area

The graphs in Figure 61 show the distribution of the fishing effort in each Area at different depths. In all Areas except Areas 5,6 and 7 there has been little change in the depth where fishing occurred. In Areas 5, 6 and 7 there was an increase in fishing in depths of less than 40 fathoms in the first year of quota which corresponded to a decrease in fishing at depths of 40 to 80 fathoms. However this effect did not continue in the second year of quota. It can also been seen from these graphs that fishing in Areas 5, 6 and 7 tends to be more variable. Therefore it is hard to attribute the increase in shallower depth fishing which occurred in the 1998/99 season to the introduction of quota alone. It is probable that there were other factors contributing to this change, like weather or abundance of sized lobster.

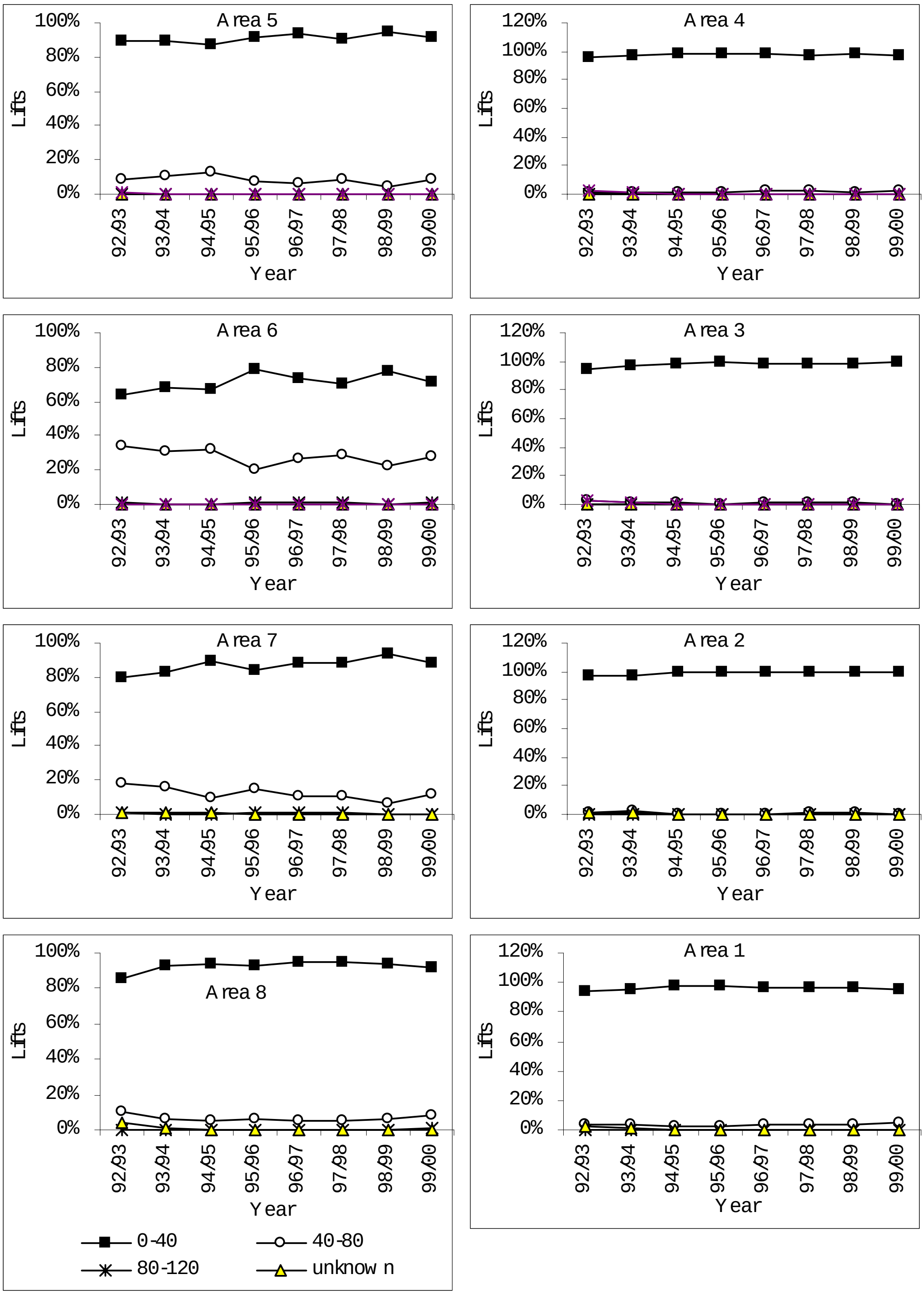

Figure 61. The distribution of effort in each Area in relation to depth.

6.6 Conclusions on analyses of fleet dynamics

While it is difficult to isolate changes that have occurred in the last two years and attribute them to quota alone, some trends in fishing patterns have emerged.

Observations apparent from fleet dynamics over the first two years of QMS are that:

- The number of skippers and vessels participating in the fishery has continued to decline, with the number of vessels decreasing by 11% per annum since the introduction of QMS.
- The number of entitlement owners has continued to decline following the introduction of QMS.
- The proportion of vessels operated by owner-operators has remained stable.
- The length composition of vessels participating in the industry has remained stable.
- Mobility of fishers between stock assessment Areas appears unaffected by the introduction of QMS.
- There has been a continuation of a trend of increasing fishing effort in winter and less in summer. This trend has been apparent for 10 years.
- Effort in Areas 4,6,7 and 8 has been redirected from summer to the rest of the year, while effort in Area 3 has been redirected from winter to autumn.
- There has been no apparent shift in effort between regions.
- There has been no apparent shift in effort between depths.

7. Socio-economics of the Tasmanian rock lobster fishery.

Biology and resource related issues are one side of the Tasmanian rock lobster industry. The other side is the socio-economics of the industry, involving those who catch and sell rock lobster. Put simply, the Tasmanian rock lobster industry, worth approximately A$50 million each season, is as dependent for its existence on fishers and associated socioeconomic infrastructure as it is on rock lobster.

Research has been underway since March 2000 into the socio-economic impacts of the introduction of a quota management system (QMS) in the Tasmanian rock lobster industry. Staff at the School of Geography and Environmental Studies at the University of Tasmania are approximately three-quarters of their way through a type of census of the industry. To date, more than 200 people have been interviewed across Tasmania from all sectors of the industry. Approximately 140 interviews have been tape recorded for detailed analysis. Most regional centres have been visited, and only telephone interviews with mainland Australian licence holders and a final series of interviews with industry participants in greater Hobart remain before completing the interview component of the research. In all, it is estimated that approximately 300 interviews will be conducted.

It is anticipated that this work will produce four main outcomes. First, linking with fishery assessment, socio-economic research aims to provide first-hand data regarding fleet dynamics. Here data is being collected about changes in fishing patterns in space and time and about the factors that underlie those changes. For some, the new management regime has meant more fishing closer to their 'home' port, for others it has meant more inshore fishing. The extent of any shift into winter is being analysed. Exploration of the effects of beach prices, fishing costs, catch rates and other factors on such changes is important for predicting future harvest strategies. Several valuable longitudinal records in the form of log books detailing several years of individual fishing activity have been acquired.

Second, again contributing to stock assessment, socio-economic research will furnish fishery managers with data concerning technology uptake and use in the Tasmanian rock lobster fishery. Data on fishers' assessments of the impacts of different technologies on their 'fishing power' is being collected and will be presented in a form useful to fishery managers. Such data will help interpretation of recent trends in stock levels and catches.

Third, socio-economic research will principally be oriented towards the production of a social impact assessment of the introduction of a QMS in the Tasmanian rock lobster industry. The change to an output management system has had a significant impact on the operations and livelihoods of many industry participants. The wide range of adjustment strategies evident amongst owners and licensees has far-reaching implications for the communities that are partly supported by rock lobster fishing. These communities include many of the more isolated ports in the state. It is important that management of the biological balance of the industry takes place in a context that recognises the socio-economic value of the industry to coastal communities in Tasmania.

Finally, mainly qualitative socio-economic research of the type being undertaken is also an attempt to reach as many in the industry as possible in ways and places not normally possible for fishery managers. The circumstances and opinions of people in the industry throughout Tasmania are being investigated, and this includes participants' views on the future of the industry. Collation of these views from an industry as diverse as the rock lobster industry will help inform discussion about visions for an appropriate future. Industry input to future decision-making is important and should focus on ensuring biological and socio-economic sustainability of maximum benefit for the state.

8. Ecosystem Impacts

8.1 Bycatch

Lobster pots have been recorded to catch over 9 species of crustaceans, 33 species and finfish, 21 species of molluscs and 7 species of echinoderms in Tasmanian waters when the escape gaps are closed (Table 10).

Table 10. List of species and numbers caught in 18,302 rock lobster potlifts from 1992 to 1997.

CRUSTACEANS : 9 species		
Hermit Crab	*Strigipagurus strigimanus*	88486
Rough Rock Crab	*Nectocarcinus tuberculosis*	9253
Cleft Fronted Shore Crab	*Plagusia chabrus*	606
Great Spider Crab	*Leptomithrax gaimardii*	65
Giant Tasmanian Crab	*Pseudocarcinus gigas*	49
Pie Crust Crab	*Cancer novaezealandiae*	25
Others	3 species	15
FINFISH : ~33 species		
Rosy Wrasse	*Pseudolabrus psittaculus*	2192
Degen's Leatherjacket	*Thamnaconus degeni*	2175
Barber Perch	*Caesioperca rasor*	1980
Blue-Throat Wrasse	*Pseudolabrus tetrians*	1452
Purple Wrasse	*Pseudolabrus fucicola*	883
Southern Conger Eel	*Conger verreauxi*	865
Red Gurnard Perch	*Helicolenus papillosus*	690
Draughtboard Shark	*Cephaloscyllium laticeps*	539
Bearded Rock Cod	*Pseudophycis barbata*	558
Brown-Striped Leatherjacket	*Meuschenia australis*	505
Velvet Leatherjacket	*Parika scaber*	389
Morwong	*Nemadactylus macropterus*	231
Toothbrush Leatherjacket	*Penicipelta vittiger*	99
Scorpaenid-Unidentified		88
Senator Wrasse	*Pictilabris laticlavius*	80
Butterfly Perch	*Caesioperca lepidoptera*	51
Others	17 species	97
MOLLUSCS : ~21 species		
Octopus	*Octopus maorum*	647
Others	~20 species	96
ECHINODERMS : ~7 species		
Starfish and Urchins	7 species	38

Although the bycatch caught per pot is low, there was approximately 1.45 million pots lifts undertaken in Tasmania in the 1999/00 fishing season. However, the use of escape gaps, which are mandatory in the Tasmanian fishery, reduce bycatch by over 80% (Frusher and Gibson, 1998)(Table 11).

Table 11. Reduction in bycatch of rock lobster pots due to the inclusion of escape gaps (esc. gaps). IN = insufficient numbers caught to undertake a comparison.

Coast/pot type	**south/steel**	**east/steel**	**east/stick**
Pots sampled (esc. gaps / no esc. gaps)	247 / 1219	236 / 1039	60 / 296
SPECIES		% reduction	
Hermit Crab	92.4	96.3	66.7
Rough Rock Crab	96.6	74.2	100.0
Southern Conger Eel	87.3	86.2	17.8
Rosy Wrasse	100.0	100.0	97.8
Draughtboard Shark	7.5	-3.6	IN
Cleft Fronted Shore Crab	91.2	83.7	100
Purple Wrasse	90.7	100.0	100
Great Spider Crab	75.9	IN	IN
Bearded Rock Cod	86.7	81.7	38.3
Degen's Leatherjacket	100.0	94.2	100.0
Octopus	100.0	95.4	-146.7
Blue Throat Wrasse	100.0	96.4	100.0
B’wn Striped Leatherjacket	75.3	35.0	93.0
Velvet Leatherjacket	100.0	76.8	100.0
Red Gurnard Perch	34.2	92.2	71.0
Butterfly & Barbers Perch	100.0	100	100.0
Toothbrush Leatherjacket	IN	80.0	IN
Triton Shell	IN	-46.8	IN

Larger species such as draughtboard sharks and southern conger eels are unable to utilise the escape gaps. Both these species are being tagged and released during ongoing lobster research surveys and it is planned to investigate the fate of these species in more detail.

The cause of the increase in octopus bycatch in stick-pots in unknown but is being investigated in a project funded by ARC / Industry / DPIWE titled “Biology and ecology of Octopus maorum and its interaction with the Tasmanian rock lobster fishery”.

8.2 Ecosystem impacts

In 1991, 5 marine reserves were established in Tasmania. The largest of these reserves was established at Maria Island on the east coast of Tasmania. Routine monitoring at this site has shown that lobster numbers and average size have increased (Edgar and Barrett, 1999). However, there has been no major observable change in biodiversity to-date. Changes in abundance of various exploited species within the reserves have led to no detectable effect on rock lobster recruitment. This research is ongoing and a detail assessment of changes in the reserves is planned for 2001.

Of concern in Tasmania is the spread of introduced species (i.e. *Undaria*, *Asterias*) and new invasions (*Centrostephenious*). Research is currently underway (*Undaria*, *Asterias*) or proposed (*Centrostephenious*) to evaluate the impact of these species.

8.3 Interaction with endangered or protected species

Marine species which are listed on the Tasmanian Threatened Species Protection Act 1995 and the Commonwealth Endangered Species Protection Act 1992, as of early 1999 are shown in Table 12.

Interaction between rock lobster fishing and threatened marine invertebrates or fish is considered unlikely due to differing habitats. Great white sharks *Charcharodon carcharias* have been seen by rock lobster fishers in South Australia and Western Australia, and several years ago one became tangled in a buoy line (in SA) and was killed (Pers. Comm. Barry Bruce, CSIRO).

An undescribed species of handfish was collected in 1998 in a lobster pot from the Tasman Peninsular and is now in the CSIRO fish collection. This specimen is the only reported catch of a handfish from rock lobster fishing (Pers. Comm. Barry Bruce, CSIRO). As the species is undescribed, it is clearly not listed as threatened - but all handfish are protected. The only listed species of handfish is the spotted handfish. As these are primarily found over soft substrate, it would be unusual for a rock lobster fisher to interact with them.

No interactions with whales have been reported although sightings have occurred. Although capture of threatened whale species with lobster gear is highly unlikely, it is possible. An individual of a non-listed species (pilot whale) became entangled in a giant crab buoy line in Victoria in 2000 but was released apparently unharmed (reported at giant crab workshop, MAFRI, 2000).

Interactions between rock lobster fishers and seabirds are numerous. Birds are sighted, scavenge discarded bait, and roost on vessels. Identification of most threatened species is relatively difficult with few fishermen able to confidently distinguish between threatened and non-threatened species. Nonetheless, some species such as sooty and wandering albatross are more easily identified. These species are sighted frequently, and often roost on vessels while they are moored overnight. No mortalities to oceanic seabirds through lobster fishing operations have been reported in 2000, although fishers reported seabirds crashing into vessels fishing at night with lights in 1998. This practice was subsequently prohibited at the request of the fishing industry.

Coastal seabirds, specifically cormorants, were occasionally accidentally trapped and drowned in very shallow sets of rock lobster pots during 1999/00. No Australian cormorant species is listed as threatened.

Information on interactions with sea turtles is collected on an ad-hoc basis, with fishers encouraged to report entanglement. The incidence appears to be very low. The Draft Recovery Plan for Marine Turtles in Australia (Anon EA 1998) requires Tasmania to quantify the entanglement events and the mortalities as a result of rock lobster pot lines.

Information collected for inclusion in the draft recovery plan concluded there had been 118 sightings of turtles in 10 years. These sightings are not separated to provide mortalities, therefore it is reasonable to assume that the number of interactions that result in the death of the turtle is likely to be a rare event. In the last 10 years 4 turtle deaths have been recorded from entanglements in fishing gear (Anon. EA 1998). Bone

(1998) undertook a preliminary investigation into the abundance and occurrences of the leatherback turtle *Dermochelys coriacea* in waters around Tasmania. This investigation concluded that the presence of turtles in Tasmanian waters may be higher than previously thought.

Table 12. Threatened marine and coastal species of Tasmania.

Species		Tas. Listing	Commonwealth Listing
Arctocephalus forsteri	New Zealand fur seal	Rare	-
Balaenoptera musculus	Blue whale	Endangered	Endangered
Balaenoptera physalus	Fin whale	Vulnerable	Vulnerable
Eubalaena australis	Southern right whale	Endangered	Endangered
Megaptera novaengliae	Humpback whale	Endangered	Vulnerable
Diomedea exulans	wandering albatross	Endangered	Vulnerable
Halobaena caerulea	blue petrel	Vulnerable	Vulnerable
Macronectes giganteus	southern giant petrel	Nominated	-
Macronectes halli	northern giant petrel	Nominated	-
Oceanites oceanicus	Wilson's storm petrel	Rare	-
Pachyptila turtur subantarctica	fairy prion (sub-species)	Vulnerable	Vulnerable
Phoebetria fusca	sooty albatross	Nominated	-
Phoebetria palpebrata	light-mantled albatross	Vulnerable	-
Pterodroma lessonii	white-headed petrel	Vulnerable	
Pterodroma mollis	soft-plumaged petrel	Vulnerable	Vulnerable
Sterna albifrons sinensis	little tern	Endangered	Endangered
Sterna nereis	fairy tern	Rare	-
Sterna striata	white-fronted tern	Rare	-
Sterna vittata bethunei	Antarctic tern	Endangered	Endangered
Thalassarche cauta	shy albatross	Vulnerable	Vulnerable
Thalassarche chrysostoma	grey-headed albatross	Vulnerable	Vulnerable
Thalassarche melanophrys	black-browed albatross	Vulnerable	-
Brachionychthys hirsutus	spotted handfish	Nominated	Endangered
Charcharodon carcharias	great white shark	Nominated	-
Marginaster littoralis	*seastar*	*Endangered*	-
Patiriella vivipara	*live-bearing seastar*	*Endangered*	-
Smilasterias tasmaniae	*seastar*	*Rare*	-

9. Industry Issues

The rock lobster fishing industry is represented at the rock lobster assessment-working group and several issues were raised in relation to the results presented in this report and also in relation to future assessments.

These issues were:

- The use of industry vessels for conducting research surveys should be investigated as an alternative option to the use of *FRV Challenger*.

- The open season for male rock lobsters was extended in 2000 until the end of September. In many areas, this raises the proportion of animals captured in a soft-shell state. Industry members expressed concern that this may increase fishing mortality through several mechanisms. These were: (i) increased mortality of discarded lobsters; (ii) increased mortality of animals retained in wells and then discarded prior to landing; (iii) reduced weight of animals after moulting leading to greater number of animals removed for an equivalent quantity of quota.

- The influence of interannual change in depth fished on estimates of performance indicators is not considered and would be a useful addition to the assessment process.

- Concern was expressed at the rise in recreational fishing effort. Recreational fishing effort constitutes over 50% of the catch taken from shallow regions on the east coast. Since 1996, recreational pot and dive licences have increased by 40 and 43% respectively. The number of recreational licenses increased by over 5% in the last year. Catch of recreational fishers is not capped, so it is probable that the increase in biomass of rock lobsters has led to an increase in the total catch per recreational fisher. The lobster industry suggested an improved understanding of the magnitude of this catch would assist future assessments. An option was proposed of requiring that animals be antennal-tagged after capture, using a set number of tags issued with the license. Tags that were unused at the end of the season could be returned for a refund. The value of this system is that it provides a method for estimating the total catch by recreational fishers on an annual basis.

- Industry stated that they anticipate a future increase in the TACC, should the current trends of increasing biomass and egg production continue. They feel that this should be in the order of a 70 tonne increase in the TACC (4.6%), which would raise the catch of individual units to 150kg.

10. Aquaculture

The current management plan lists the provision of marine farming opportunities for rock lobster as a management objective. The focus of the objective in relation to the wild fishery was to provide for the development of an aquaculture industry through the limited and controlled harvest of puerulus. This issue has progressed although not to the point of harvest of puerulus. Developments[1] are summarised below.

Initial proposals in 1997 to obtain puerulus from the wild immediately caused conflict with the historical users of the resource – the rock lobster fishers. At the time, the rock lobster fishing industry was in a process of significant management change to enable rebuilding of the resource. Harvest of puerulus for ongrowing in aquaculture operations appeared counterproductive to this goal.

Recognising this conflict, the management plan proposed strategies in relation to the harvest of puerulus from the natural resource. These were primarily for biological neutrality of harvest, appropriate compliance for undersize lobsters, and prevention of the introduction of disease through aquaculture.

10.1 Biological Neutrality

The strategies for rock lobster aquaculture outlined in the 1997 Management Plan suggested that biological neutrality of puerulus harvest could be achieved through retiring quota from the fishery. Although this mechanism has been adopted in New Zealand, there were concerns regarding regional resource implications. Since that time an alternative strategy termed "reseeding" has been proposed and is now the preferred option of the Rock Lobster Aquaculture Working Group.

The option of reseeding utilises the fact that a large portion of the puerulus that settle onto coastal reef will not survive the first year. By ongrowing puerulus for this first year, then reseeding a portion of those juveniles equivalent to that which would probably have survived under normal circumstances – biological neutrality is theoretically possible.

The use of reseeding to achieve biological neutrality was preferred over quota-buy-back for several reasons.

1. The information requirements are less demanding – which implies the risk of incorrect assumptions is reduced. Reseeding requires an estimate of mortality in the first year, whereas quota-buy-back requires estimates of mortality and growth for every year from settlement to recruitment.

2. Reseeded juveniles can be returned to the same region from where puerulus were extracted. The spatial effects of quota-buy-back are impossible to predict as the locations where puerulus harvest occurs and where quota is retired are unrelated.

3. Quota-buy-back does not compensate for egg production of females before they reach legal size.

4. Reseeding has the potential to deliver direct enhancement benefits to areas where egg production is most depleted.

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[1] In early January the Government advertised for expressions of interest for a total harvest of 350,000 puerulus.

5. Reseeding results in a net socio-economic gain to both aquaculture and wild fishery operations, while quota-buy-back results in a net loss from the wild fishery.

10.2 Rock Lobster Aquaculture Research

The use of reseeding as a tool for achieving biological neutrality is reliant on achieving high survival of those cultured juveniles that are replaced on natural reef. An FRDC funded project was completed during the last year, which aimed to develop techniques for assessing survival after release. This preliminary project was successful and has led to further research to apply the methods to larger scale reseeding operations (Gardner *et al*., 2000). Copies of the final report are available online at http://www.utas.edu.au/docs/tafi/TAFI_Download.htm#TAFI Reports to Funding Agencies.

Research has also been conducted on larval culture and techniques for large scale collection of puerulus. Critical issues for maximising the collection of puerulus were found to be the seasonal timing of collector deployment, collector design, collector conditioning, handling and placement. Based on current costs of collector construction, puerulus harvest appears economically feasible with costs per animal considerably less than $1, which has been used as an economic target value for viable hatchery production.

Research to investigate disease risks associated with the release of cultured lobsters has been formulated and submitted to funding bodies.

11. Appendix 1: List of Management Objectives and Strategies

There are eight policy objectives and associated strategies in the current rock lobster fishery policy document (Anon, 1997). Note that while this plan remains current, opinion has shifted in some aspects and these are highlighted throughout by footnotes. Policy objectives listed in the plan are:

11.1 Maintaining biomass and fish recruitment.

To maintain fish stocks at sustainable levels by constraining the total catch and size of individual rock lobster taken by the commercial and recreational sectors. In particular, to ensure that:

- Rock Lobster are harvested at sustainable levels.
- Biomass and egg production do not decrease and that reasonable levels of egg production are maintained in all regions of the fishery.
- Biomass levels are increasing over time to the level required for producing the maximum yield from the fishery.

11.1.1 Strategies

- Limiting the commercial catch through setting a total allowable commercial catch (TACC) and using individual transferable quotas to allocate proportions of the TACC.
- To minimise the opportunity for illegal activity through a monitoring, compliance and enforcement strategy.
- Limiting the recreational catch through the use of daily bag limits and possession limits, requiring fishers to be licensed and limiting fishers to one rock lobster pot per person or other specified fishing gear or methods.
- Conserving egg production and constraining fishing mortality on spawning female lobster by the use of minimum size limits and the closure of the fishery for female lobster during the peak spawning period[2].

[2] The use of seasonal closures as a management strategy is under review at the time of preparation of this assessment report. This is an industry initiative and initial steps involve a polling of industry opinion, research sampling during an extended season opening in September 2000 and model simulations (Gardner and Frusher, 2000).

11.2 Sustaining yield and reducing incidental fishing mortality

To take fish at a size likely to result in the best use of the yield from the fishery. To provide measures to protect undersized lobster. To minimise incidental fishing mortality as a result of fishing operations.

11.2.1 Strategies

- Maintenance of size limits.
- Restriction of size at first capture by requiring rock lobster pots to have escape gaps and to conform to size specifications.
- To reduce incidental mortality by limiting the set duration for rock lobster pots.
- Require rock lobster fishing vessels to be able to carry all pots on the vessel at any one time.

11.3 Managing commercial fishing interactions

To mitigate any conflict that results from competition between different fishing methods for access to shared fishing grounds.

11.3.1 Strategies

- Restrict the number of rock lobster pots that can be used from individual fishing vessels.
- Restrict the number of rock lobster fishing vessels in the fishery.

11.4 Ensuring access to fish stocks by recreational fishers

To maintain or provide reasonable access to rock lobster stocks for recreational fishers.

11.4.1 Strategies

- Encourage communication between the commercial and recreational sectors.
- Promote the development of a Code of Practice for recreational fishing for rock lobster.
- Maintain existing recreational fishing areas where no commercial rock lobster fishing will be permitted.

11.5 Providing marine farming opportunities for rock lobster

To provide for the development of a rock lobster aquaculture industry through the limited and controlled harvest of puerulus (juvenile rock lobster)[3].

11.5.1 Strategies

- Ensure that any harvest of puerulus is biologically neutral.
- Develop appropriate conversion ratios between puerulus and kilograms of quota[4].
- Ensure that the future development potential for the marine farming of rock lobster is achieved with no significant additional net mortality from the wild fishery.
- Ensure that any change in the TACC, and therefore the pot allocation, is matched with a corresponding change to the conversion ratio between puerulus and kilograms quota.
- Develop appropriate compliance mechanisms to ensure illegally taken undersized wild rock lobster do not enter the market.
- Identify methods of collecting puerulus that result in minimal incidental mortality and minimal damage to puerulus.
- Undertake research to assess possible impacts on the wild rock lobster fishery through the harvesting of puerulus
- Investigate opportunities to undertake research into growing puerulus from the egg stage[5].

11.6 Providing socio-economic benefits to the community

To recover a financial contribution from both commercial and recreational rock lobster fishers to contribute to the real costs of management, compliance and research. To ensure the rock lobster fishing fleet continues to provide employment and an economic return to coastal communities of Tasmania.

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[3] The Government position on this objective has changed since the completion of the current management plan. Although the current plan implies that puerulus harvest is to be undertaken for the development of a permanent industry, the current minister has stated that puerulus harvest is intended to be an interim activity until the viability of hatchery production can be more fully evaluated.

[4] Points 2 and 4 assume a quota buy-back option is implemented. Subsequent to the publishing of the rock lobster fishery policy document (Anon, 1997), concerns were expressed at the limited ability of this option to achieve biological neutrality due to a) loss of egg production from sub-legal females and b) effective shift of effort towards the east coast. Consequently, a reseeding option was proposed to overcome these problems.

[5] Research into phyllosoma culture has subsequently commenced (at T.A.F.I. in 1997). Larvae have survived to 400 days of age although there has been no survival to the first juvenile stage or puerulus.

11.6.1 Strategies

- Determine the real costs of management, compliance and necessary research costs for the rock lobster fishery.
- Equitably pass on management and research costs to participants in the rock lobster fishery, sufficient to achieve cost recovery over time. Full cost recovery will not be achieved during the term of this plan.
- Provide mechanisms to ensure that the rock lobster fleet continues to provide economic and social benefits to the Tasmanian community.

11.7 Accounting for environmental interactions.

To minimise the environmental impact of rock lobster fishing methods particularly on areas of special ecological significance and reduce bycatch of juveniles and non-target species.

11.7.1 Strategies

- Establish marine protected areas for the protection of valuable coastal habitats and to maintain biodiversity[6].
- Require rock lobster pots to be fitted with escape gaps.

11.8 Providing high quality produce

To promote and maintain handling and processing practices which ensure the highest quality rock lobster product for human consumption.

11.8.1 Strategies

- Promote quality carrying, handling and storage practices for rock lobster on board fishing vessels and by fish processors, through the use of codes of practice and industry initiatives.
- Undertake research to identify the differences between wild harvested rock lobster and rock lobster reared in an aquaculture facility.

[6] This strategy assumes no harm to biodiversity through the use of MPAs in conjunction with QMS in the rock lobster fishery. FRDC funding has been obtained to research the implications of MPAs for fisheries management and that study has not yet been completed.

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

12.1 Performance Indicators

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

12.1.1 Catch per unit effort (CPUE)

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

12.1.2 Biomass

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

- Biomass will be estimated by two different techniques. The first will be a length structured, 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.

12.1.3 Egg production

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

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

12.1.4 Relative abundance of undersized lobster

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

12.1.5 The total annual commercial catch

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

12.1.6 The size of the rock lobster fleet

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

12.1.7 The recreational catch

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

12.2 Trigger Points

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

12.2.1 Catch per unit effort (CPUE)

- Annual CPUE from commercial catch returns falls below 95% of the CPUE for the reference year with the lowest catch rate (ie. 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.

12.2.2 Legal-sized biomass

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

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

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

12.2.3 Egg Production

- The estimate of global (state-wide) egg production falls below that of Egg_{low}. An exception to this can be invoked if the estimated egg production is within 5% of Egg_{low} provided that the reduction is restricted to areas with egg production levels which exceed 40% of that of the estimated unfished (virgin) stock.

- Any regional estimates of egg production falls to less than 95% of the related egg_{low} unless the affected regions have egg production levels which exceed 40% of that of the estimated unfished stock.

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

12.2.4 Relative abundance of undersized lobster

- Annual CPUE of undersized lobster in the pre-recruit size class falls below 95% of that estimated for the reference years already mentioned, for the same sampling 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.[7]

12.2.5 The total annual catch

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

12.2.6 The size of the rock lobster fleet

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

12.2.7 The recreational catch

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

13. Appendix 3: Fishery Description

13.1 General Overview

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

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

(ii) The current management plan commenced in 1998 for a three year period and is being reviewed in 2000. A new management plan will be introduced in 2001.

[7] 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.

(iii) This assessment report contains information available up to the end of the second quota year in February 2000.

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

A recent initiative undertaken by the Tasmanian government was to investigate the potential for rock lobster aquaculture. While the long term future of lobster aquaculture is considered to be associated with ‘closing the life cycle’ and thus operating independently of the fishery, the initial development plans to source puerulus from the wild. Although collection has yet to commence, it is anticipated in 2001. As any quantities either extracted from or returned to the resource will impact on the resource, a chapter on aquaculture has been added to this report.

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

COMMERCIAL	
Management zone	one management zone for the State
Limited entry	314 licenses
Limited seasons	In 2000: closed season 24-49th February (both sexes); 1st October-14th November (both sexes); 1st May-1st October (females).
Limits of pots on vessels	minimum of 15 pots, maximum of 50 pots
Quota	Total allowable catch of 1502.5 tonnes
Restrictions on setting pots	pots cannot be set, or pulled, between two hours after sunset and two hours before sunrise
	pots must be hauled no longer than X days after being set
Restrictions on pot size	maximum size of 1250 mm x 1250 mm x 750 mm.
Escape gaps	one escape gap at least 57 mm high and 400 mm wide and not more than 150 mm from the inside lower edge of the pot, or two escape gaps at least 57 mm high and 200 mm wide and not more than 150 mm from the inside lower edge of the pot
Minimum size limits	105 mm CL for females, 110 mm CL for males
Berried females	taking of berried females prohibited
RECREATIONAL	
License requirements	rock lobster potting licence - 1 recreational pot per person, rock lobster diving licence, rock lobster ring license – 4 rings per person.
Daily limit	5 per recreational license holder
Limited seasons	In 2000: closed season 1st May-10th November (females); 1st September-10th 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.

13.2 History of Tasmanian Commercial Rock Lobster Fishing

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

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

In the mid to late 1980's concern over the resource was again expressed by fishers as catch rates declined (Figure 62). A working group of fishers and government representatives was formed in the early 1990's to evaluate options to stem this decline (Anon, 1993). The working group clearly identified increased effort as the major problem and expressed concern at the potential for further increases as latent effort was considerable. The lack of consensus on the appropriate management method to adopt resulted in a number of Industry polls. This culminated in a poll in 1996, which resulted in a marginal preference for quota management. In March, 1998 an individual transferable quota (ITQ) management system commenced.

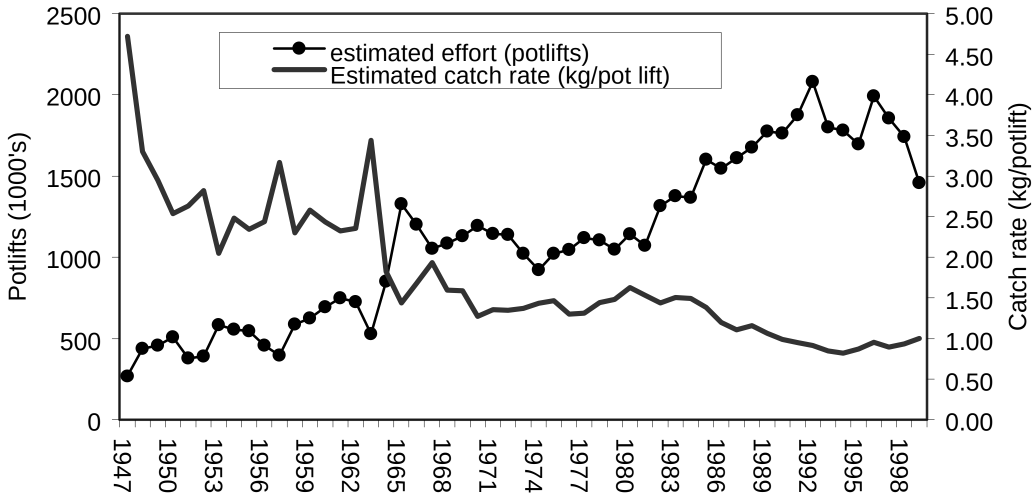


Figure 62. Historical patterns in statewide lobster fishing effort and catch rate.

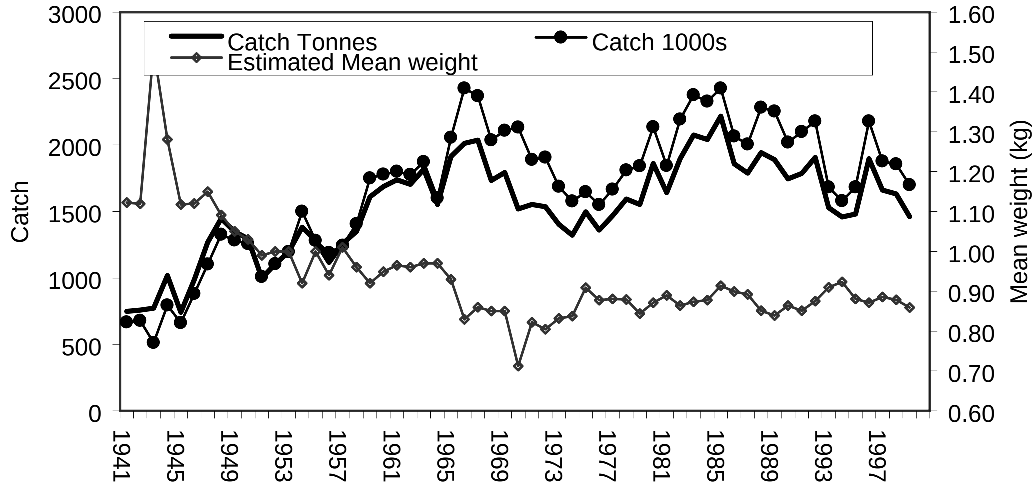
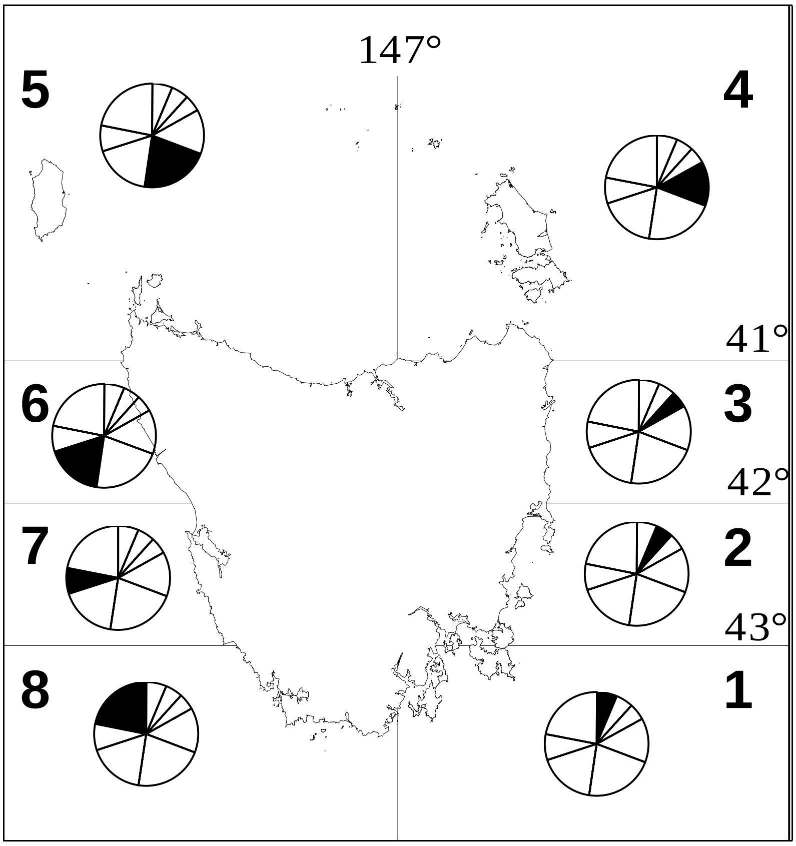


Figure 63. Historical patterns in statewide catch.

13.3 Commercial Rock Lobster Fishery

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

Since 1970 fishers have recorded their daily catch in degree blocks around Tasmania which has allowed for regional trends to be documented. This report presents information for the 8 regions used in the rock lobster assessment model (Punt and Kennedy, 1997; Figure 64).



Region	% of catch
1	6.2
2	5.5
3	4.9
4	14.1
5	21.4
6	17.5
7	8.6
8	21.8

Figure 64. Location of the eight regions used in this report and their percentage contribution to the 1999/00 commercial catch (March to February inclusive).

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

Although lobsters have been recorded from depths greater than 200m, few lobster are caught in depths below 125m (Figure 65). With the exception of area 6 where over 40% of the catch comes from waters deeper than 62m, most of the catch comes from waters less than 62 m. Shallow water grounds less than 18 m are especially important in areas 2 and 3 with greater than 30% of the catch from this depth range.

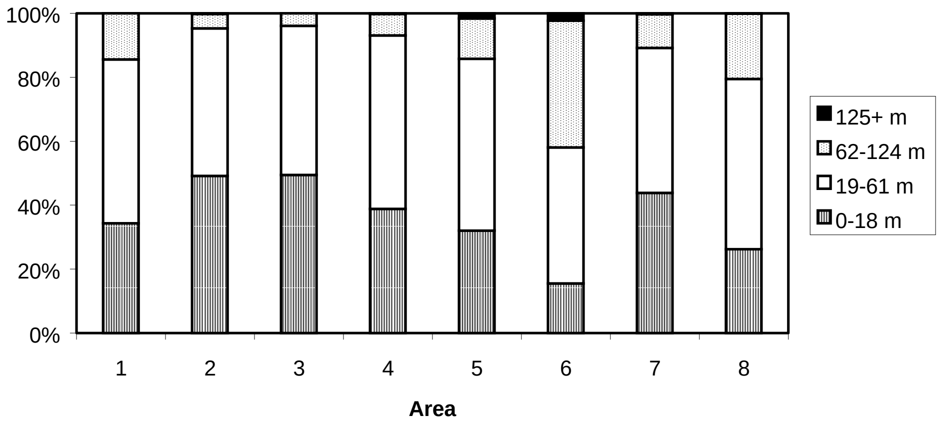


Figure 65. Regional depth distribution of catch from March 1998 to February 1999.

13.3.1 Fishing methods

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

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

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

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

13.3.2 Catching sector

In January 1997 the rock lobster fishing fleet comprised 321 vessels and this had reduced to 314 vessels in February 1999, and further reduced to 270 for the period November 1998 to September 1999. Vessels range in size from 6-26 metres in length. The majority of vessels are used primarily for rock lobster fishing but have the capacity to diversify into other fisheries on a seasonal basis. The vessels are a mixture of wooden and steel hulls with a few fibreglass vessels. The majority of the fleet is of the displacement hull style with a small number of planing hull vessels. The average age of the fleet exceeds 15 years, with very few new vessels operating.

Each licence has a quota allocation ranging from 5 to 100 rock lobster quota units. Each vessel has a rock lobster pot allocation based on either the length or tonnage of the vessel. The pot allocation varies between a minimum of 15 and a maximum of 50 pots. A total of 10,507 pots were able to be used throughout the fleet in February 1999, however under quota less pots than this are being used. The majority of vessels are owner operated, but there is a trend toward the leasing of vessels and licences.

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

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

14. Appendix 4: Biology of the southern rock lobster

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

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

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

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

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

14.1 Reproduction

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

14.2 Larval Period

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

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

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

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

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

Annual trends in puerulus index and implications for future recruitment are discussed in detail elsewhere in this assessment (Section 5, page 31).

14.3 Growth

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

In terms of this stock assessment report, the moulting process has some important points. Firstly, during the moulting process the lobster is very vulnerable until the shell (its body armour) has hardened. As such, lobsters will not leave their refuge during moulting and are not catchable by pots. Also, the appetite of lobsters decreases prior to moulting so they are less attracted to baits. However, once the shell has hardened at the completion of the moult, the tissues within the lobster contain a large proportion of water. This causes the lobster to become extremely hungry and vulnerable to being caught in pots (Figure 66).

Moulting is relatively synchronised in rock lobsters with similar sized lobster moulting at approximately the same time in the same region. Male lobsters moult from August to November in southern Tasmanian and a little later in northern Tasmania. Because of this, the opening of the rock lobster season in November[8] just after the majority of male lobsters have moulted, is often classified by fishers as the ‘run of new shellers’. Female

[8] Prior to quota implementation in March 1998, the fishing season was from November to August of the following year. The season now runs from March to February of the following year.

lobster generally moult in April and May after which mature female lobsters carry eggs. The season for female lobsters is closed from the 1st of April to mid November of each year. Because of the male moult prior to the start of each season, catchability of lobsters is highest during November. These changes in catchability implies that some estimates of abundances such as catch per unit effort will vary seasonally. The problem is overcome in the stock assessment model by incorporating this effect as a "catchability coefficient" which varies between months.

Recent research undertaken by TAFI has attempted to improve our understanding of these monthly changes by directly measuring the catchability of lobsters in an un-fished population (Figure 66). Catchability was best described as a function of the water temperature, moulting and mating (Ziegler *et al.*, in prep). The use of an unfished region or reserve for this research allowed catch rate changes to be related directly to catchability changes. This direct link between catch rate and catchability cannot be made in fished regions, where catch rates also change during the season through depletion.

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

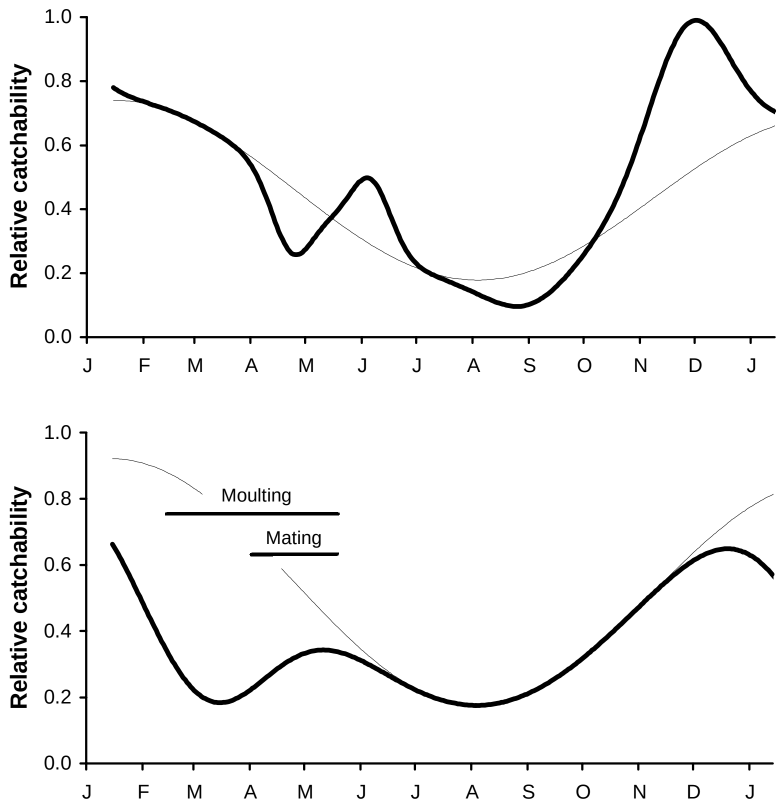


Figure 66. Monthly patterns of catchability of male (upper) and female (lower) rock lobsters from an unfished population at Crayfish Point. "Catchability" is a measure of how vulnerable lobsters are to being caught in pots. Heavy lines represent relative catchability, while thin lines represent change in water temperature. Catchability is influenced by temperature, with overlying affects from biological processes of moulting and mating. Mating reduces catchability of both sexes in April/May, which is followed by heightened catchability afterwards. Likewise, the male moult in September leads to reduced catchability, followed by heightened catchability in November, presumably due to compensatory feeding. While these general patterns are well known to fishers, the research shown here is important as it allows the seasonal changes in catchability to be quantified.

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

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

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

The size at which lobsters become mature appears to be related to age rather than size and thus faster growing lobsters mature at a larger size than slower growing lobsters. In southern waters greater than 40m in depth, female lobsters mature at 60 to 65mmCL. In contrast, in shallower (<40m) water in northern regions of the fishery, female lobsters mature at sizes greater than 110mmCL (Figure 67).

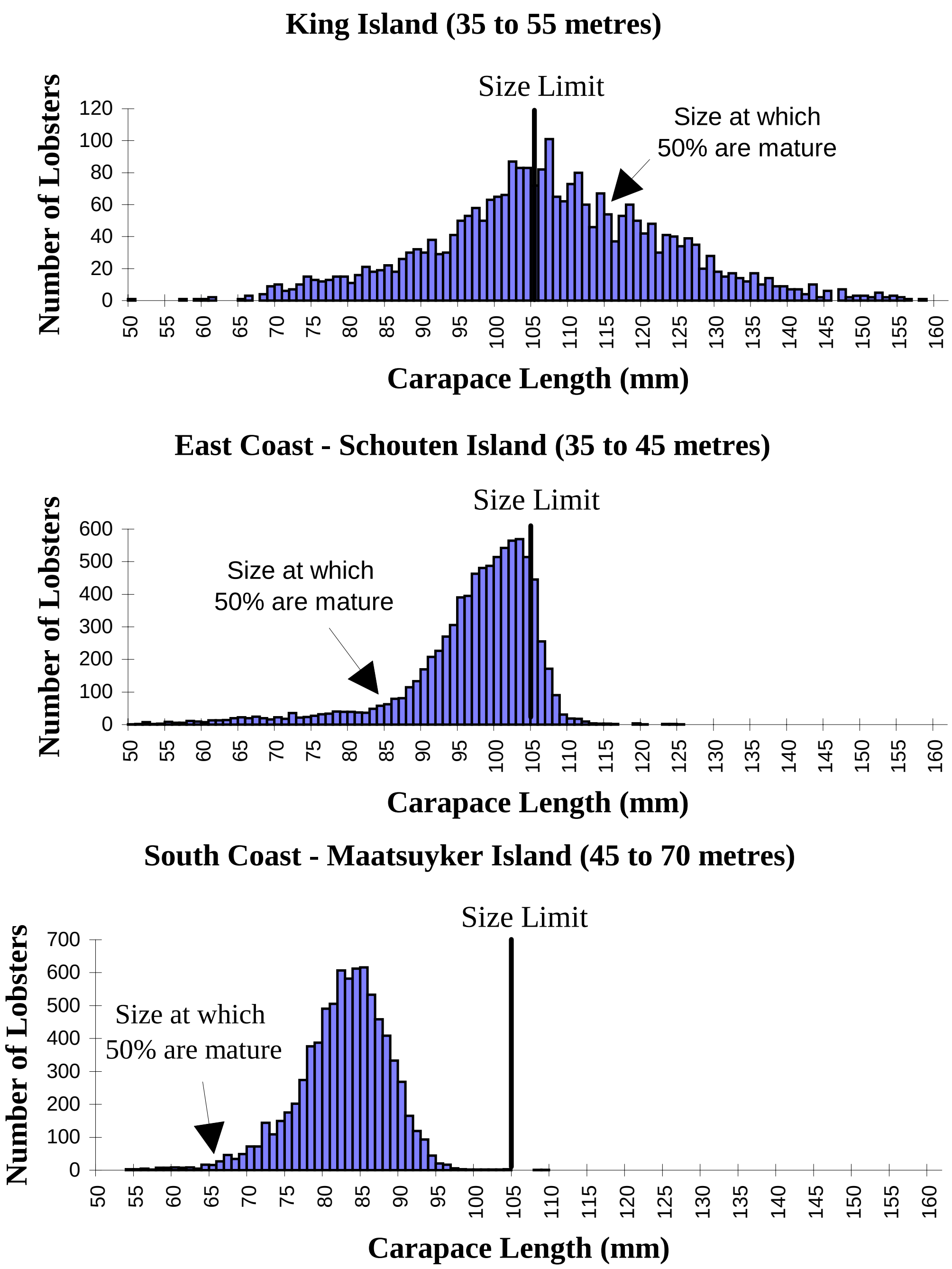


Figure 67. Size structure and size at maturity of female lobsters caught at three locations in Tasmania.

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