REPORT

Sex and the setae:

maintaining reproductive success in rock lobsters

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1. Introduction

In the last decade, there has been a distinct change in the seasonality of fishing in parts of the New Zealand rock lobster fishery. Historically, most fishing occurred during the summer months due to favourable weather conditions and higher catch rates. In the 1990/91 fishing year, 8 of 9 rock lobster QMAs landed less than 42% of their catch in autumn/winter. In the early 1990's, higher live lobster market prices during winter resulted in a shift in fishing effort in many areas. During the 1999/2000 fishing season, 6 of 9 QMAs landed greater than 75% of their catch in autumn/winter (Figure 1).

Rock lobster breed in late spring and early winter and the females bear eggs through the winter months. Since 1952, there has been a prohibition on the taking of egg bearing ("berried") females to protect the fertilised eggs that they hold. While the fishery was summer-based, this prohibition did not have a major impact on the catch composition. However, now that the fishing is occurring predominantly during winter, and females bear eggs at this time, there has been an increase in the proportion of males in the retained catch (Figure 2).

It has been suggested that the higher proportion of males in the catch has reduced the number of males in the population and therefore impacted on breeding success. The availability of suitable mates may limit the reproductive success in lobsters (MacDiarmid and Butler 1999). Decreasing abundance of large male rock lobsters may cause the females to mate with smaller males (MacDiarmid *et al.* 2000). These smaller males have less sperm available to fertilise eggs and the clutch size is reduced (MacDiarmid *et al.* 2000). In fact, mating can be completely unsuccessful if the female is much larger than the male (MacDiarmid *et al.* 2000).

Fishermen have observed "pink" females and females with long ratty setae, which show no evidence of egg bearing, during the berry season. When females are not fertilised their eggs are reabsorbed into the ovaries resulting in pink staining of the blood and muscle (MacDiarmid *et al.* 1999). Premoult lobsters can also appear to be slightly pink and it is possible that these make up some of the sightings.

Until now there has not been a formal assessment of whether there has been an increase in the number of females that have not mated successfully. Trophia Ltd. was commissioned by the NZ Rock Lobster Industry Council (NZ RLIC) to examine the available data for evidence of changes in the breeding success of rock lobster populations. In this report, we also highlight further research needed to investigate this issue and suggest alternative management strategies for mitigating the effects of changes in fishing season on egg production.

Figure 1. Proportion of rock lobster landings in the Autumn/Winter period within CRA 2, 4, 5 and 8.

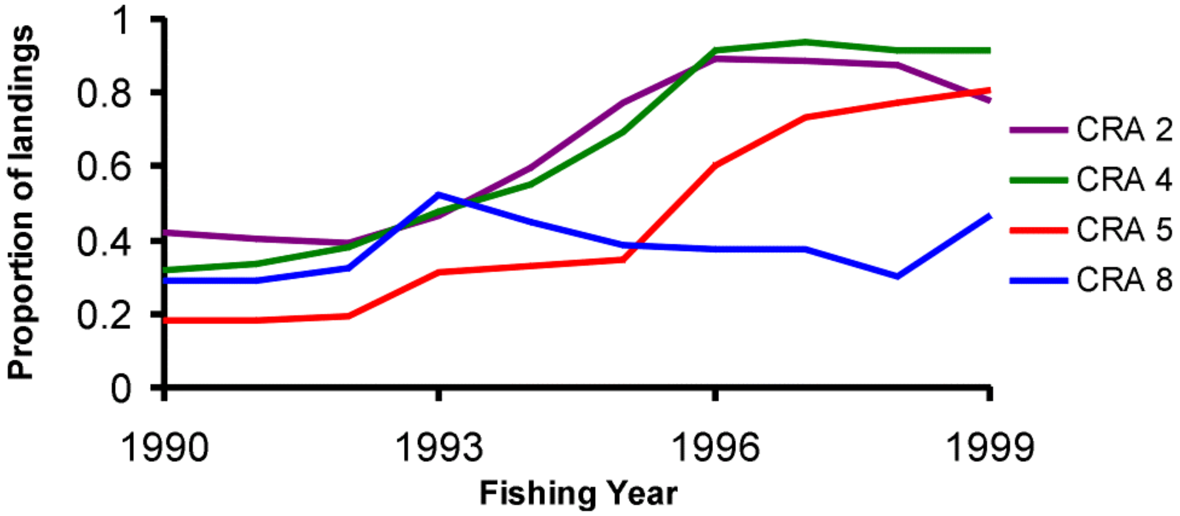
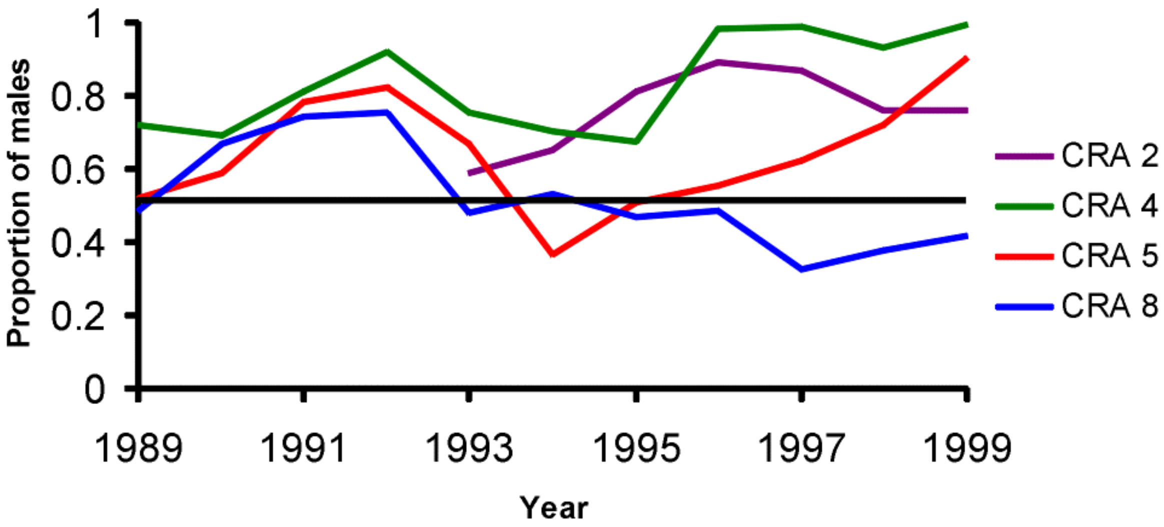


Figure 2. Proportion of male rock lobsters in the retained catch from CRA 2, 4, 5, and 8.



2. Methods

We examined catch sampling data from industry logbooks and scientific observers, and used the proportion of mature females in berry as an index of breeding success. Details from over 270,000 female lobster captures were used in the analysis.

Several factors affect the proportion of mature females in berry. These include the water temperature, depth of potting, and year. In order to separate the effects of these factors, from actual changes in the proportion of mature females in berry between fishing years, a standardisation of the catch sampling data was undertaken. In the standardisation model, females were assumed to start to enter into berry when the average monthly sea surface temperature fell to a certain level. The model assumed that the berried females shed their eggs after the accumulated temperature had reached a level high enough for egg development. This is consistent with laboratory observations on the timing of egg shedding relative to temperature in spiny rock lobster (Tong et al 2000).

Four QMAs were chosen for analysis. CRA 2, CRA 4 and CRA 5 have shown marked changes from summer to winter based fisheries. CRA 8 was chosen to contrast these areas, as it has not had a marked shift in the seasonality of the fishery. Within each of these QMAs a part of the fishery was selected based on the availability of long running catch sampling and sea surface temperature data (Table 1).

Table 1. Description of the areas used for analysis

Name	CRA Area	Statistical Areas
Bay of Plenty	2	906 and 907
Wairarapa	4	912 and 913
Kaikoura	5	917
Fiordland	8	926 and 927

3. Results

The model's predicted values for reproductive success fit observed values well for the Bay of Plenty (Figure 3), Wairarapa and Kaikoura. However, the model did not provide a robust fit for the Fiordland data due to the low quantity of data available from the peak egg bearing period. A model that fits to time of year rather than temperatures could fit the Fiordland data more satisfactorily.

Where there is a distinct difference in temperatures between areas and years, the effect of temperature can be clearly seen in the model (See Figure 4). Low temperatures are required to trigger the females to enter berry. For example, in the Bay of Plenty, these temperatures are reached earlier in 1999 than in 1993. Due to higher temperatures the predicted proportion of berried females increases later in the year in 1999 than in 1993. The model estimated that 16 ^{0}C was the critical temperature at which 50% of the females enter the berried state.

The proportion of berried females decreased with depth, although this effect was slight. In Fiordland (where this effect was greatest), the model predicted that at 80-100m depth the proportion of mature females in berry would be about 75% of the proportion at 0-20m.

The effect of years on the proportion of mature females in berry varied between areas (See Figure 5). In the Bay of Plenty, the year effects were high and had low uncertainty. On the Wairarapa Coast, the year effects varied considerably until 1996 when the year effect became high and uncertainty was reduced. On the Kaikoura Coast from 1989 to 1994, the year effects were variable with high uncertainty. However from 1994 onwards the year effect was high and had lower uncertainty. In Fiordland, the year effect on the proportion of mature females in berry varied greatly from year to year and had high uncertainty.

Figure 3. Observed and predicted proportions of berried females in the Bay of Plenty.

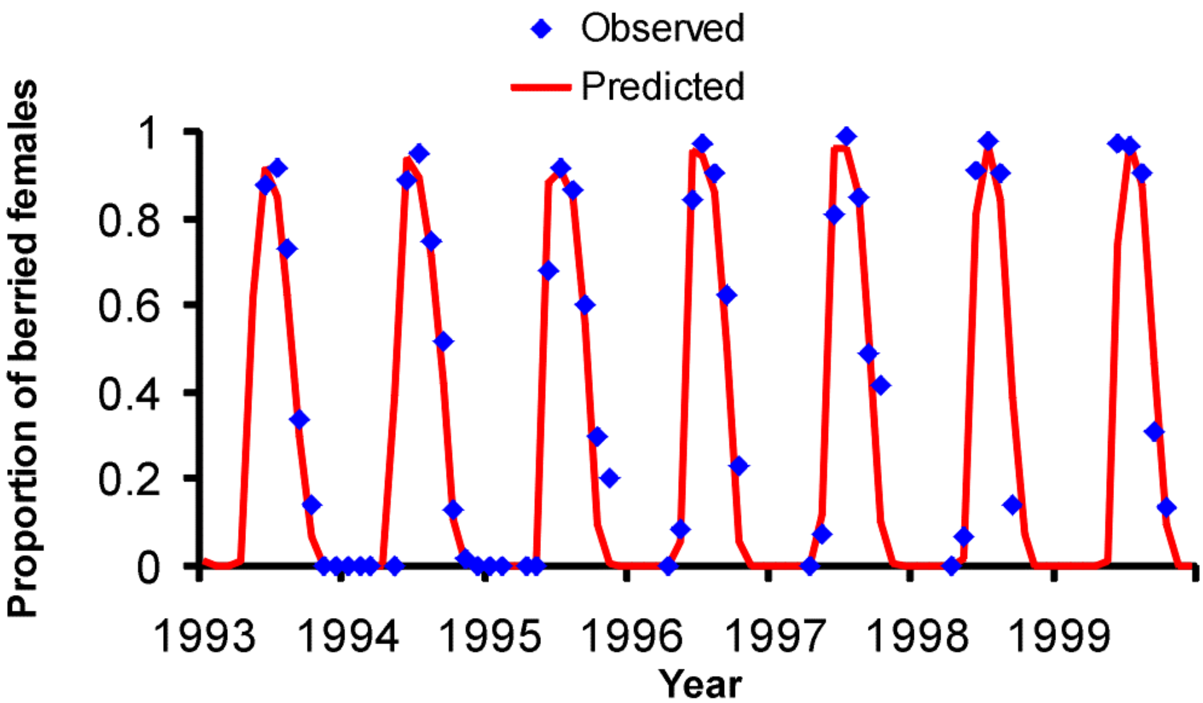


Figure 4. Temperature (°C) and predicted proportion of females in berry in the Bay of Plenty in 1993 and 1999.

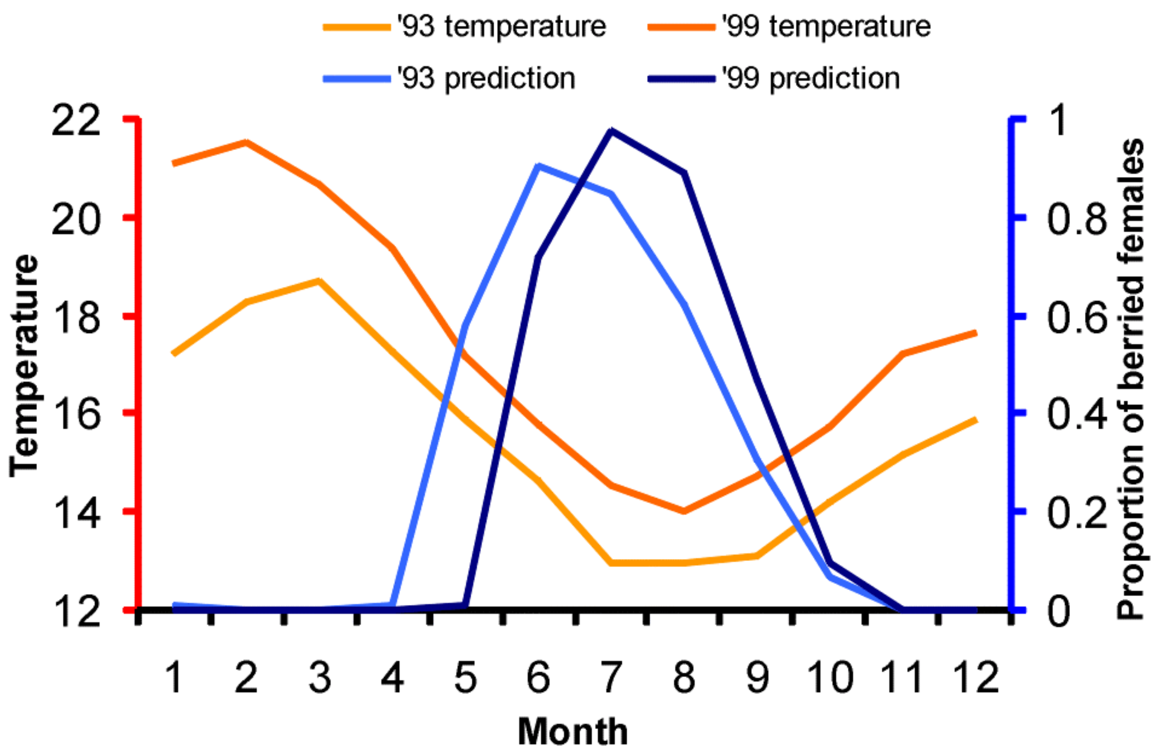
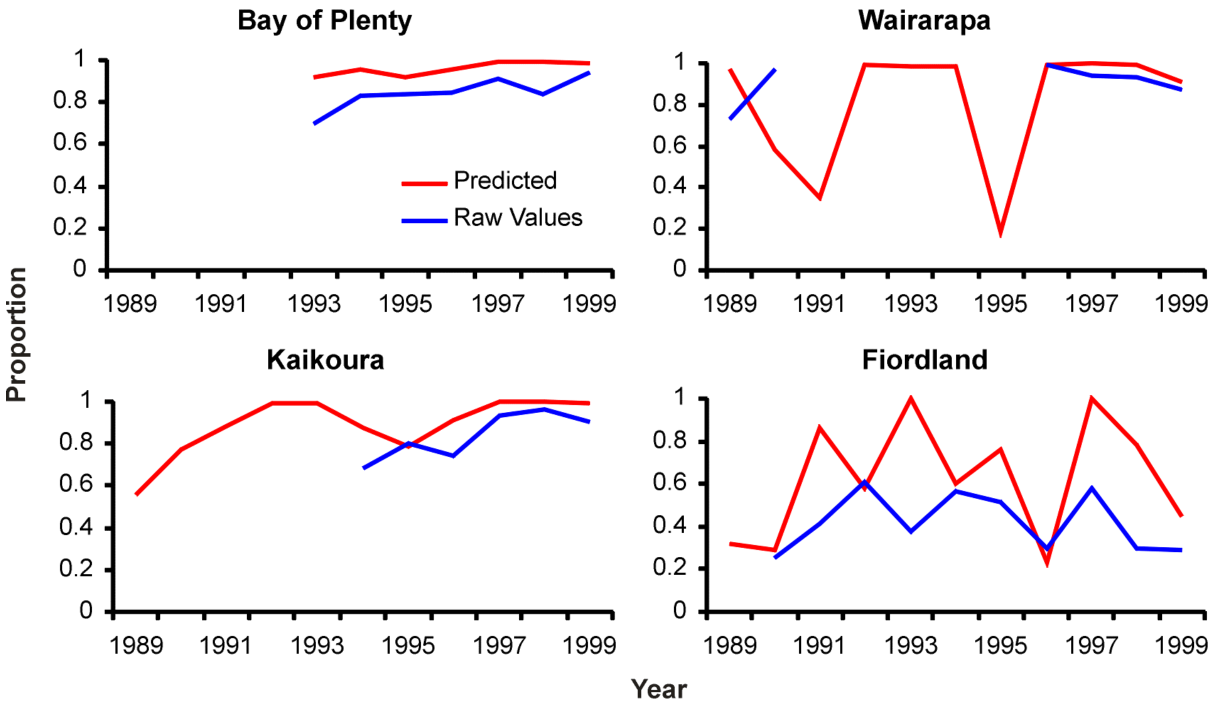


Figure 5. Raw values (from the peak three months in berry) and the yearly predictions for the proportion of mature females in berry.



4. Discussion

There is no evidence from this analysis to suggest that there has been a reduction in the proportion of mature females in berry. However, this result must be interpreted with caution due to limitations of the data.

Firstly, in some areas, in some years there was little data available for the months during which females were in berry. This can be seen in the Wairarapa, where there is no data available from 1991-1995 from the peak months for the proportion of females in berry (See Figure 5). This limited the ability of the standardisation to estimate some year effects from these years.

Secondly, females that are not successfully fertilised (pink females) may not enter pots as often as berried females. When females have ripe ovaries they do not feed, possibly due to the large size of their ovaries (MacDiarmid *et al.* 1999). Once they have extruded their eggs the newly berried females enter the pots very readily. In comparison the pink females may not feed due to their still large ovaries, these animals may gradually start to feed as their eggs are reabsorbed. This may mean that pink females do not enter pots as readily as berried females. Therefore it is possible that an increase in pink females will be masked in catch sampling data.

Finally, the data used in this analysis allowed only for the presence/absence of eggs to be examined. The reproductive success of rock lobsters may also be reduced by a decrease in clutch size. Changes in the average number of eggs held by berried females would be the best way to assess the effects of higher exploitation rates on males. In order to detect such changes, data on the number of eggs per female would be needed.

Possible effects on the fisheries

A reduction in breeding success will effect egg production. This effect may last longer than one mating season. The reabsorbtion of eggs damages the ovaries and reduces the clutch size for at least the following mating season (MacDiarmid *et al*. 1999).

The results of stock assessments suggest that recruitment variation is an important factor in New Zealand rock lobster fisheries. Recruitment to the fishery is not solely a function of egg production, it is also dependent on environmental factors which alter the settlement and survival rates of larvae and juveniles. While the recruitment to the fishery in any one year probably has more to do with environmental variation than with egg production, the chances of getting low recruitment are higher if egg production is lower.

Current regulations protect females with fertilised eggs. But it is not necessarily the most effective way to ensure high egg production. Males and mature females not in berry are just as important as berried females in the production of fertilised eggs. If a mature female is taken just before she goes into berry, the effect on total egg production is the same as if she is taken when bearing eggs. Thus, while the existing regulations protecting berried females are an intuitively appealing way to maintain egg production there may be more effective measures.

Management strategies to enhance reproductive success

While this research has shown that there has been no detectable change in the proportion of females in berry, there is a range of management strategies that could be considered if indicators of poor breeding success became evident in future stock monitoring. If the economic incentives to fish during the winter continue, reductions in the TAC alone may not be sufficient to increase the breeding stock abundance unless they effectively constrain catches taken during the winter. Below are several management strategies that could be included within the current management objective of B_{MSY} (the biomass that produces maximum sustainable yield). The strategies suggested aim to optimise the reproductive success of the fishery by better balancing the fishing pressure between the sexes.

Lift the prohibition on the capture of berried females

Lifting the prohibition on the capture of berried females would even up the exploitation rates on males and females. The size at which females mature and the minimum legal size limit vary among areas. However, in most areas the size limit is high enough to ensure that most females are mature before they can be caught. This, and limits on exploitation rates brought through catch quotas, may allow sufficient egg production to be maintained even though some fertilised eggs will be removed. This strategy assumes that reducing the exploitation rate on males would increase the numbers of larger males, which would increase breeding success enough to compensate for those eggs being removed when berried females were retained. This strategy would have the advantage of allowing fishers to catch more lobsters for the same effort when market prices are high.

A variation on this strategy would be to have a brief ‘open season’ during the winter when berried females can be caught. This would reduce the fishing pressure on the males while still maintaining some protection for females in berry.

Divide quota between the autumn/winter and spring/summer seasons

This would force fishers to catch some of their quota during the summer when females are not in berry and thus reduce pressure on males. Its effect would be similar to removing the prohibition on taking of berried females – a mature female taken during summer is one that could bear eggs in the following season. This strategy would force fishers to take catch when prices are not as high and require rock lobster exporters to reconsider existing marketing arrangements and develop new markets to retain the current economic return for the commercial catch. This strategy would be more difficult to enforce than current quota arrangements.

Divide quota between the sexes

Quota could be divided between the sexes, without changing the prohibition on taking berried females. This would reduce the fishing pressure on males and allow a more balanced sex ratio. Research to determine the ideal sex ratio would be required. Females would need to be targeted when they are out of berry, when the market prices are lower. This strategy is probably the hardest to enforce, as the sexes would need to be recorded separately by the fish receivers.

Alternative size limits for males

Increasing the minimum legal size for male lobsters will increase the abundance of male lobsters, ensuring that there are more males available to fertilise eggs. These males would be relatively small, resulting in reduced clutch sizes but fewer females would need to reabsorb their eggs.

Establishing a maximum legal size for males would protect the larger males, which are able to fertilise larger clutches. However a maximum legal size would increase the fishing pressure on males below this size. Most of these males would be taken out of the population before they reach the maximum legal size. While these options would be reasonably easy to enforce, they are not necessarily very effective.

Marine Protected Areas

Marine protected areas would provide spatial refuges for both males and females. This would provide guaranteed egg production from these areas. However, there is uncertainty over what proportion of the population would need to be protected in order to provide sufficient egg production to the fishery as a whole. Too large an area under protection may be counterproductive if it causes higher fishing pressure in surrounding areas. This effect will depend on the level of movement of lobsters from reserves to fished areas and the relative egg production in protected and unprotected areas. Such refuges for breeding stock (areas closed to rock lobster fishing) already exist in CRA 1, CRA 2, CRA 3, CRA 5, CRA 7, CRA 8 and CRA 9, but their effectiveness is unknown.

What's next?

To better assess the status of rock lobster reproductive success further monitoring is necessary. Firstly and most simply, the catch sampling performed by technicians and fishermen need to record 'pink' females. It will be important to separate the lobsters that are about to moult (which can appear to be slightly pink) from the pink females whose colouring is caused by the retention of the unfertilised egg mass. Secondly, monitoring the average clutch size and the abundance of mature females would allow for estimates of the overall reproductive success in terms of overall numbers of eggs produced by the population.

5. Acknowledgements

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6. References

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