counterpart in paddy cultivation, in the same field and for more or less the same period of time. In West Bengal, of total export value of 43 crores, up to 25 crores is realized by farmers for their production of shrimp through culture reflecting better unit return for their raw material than that realized by the processor/exporter of the end-product. Therefore, bringing additional areas under shrimp culture will directly affect the socio-economic status of the rural people employing an average of 5 persons/ha, and indirectly affect no less than 15,000 casual workers in the seafood processing industry by additional utilization of manpower and working hours.

As productivity from capture appears bleak, brackish-water shrimp culture has been accorded top priority in India's national developmental programmes for more harvest from aquatic sources otherwise termed the "Blue Revolution."

Larval Growth and Survival Optima for Four Species of Penaeids from Australia, as Indicated by their Distribution and Abundance in the Field

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Prawn catches from tropical northern Australia are dominated by four species of prawns: *Penaeus merguiensis*, *P. semisulcatus, P. esculentus* and *P. latisulcatus.* Three of the species (*P. merguiensis*, *P. semisulcatus* and *P. latisulcatus*) are widespread throughout the Indo-Pacific, while *P. esculentus* is endemic to northern and eastern Australia. The species appear, however, to have well defined and limited distribution on a smaller scale. Surveys of the larvae in the Gulf of Carpentaria, northern Australia, have shown both spatial and temporal heterogeneity in the abundance of all four of these species.

Assessing the temperatures and salinities in which the larvae were caught may be a realistic indicator of conditions suitable for reproduction, as well as growth and survival of the larvae. Means of these distributions may be deemed optima and ranges indicate tolerances.

Most of the larvae of all four species are found in water above 26°C and 31 ppt. However, the mean temperatures and salinities vary significantly between species. *P. merguiensis* has the lowest salinity optimum (31.8 ppt) and the highest temperature optimum (29.0°C). the other three species are similar for both temperature and salinity optima. *P. latisulcatus* has the lowest temperature optimum of 27.4°C compared with *P. semisulcatus* at 27.9°C and *P. esculentus* at 28.5°C. The salinity optima for these three species are almost indentical at approximately 33.2 ppt.

While the ranges of temperatures of all four species are similar (21.5-30.6°C), the ranges of salinities in which the larvae are found coincide with the size of the biogeographic distribution of the species. The three widespread species have large salinity ranges: *P. merguiensis,* 26.2-34.9 ppt *P. semisulcatus,* 27.8-34.9 ppt: and *P. latisulcatus,* 28.6-34.9 ppt. The Australian endemic, *P. esculentus,* has the smallest and highest range, 30.1-34.6 ppt. This apparent inability of *P. esculentus* to tolerate low salinity water may restrict dispersal during the larval stages.

Description of the Embryonic Stages of *Penaeus notialis* and the Influence of Some Abiotic Factors on the Species

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The embryonic development of the shrimp *Penaeus notialis* Farfante, 1967 is studied. The duration from spawning to hatching of the nauplii was 14-16 hr. As soon as spawning occurs, a sequence of transformations is observed in the characteristic cell mitosis up to the formation of the embryo which breaks the membrane and emerges as the first naupliar stage. The process of development is very similar to other penaeids and the duration of each stage is characteristic of the species. The influence of salinity and pH on spawning, hatching rate and survival, and the optimal values for each factor were determined.

Thermal Tolerance of Larval Greentail Prawn *Metapenaeus bennettae* (Racek and Dall) — A Comparison with School Prawn *Metapenaeus macleayi*

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The thermal tolerance of four larval stages of *Metapenaeus bennettae* was studied in the laboratory. Critical Thermal Maximum (CTM), One hour Median Lethal Temperature (lhLT50), and Median Resistance Time (MRT) were measured. Moulting rate of larvae and hatching rate of embryos were also monitored to study the delayed effect of thermal stress.

Thermal tolerance was shown to be strongly dependent on acclimation temperature (TA) at all larval stages, which

showed ontogenetic development of thermal resistance. Moulting of larvae was hindered at temperatures (37.2°C for nauplius when TA=25°C) well below lhLT50 (38.1°C for nauplius when TA=25°C). The embryonic stages were more susceptible to thermal stress than the larval stages. The salinity effects were also significant. Nauplius and protozoea stages showed their highest CTM values at the salinity in which they were spawned.

When compared with another penaeid *M. macleayi* (offshore breeder), *M. bennettae* (estuarine breeder) was found to have higher thermal resistance, but was less adaptive to changes in acclimation temperature.

Growth and Productivity of Juvenile Banana Prawns, *Penaeus merguiensis* in Natural and Laboratory Systems

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Growth and survival of *Penaeus merguiensis* juveniles were measured over four years in the Norman River estuary, south-eastern Gulf of Carpentaria. Growth in carapace length for the first 8-9 weeks after settlement was essentially linear and averaged 1.2 mm/week in summer at 29.5°C and 0.45 mm/week in winter at 19.5°C. A comparison of different cohorts under varying temperatures and salinities indicated that growth was temperature- but not salinity-dependent. Survival of newly settled postlarvae varied seasonally and was highest in spring (October-November).

In the laboratory, a study of moulting rate and moult increment at 15, 20, 25, 30 and 35°C demonstrated that the optimal temperature for growth was 25-30°C. Survival of juveniles was also highest at intermediate temperatures. Effects of salinity and food ration amounts are discussed.

Water Quality Criteria for Farming the Grass Shrimp, *Penaeus monodon*

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Physiological and growth effects of pH, salinity, temperature, heavy metals, pesticides and others on juvenile grass shrimp *Penaeus monodon* have been investigated to determine the biologically safe concentrations. Optimal pH, salinity and temperature are found to be in the range of 8.0-8.5, 15-25 ppt, and 28-33°C, respectively. A dissolved oxygen concentration of 3.7 ppm seems to be the critical oxygen pressure to support the normal life of grass shrimp. To avoid poor survival and retarded growth, the recommended level for each pollutant are: heavy metals, 0.0025 ppm Hg, 0.1 ppm Cu, 0.15 ppm Cd, 0.25 ppm Zn; pesticides, 0.0004 ppb parathion, 0.001 ppb malathion, 0.008 ppb rotenone, 0.01 ppb Azodrin, 0.033 ppb Saturn, 0.01 ppb paraquat, 0.01 ppb Endosulfan, 1 ppb Butachlor; surfactants, 0.1 ppm Dunall OSE, 0.2 ppm BP 1100, 0.5 ppm Seagreen 805; and others, 0.033 ppm H_2S, 0.1 ppm NH_3.

Genetic Changes During Development of Penaeid Shrimp

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As penaeid shrimp grow from the earliest naupliar stages, through protozoeal and mysis stages, to postlarvae, they develop greater morphological and behavioral resemblance to the adults. Electrophoretic analysis of cytoplasmic enzymes from nauplii, protozoea, mysis, postlarvae, and adults show that each stage has a unique pattern of gene activity. Thirteen enzyme stains and a general protein stain have been used on larval samples from *Penaeus stylirostris, P. vannamei* and *P. aztecus.* Some enzymes, such as phosphoglucose isomerase, are produced in the same isozymic form during all of the stages. Other enzymes exhibit changes in the number and position of isozymic bands during development, e.g. glutamate dehydrogenase. Some of these differences among developmental stages can only be explained by changes in the number and/or identity of the genes that are active at each stage. This finding suggests larval and adult responses to selection may be relatively independent.

Osmotic, Total Protein and Chloride Regulation in *Penaeus monodon*

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The osmotic, total protein and chloride ion regulation in two size groups (10 and 30 g) of *Penaeus monodon* Fabricius was investigated. Preliminary experiments showed that osmolality, total protein and chloride concentrations tend to