IN SITU REARING OF PRAWN LARVAE - TESTING THE STARVATION HYPOTHESIS

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One of the major problems facing larval biologists is obtaining quantitative estimates of mortality due to factors such as starvation, predation or advection to an unfavourable environment. In fisheries biology, it is well established that variation in the survival of planktonic larvae is an important determinant of year class strength (Cushing 1975). The need to determine causes of larval mortality is most urgent for those species which show little apparent relationship between adult stock size and recruitment.

Some species of tropical penaeid prawns well illustrate the mismatches that can occur between reproductive output and subsequent recruitment to fisheries (Staples 1991). This mismatch is particularly pronounced in the banana prawn (*Penaeus merguiensis*) in the Gulf of Carpentaria, Australia (Rothlisberg *et al.* 1985; 1987). A relatively small number of larvae in the spring are responsible for the major pulse of recruitment to the fishery; conversely the major peak of larvae in autumn gives rise to a disproportionately small number of adults (Table 1). One possible explanation for this is seasonal differences in larval advection (Rothlisberg 1982) but other sources of larval mortality such as predation or starvation could also be important.

In a review of food limitation of planktotrophic marine invertebrate larvae, Olsen and Olsen (1989) proposed that crustacean larvae are sensitive to starvation. This has rarely been tested *in situ* and little is known about the natural diet of prawn or other crustacean larvae. *In situ* rearing of larvae in enclosures can provide information about natural diets and indicate the importance of starvation. This type of approach has often been successfully used for larval fish studies (e.g. de Lafontaine and Leggett 1987). Early attempts to rear crustacean larvae *in situ* using simple mesh enclosures met with little success (Thorson 1946). More recently, after some modifications in enclosure design, quantitative estimates of the survival of crab larvae (Epifanio *et al.* 1991) and prawn larvae (Preston *et al.* in press a and b) have been obtained. The studies of prawn larvae also revealed qualitative aspects of larval diet. The aim of this paper is to describe the methodology and illustrate the advantages and disadvantages of *in situ* rearing of crustacean larvae using examples from a recent study in Albatross Bay, Gulf of Carpentaria (Preston *et al.* in press a).

Enclosures alter the natural environment and this will always result in some artifacts. The most serious of these are the interruption of the normal flow of water and the restriction of the movements of larvae and their prey. These limitations have to be weighed against the major benefits of excluding predators whilst allowing larvae access to their natural food. Furthermore, controlling the location and water depth of caged larvae can provide detailed information about temporal and spatial variations in supplies of natural food. Such information cannot be gained from studies of net plankton alone because the previous origin and feeding history of the larvae is unknown.

In designing enclosures, care has to be taken to select the most appropriate mesh size and overall dimensions. Pilot studies are required to determine the most suitable mesh size for excluding predators, preventing entanglement of the larvae and allowing natural food to enter the enclosure. The Albatross Bay study demonstrated low survival of *P. merguiensis* larvae in enclosures with a mesh size 250µm; this was probably due to the entanglement of larval limbs. Reducing the mesh size to 140µm significantly improved survival. A comparison of the gut contents of caged larvae with larvae captured in plankton nets indicated no reduction in the range of food items ingested by caged larvae.

In determining the overall dimensions of the enclosures, factors to be considered include the depth of water to be sampled and the ease of deployment and recovery of enclosures at sea. The enclosures used in the shallow waters of Albatross Bay (Figure 1) extended the total depth of the water column (9 m). Pilot studies in which larvae were placed in enclosures for one hour revealed pronounced variation in recapture rates in relation the total length of the enclosures. Recovery rates ranged from <40% in 9m enclosures with no internal partitions to >95% when the same enclosures were subdivided into 3 m lengths. The low recovery rates from the unpartitioned enclosures were due to the trapping of larvae in folds of the flexible enclosures during handling.

In situ rearing studies are well suited for short term studies of the natural diet and nutritional state of larvae. For very small larvae, such as prawn protozoeae, many individuals may be required in order to obtain sufficient material for biochemical analysis. Enclosures offer the means to rear large numbers of individuals at many different locations in a short space of time; this is a distinct advantage over capturing larvae with nets or pumps. *In situ* rearing studies provide a rapid method of identifying the appropriate diet for rearing larvae in captivity. The technique can also provide a sensitive assay of water quality in aquaculture ponds (Preston *et al.* in press b).

In Albatross Bay estimates of survival were obtained over a period of four days (one moult stage). The survival rates obtained in enclosures were similar to published estimates of survival based on the decrease in abundance of prawn larvae in the plankton (e.g. Jones *et al.* 1970). The potential for obtaining estimates of survival in longer term experiments (over several moult stages) remains to be established. However, problems will be encountered in reproducing natural conditions due to fouling of enclosures and because of progressive changes in the diet of larvae from herbivory to omnivory. Increasing the overall dimensions of cages, regular cleaning of the mesh and and/or supplementary feeding with natural zooplankton may help to overcome these problems. However, the most appropriate application of enclosures for studies of prawn larvae is in short term (one or two moults) experiments to determine interactions between larvae and their nutritional environment during early herbivorous stages.

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Table 1. The relative importance (mean percentage over 4 years) of the two generations of *Penaeus merguiensis* in Albatross Bay, Gulf of Carpentaria, Australia

Unpublished data compiled by CSIRO Division of Fisheries, Cleveland. (CL - carapace length).

Life stage	Autumn	Spring
Zoea	99	01
Mysis	90	10
Planktonic post-larvae	40	60
Benthic post-larvae	38	62
Juveniles >10mm CL	25	75
Emigrants 10-20mm CL	04	96
Adults >25mm CL	<1	>99

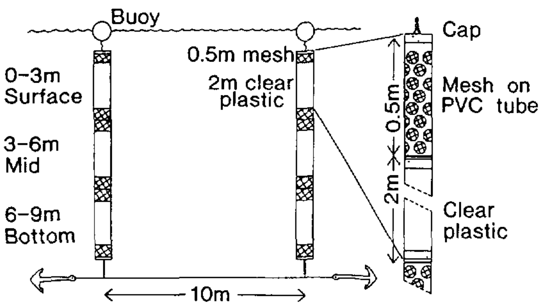

Figure 1. Schematic of enclosures used for *in situ* rearing of *Penaeus merguiensis* larvae in Albatross Bay.