CONTROLLED REARING OF DUNGENESS CRAB LARVAE AND THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON THEIR SURVIVAL

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ABSTRACT

Dungeness crab larvae, when reared at different larval concentrations of 5, 10, 20, and 40 per 200 ml of water, exhibited no optimum larval density although survival was generally highest at 5 per ml. Times of molting were generally similar at each larval concentration. Average size of megalopae at 5 and 10 larvae per flask was 8.0 and 8.1 mm in length, respectively.

Tests showed that the zoeal stages of Dungeness crab react differently to light. Generally the response was positive by all but the fourth stage zoeae.

Zoeae and laboratory reared megalopae displayed a positive phototropism at 25 and 340 ft-c and a negative response at 990 ft-c. Interaction between zoeal stages and light intensities was not significant.

Dungeness crab zoeae generally exhibited no positive rheotaxis at a velocity of 33.8 mm/second. Laboratory reared megalopae swam slowly while wild megalopae swam actively in the swimming chamber.

Post larvae crabs preferred a sand bottom over a gravel bottom and rejected plexiglass and mud substrates.

INTRODUCTION

This report covers studies conducted on Dungeness crab larvae from July 1, 1969, through June 19, 1970. Principal objectives were to determine the following: (1) the effects of crab larval concentration on growth and survival; (2) the effects of light intensity on the swimming behavior of crab larvae; (3) the effects of water current on the swimming behavior of crab larvae; and (4) the preference of post larvae crab for different bottom types.

METHODS AND MATERIALS

Dungeness crab larvae were generally subjected to similar rearing conditions as reported in last year's progress report (Gaumer, 1969). The only significant differences were that I changed the rearing water and fed the larvae twice rather than three times a week, and all larvae were fed at a concentration of 10 San Francisco brine shrimp (Artemia salina) per ml of rearing water.

Effects of Crab Larvae Concentration on Growth and Survival

An understanding of the optimum concentrations of crab larvae reared per unit of water is important in designing future experiments where large numbers of experimental animals are required.

Three tests were conducted to determine the effect of crab larvae concentration on growth and survival. The first test, comparing larvae reared at concentrations of 5 and 10 per 200 mls of rearing water, was interrupted after 16 days when unauthorized personnel changed the thermostat on the temperature water bath and all crab larvae were killed. The second test was not interrupted until intentionally terminated prior to the molt of fifth zoeae to megalopae. The third test (not completed by report time) will compare the survival and growth of crab larvae reared in concentrations of 5, 10, 20, and 40 per 200 ml of rearing water.

Effects of Light Intensity on the Swimming Behavior of Crab Larvae

The plexiglass cyclinder, used to test the effects of light intensity on the swimming behavior of crab larvae in 1969, was modified by doubling its length to 308 cm. It was equipped at one end with an adjustable incandescent microscope light capable of producing approximately 8,100 foot candles (ft-c) of light. The chamber was placed in a darkened, aquaria room to eliminate incidental light. The chamber was filled with filtered and ultraviolet treated seawater at 11 C $\pm$2C and was changed after approximately 1 hour of use to minimize a temperature increase.

Crab larvae of the five zoeal stages and laboratory and wild megalopae were introduced individually in the middle of the chamber and subjected to one of three light intensities (25, 340, and 990 ft-c). The time the larvae required to reach the bottom, positive or negative movement (in cm) during this period and location after 1, 2, 3, 4, and 5 minutes were recorded.

Effects of Water Current on the Swimming Behavior of Crab Larvae

Due to operational problems experienced in 1969, the swimming chamber was reconstructed to test the effects of water current on the swimming behavior of crab larvae. The new chamber is a cylindrical plexiglass tube, 102 mm in diameter, 258 cm long, and with side walls 3 mm thick. The chamber was painted black with a 140 cm viewing window left unpainted 118 cm from the inflow end. A meter stick was placed behind the viewing window to measure crab larvae movement. The light, as used in 1969 to attract crab larvae, was eliminated from the new apparatus because of the uncertainty of the reaction of larvae to it. The chamber was equipped with a pump capable of discharging 38 liters per minute at maximum capacity. Flows were measured by a calibrated flow meter and regulated by either a rheostat or a valve. Water temperature was maintained at 11 C $\pm$2.0 C.

All crab larval stages were subjected to a water velocity of approximately 34 mm per second. This was the slowest current obtainable with the existing apparatus. Previous experiments indicated that a water current faster than this quickly flushed the zoeae from the chamber.

Crab larvae were placed in the chamber individually. Observations were terminated after the larvae settled to the bottom or were swept from the tube before reaching the bottom. It was necessary to stop the testing at this point due to friction creating a reduction in current near the side walls of the chamber. Time and distance each larvae moved from point of entry were recorded.

The Preference of Post Larval Crabs for Different Bottom Types

A chamber, 58.4 cm long, 58.4 cm wide, 21.5 cm deep, and made of 6.35 mm thick plexiglass was constructed to test the acceptibility of several bottom types to post larval crabs. Strips of plexiglass, 5.1 cm wide, were used to divide the bottom into four 29.2 x 29.2 cm square sections.

Two preliminary tests were conducted. In the first, each of the sections was filled with a different substrate (plexiglass, mud, sand, and gravel 26 to 52 mm in diameter). Thirty wild crab megalopae, collected from Yaquina Bay, were placed in the center of the chamber and their locations after molting were recorded. Ambient bay water temperatures of 11 to 12 C were maintained. In the second test, the plexiglass and mud sections were replaced with sand and gravel. This presented post larvae crabs the opportunity to select either of two gravel or sand subsections. Sand and gravel sections were filled diagonally to each other.

RESULTS

Effects of Crab Larvae Concentration on Growth and Survival

Survival of crab larvae, reared at a concentration of 5 and 10 per 200 ml of water after 16 days, was 92.5 and 95.5%, respectively. As previously stated, this experiment was terminated prematurely and subsequently repeated. In the second test, survival of the larvae reared at densities of 5 and 10 zoeae per flask (after 81 days) was 60.0 and 33.3%, respectively. Mortality, for larvae reared 10 per flask, was highest between day 18 and 40. Mortality for zoeae reared 5 per flask was generally regular throughout the test period (Figure 1). Survival last year, at larvae concentrations of 5 and 11 per flask after 77 days of rearing, was 80.0 and 9.6%, respectively (Gaumer, 1969).

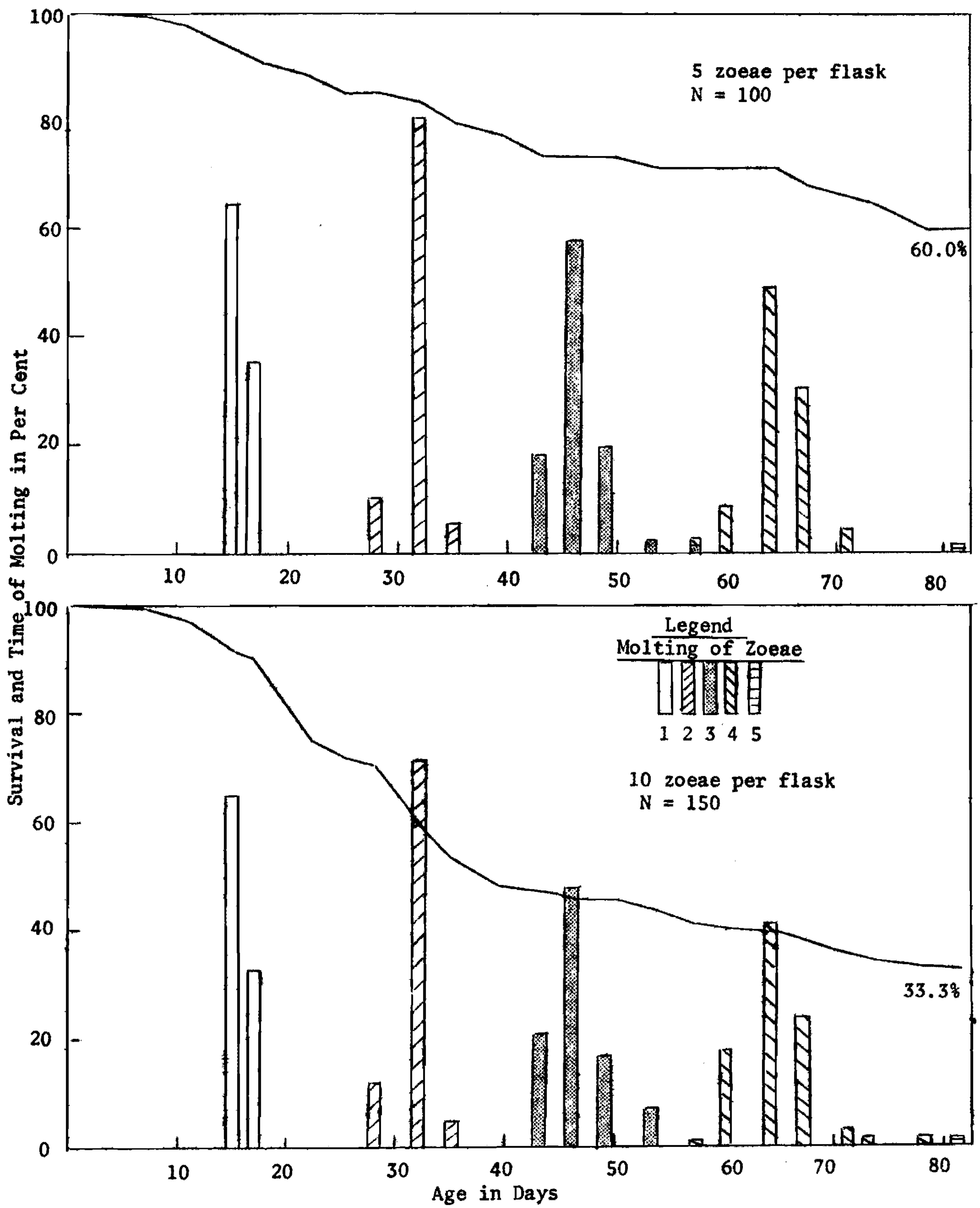

Figure 1. Survival of Dungeness Crab Zoeae (Line) and Molt of Survivors (Histogram) at Two Larvae Concentrations

Growth or time of molting was generally similar for the two groups of crab larvae. The first observed molting of zoeae from the first, second, third, fourth, and fifth zoeal stages occurred on the 15th, 28th, 43rd, 57th, and 81st day, respectively, for each group (Figure 1).

The average size of the megalopae reared at larval concentrations of 5 and 10 per flask and of wild megalopae collected from Yaquina Bay were 8.0, 8.1, and 11.7 mm in length, respectively (Table 1). Megalopae reared last year at a concentration of five larvae per flask were 8.5 mm long (Gaumer, 1969). Megalopae were measured from tip of rostral spine to tip of telson when fully extended.

Table 1. Size Composition of Dungeness Crab Megalopae, 1970

Larval Concentration	Size Range (mm)	Average Size (mm)
Five/flask	6.3-8.8	8.0
Ten/flask	7.8-8.6	8.1
Bay Megalopae 1/	11.0-12.0	11.7

1/ *Not reared in laboratory.*

The experiment on determining the survival of crab larvae at concentrations of 5, 10, 20, and 40 per 200 ml of water is not completed. Preliminary results, after 60 days of rearing, are contradictory to those observed in previous experiments. Survival at 5, 10, 20, and 40 larvae per flask was 77.3, 94.0, 79.0, and 66.0%, respectively (Figure 2). In 1969, at day 60, survival at 5 and 11 larvae per 200 mls of rearing water was 83.3% and 26.7%, respectively. This year in test number 2, survival of 5 and 10 larvae per 200 mls after 60 days was 71.0 and 40.7%, respectively.

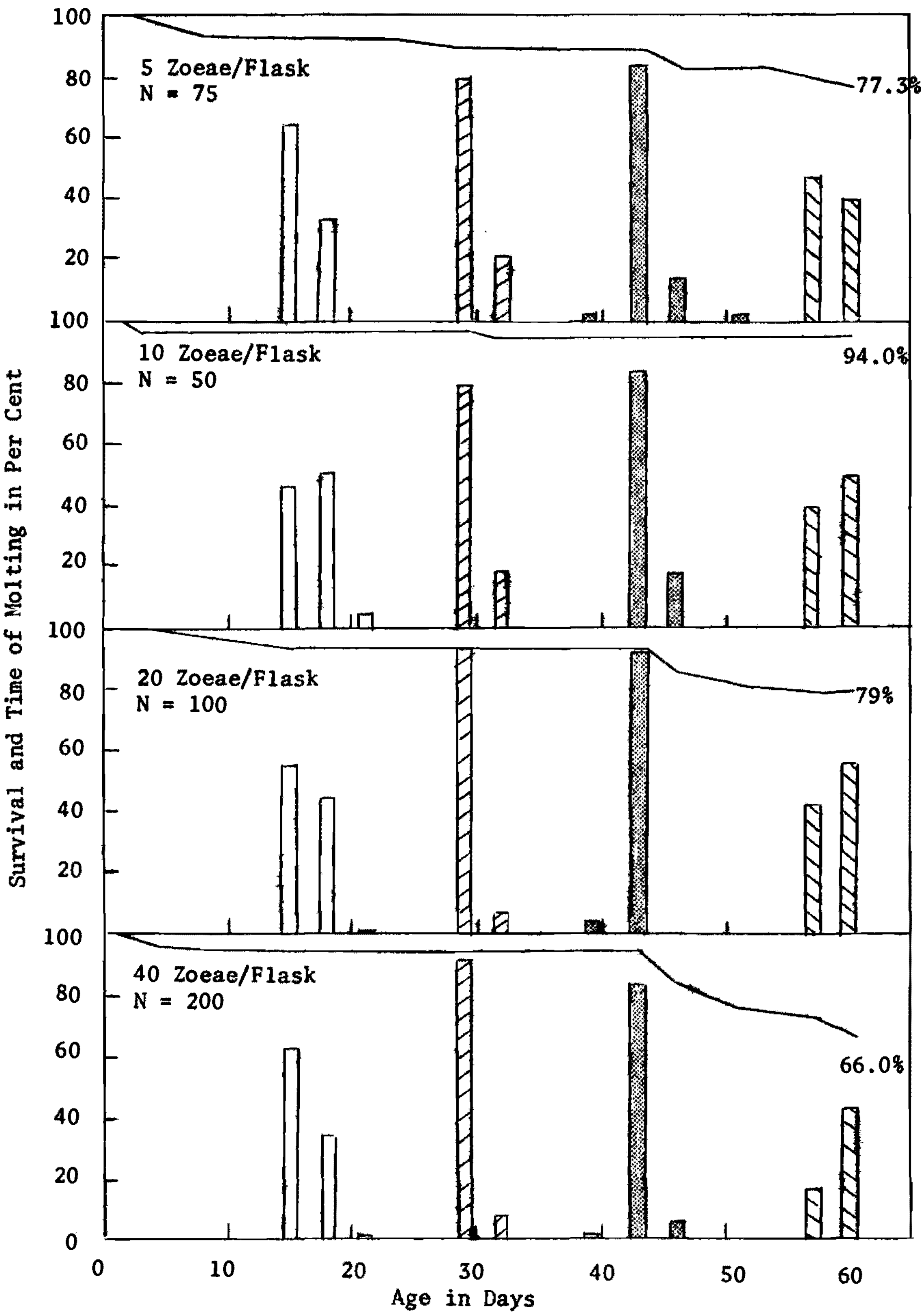

Figure 2. Survival of Dungeness Crab Zoeae (Line) and Molt of Survivors (Histogram) at Four Larval Concentrations, 1970. (Legend Same as Figure 1)

It is interesting that survival at five larvae per flask was generally comparable in all three experiments (71.0 to 83.3%) while at 10 or 11 per flask, it ranged from 26.7 to 94.0%. All rearing conditions were identical for these tests.

Growth as measured by per cent of the crab larvae molted per observation period was generally similar at each larval concentration with the first, second, third, and fourth molts first being observed on the 15th, 29th, 39th, and 57th days, respectively (Figure 2).

Effects of Light Intensity on the Swimming Behavior of Crab Larvae

An analysis of variance was performed on the data showing response of crab larvae to different light intensities. Responses of crab zoeae are summarized in Table 2 and of laboratory reared crab megalopae in Table 3. Statistical tests have not yet been completed for the effects of light on bay megalopae. First and fifth stage zoeae exhibited a significantly different response to light intensity than the second, third, and fourth stages. There was no significant difference in response between the first and fifth zoeal stages nor between combinations of the second, third, and fourth stages. Generally, there was a positive response towards the light by all but the fourth stage zoeae (Table 4).

Zoeae subjected to light intensities of 25 and 340 ft-c displayed a significantly different reaction (positive response) than zoeae exposed to 990 ft-c (negative response). No significant differences in behavior was observed between those exposed to 25 and 340 ft-c. Interaction between zoeal stages and light intensities was not significant.

An analysis of variance on the effects of different light intensities on the swimming behavior of laboratory reared megalopae showed a significantly different reaction between those subjected to 25 and 340 ft-c and those exposed to 990 ft-c. The response was generally positive at 25 and 340 ft-c and negative at 990 ft-c. No significant differences in larvae behavior was noted between 25 and 340 ft-c.

Table 2. Analysis of Variance of Cancer magister Zoeae Swimming Behavior at Different Larval Stages and Light Intensities

Source of Variation	Sum of Squares	df	Mean Square	F 1/
Larval Stages				
1+5 vs 2+3+4	210.4531	1	210.4531	6.56
1 vs 5	13.1208	1	13.1208	<1
3 vs 2+4	24.4297	1	24.4297	<1
2 vs 4	13.6958	1	13.6958	<1
Light Intensity				
25+340 vs 990 (ft-c)	168.3281	1	168.3281	5.25
25 vs 340	0.0307	1	0.0307	<1
Stages-Light Intensity Interaction	78.4505	8	9.8063	<1
Error	1923.7955	60	32.0632	

1/ $F_{.05}$ = 4.00 with 1 and 60 df; 2.10 with 8 and 60 df.

Table 3. Analysis of Variance of Cancer magister Megalopae Swimming Behavior at Different Light Intensities

Source of Variation	Sum of Squares	df	Mean Square	F 1/
Light Intensity				
25+340 vs 990 (ft-c)	71.7158	1	71.7158	9.53
25 vs 340	1.4334	1	1.4334	<1
Error	90.3239	12	7.5270	

1/ $F_{.05}$ = 4.75 with 1 and 12 df.

Table 4. Average Total Movement (in mm) of Dungeness Crab Larvae by Light Intensity and Larval Stage 1/

Light Intensity (ft-c)	1	2	3	4	5	Lab. Megalopae	Totals by Light
25	20.99	0.36	19.16	0.70	19.33	9.53	70.07
340	22.59	2.76	10.69	-1.43	27.17	5.75	67.53
990	-1.92	-0.51	-13.93	-16.93	15.00	-15.55	-33.84
Totals by Stage	41.66	2.61	15.92	-17.66	61.50	-0.27	

1/ *Positive numbers indicate positive movement towards light and negative numbers indicate movement away from light.*

Effects of Water Current on the Swimming Behavior of Crab Larvae

Dungeness crab zoeae generally displayed no positive rheotaxis to a current of 33.8 mm/second. The zoeae, when released, usually drifted with the current and at the same time slowly settled to the bottom of the chamber. Average time required for the zoeae to settle to the bottom or leave the swimming chamber before touching the bottom was 16.5, 46.3, 11.4, 29.4, and 5.6 seconds for the first, second, third, fourth, and fifth stages, respectively. Megalopae reared in the laboratory generally were able to maintain their position in the water column whereas wild megalopae actively swam back and forth in the swimming chamber. Average time required before the laboratory and wild megalopae settled to the bottom was 118.4 and 15.6 seconds, respectively. The laboratory megalopae, because of their slow swimming behavior, remained up in the water column while the bay megalopae touched the bottom shortly after release and continued to frequently touch the bottom as they actively swam back and forth in the swimming chamber.

Swimming speed as measured by the difference in rate of movement covered by the zoeae before touching the bottom in relation to the speed of the water current is shown in Figure 3. Of the zoeae, larvae of the fourth stage swam most actively (13.1 mm/second) while the fifth stage zoeae exhibited the least desire to swim (0.54 mm/second).

Laboratory and wild magalopae displayed a significantly more active swimming behavior than the zoeal stages. Laboratory megalopae generally maintained their position in the water current whereas wild megalopae had a swimming capability of 62.7 mm/second (Figure 3).

Preference of Post Larval Crab for Different Bottom Types

Preliminary observations were completed on the preference of 30 post larval crabs for different bottom types. Four days after release 4.0, 32.0,

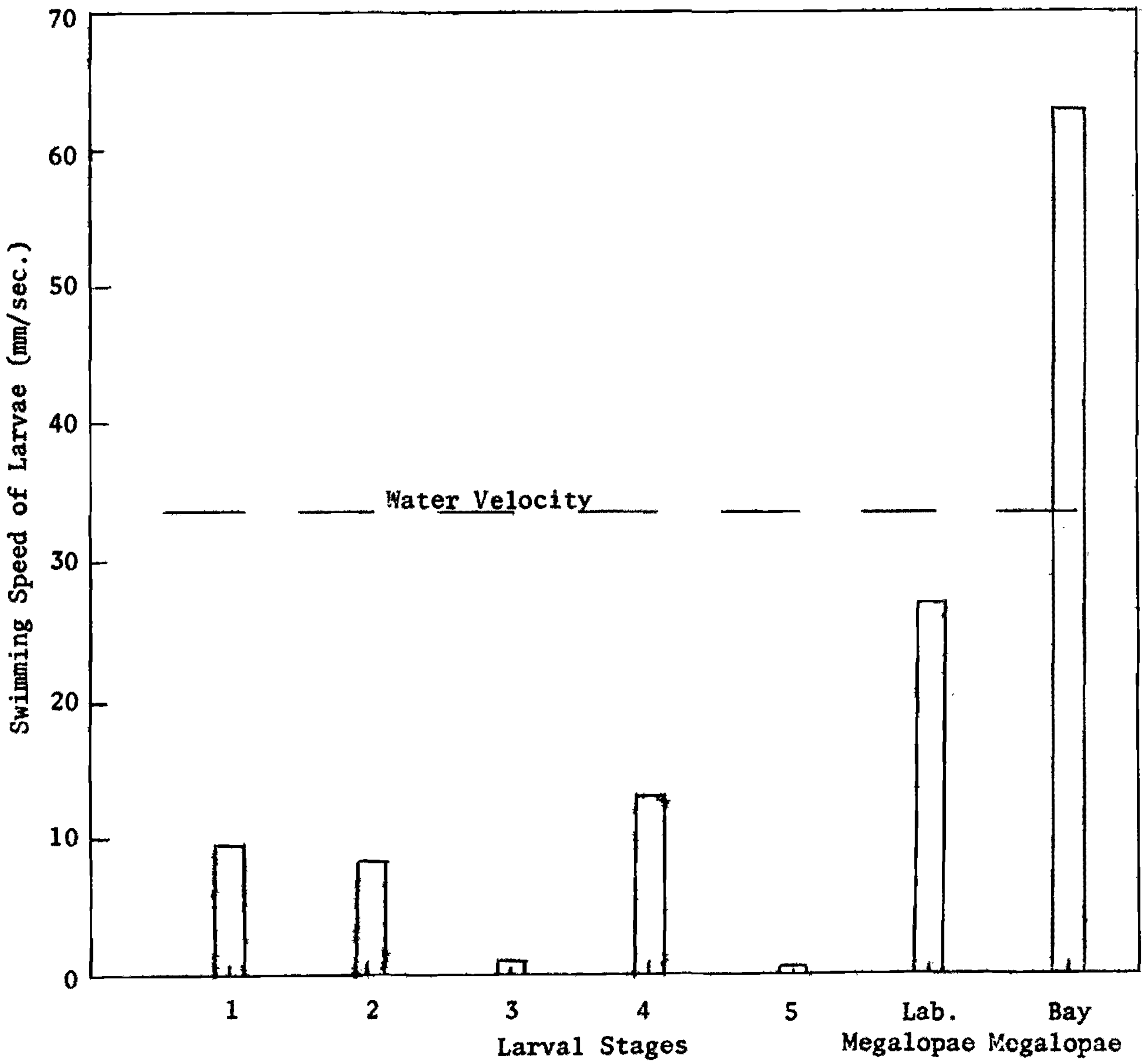

Figure 3. Average Swimming Speed 1/ of Crab Larvae, by Stage, When Subjected to a Water Current of 33.8 mm/Second.

1/ *Swimming speed = water velocity ± rate of movement of larvae from starting point.*

and 64.0% of the crabs had molted from the megalopae stage and had established positions on plexiglass, sand, and gravel bottoms, respectively. None of the crabs established positions on the mud bottom. By day 11, their preference had shifted and 60.9 and 39.1% of the larvae were counted on the sand and gravel bottoms, respectively.

Due to this obvious preference for sand and gravel bottom types, I modified the test apparatus by eliminating the plexiglass and mud substrate and replaced them with sand and gravel. This allowed the crabs to select between two sand and two gravel filled subsections.

One day after release, 60.0 and 40.0% of the post larvae crabs had selected sand and gravel substrates, respectively. After 3 days the preference for sand bottom had increased to 80.8% of the crabs.

LITERATURE CITED

Gaumer, T. F., 1969. Controlled Rearing of Dungeness Crab Larvae and the Influence of Environmental Conditions on Their Survival. Commercial Fisheries Research and Development Act Progress Report, July 1, 1968, to June 30, 1969. Fish Commission of Oregon Processed Report. 17 p.