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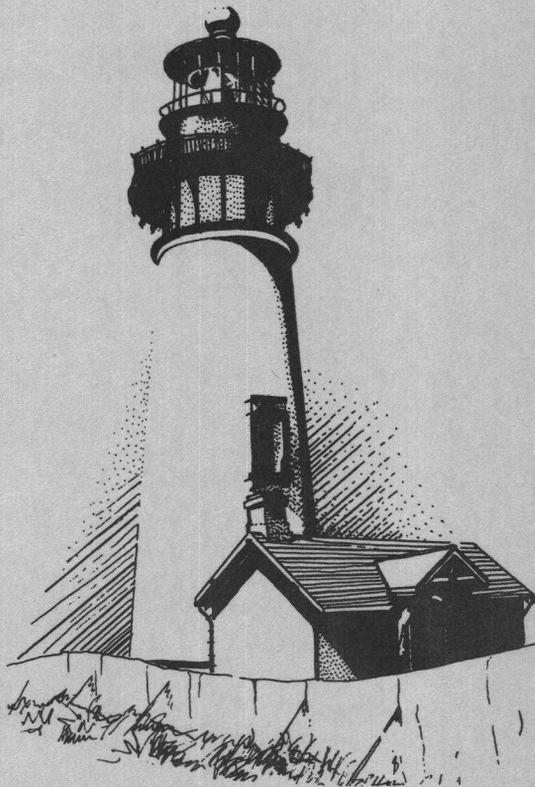# AN EPIBENTHIC SAMPLER USED TO STUDY THE ONTOGENY OF VERTICAL MIGRATION OF *PANDALUS JORDANI* (DECAPODA CARIDEA)

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SEA GRANT
COLLEGE PROGRAM

AN EPIBENTHIC SAMPLER USED TO STUDY THE ONTOGENY OF VERTICAL MIGRATION OF *PANDALUS JORDANI* (DECAPODA, CARIDEA)[1]

Pandalus jordani Rathbun, like many other species of pandalid shrimps, undergo regular diel changes in their vertical distribution (Tegelberg and Smith 1957; Alverson et al. 1960; Pearcy 1970, 1972; Robinson in press). Little is known, however, about the vertical distribution and diel migrations of larval and juvenile shrimp, or at what stage of the life history vertical migration and benthic existence are initiated.

Berkeley (1930) found that size or age of larval *P. danae* increased with increasing depth in a semienclosed embayment in British Columbia. Pearcy (1972) published the only information on day/night differences in benthic occurrence of juvenile *P. jordani*. Using a plankton net mounted on a beam trawl, he collected more juveniles (<7.0

mm in carapace length) near the bottom during day than night.

In order to sample the water column completely, it was necessary to supplement plankton tows with a discrete, quantitative sample on or just off the bottom. Various methods have been used for this purpose but we thought that all of them were inadequate for the present study. Many epibenthic samplers do not have an opening/closing device and therefore are subject to contamination from the water column above (Russell 1928; Frolander and Pratt 1962; Pearcy 1972; Beardsley 1973). Others are only capable of collecting small samples, in relatively shallow water (Clutter 1965; Macer 1967). In others the opening/closing device seems inefficient or overly complex (Bossanyi 1951; Wickstead 1953; Macer 1967; Hesthagen 1970). Design criteria for the sampler used in this study were: a simple, substrate activated, opening/closing device capable of quantitatively sampling in depths greater than 150 m and sampling at least 500 m³ of water with no loss of filtration efficiency.

Epibenthic Sampler Design

The epibenthic sampler consists of a sled and a box, to which are attached a plankton net and a substrate-actuated opening/closing device (Figure 1). The frame of the sled was welded from flat steel strap (5.1 × 0.6 cm). The runners (23 × 0.6 cm mild steel plate) are joined across the front by a piece of the same steel bent to conform to the front of the sled. This serves to carry the sled over small obstructions on the seabed and further protect the door of the box when it is in the open position. A bumper bar (5.1 × 0.6 cm) was also fitted across the front of the sled to prevent large obstacles from entering the mouth of the sampler. Two brackets on either side of the sled serve as attachment points for the box. The six different positions allow the box to be positioned from 2.5 to 22.9 cm off the bottom. Two pieces of strap (5.1 × 0.6 cm) were welded along the top of the frame with nine holes to provide various attachment points for the towing bridle. In addition, four pairs of towing points were placed around the front of the frame.

The box (106.7 × 45.7 × 53.3 cm), made of 3.2-mm mild steel plate, is reinforced in front by steel strap (2.5 × 0.32 cm), forming a lip around the mouth of the box (Figure 1B). The box is further reinforced by L stock (2.5 × 0.32 cm) placed around the box 10 cm from the rear edge. Attach-
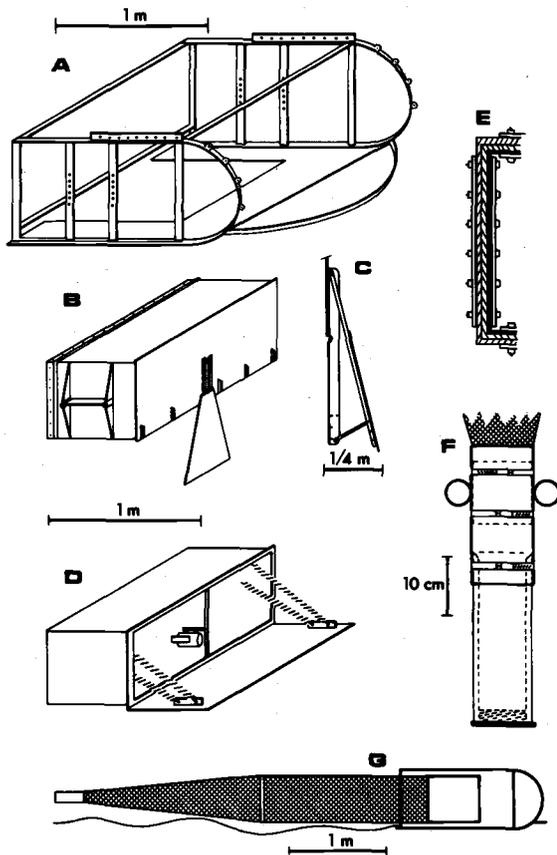
FIGURE 1.—Opening/closing epibenthic sampler: A) sled frame; B) box with door closed; C) detail, side view of shoe, hinge, and shoe adjustment device; D) box with door open showing flowmeter and springs for closing door; E) schematic net attachment, solid line is box wall, two cross hatched lines are collars of coarse mesh liner (inner) and plankton net (outer), open bars are stainless steel straps with bolts; F) safety collar insert with rings for cable attachment protruding through collar and PVC cod end with threaded teflon plug; G) schematic lateral view showing sled, box, net, and canvas chafing gear.

ment points for affixing the box to the sled were made from 3.8-cm round stock, tapped to 9.5 mm and reinforced with 5.1 × 0.48 cm flat stock. The box is fastened to the sled by four stainless steel bolts (0.95 × 3.8 cm).

The door of the box was made from mild steel plate (109.2 × 48.3 × 0.48 cm) and is hinged with a 6.4-mm stainless steel rod at five points along the bottom. The shoe which opens the door upon contact with the sea floor is triangular shaped (33.0 × 50.8 × 0.48 cm) and is hinged to allow adjustment, depending on the distance the box is set off the bottom (Figure 1C). Four large springs (5.1 × 22.9 cm), attached internally, pull the door

shut when the sled leaves the sea floor (Figure 1D). The door-to-shoe surface area ratio is about 5:1, so that water pressure effectively holds the door shut on descent and ascent (Figure 1B). A TSK flowmeter[2] is mounted in the middle of the mouth by a brace (1.9 × 0.48 cm). The nets are attached to the rear of the box by sandwiching them between stainless steel straps (5.1 × 0.48 cm) bolted together at 7.6-cm intervals (Figure 1E). The inner strap has 6.4-mm stainless steel bolts welded to it, while the outer strap has holes drilled to correspond to the bolts in the inner strap, as well as the holes in the box and net collars. The entire sled, except for the springs and stainless steel fittings, was hot dipped galvanized.

The plankton net was made of 571-μm mesh nylon monofilament. The filtering area to mouth area ratio is 9:1. The "cylinder"/"cone" net had a total mesh area of 7.7 m², with 2.6 m² in the cone and 5.1 m² in the cylinder. The collars were made of plastic coated nylon webbing. The cod end is a 30.5-cm piece of 10.2 cm outside diameter schedule 80 polyvinyl chloride (PVC) pipe, with a threaded teflon plug for removing the sample. There is also a stainless steel insert above the cod end fitted with two rings protruding through slits in the collar, for attachment of safety wires from the sled frame to the cod end, in the event a large amount of sediment was retained (Figure 1F). Overall length of the net including collars and cod end is 5.1 m (Figure 1G). A small coarse mesh net 1 m deep (2.5-cm stretched mesh) was mounted inside the plankton net (see Figure 1E) to catch any large animals or objects and prevent them from damaging the plankton net or the sample in the cod end. A piece of heavy canvas (1.2 × 3.7 m, no. 4 duck) was attached to the rear of the sled by shackles, to protect the plankton net from chafing on the sea floor (Figure 1G).

Epibenthic Sampler Operation

Because of its size and weight (ca. 150 kg in air) the epibenthic sampler can only be used from a vessel with a suitable trawl winch; in the present study the 24.4-m RV *Cayuse* with a 9.5-mm diameter trawl wire was used. The sled was fastened to the trawl wire with a ball bearing swivel and a 3-m bridle of 9.5-mm wire attached to the

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second set of attachment points from the front of the sled. From these towing points the sled proved to be stable, never landing on the bottom upside down. It could be launched and recovered by two people in moderate-to-rough seas. The sled was launched while underway at 2 knots. A 20-min tow (bottom time) at 2 knots was calculated to be sufficient to filter 500 m^3 of water. Presence on the bottom was detected by the winch potentiometer.

Filtering efficiency of the sampler, based on the degree of clogging, was never markedly reduced over this time interval. However on soft muddy-sand bottoms, characteristic of *P. jordani* grounds, bottom times were reduced to 10 min because of the amount of fine sediment and meiofauna stirred up and retained in the cod end. Large organisms, including adult *P. jordani*, as well as the fragile urchin, *Allocentrotus fragilis*, and slender sole, *Lyopsetta exilis*, were effectively retained in the coarse mesh liner and prevented from reaching the sample in the cod end. Flowmeter readings indicated that at no time did the number of animals retained in the liner seriously occlude the mouth of the plankton net and affect its efficiency. On coarse sand bottoms, the samples were very clean, with little sediment and meiofauna retained, even when the net was only 5-8 cm off the bottom.

Though the sled was never observed firsthand while on the bottom, evidence from skid marks on the runners and shoe, behavior of the potentiometer while the sled was on the bottom, and the relationship between flowmeter readings and bottom time indicated that the epibenthic sampler was stable and not prone to dig in or bounce off the bottom while being towed.

Vertical Distribution of Larval *Pandalus jordani*

On 30 and 31 May 1972 the epibenthic sampler was used to sample near-bottom fauna and open bongo nets were used to obtain a series of quasi-vertically stratified plankton samples 10 nautical miles off Cascade Head, on the central Oregon coast (lat. 45°04.0'N, long. 124°15.1'W). The 0.7-m diameter bongo frames had paired cylinder/cone 571-μm Nitex nets, 5.1 m in length with an effective filtering area to mouth area ratio of 8:1. A scope to depth ratio of 2:1 was maintained by using a 40-kg multiplane kite otter as a wire depressor (Colton 1959). All nets contained TSK flowmeters. A time-depth recorder was fixed to the wire just

above the bongo nets. Tows were made at four strata (0-10, 11-50, 51-100, 101-150 m) with the open bongo nets, and a bottom sample was taken with the epibenthic sampler at 160 m. Replicate tows were taken at each depth interval, both day (1200-1930 h) and night (2105-0400 h). Contamination in the open bongo net was minimized by lowering to the depth interval as fast as possible, doing a stepped oblique tow through the horizon, and then raising the net as quickly as possible. Towing time at depth was long enough to keep the period of contamination below 20% of the total sampling time for the deepest tows.

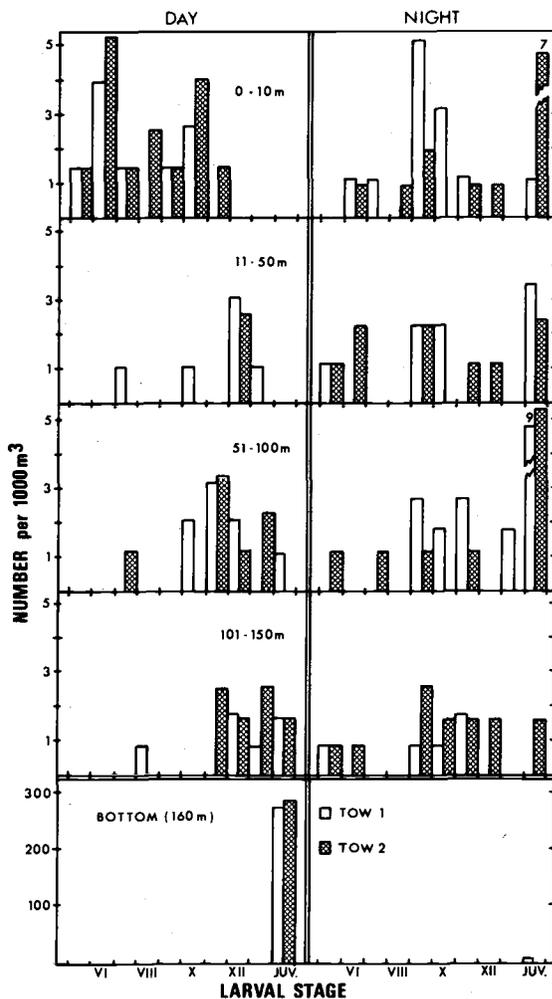The vertical distribution of *P. jordani* larvae and juveniles is summarized in Figure 2. During

FIGURE 2.—Vertical distribution of larvae and early juvenile *Pandalus jordani*, during one day and one night period. All tows were replicated.

the day, larvae were distributed throughout the water column and were most abundant in the 0- to 10-m depth interval. A trend of increasing age with depth was evident. Early juveniles were present in low numbers in the 51- to 100-m and 101- to 150-m intervals. The sled tows revealed a very high concentration of early juveniles (284 and 290/1,000 m³) on the bottom during midday.

At night larval shrimp were still distributed throughout the entire water column. The younger stages (V and VI), found in some abundance in the 0- to 10-m interval during the day, were not collected at night. Furthermore, an age gradient with depth was no longer present. This was due, in part, to the presence of late larvae at all depths in the water column. The most dramatic feature of the night distribution was the vertical migration of the early juveniles as indicated by their virtual absence on the bottom (0 and 4/1,000 m³) in the sled samples. Juveniles were again present in the lower portion of the water column (101-150 m) and had migrated into the upper 100 m, including the top 10 m. There was no evidence that larvae younger than Stage XIII migrated to any extent. Vertical migratory behavior starts late in the larval phase, before the molt to juvenile and recruitment to the bottom.

Acknowledgments

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