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WILL THE REMOVAL OF CLOSED SEASONS FROM THE MANAGEMENT SYSTEM OF THE TASMANIAN ROCK LOBSTER FISHERY HARM THE RESOURCE?

C. Gardner and S. Frusher

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Tasmanian Aquaculture and Fisheries Institute
Marine Research Laboratories

Will the removal of closed seasons from the management system of the Tasmanian rock lobster fishery harm the resource?

Caleb Gardner and Stewart Frusher

Summary

The Tasmanian rock lobster fishery is managed by a total allowable commercial catch (TACC) under an individual transferable quota (ITQ) management system, which was implemented in 1998. Under ITQ, it may be possible to remove seasonal closures without increasing fishing mortality. The incentive for removing seasonal closures is to allow fishers to maximise the economic benefit from lobsters by fishing when returns are highest.

This system negates the incentive for speculation on lobster prices by holding them in tanks or cages until they can be sold at the market peak. Although closed seasons appear to be superfluous under ITQ, concerns have been raised about the effect on discard mortality. Discard mortality is an additional increase in mortality due to fishing, so an increase represents a hidden increase in the TACC.

Issues relating to the removal of closed seasons that are discussed in this report are:

i) the effect of increased fishing effort during the period when females are ovigerous or berried. As berried females will be discarded, removing closed seasons may increase discard mortality.

ii) seasonal patterns in octopus predation. By shifting effort between different months, the extent of octopus predation in pots can be altered.

iii) the effect of increased exploitation of males on sex ratios. More females will lead to increased egg production, but infertility due to lack of males may also result.

iv) the effect of increased handling on damage to females. Limb loss reduces growth and can prevent reproduction in severe cases.

v) the effect of closed season on egg production and legal sized biomass.

This analysis concluded that the removal of closed seasons would lead to slightly higher egg production, and slightly lower residual legal sized biomass. However, both these effects are likely to be minor. Available data on issues i) to iv) listed above are presented although it was not possible to fully evaluate the effects of these factors with available data. Further research on product quality is planned during the extended opening in September 2000.

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1. Introduction

Closed seasons are widely used in fisheries management as a control on effort. In short lived species such as prawns, the timing of seasonal closures can influence the mean size at capture and thus the yield of the stock (Somers and Wang, 1997). Seasonal closures are generally more simplistic in longer lived species where they serve as a constraint on effort, although there is often an attempt to link the closed period to an annual pattern of aggregation or reproduction. Most lobster fisheries incorporate seasonal closures of some kind (Phillips *et al.*, 1994) and these can be timed around the periods when females are carrying eggs, or when moulting occurs.

The recent change to quota management in 1998 has resulted in an industry proposal to remove closed seasons - do we really need this input control when catch is capped?

Closed seasons in the Tasmanian lobster fishery have aimed to limit the harvest of soft shelled males in late spring, and also to prevent the harvest of females during winter and spring when they are carrying eggs. The goals of these management restrictions are varied and include: i) reduced wastage of discarded dead soft-shelled males; ii) protection of market demand by minimising the distribution of poor quality males; iii) protection of egg production.

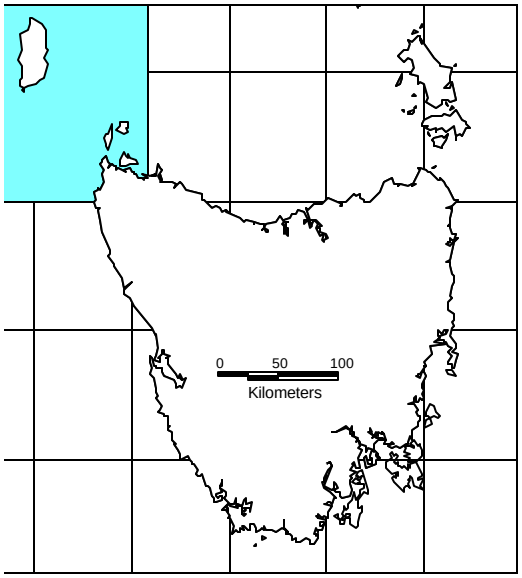
The last of these objectives, the protection of egg production, is of particular importance as egg production is an area of concern in the current management plan (Anon, 1997). Readers of this report should note that all analyses assume retention of the current management restrictions that prevent the taking of berried females. This restriction tends to closely simulate the effect of the female closed season as most females above legal size are berried during the period currently closed for harvest of females. The protection of berried females is a traditional management measure, which shifts effort from females to males.

Seasonal closures are an important issue for the commercial fishery as they can have a profound impact on the economic yield of the resource. Market prices fluctuate on a seasonal basis (Gardner, 1999) and the requirement for fishers to sell all stock by the end of the open season creates a short period of excess supply which reduces prices. Conversely, proposals to lift closed season restrictions has concerned some processors as they anticipate it will result in the increased landing of soft-shelled or recently moulted fish. It is argued that these poorer quality animals may affect market demand for the State's supply of Australia's premium lobster.

1.1 Historical patterns of seasonal closures in the Tasmanian rock lobster fishery

Closed seasons were first considered in Tasmania by the Royal Commission on the Fisheries of Tasmania, 1882 who recommended a closed season for lobsters from December to February when lobsters were "soft in the flesh and considered unfit for consumption" (Winstanley, 1973). This recommendation was not included in the subsequent Fisheries Act of 1889.

It was not until 1926 that closed seasons were first introduced in Tasmania by the Sea Fisheries Board (see Table 1 and Table 2). This closure was for the months of November and December and was intended to protect soft shelled males. After only one year it was decided that the closure was not worthwhile so it was dropped in favour of restrictions on the taking and possession of soft shelled lobsters (Winstanley, 1973). Closures were discussed several times over the following years until in 1947 new provisions were made in the Sea Fisheries Regulations to prevent the harvest of females from June to November (inclusive) and males from 1 September to 14 October. A small region of the north-west from Bluff Point to Duck river was treated separately and was closed for males during January only. The closed season for females was reduced by one month in 1960 so that it ran from June to October (Winstanley, 1973).



These restrictions remained largely in place over the following two decades although the closed season for males was later extended to finish at the end of October, as for females (Harrison, 1986).

In the 1990's, closed seasons were extended in an attempt to reduce effort (Frusher, 1997). These changes included commencing the closed season for females one month earlier in May (Kennedy, 1992), extending the closed seasons for both sexes until later in November (eg 18 November, 1996), the introduction of a closure over the Christmas break (21 December - 3 January), and a two week closure at the end of February. These additional closures appeared to have no impact on annual effort and compounded the marketing problems of a glut of product immediately prior to the season closure.

A two-week closure in the last half of February was introduced in 1997 in an attempt to reduce annual effort. Although unsuccessful at reducing effort, the closure was retained in 1998, which was the first year of quota management. This is because it provided a useful gap for enforcement of the end of the quota year, which runs from 1st March each year. In subsequent years this gap was reduced to a single week and the short closure over Christmas was abandoned as it was considered counterproductive to optimising economic return.

The closed season for males has been reduced over the period 1997-2000 to provide fishers with the flexibility of taking their quota at this time if they believe economic yield can be optimised. The opening of September in 2000 was also driven by predicted increase in demand for rock lobsters on the domestic market during the Olympic games in Sydney.

Male rock lobsters from the south of the State are often soft shelled during September and in poor condition, while those in Northern regions have less defined moulting periods and are more likely to be in marketable condition. Industry opinions on the need for a closed season are mixed, with some participants favouring retaining the seasonal restrictions of 1999, while others would prefer to remove them entirely. Consideration of the need for closures is difficult without information on their impact, which this report aims to address.

Table 1. Seasonal closures for male lobsters: 1925-2000.

	J	F	M	A	M	J	J	A	S	O	N	D
1925												
1926											1st	31st
1927												
⋮												
1946												
1947									1st	14th		
1948									1st	14th		
1949									1st	14th		
1950									1st	14th		
1951									1st	14th		
1952									1st	14th		
1953									1st	14th		
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1959									1st	14th		
1960									1st	14th		
1961									1st	14th		
1962									1st	14th		
1963									1st	31st		
1964									1st	31st		
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1991									1st	31st		
1992									1st	31st		
1993									1st		14th	
1994									1st		14th	
1995									1st		30th	
1996									1st		18th	21st →
1997	3rd	15th-28th							1st		21st	21st →
1998	3rd	15th-28th							16th		14th	
1999		24th-28th							16th		13th	
2000		24th-29th								1st	14th	

Table 2. Seasonal closures for female lobsters: 1925-2000.

	J	F	M	A	M	J	J	A	S	O	N	D
1925												
1926											1st	31st
1927												
|												
1946												
1947						1st					30th	
1948						1st					30th	
1949						1st					30th	
1950						1st					30th	
1951						1st					30th	
1952						1st					30th	
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1960						1st				31st		
1961						1st				31st		
1962						1st				31st		
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1992						1st				31st		
1993					1st						14th	
1994					1st						14th	
1995					1st						30th	
1996					1st						18th	21st →
1997	3rd	15th-28th			1st						21st	21st →
1998	3rd	15th-28th			1st						14th	
1999		24th-28th			1st						13th	
2000		24th-29th			1st						14th	

2. Methods

The effect of closed seasons was evaluated by simulation with the Tasmanian rock lobster stock assessment model with separate simulations conducted for each of the eight stock assessment regions (Figure 1). Some issues are beyond the capability of this model and information is presented on these separately. These additional issues are: i) the seasonal patterns of octopus predation; ii) change in the sex ratio; and iii) increased damage to limbs and antennae.

The structure of the rock lobster stock assessment model is described elsewhere and will not be discussed here in detail (Kennedy, 1998; Punt and Kennedy, 1997; Punt *et al.*, 1997). Fixed aspects such as size limits and recreational catch estimates were the same as those described by Gardner (1999). Simulations with the stock assessment model were conducted with the TAC fixed at 1500 tonnes per annum and estimable parameters based on the model fit used for the 1998/99 stock assessment (Gardner, 1999). Simulations presented here are the means of 100 simulations per scenario. Biomass estimates are for the month of November.

Closed seasons were simulated for whole months only with the female closed season running from May to October (inclusive) and the male closed season running from September to October (inclusive). It was considered that any effect of the current management regime of a single week closure at the end of February would be trivial and this closure was ignored. Fishing mortalities in months historically closed to fishing were estimated based on the fishing mortality of either August or November (whichever was highest).

Unlike previous applications of this model for simulation purposes, discard mortality was included in the model at a fixed estimated value of 5% (Frusher and Gardner, 1999; Gardner, 1999; Frusher, 1997; Kennedy, 1998).

Data for octopus predation of lobsters in pots was drawn from both commercial logbook data and research catch sampling data for the period September 1992 to August 1999. This represents a survey of over 14 million commercial pot hauls and 34 thousand research pot hauls. Research data was necessary for providing information on rates of octopus kills during closed seasons.

Research catch sampling data from 1992 to 1999 was also used for analysis of the effects of closed seasons on limb loss and other damage. Damage to all animals captured in this program is recorded with new damage differentiated from old damage by the presence of a black plaque over the damage site.

Sex ratio information is derived from biomass estimates of the stock assessment model for the month of November in each year. Legal sized biomass was combined with the biomass of animals one moult increment below legal size. No attempt was made to weight this biomass by size at maturity to provide a sex ratio for mature animals only. This is because size at maturity of males is not known. Sex ratios presented here simply represent the ratio of the biomass of males relative to the biomass of females. In practice, this will skew the ratio towards males as females tend to lighter, however, interannual comparisons remain legitimate as the bias is consistent.

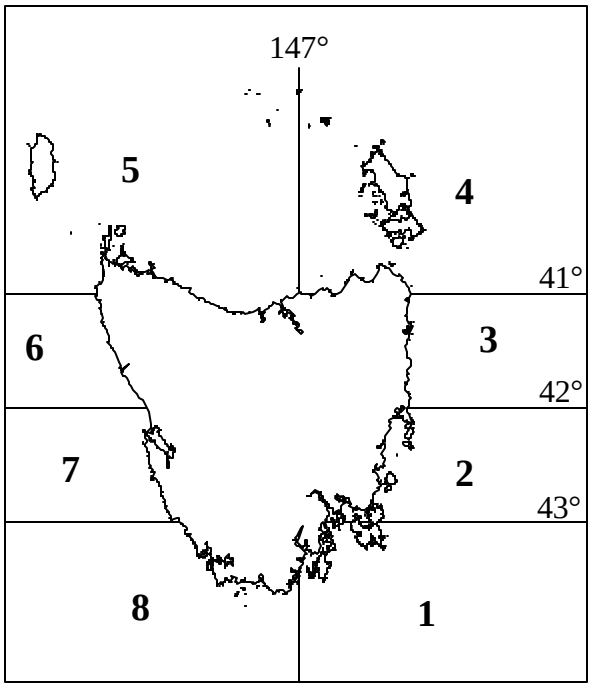

Figure 1. Eight stock assessment regions used for simulating the effects of seasonal closure. Biological parameters vary around the state, particularly between north and south, so regional patterns can be expected to differ.

3. Model outputs on the effect of removing closed seasons on egg production and biomass

The removal of closed seasons generally led to increased egg production (Figure 3), but reduced legal sized biomass (Figure 2). These patterns were consistent at a regional level and on a statewide basis. The mechanism of the change in egg production and legal sized biomass appeared to be the shift of fishing effort away from females and onto males. Egg production increases as more females are retained in the fishery. Legal sized biomass is reduced as males tend to grow more than females, so the potential increase in biomass from residual legal sized animals is reduced.

Increase in egg production as a result of the removal of closed seasons tended to be more pronounced the north, while biomass effects were similar for all regions.

The simulations suggest that although the removal of closed seasons affect egg production and biomass, the magnitude of the effects are small, and probably insignificant for management purposes (Figure 4 and Figure 5).

While this appears encouraging for the removal of closed seasons, given the potential economic benefit of harvesting lobster when prices are highest, the model contains assumptions and omissions that may be important. In particular, these include the assumption that discard mortality is consistent year round and is 5%. We know that octopus predation and moulting are seasonal so this assumption is doubtless violated, but the importance of any seasonal effect may be trivial. Likewise the model does not incorporate any loss of fertility due to reduced proportion of males in the population.

Another important variable in the model outputs is the effect of season on catchability. Male lobsters tend to have low catchability during the months August to October as they feed less when the water is cold and they are approaching a moult in late October/November. This low catchability is one reason why the effect of seasonal closure is so trivial in these projections. An implication of this is that if the estimates of monthly catchability used in the model are incorrect, then the projections won't represent reality. While we would have faith in projections for most months of the year, we have very little data for the months of September and October, simply because the fishery is normally closed at this time. Catchability in the model is estimated arithmetically from commercial data in the stock assessment model so research data collected during the closed season does not contribute (Punt and Kennedy, 1997).

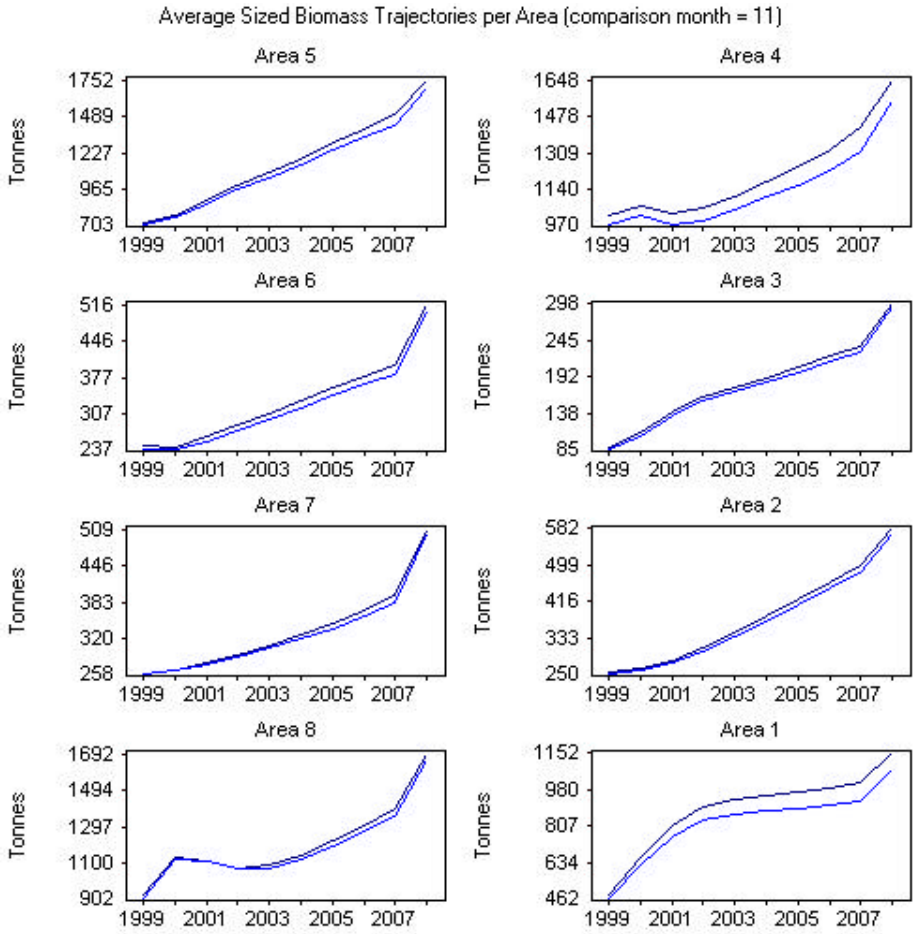

Figure 2. Predicted legal-sized biomass projections under scenarios of no closed season (lower pale line in all plots) and with closed season (upper dark line in all plots). Note that closed seasons tend to increase the legal sized biomass, but that the effect is relatively small.

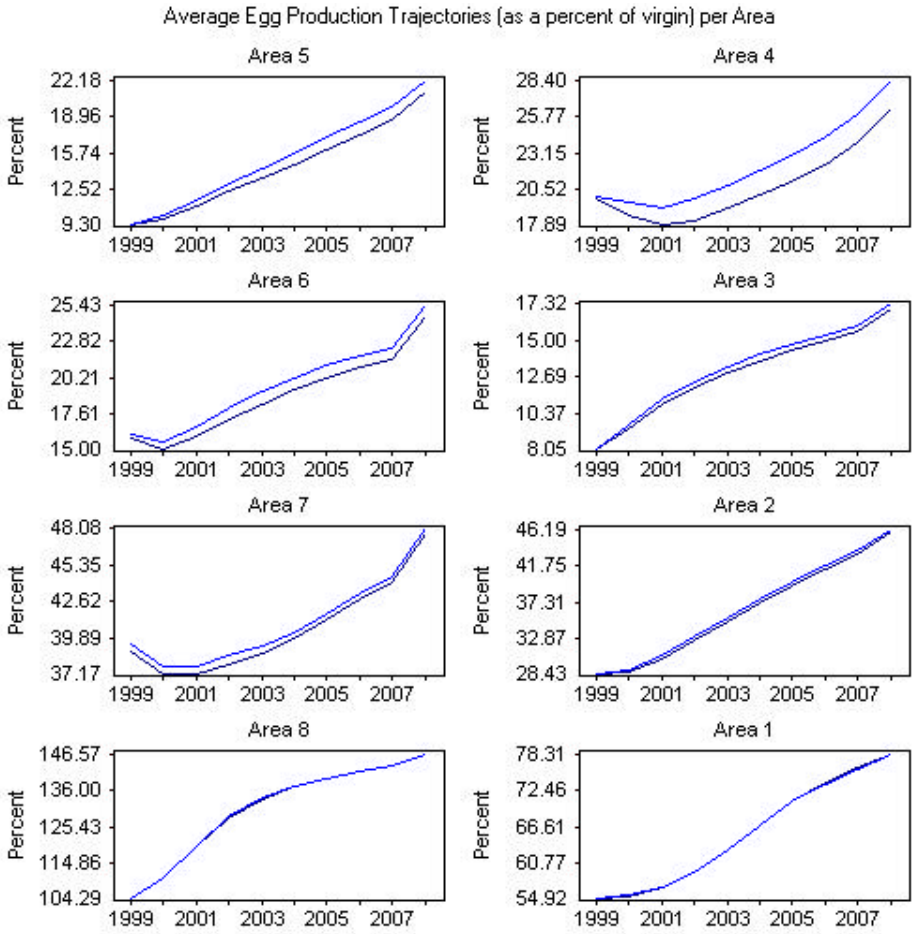

Figure 3. Predicted egg production relative to virgin projections under scenarios of no closed season (upper pale line in all plots) and with closed season (lower dark line in all plots). Note that closed seasons tend to reduce the egg production relative to virgin, but that the effect is relatively small.

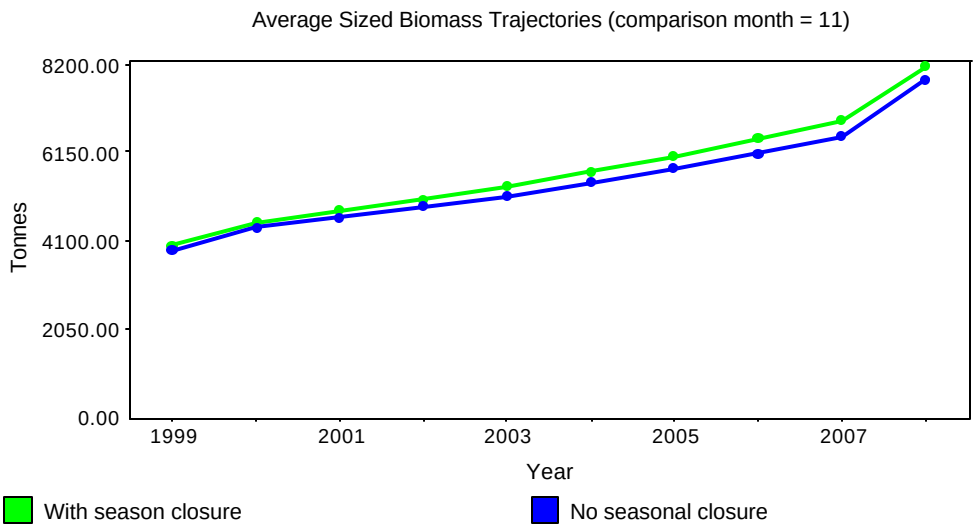

Figure 4. Predicted legal sized biomass projections on a statewide basis under scenarios of no closed season and with closed season. Note that closed seasons tend to increase the legal sized biomass, but that the effect is relatively small.

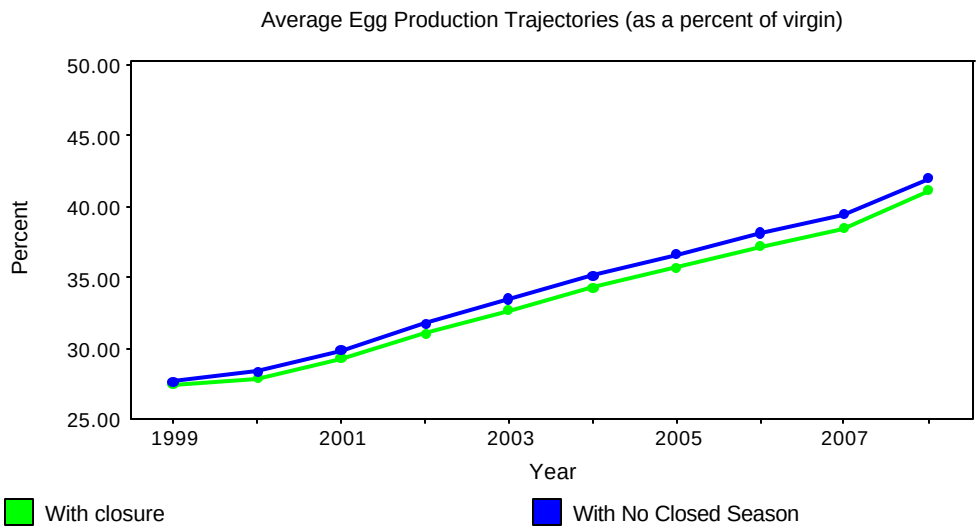

Figure 5. Predicted egg production relative to virgin projections on a statewide basis under scenarios of no closed season and with closed season. Note that closed seasons tend to reduce the egg production relative to virgin, but that the effect is relatively small.

4. Seasonal patterns in octopus kills

Octopus kills are an important source of mortality of rock lobsters associated with fishing and were one of the first issues to be considered in management of the Tasmanian rock lobster resource by the Colony of Tasmania in 1882. Tasmanian fishers in the late 1800's and early 1900's opposed the use of pots on the basis that they increased kills by octopus (Wilson, 1986). This reluctance to adopt the use of pots bewildered the Commissioner of Fisheries in 1884 who commented that "the use of crab pots, as utilised in almost every other country on the face of the globe, might be advantageously recommended to the fishermen of Tasmania" (Saville-Kent, 1884). Legislation to allow the use of lobster pots was finally introduced in 1926 (Winstanley, 1973).

Because we assume that confinement of lobsters within the trap increases the ability of octopus to kill lobsters, this mortality is considered a form of fishing mortality. If the incidence of octopus predation increases during the months that are currently closed, then we would expect the lifting of seasonal closures to have a negative impact - in effect, the total catch would be raised, even if landings remained at 1500 tonnes.

We first looked at the issue of rock lobster mortality due to octopus in relation to the sex of the lobster: would changes in the sex ratios of catches during the months of September and October affect mortality ? The results of this analysis showed that sex of the lobster had no effect on the likelihood of it being killed by an octopus - clearly octopus don't target a particular sex of lobster, which is no surprise (Table 3).

Table 3. The effect of lobster sex on octopus kill rate using arc-sine square root transformed data. Monthly results are treated as replicates for research samples from September 1992 to August 1999. Samples with less than 400 animals of either sex were excluded. It is not possible identify the sex of around 5% of lobsters killed by octopus and these animals were excluded.

Source of variation	D.F.	S.S.	F	Prob.>F
Sex	1	0.000085	0.0276	0.869
Error	70	0.2147		

Seasonal patterns in octopus kills reported by commercial fishers and in research sampling are shown in Figure 6. Octopus predation peaks around the time of the closed season so we may expect increased octopus predation through increased fishing effort in September and October. Estimating the potential increase in octopus predation through the removal of closed seasons is impossible without: i) infomation on the likely shift of fishing effort into months currently closed; ii) improved analysis of spatial and depth patterns of octopus predation; and iii) improved information on the temporal patterns of octopus predation during September and October.

Without the ability to conduct meaningful, accurate, estimates of the effect of removing closed seasons on octopus-related mortality, it may be helpful to consider extreme possibilities. For instance, what if the higher seasonal octopus predation in September and October doubled the total number of octopus kills from that which we see currently?

The average total weight of rock lobsters in traps killed by octopus per annum for the last 7 years was around 45 tonnes, so an increase of 100% would cause an increase in the total mortality equivalent to around 50 tonnes statewide. Although this is not ideal, it doesn't represent a major impact as an extreme upper limit.

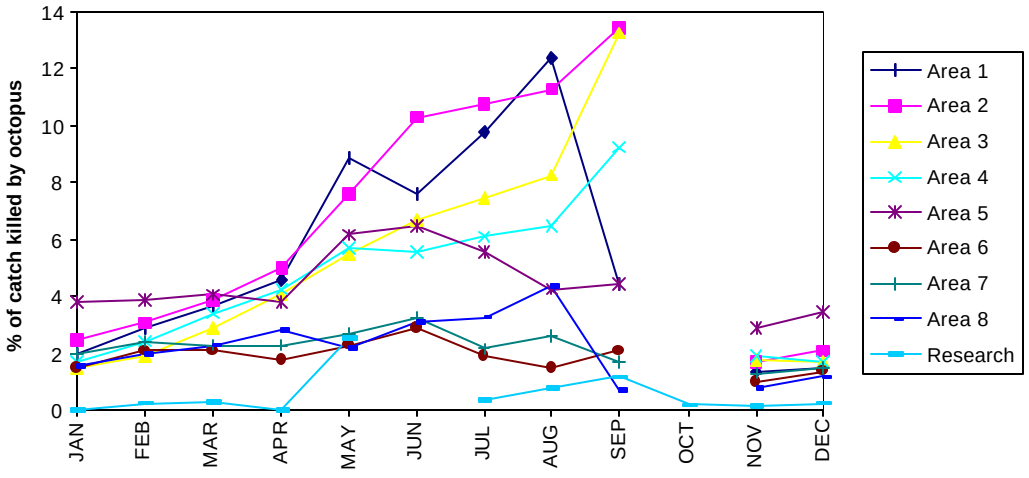

Figure 6. Seasonal patterns in octopus kills from each stock assessment area (commercial data) and from research sampling. The months of September and October are currently closed. September appears to be a peak period for octopus kills. We have very little data on octopus kills from October although research data suggests that the rate of octopus-kills drops dramatically from September to October.

5. The effect of seasonal closures on sex ratios.

Sex ratios of catches are estimated in the stock assessment model based on the reported sex ratios in research catch sampling and other associated projects. Model projections of biomass are split into sexes by necessity as growth rates vary for each sex. This has made it possible to examine the effect of seasonal closure on sex ratio, which is of some concern due to recent research in New Zealand. MacDiarmid and Butler (in press) have demonstrated that the size of female egg clutches is influenced by the size of the sperm packet that is received at mating. In populations where the ratio of males to females is strongly skewed towards females, sperm can become limiting and egg production declines. In extreme situations where mating does not occur, the eggs are not extruded from the ovary and are resorbed into the haemolymph (blood). This can result in ovarian scaring which results in reduced future broods, or even death of the female.

Removing the closed season would be expected to increase the fishing pressure on males, but reduce the pressure on females, so that the sex ratio becomes skewed towards females. Model projections of this effect are shown in Figure 7. Results of the model simulation process indicate that the effect of seasonal closure on sex ratio is only of the same order as normal fluctuations in sex ratios seen since 1970. These "normal" fluctuations result from changes in fishing effort during months when the fishery is open but females are berried.

There are several other issues associated with the effect of seasonal closures on sex ratio which are difficult to assess. Most importantly, the analysis shown in Figure 7 does not consider the ratio of mature males to mature females, because we have no information on size at maturity of males. This information could dramatically alter our interpretation of the effect of opening seasons on the potential for sperm limitation.

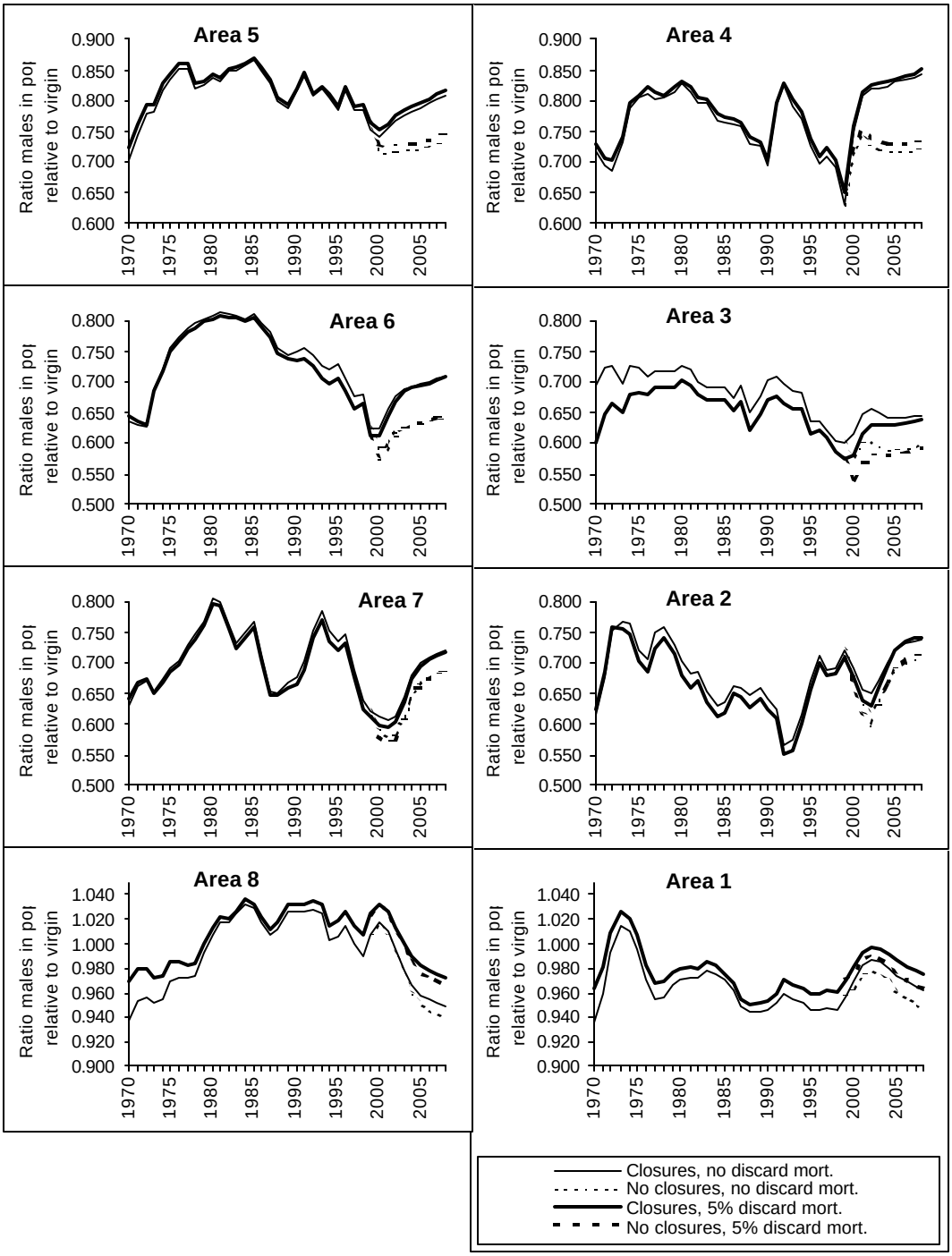

Figure 7. The effect of seasonal closures on the sex ratio of lobsters in November from 1970 to 2008. Simulations were conducted for each area - these were simulations with and without discard mortality, and with and without closed seasons. A sex ratio of 1 represents a situation of 1 male to 1 female. Sex ratios of less than 1 represent situations s kewed towards females so that a ratio of 0.5 represents a situation of 2 females to every male. Data is for legal sized animals and undersized of 1 moult below legal size combined. Note that the inclusion of discard mortality into the model results in some variation in estimates of sex ratio. Simulations of the fishery without seasonal closures indicate that the proportion of males will decline, but predictions are that the magnitude of the change is less than historical fluctuations.

6. Discard Mortality and Damage

An effect of removing seasonal closures will be that more females are captured and then returned or discarded. This was discussed in relation to octopus kills above, but another impact may be the increased loss of legs and antennae from animals that are captured and returned on several occasions.

To examine the importance of damage to lobsters during normal fishing operations we reviewed the extent of damage that occurred capture of rock lobsters for research catch sampling (Table 4). This indicated that around 9% of animals suffered damage or loss to one or more legs. A reduction in growth is of concern for fisheries management as this may reduce the sustainable yield. However, the effect of the problem will be controlled by the extent of fishing that would occur during the months that are currently closed.

Damage to females during handling already has a negative impact on yield from the resource during the period when the female season is closed and the male season is open. Note that reduced growth through damage is negative only in terms of yield from the resource. Egg production may actually increase as females may have more mature instars below legal size, although brood size is reduced (Norman and Jones, 1993).

A more thorough analysis of the effect of damage on growth is required to evaluate this aspect in more detail. A brief analysis of damage in Southern rock lobsters was conducted by Leslie (1997) who concluded that growth is affected by damage, which is typical of crustaceans (Shirley and Shirley, 1988; Smith, 1990). Leslie (1997) found that damage tended to reduce growth, but generally of a magnitude less than normal variation between individuals. Damage effects on growth were difficult to detect in lobsters from slower growing areas in the south, or areas with high variation in the north. Effects of damage were most apparent in faster growing areas on the east coast where loss of one or two legs resulted in a 27% and 29% decrease in moult increment for males and females respectively.

Damage to limbs of rock lobsters would also be expected to increase discard mortality as this has been documented in other crustaceans (Kirkwood and Brown, 1998). The magnitude of this effect may be trivial but requires further analysis. This could be completed with existing tag-recapture data from Tasmanian research programs.

Table 4. Proportion of lobsters in research surveys with significant damage considered likely to influence growth.

This damage includes loss of legs, antennae, uropods or severe damage to carapace or abdomen. Lobsters with both old and new damage are recorded once only under new damage. Survey data is from the period September 1992 to August 1999.

	N	% of total
Total lobsters	160858	
Lobsters with no damage	121775	75.7
Lobsters with new damage	14410	8.9
Lobsters with old damage	24673	15.3

7. Conclusion

Analyses of the effect of lifting closed seasons presented indicated that although negative biological impacts may occur, they are likely to be small or even trivial in scale. This conclusion is made with the caveat that several aspects of the biology of rock lobsters in Tasmania needed for fully assessing the impact of closed seasons remain unknown. These areas are identified as topics for future research below. Nonetheless, with available information, it appears that the impact of the removal of closed seasons on economic yield from the resource is expected to of greatest importance.

The most important biological effect will be a shifting of effort from females to males. Model simulations predict that this will cause a slight decrease in biomass and a slight increase in egg production. Sex ratios will shift with an increase in females and a decrease in males predicted. The implications of this on reproduction are difficult to predict - increased number of females may result in increased egg production unless sperm limitation results in reduced fertility on a population level. Further research to investigate mate choice and onset of sexual maturity in males from different regions is recommended.

Increased fishing during periods when females are discarded will result in increased octopus predation and limb loss from females. The magnitude of both of these effects is difficult to predict with available information and further research is recommended.

The reduced closed season planned for 2000 will provide a valuable opportunity for assessing the effect of closed seasons on landed product. Aspects that should be monitored include the fluctuation in beach price during this period, landed catches, and the extent of landings of soft-shelled males. Research attention should also be paid to the potential for increasing fishing mortality by catching lobsters when their density is lower after moulting. Newly moulted animals may weigh less than intermoult animals which would result in more animals being captured in a unit of quota, which is based on weight.

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