study. Also, we did not detect any morphological changes that accompany formation of the epitokes as described by Simpson (1962).

Swimming bloodworms at night have also been reported for two other Maine inshore waters. Dean[3] saw 22 bloodworms during observations made between 24 January and 29 March 1977 on 33 nights. The worms were present during five nights in March and 15 were collected under a night-light in the Damariscotta River, Maine—8 on 11 March and 7 on 12 March. The gametes of the worms were not sexually mature and the presence of the worms near the surface at night was not related to spawning. Dean also reported that buoyed and anchored nets set in Montsweag Bay and the Sheepscot estuary between 1970 and present captured 22 glycerids, some of which were *G. dibranchiata*. In contrast, the senior author of this paper did not capture bloodworms in buoyed and anchored nets set in the Sheepscot estuary over the same time period and in the same vicinity. Possibly, the swimming of bloodworms at night is sporadic.

A recent study of residual currents in Sullivan Harbor suggested that the relatively shallow nets above the edge of the channel (Figure 1) and at the surface over the tidal flats strained a residual seaward flow transporting tychoplankters and the relatively deep nets strained a residual landward flow. Distribution of bloodworms throughout the water column would, therefore, insure their wide dispersal by horizontal tidal currents, and it is unlikely that after a tidal cycle they would regain the location of their original burrows.

We hope to study further the bloodworms of Sullivan Harbor and do not wish to speculate on their origin or fate at this time. Rather, it is our purpose to suggest that researchers investigating bloodworms within their bottom habitat should also examine their possible role as tychoplankters for two reasons: populations of this important commercial species in separate flats may become intermixed, introducing problems in their management; and the reestablishment of worm populations previously destroyed by pollution or other environmental catastrophe might proceed more rapidly in those areas where there is winter transport of mature worms, as well as the "normal" dispersion of late spring larvae.

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[3] Dean, D. The swimming of bloodworms (*Glycera* spp.) at night. Unpubl. manuscr.

SIMULATED FOOD PATCHES AND SURVIVAL OF LARVAL BAY ANCHOVY, *ANCHOA MITCHILLI*, AND SEA BREAM, *ARCHOSARGUS RHOMBOIDALIS*

Survival rates of laboratory-reared marine fish larvae often are directly related to prey concentration. Best survival usually has been reported when prey are available at concentrations >1,000/l (O'Connell and Raymond 1970; Laurence

1974, 1977). Houde (in press) recently demonstrated that survival of three species of marine fish larvae from hatching to metamorphosis was 10% or higher when mean prey concentrations were only 34-130/l. But, he also found enhanced survival when food concentrations were increased. For significant numbers of larvae to survive the transition stage from yolk nutrition to active feeding, some researchers believe that dense patches of prey must occur in the sea (O'Connell and Raymond 1970; Hunter 1972). Such patches might occur at densities of 10 to 1,000 times above the mean prey density. Lasker (1975) has discussed the dense patches of the dinoflagellate *Gymnodinium splendens,* which serves as prey for larval northern anchovy, *Engraulis mordax,* in the California Current and their possible relationship to larval survival. Hunter and Thomas (1974) demonstrated that larval northern anchovies were able to remain in patches of *G. splendens* that were artificially created in laboratory experiments.

In two series of laboratory experiments we have examined the effect of two simulated patches of prey on survival in the bay anchovy, *Anchoa mitchilli,* and the sea bream, *Archosargus rhomboidalis.* Patches were simulated during the first 6 days after hatching, when these larvae are most susceptible to starvation mortality. The purpose of the experiments was to determine if prey at high density that were offered for more than some minimum period would result in survival rates of larvae that approached those obtained at a high, constant prey concentration. This would indicate that the larvae were able to obtain a daily ration suitable for maintenance and growth by increasing their feeding rate during the period of exposure to the patch concentration of prey. At the low prey concentrations usually found in the sea, a relatively great expenditure of energy would be required by larvae to obtain the minimum daily ration for maintenance and growth. Such larvae might weaken or fail to grow and thus be more susceptible to starvation or predation.

Methods

Larvae were hatched from fertilized eggs that were collected in plankton nets from Biscayne Bay, Fla. In each experimental trial 140 sea bream eggs were stocked (2.0/l) and 280 bay anchovy eggs were stocked (4.0/l) in a 76-l glass aquarium. Larvae were reared for 10 days at 26±1°C. Salinities ranged from 30.0 to 32.5‰ for bay anchovy and 33.0 to 33.5‰ for sea bream. Lighting was provided at 2500-2800 lx by 40-W, cool-white fluorescent tubes. A 13 h light-11 h dark schedule was maintained. Tanks were isolated in a black plastic enclosure and all light was extinguished during the dark periods. Sea bream and bay anchovy larvae do not feed in the dark. At the end of experiments, survivors were preserved in 5% Formalin[1] and measured using an ocular micrometer.

Prey were the nauplii and copepodid stages of copepods, approximately 50-100 μm in diameter, that were collected in 53-μm mesh plankton nets. Prey concentrations were determined by counting organisms in 100- to 200-cm^3 aliquots from the rearing tank (Houde 1975, 1977) several times per day during the 13-h feeding period. Background (i.e., nonpatch) prey levels were set at 25-50/l; this concentration was maintained when patch concentrations were not offered from 2-6 days after hatching and continuously from 7-10 days after hatching. The patch concentration was 500 prey/l. Patches were provided for periods ranging from 1.5 to 11 h (Tables 1, 2). Both 0 h, at which no patches were provided, and 13h, at which a constant 500/l prey concentration was maintained, also were included in the series of experiments for each species. The patch schedules were maintained for only the first 5 days of active feeding because larvae that survived that period had greatly increased their searching ability and were less dependent on high prey concentrations for successful feeding.

Patches were created by adding prey to obtain the 500/l concentration. After larvae had fed at the patch concentration for the desired period, prey were reduced to 25-50/l by siphoning them out of the system through a 280-μm mesh screen and replacing the siphoned water with 26°C filtered seawater from a 150-l header tank. Sea bream larvae had no difficulty avoiding the siphon and its screen during water exchanges, but precautions were necessary for bay anchovy larvae. A 280-μm mesh partition was used to "herd" anchovy larvae toward one end of the tank prior to each siphoning procedure. Siphoning procedures and water exchanges also were carried out in the 0-h and 13-h patch period experiments to insure that those larvae were exposed to the same procedural disturbances as larvae in experiments where prey concentration was being varied.

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[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Larvae were exposed to the patch concentration twice during each 13-h feeding period to obtain the total desired time at the patch level. For example, for a 6-h patch exposure, the prey concentration was adjusted to 500/l from 0800 to 1100; it was then quickly reduced to 25-50/l, where it was maintained until 1800, when the prey concentration was readjusted to 500/l for the remaining 3 h of the light cycle.

Results

Anchoa mitchilli

Percent survival ranged from 0.36% at 0-h patch exposure to 22.86% at 13 h (Table 1). The steady increase in survival as patch exposure time was increased was described by an exponential function, $Y = 0.3038\, e^{0.3419X}$, where Y = percent survival and X = hours at 500/l prey concentration (coefficient of determination, $r^2 = 0.98$). For the 500/l patch concentration, there was no minimum time of exposure above which larval anchovy survival increased sharply or equalled the survival obtained when larvae were exposed throughout the day to the 500/l prey concentration.

Surviving bay anchovies at 10 days after hatching differed significantly in mean standard lengths (Table 1) among patch exposure times (analysis of variance, $P<0.001$). Mean lengths at 3-, 6-, and 9-h patch exposure times were significantly greater than those at 11 and 13 h (Student-Newman-Keuls test, $P<0.05$).

TABLE 1.—Survival and standard lengths of *Anchoa mitchilli* larvae at 10 days after hatching based on 280 eggs and variable patch exposure times. A patch is a prey concentration of 500/l. Nonpatch levels were 25-50/l. Patch conditions were presented to larvae on days 2-6 after hatching.

Patch exposure time (h)	Survival		Standard length (mm)	
	Percent	No.	Mean	SD
[1]0.0	0.36	1	6.75	—
3.0	0.70	2	7.79	0.17
6.0	1.79	5	7.50	0.68
9.0	9.29	26	7.18	0.64
11.0	13.93	39	6.41	0.76
[2]13.0	22.86	64	6.58	0.58

[1]Food concentration was held constant at 25-50/l during days 2-6.
[2]Food concentration was held constant at 500/l during days 2-6, then reduced to 25-50/l during days 7-10.

Archosargus rhomboidalis

Survival ranged from 3.57 to 66.43% for sea bream larvae over the range of patch exposure times (Table 2). The relationship between percent survival and patch exposure time was described by a power function, $Y = 25.0739X^{0.2878}$, where Y = percent survival and X = hours at 500/l prey concentration. Although the power function described the relationship reasonably well (coefficient of determination, $r^2 = 0.94$), an asymptotic regression might be better to describe the relationship because sea bream larvae exposed to a 500/l patch density for between 3 and 6 h daily apparently survived as well as when the 500/l prey concentration was offered throughout the day. The power function is retained here because fits to the data by asymptotic regressions gave lower coefficients of determination, due to the relatively high variability in observed survival as patch exposure times increased.

TABLE 2.—Survival and standard lengths of *Archosargus rhomboidalis* larvae at 10 days after hatching, based on 140 eggs and variable patch exposure time. A patch is a prey concentration of 500/l. Nonpatch levels were 25-50/l. Patch conditions were presented to larvae on days 2-6 after hatching.

Patch exposure time (h)	Survival		Standard length (mm)	
	Percent	No.	Mean	SD
[1]0.0	3.57	5	4.21	0.44
1.5	22.00	31	4.04	0.56
3.0	32.14	45	3.77	0.56
6.0	59.29	83	3.87	0.40
9.0	41.43	58	3.31	0.41
11.0	66.43	93	4.18	0.28
[2]13.0	42.00	59	4.21	0.31

[1]Food concentration was held constant at 25-50/l during days 2-6.
[2]Food concentration was held constant at 500/l during days 2-6, then reduced to 25-50/l during days 7-10.

Mean lengths of survivors at 10 days (Table 2) differed significantly among patch exposure times (analysis of variance, $P<0.001$), but there was no clear relationship between the mean lengths that differed significantly (Student-Newman-Keuls test, $P<0.05$) and the time of exposure.

Discussion

There was a marked difference in response of bay anchovy and sea bream larvae to the simulated patch conditions. Sea bream survival improved greatly when larvae were presented with prey at 500/l for more than 3 h/day, the observed survival then equaling that when they were offered a constant 500/l prey concentration. Bay anchovies were less successful in using the patch conditions to improve their survival, although increased survival rates did occur when larvae were exposed for more than 6 h to the patch concentration. Results imply that first feeding bay anchovy may require a high and stable prey density to attain best survival in the sea, but that sea bream are better adapted to survive under fluctuating food conditions.

Survival observed in these experiments can be compared with that reported previously (Houde in press), when survival was related to prey densities that were held constant from day 2 to day 16. Predicted survivals at constant prey densities of 25-50/l and 500/l were 0.72-3.86% and 29.31%, respectively, for bay anchovy larvae; and 5.94-16.61% and 70.45% for sea bream larvae. Observed survivals at 0-h and 13-h patch exposures (Tables 1, 2), which correspond to the 25-50/l and 500/l constant prey concentrations, were only slightly lower than those reported in the constant prey level experiments (Houde in press). The small differences probably were caused by the siphoning and water exchange procedures which did subject larvae to some stress. The similarity of results in the two reports indicates that the patch simulation procedure was effective in demonstrating the impact of patches on larval survival.

Growth results were inconclusive. Significant differences in mean lengths were observed among patch exposure times for both species (Tables 1, 2). In sea bream there was no clear relationship between mean lengths and patch exposure times, but, unexpectedly, bay anchovy mean lengths were smallest at the longest patch exposure times. Presumably only the hardiest larvae survived when patches were presented for only a short time, and these larvae also may have had a relatively great potential for growth. At the long exposures to patch densities, survival was better, but no improvement in growth was noted, possibly because some larvae with relatively poor growth potential survived, or because of density-dependent effects on growth that have been previously observed (Houde 1975, 1977). Another compensating factor was that patches were only presented on day 2 to day 6 of the experiments, the prey concentrations in all experiments being held constant at 25-50/l from day 7 to day 10.

Only one possible patch regime was used in these experiments. It is possible that other patch densities or exposure schedules might alter results or conclusions. An infinite number of possible patch conditions could be simulated but future experiments should be delayed until the temporal and spatial scales of patchiness of organisms consumed by marine fish larvae are better known. Conditions that were simulated in these experiments do not discount the possible ability of larvae in the sea to maintain themselves within prey patches that retain their integrity for days or weeks. Hunter and Thomas (1974) demonstrated that northern anchovy larvae could maintain themselves within small patches of *Gymnodinium splendens* in laboratory tanks. Lasker (1975) found that feeding northern anchovy larvae were relatively more abundant in the chlorophyll maximum layer of the Los Angeles Bight, where *G. splendens* was abundant, than in surface waters, and he suggested that larvae might be able to maintain themselves in this rich source of food. Bay anchovy larvae in our experiments derived small benefits from the patch regime that we provided, but there may be stable patch conditions in the sea which could greatly increase their potential for survival.

Acknowledgments

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DISCOVERY OF JUVENILE PACIFIC SALMON (COHO) IN A SMALL COASTAL STREAM OF NEW BRUNSWICK

Three juvenile Pacific salmon (Figure 1) were discovered in a small coastal stream in southern New Brunswick (Figure 2) in October 1976 while young Atlantic salmon, *Salmo salar*, were being collected for laboratory experiments. The Pacific salmon were not recognized by the electrofishing team, and their presence among the Atlantic salmon was not realized until the fish were sorted in the laboratory some days or weeks later. Identification as either coho salmon, *Oncorhynchus kisutch*, or chinook salmon, *O. tshawytscha*, was later confirmed by W. B. Scott of Huntsman Marine Laboratory, St. Andrews, N.B. Positive identification to species of these juvenile fish was not possible, but they were almost certainly coho salmon because of recent introductions of this species to the Atlantic coast.

Coho salmon are not native to the Atlantic, and no populations reproducing in natural streams of the Atlantic coast are known. Two aquaculture operations using coho salmon are under way in Maine, and coho salmon smolts have been released in streams in New Hampshire and Massachusetts since 1969 and 1971, respectively (Figure 2, inset). Presumably, the parents were from one or more of these four operations. No adults have been reported from New Brunswick streams.

When the coho calmon were recognized, further trips were made to obtain an estimate of their numbers in the stream, their size, and habitat preference in comparison with Atlantic salmon and brook trout, *Salvelinus fontinalis*, which were also present.

The stream, known locally as Frost Fish Creek, drains into the estuary of the Digdeguash River about 250 m from the Digdeguash Falls. It is a small stream approximately 3 m wide in the lower kilometer where all fishing took place. Its drainage area is approximately 570 ha. Discharge during low summer flow reaches as little as 80 l/s (Symons and Harding 1974). The lowermost 0.25 km is steep with cascades and pools. The stream here is either open to the sky or overhung with alders. Most of the Atlantic salmon yearlings occur in this portion of the stream. Through the next 0.25 km upstream the gradient decreases; occasional riffles are separated by pools and slow-flowing water. Bankside cover consists of coniferous softwoods partially clearcut. Atlantic salmon yearlings and underyearlings occur in the riffles of this section while the pools and quieter water are inhabited by brook trout. Above this section the

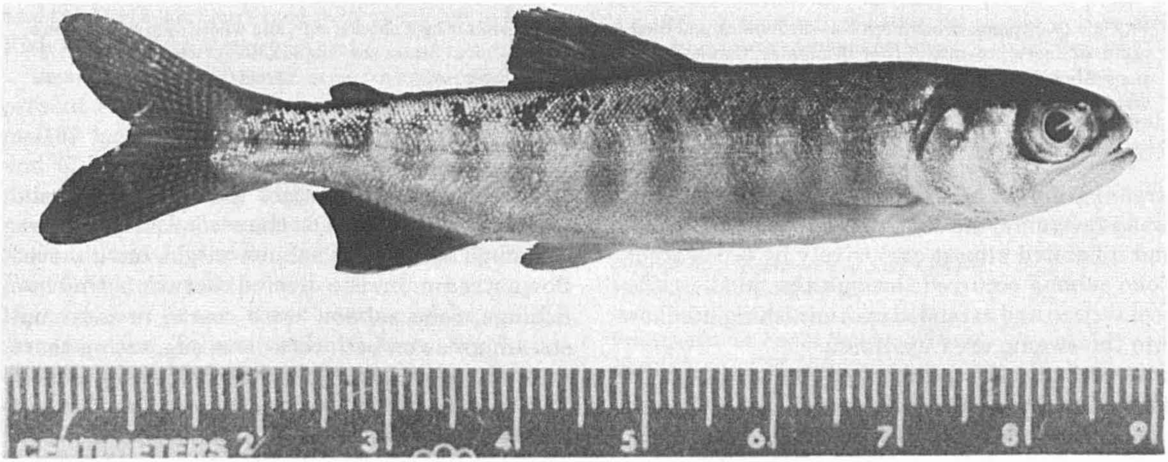

FIGURE 1.—Underyearling coho salmon captured on 28 October 1976 in Frost Fish Creek, N.B.