Evaluation of Techniques for Estimating Fishery Assessment Parameters in the Tasmanian Rock Lobster Fishery

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Abstract

Rock lobsters are one of the premiere seafood products around the world. High demand has led to most lobster fisheries being over or fully exploited. The Tasmanian rock lobster fishery is no exception and has become a major industry for Tasmania since its rapid commercialisation in the early part of the last century. The Tasmanian fishery, based on the southern rock lobster *Jasus edwardsii*, is the backbone of the Tasmanian fishing fleet and provides valuable socio-economic input into many of Tasmania’s coastal rural towns. For this reason, the Government requires scientists to try to provide accurate and precise assessments of this fishery for their managers.

The most recent change in the assessment of this fishery was the development of a mathematical assessment model. In addition to assessing the current state of the resource, the model has forward projection capabilities so that future harvest strategies can be evaluated. Like all fishery models, the Tasmanian assessment model is based on a number of assumptions for estimating biomass and egg production. In addition, the model assumes that the dynamics of fishing remain constant from year to year. However, the dynamics of the fishery are changing as management, technology and markets change the behaviour of fishers. The change to an Individual Transferable Quota management system in 1998 has seen fishers focus on the dollar return per kilogram, rather than maximising their catch, as a way to improve profitability. Global positioning and echo sounder technology enable fishers to locate and chart lobster habitat better than ever before, and the rapid expansion of air transportation has seen the opening of Asian markets for premium priced live lobsters. To ensure that model estimates are reliable under changing patterns of exploitation, model estimates need to be validated. This is best achieved by estimating the same parameters using different techniques.

Trials to obtain estimates of exploitation rate and biomass using change-in-ratio (CIR) and index-removal (IR) techniques have provided encouraging results for southern regions of the Tasmanian rock lobster fishery. The latter two methods require that there be (at least) two surveys within a year, with harvest(s) occurring between surveys. The two methods have generally provided similar results. However, on
occasion, the CIR and IR results were widely divergent with the IR estimates of exploitation rate much higher than the CIR estimate. I examined the assumptions required to be meet for use of each of these techniques, especially the assumptions regarding catchability. Diagnostic tests were developed for each of the techniques to ensure that the assumptions of catchability are met. The CIR technique, which has a weaker assumption of catchability, was more robust than the IR technique. Application of the diagnostic tests resulted in several estimates being discarded. Despite this, exploitation rate estimates were available for five of the six fishing years. The diagnostic tests also demonstrated when an earlier than expected moult had occurred in the fishery. This moult affected the end of season sample which could no longer be used to obtain exploitation rate estimates.

In northern regions of Tasmania, moulting occurs within the fishing season and the CIR and IR techniques can not be used. This thesis evaluates an alternative approach to stock assessment using multi-year tagging studies to estimate fishing and natural mortality in northern regions of the fishery. Data obtained from a tagging project undertaken from 1992 to 1995 were analyzed. The most parsimonious model was based on using three tagging events each fishing season, and estimating annual fishing mortalities and a single natural mortality estimate over the duration of the study. Fishing mortality was partitioned to the period of the year based on the amount of fishing effort between tagging events. Natural mortality was partitioned to the period based on the amount of time elapsed between tagging events. Although annual fishing mortalities could be estimated for each sex, a more parsimonious model was obtained when female fishing mortality was set as a proportion of male fishing mortality dependent on the amount of fishing effort in the female fishing season relative to the amount of effort in the entire fishing year. Tag reporting rate was also held constant in the model over the period of the study. Results demonstrated that relatively precise estimates of annual fishing mortality and tag reporting rate could be obtained but natural mortality was imprecisely estimated. Annual estimates of instantaneous fishing mortality were high, averaging around 1.0 to 1.2 per year, and were similar to those obtained by the assessment model. The precision of annual fishing mortalities estimated in the years after tagging ceased declined due to the low number of tags returned. Low tag returns were associated with the high exploitation rates and low tag reporting rate (estimated to be 22%). Natural mortality was estimated for all years.
combined. The estimate of natural mortality was zero with a standard error of 0.2 per year. Natural mortality is an extremely difficult parameter to estimate. Current estimates, which are used in models for southern rock lobster throughout its range in Australia and New Zealand, are based on a small number of long term recaptures from southern Tasmania.

Often, in fisheries such as the Tasmanian rock lobster fishery, a major management objective is to rebuild the stock and lower exploitation rates. Under declining exploitation rate, the need for a precise estimate of natural mortality increases. This thesis investigated four different ways to improve precision of estimated parameters using multi-year tagging models. Simulations were patterned after that Tasmanian rock lobster fishery and showed that the best gains in precision were obtained by either increasing the tag reporting rate or increasing the duration of the study. Although there was considerable potential to increase tag reporting rate as the estimate from the above study was low, there can be no guarantee that either increased rewards or improved publicity will result in an increase in tag reporting rate. The most certain way of increasing the precision of natural mortality was by increasing the duration of the study. This thesis suggests a design based on three years of twice a year tagging followed by three years of once a year tagging.

This thesis also investigated selectivity estimates from the fishery because selectivity is assumed to be constant from year to year in the assessment model. Selectivity was found to change as the size composition of the lobster population changed. Large lobsters were found to inhibit the catchability of small lobsters. As large lobsters are removed from the population over time the catch rate of small lobsters can be expected to increase. Thus selectivity can be expected to vary as a function of the exploitation rate. Assessment models, which are based on size structure, need to account for changes in selectivity as the size structure of the population changes. Otherwise, if the increase in catchability of small lobsters is not accounted for, it is likely that declining recruitment to the fishery will not be fully detected.

This study found selectivity to be an important parameter in some crustacean trap fisheries and identified the need to validate the assumption of constant selectivity both within and between fishing seasons.
Acknowledgements

PhD theses generally require a dedicated effort and single mindedness that impact on those close to the candidate. However, when the candidate has additional pressure through existing work requirements and family commitments then the impact on work colleagues, friends and family is exacerbated.

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Dan Hepworth at the Virginia Institute of Marine Science was tremendous in getting the SURVIV program up and running and, after corrupting the copy on my computer, put up with numerous desperate emails requesting ‘just one more run’.

The brunt of the impact of undertaking and completing the thesis was borne by my family, particularly my wife. Undertaking all the additional duties in an already heavily committed household was a level of support that can never be repaid. I will always be deeply in debt.
Finally, my children persevered with the added level of chaos placed on their lives. However, there was one occasion when I knew that there could be no turning back:

On one hot and humid summer morning in Virginia I had hassled my daughters on several occasions to hurry up so that I could arrive at work early. Having driven to the end of driveway I suddenly remember that I had left my notes behind. My wife commented that I was 'becoming an absent-minded professor like John' (my supervisor). My daughter quickly replied “Dad’s not an absent-minded professor, he’s just an absent-minded person without a PhD”. Something had to be done!
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