REPORT

to the

FISHING INDUSTRY RESEARCH AND DEVELOPMENT COUNCIL:

PROJECT No 90/6

Behavioural and physiological studies on phyllosoma larvae of the Western Rock Lobster.

INTRODUCTION

The Western Rock Lobster (*Panulirus cygnus* George) is the most valuable single species fishery in Australia with an annual value in excess of $250 000 000. Consequently, there has been a substantial research effort geared towards gaining a better understanding of the basic biology of this species which has resulted in a comprehensive management programme by the Fisheries Department of Western Australia. This research effort has revealed, amongst other results, a correlation between the relative strength of post-larval recruitment and inter-annual variation in oceanographical processes. More specifically, the strength of puerulus settlement has been shown to correlate positively with the relative strength of flow of the Leeuwin Current as inferred by mean monthly sea level (Pearce & Phillips 1988). There is as yet no strong evidence to suggest a mechanism which might account for this correlation. This is due largely to the scarcity of information available regarding the pelagic larval phase of the Western Rock Lobster's life cycle.

The bulk of our knowledge concerning the pelagic larval phase of the life cycle emanates from a series of oceanographical surveys conducted by the CSIRO in the 1970's which documented the horizontal and vertical distribution of phyllosomata off the coast of Western Australia. The results of these surveys suggested that phyllosomata may modify patterns of daily vertical migration in order to take advantage of surface and subsurface circulation features such that horizontal transport conducive to recruitment is achieved (Rimmer & Phillips 1979). Correlational evidence suggests further that light may play an important role in regulating the depth distribution of phyllosomata and also that larval response to light may change with development. These investigations did not, however, address the relative role of the Leeuwin Current in larval recruitment dynamics.

There is no laboratory based information available on the relative effect of light and temperature on phyllosoma behaviour and physiology due largely to the difficulties associated with reliable larval culture. Such information is vital to a comprehensive understanding of the possible mechanisms by which inter-annual oceanographic variation may affect larval growth and, ultimately, post-larval recruitment. The purpose of the present study was tto investigate the behavioural ressponse to light and the physiological response to temperature of early and mid-stage phyllosomata cultured in the laboratory. The study was made possible because of recent advances in larval culture technology developed at the Marine Biology Laboratory of the Department of Zoology, University of Western Australia.

METHODS

Temperature effects on growth and development.

A series of long term growth and development experiments conducted from 1990 -1992 investigated the effect of temperature and feeding on survivorship, developmental rate and incremental growth of early and mid-stage phyllosomata. Both constant and cycling temperature regimes were used in conjunction with extended (24 hour) and punctuated (12 hour) feeding regimes. Four experiments were completed, ranging in length from 40 to 90 days, and are summarised as follows:-

Experiment 1: Effects of temperature and feeding on survivorship and moulting frequency of instars 1 - 10.

Treatments
20° C constant, 12 hour feeding
20° C constant, 24 hour feeding
25° C constant, 12 hour feeding
25° C constant, 24 hour feeding
20 - 25° C cycling, 12 hour feeding
20 - 25° C cycling, 24 hour feeding

Experiment 2: Effects of temperature and feeding on survivirship, moulting frequency and incremental growth of instars 1 - 5.

Treatments
25° C constant, 12 hour feeding
25° C constant, 24 hour feeding
20 - 25° C cycling, 12 hour feeding
20 - 25° C cycling, 24 hour feeding

Experiment 3: Effects of temperature and feeding on survivorship moulting frequency and incremental growth of instars 1 - 4.

Treatments
25° C constant, 12 hour feeding
25° C constant, 24 hour feeding
20 - 25° C cycling, 12 hour feeding
20 - 25° C cycling, 24 hour feeding

Experiment 4: Temperature effects on survivorship, moulting frequency and incremental growth of instars 1 - 5.

Treatments
23° C constant, 12 hour feeding
25° C constant, 12 hour feeding
20 - 25° C cycling, 12 hour feeding

Behavioural responses to light of early and mid-stage phyllosomata.

Two separate experiments were conductedto investigate photoresponse in early and mid-stage phyllosomata with the purpose of determining whether:

i) light served served as the initiating and orientating cue for vertical migration, and,

ii) a measurable change in photoresponse consistant with that proposed by Rimmer & Phillips (1979) occurred during larval development.

Experiment 1: larval phototaxis.

Larval directional swimming response was tested for instar 2 phyllosoma to determine whether larvae were able to distinguish between isolumes, and also to determine whether they showed a preference for a particular isolume. Three test isolumes were used:
8.5 microEinsteins (μE) m^{-2} sec^{-1}, 91 μE m^{-2} sec^{-1}, and 162 μE m^{-2} sec^{-1}.

Experiment 2: larval photokinetic response.

The photokinetic response, measured as positive (upward), neutral and negative (downward), was tested for instar 1 - 4 larvae in a specially designed vertical test chamber in which both active and passive behavioural reponses were assessed. Each instar was tested against a series of isolumes, ranging from total darkness to 1.0 μE m^{-2} sec^{-1}. The purpose of the experiment was to determine whether a measurable change in photokinetic response occurred during development in a manner consistent with correlational observations from field sampling.

RESULTS

Growth and development experiments.

In all four experiments, moulting rate increased directly with temperature. The inter-moult period for instars 1 - 6 at 20° C (12 - 14 days) was nearly twice that at 25° C (7 - 8 days) with intermediate values at 20 - 25° C cycling and 23° C constant. In addition, larvae showed higher overall survivorship at 25° C and 23° C, with the lowest survivorship at 20° C. There appeared to be a slight feeding effect on the length of the inter-moult period in the 25° C temperature treatments, with phyllosomata in the 12 hour feeding treatments having a slightly longer inter-moult period compared to larvae in the 24 hour feeding treatments. This may reflect a metabolic cost associated with higher temperatures. On the other hand, phyllosomata in general showed larger incremental growth in both 25° C and 23° C temperature treatments compared to the 20 - 25° C & 21 - 25° C cycling treatments, irrespective of feeding, suggesting that the higher temperatures did not substantially inhibit growth. In addition, phyllosomata in the 25° C treatments of experiments two and three produced, on average, significanttly larger fourth pereopods, indicating that they were able to direct more overall energy into generating new morphological structures associated with larval development.

Phyllosomal light response.

Results from the phototaxic experiments revealed phyllosomata to be capable of distinguishing between isolumes and, furthermore, to show a clear isolume preference. Larvae swam to the 91.5 μE m^{-2} sec^{-1} isolume nearly twice as often as to the 162.5 μE m^{-2} sec^{-1} isolume, with very few choosing the 8.5 μE m^{-2} sec^{-1} isolume. These data correlate very closely with field observations of Rimmer & Phillips (1979) concerning the depth/isolume distribution of early stage phyllosomata off the coast of Western Australia. Results from the photokinetic experiments revealed a significant change in the relative photoresponses of instar 1 - 4 larvae at all test isolumes. Specifically, the kinetic responses became increasingly negative with development, results which are consistent with the observational data from plankton sampling of Rimmer & Phillips (1979).

SUMMARY

The studies carried out under this research programme must be regarded to have achieved, successfully, the objectives set forth in the application for funding from FIRDC. Results from the growth and development experiments demonstrate that phyllosomata show faster and superior growth at elevated temperatures. It is important to note that these temperatures are within observed limits encountered within the geographic distribution of the larvae and, furthermore, that significant differences have been documented within the known time-frame (of weeks to months) of oceanographical processes such as warm water gyre formations emanating from the Leeuwin Current. Thus, phyllosomata may experience more favourable growth conditions, even if briefly, in years of strong Leeuwin Current flow which may in turn contribute to higher recruitment. Results from the photoresponse experiments provide experimental support for the proposed mechanism of larval retention based on a changing photoresponse with development. Finally, the results indicate - strongly - that an important next step in elucidating those factors controlling recruitment of the planktonic stages in the life cycle of the Western Rock Lobster ultimately into the nearshore adult stocks will be to investigate the energetics of the daily vertical movements made by the phyllosomes, particularly with the objective of elucidating the inter-relationship between larval morphology and the fine-scale structure (with respect to temperature and micro-currents) of the coastal waters throughout the geographical range of *P. cygnus*.

The work on this grant was undertaken by Mr Baldo Marinovic, as part of a Ph D programme on a Fulbright Scholarship under my supervision. Mr Marinovic is now writing his Ph D thesis, which I expect to be submitted for examination by early 1994. Following successful examination, a copy of the thesis will be available through the normal library services of the University of Western Australia. I also expect that Mr Marinovic will prepare for publication in major international scientific journals papers reports on each facet of his studies: larval rearing techniques, growth and development experiments, and the light response experiments.

REFERENCES

Pearce, A F & Phillips, B F (1988). ENSO events, the Leeuwin Current, and larval recruitment of the Western Rock Lobster. J. Cons. int. Explor. Mer, **45**: 13 - 21.

Rimmer, D W & Phillips, B F (1979). Diurnal migration and vertical distribution of phyllosoma larvae of the Western Rock Lobster *Panulirus cygnus* George. Mar. Biol., 45: 109 - 124.