MODELLING THE WESTERN ROCK LOBSTER FISHERY

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Abstract

The structure of the model used within the western rock lobster fishery reflects the data set available to researchers, the management strategies currently in use and under consideration, and aspects of the life history and biology of the animal. Distributed over a wide latitudinal range, the lobster population exhibits variation in several biological parameters. This variation, in combination with the regional nature of both the fishery and its management regulations, required the development of a length-structured spatial model. The response of fishers to management changes and to the changing distribution and availability of lobsters necessitated the inclusion of effort dynamics as a component of the model.

The model represents a synthesis of available knowledge regarding the western rock lobster and its associated fishery. Assessments based on the model may be produced readily and have been used extensively in the evaluation of a variety of alternative management strategies proposed by both fisheries managers and by the fishing industry. The model has been successful in focusing the attention of industry on the need to ensure that egg production of the stock is not further eroded by increasing fishing efficiency and by greater usage of pots (traps).

Introduction

Research on the western rock lobster, *Panulirus cygnus*, has been stimulated over recent years by the development of a length-structured, spatial model of the fishery (Walters *et al.* in press). This model integrates much of the available knowledge of the biology and fishery for this species. Development of the model has allowed researchers to provide advice, based on that understanding, to fisheries managers. For the researchers, the model has provided a strategic direction for future research by identifying areas where knowledge is inadequate.

Of course, this is not the first model of the western rock lobster fishery. A variety of models have been used to represent aspects of the fishery (Bowen and Chittleborough 1966; Morgan 1979; Hancock 1981; Caddy 1986; Fogarty and Murawski 1986; Phillips and Brown 1989; Hall *et al.* 1990; Hall and Brown 1991; and Hall and Brown in press[a]), and a review has recently been prepared by Hall and Brown (in press[b]). Until recently, the models applied have been those developed for finfish, and have not been developed specifically for the rock lobster fishery. In many cases, they have used only a subset of the available data, and many assumptions (such as the assumption that growth is continuous) lacked validity.

The currently used length-structured model was developed specifically for the western rock lobster fishery. Although inheriting many of the features of the more general models used in fisheries science, the model reflects features peculiar to lobster biology and to this specific fishery.

For this case study, it is not my intention to describe the model in great detail, as this has already been done by Walters *et al.* (1993). Instead, I prefer to concentrate on the principal features of this model that are associated with the biology and life history of the western rock lobster, the data base available, and the management needs currently experienced.

The western rock lobster fishery

The western rock lobster fishery extends over a latitudinal range of 13°, and produces an annual catch that averages around 10,500 t with a value to the fishery of about AU$200 million. Each of the 680 vessels operating within the fishery is entitled to fish within one of three management zones-south of 30°S, the coastal fishery north of 30°S, or the Abrolhos Islands region; fishermen in this last zone are entitled to fish within the coastal fishery north of 30°S from the commencement of the fishing season, November 15, until the start of the Abrolhos Islands season, March 15. A closed season operates throughout the fishery from July 1 to November 14.

While nominal fishing effort (measured as pot or trap lifts) has continued to increase despite limited entry and constraints on the number of traps used within the fishery, the efficiency of effort has also increased as a consequence of improvements in fishing technology and greater mobility of the fishing vessels (Brown *et al.* in press). This has been of growing concern to fisheries managers, as the fishery is regarded as being highly exploited, and its capacity to withstand further increases in the level of exploitation is uncertain.

The fishery is managed by the Fisheries Department of Western Australia. A statutory committee, the Rock Lobster Industry Advisory Committee (RLIAC), with membership drawn principally from the fishing and processing sectors of the industry, advises the Minister for Fisheries. This committee receives advice from the Research Division of the Fisheries Department and receives input from fishers throughout the fishery before formulating its recommendations.

In 1992, the fishery arrived at the end of its last management period, during which time the pot quota had been reduced incrementally by 2% per year for 5 years. The Advisory Committee had commenced deliberations of the strategy that should be adopted during the next 3 to 5 years, and was seeking advice from fisheries scientists. It was in this context that model development had been commenced, in order that advice might be given to the committee on the implications of alternative strategies.

Strategies considered by the Advisory Committee were numerous and included mid-season closures with duration extending from 2 to 6 weeks, the introduction of a maximum legal size for female lobsters, and variable pot reductions extending for various periods. The model being developed was required to evaluate the impact of such changes to the regulations. For each strategy, the model was required to provide estimates of the resulting catch and effort within each management zone, the size composition of the catch (as smaller lobsters attract a greater price), and the egg production of the population.

Brief description of the model

The model uses a grid structure to represent the spatial structure of the fishery, allowing management zones to be defined as subsets of the grid cells. Differences in growth and maturation across the latitudinal range of the fishery are represented by allocating subsets of the grid

cells to regions in which growth and fecundity are defined by the same growth and maturation schedule. The model maintains a record of the number of rock lobsters within each cell. The model assumes that migration occurs within the period (Nov-Jan) corresponding to the annual migration of lobsters from the shallow inshore coastal reefs to the deeper off-shore breeding grounds.

Time steps of two weeks are used within the model, reflecting the short duration of the period of migration, and the need for advice on closures of this duration.

For each grid cell, the model stores information on the number of lobsters of each sex within each 4 mm length class; this class interval corresponds to the size of the average moult increment. Moulting within the fishery occurs with some degree of synchrony; the model assumes that there are four moult periods that might occur each year. The moult schedule provided for each growth region specifies the proportion of the animals within each length class that may moult at each of the moult periods.

Fishing effort is allocated to grid cells on the basis of their "attractiveness", determined from the relative level of recent historical catch rates and distance from the coast. The total level of fishing effort available is determined by the trap quota, adjusted for the calculated soak time of each trap. The latter is determined from the catch rate; when the catch rate is sufficiently high, traps are lifted after one day, but the soak time increases as the catch rate falls.

Full details of the model are given by Walters *et al.* (1993). An example of model output is presented in Figure 1. This compares the management strategy current in 1991/92 with a management strategy introducing a maximum size of 116 mm for female lobsters.

Discussion

To provide timely advice to managers and to the fishing industry, it has become increasingly clear that models of the fishery must be available to carry out the extensive calculations necessary to evaluate the variety of management strategies proposed. Such models ensure that advice based on a rigorous assessment, rather than a subjective *ad hoc* analysis, is presented to managers. However, such advice must still be subjected to close scrutiny and cross-checked against information available from the fishery rather than accepted without reservation; the model output is regarded as providing a guide, rather than a precise solution.

The model has proved most effective in clarifying and communicating the concern of scientists and managers that the spawning potential of the rock lobster stock has been considerably reduced from the original unfished state. Further reduction in spawning potential was expected to continue unless additional constraints were introduced to reduce exploitation. Management objectives are now firmly focused on the need to ensure that egg production is increased and then maintained at a level that is believed adequate to ensure that the fishery is sustained.

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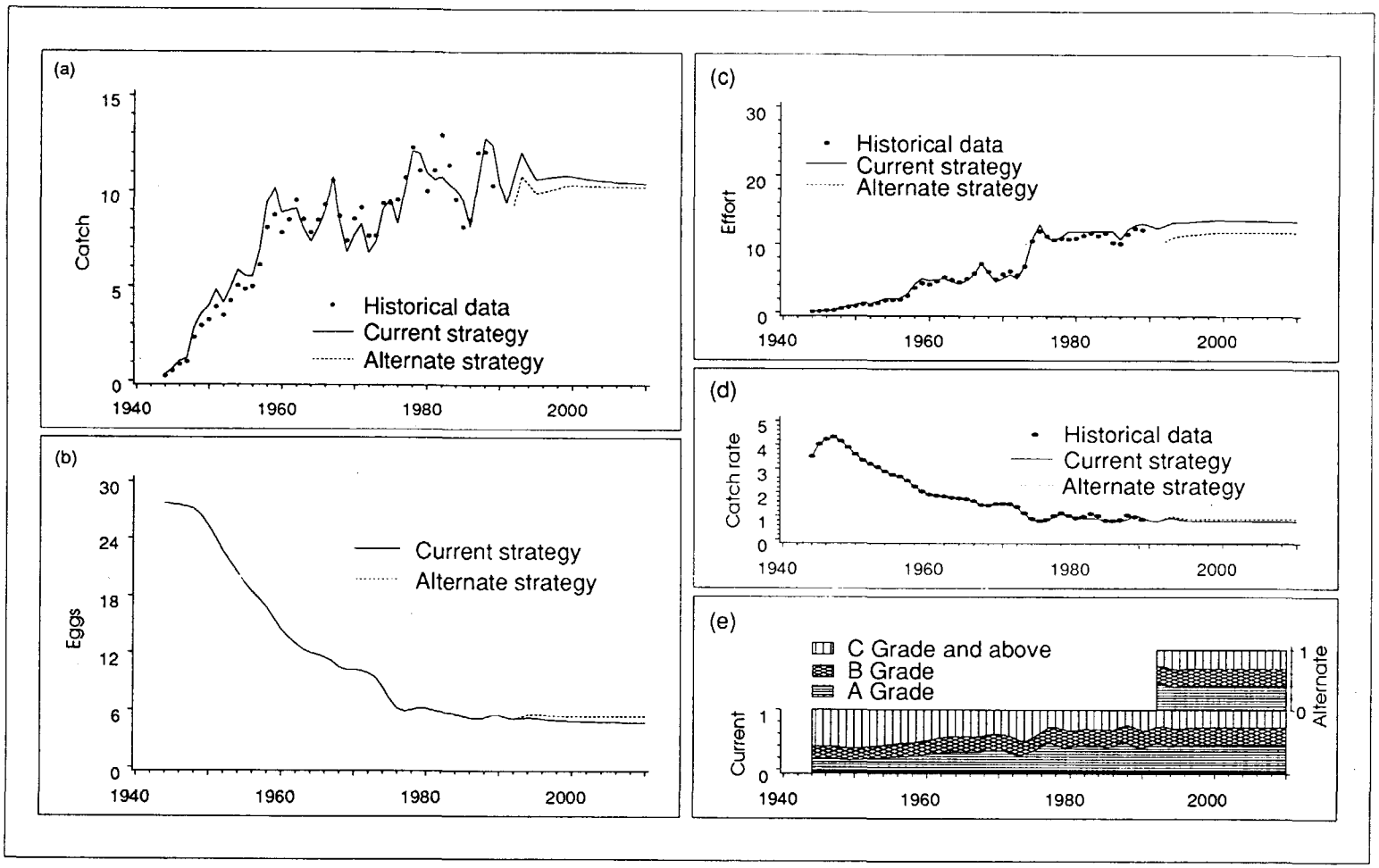

Figure 1. Model output comparing the results of a maximum size of 116 mm for female lobsters compared with the management regime current in 1991/92: (a) Catch (thousand tonnes); (b) Eggs produced (billions); (c) Effort (trap lifts); (d) Catch rate (kg per trap lift); and (e) Relative catch in each size grade (A grade = small rock lobsters, C grade and above = largest lobsters).