VERTICAL DISTRIBUTION OF ICHTHYOPLANKTON OFF THE OREGON COAST IN SPRING AND SUMMER MONTHS

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ABSTRACT

Day and night discrete-depth tows were taken off the Oregon coast in spring and summer months to assess the vertical distribution of ichthyoplankton in nearshore waters. Over 1,000 larvae representing 33 taxa of both coastal and offshore ichthyoplankton assemblages were taken; *Psettichthys melanostictus* was the most abundant coastal species and *Lyopsetta exilis* the most abundant offshore species. Larvae were generally most abundant at 10-30 m, near the seasonal thermocline in both day and night collections. Larval abundance in July was much higher than in April-May collections. Limited evidence for diel vertical migration suggests that *Psettichthys melanostictus* moves to surface waters at night and *Gadus macrocephalus* moves to deeper water at night. No trends of changes in depth distribution were observed with increasing size.

Knowledge of the vertical distributions of larval fishes is crucial to full understanding of their biology and to understanding the results of ichthyoplankton surveys (Ahlstrom 1959; Kendall and Naplin 1981). The interaction between vertical distributions and physical processes can have important effects on onshore-offshore distributions of planktonic organisms in upwelling regions such as the coastal northeastern Pacific (Peterson et al. 1979; Parrish et al. 1981; Wroblewski 1982; Rothlisberg et al. 1983). Near-surface distribution, for example, may result in shoreward transport in slicks associated with internal waves (Shanks 1983). In the coastal region off Oregon, the only information on larval fish vertical distribution is a comparison between abundances of *Parophrys vetulus* and *Isopsetta isolepis* larvae from neuston and oblique bongo net tows (Laroche and Richardson 1979) and one 24-h study with stratified samples taken by bongo nets without opening-closing devices (Richardson and Pearcy 1977). With the exceptions of the classic study by Ahlstrom (1959) and recent studies by Brewer et al. (1981) and Schlotterbeck and Connally (1982), little else is known about the vertical distribution of larval fishes in northeastern Pacific coastal waters. In this paper, we present information on vertical distributions of larval fishes off Oregon.

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METHODS

Six series of samples were collected in 1982, four during daylight (30 April, 14 May, 2 and 13 July) and two during night (2 and 6-7 July). The first two series (30 April, 14 May) were taken at station NH10, 10 nmi (18.5 km) off Newport, OR, on the Newport hydroline (lat. 44°40′N; Fig. 1). All others were collected at NH5 (9.2 km offshore). Each sample series consisted of a variable number of tows at discrete depth strata from the surface to within about 4 m of the bottom (Table 1).

Tows were stepped oblique in five intervals of 3 min each, resulting in a total sampling time of 15 min in each 5 or 10 m depth stratum. The sampler was an opening-closing Tucker trawl (Clarke 1969) with three nets and a double-release mechanism operated by messengers. The nets were 0.505 mm mesh (Nitex[3]) with a 1 m^2 mouth; all tows were at a wire angle of 45° at approximate tow speeds from 0.9 to 1.1 m/s. At this angle, effective mouth area of the net is 0.71 m^2. An uncontaminated, discrete depth sample was collected in the second net by lowering the trawl with the first net open, opening the second net for the desired sampling time, and retrieving the trawl with the third net open. Water volumes filtered were estimated with General Oceanics flowmeters mounted in the center of each net. Volumes of water filtered usually ranged between 250 and 450 m^3/sample. Temperature and salinity data were collected throughout the water column on each cruise using Niskin bottles to collect

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

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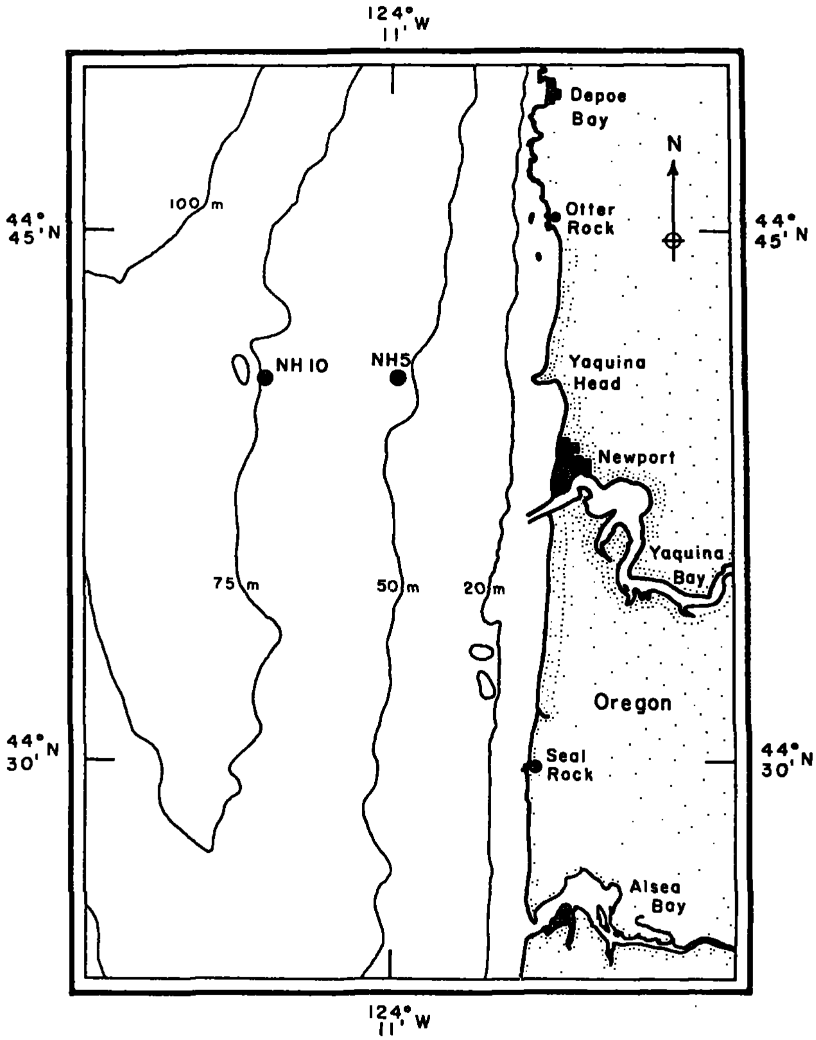

FIGURE 1.—Locations of the sampling conducted during the present study. NH5 and NH10 indicate the stations used.

TABLE 1.—Number of tows per depth stratum with total volumes filtered. (Asterisk indicates that for subsequent analysis the NH10 day sample in the two deepest categories were combined with the 50-60 m stratum.) Sample times were as follows: Day—4/30, 1018-1547; 5/14, 0808-1600; 7/2, 0608-0907; 7/13, 0554-1048; night—7/2, 0016-0514, 7/6-7/7, 2330-0410.

	Day						Night		
	NH10			NH5			NH5		
Depth (m)	4/30	5/14	Total volume filtered (m³)	7/2	7/13	Total volume filtered (m³)	7/2	7/6-7/7	Total volume filtered (m³)
0-5	2	2	1,682.7	2	2	1,392.6	2	2	1,574.8
5-10	2	2	1,783.7	2	2	1,451.2	2	2	1,575.7
10-20	2	2	1,595.7	1	2	862.9	2	2	1,292.9
20-30	2	2	1,796.7	1	2	929.3	2	2	1,237.6
30-40	1	2	1,415.8	1	2	920.5	1	2	1,184.0
40-50	1	2	1,488.1	1	2	920.9	1	2	1,034.8
50-60	1	2	1,891.2	1	2	671.3	1	1	808.3
60-70*	1	1	930.0	—	—	—	—	—	—
70-80*	—	1	704.8	—	—	—	—	—	—

water samples at 5 to 10 m intervals or using a self-contained Applied Microsystems CTD-12. The salinities of water bottle samples were determined in the laboratory using a Guideline 8400 autosalinometer. The CTD salinities from 13 July were not used because of suspected machine malfunction. The CTD temperatures from 13 July agreed with surface bucket temperatures and were used in our study.

Plankton samples were preserved at sea in 10% buffered Formalin. Samples were sorted for fish larvae in the laboratory using a dissecting microscope. Larvae were identified to the lowest possible taxon, measured (standard length), and stored in 5% buffered Formalin.

Larval abundances were calculated as number per 1,000 m^3 for each tow. The six sampling series were combined into three data sets, spring daytime samples (30 April and 14 May, NH10), summer daytime (2 and 13 July, NH5), and summer nighttime (2 and 6-7 July, NH5). In April and May the salinity profiles closely paralleled each other, with lower salinity at the surface, 30.5-31.0‰, than in deeper water, where salinities gradually increased to about 33-34‰ (Fig. 2a). Water temperatures above 50 m

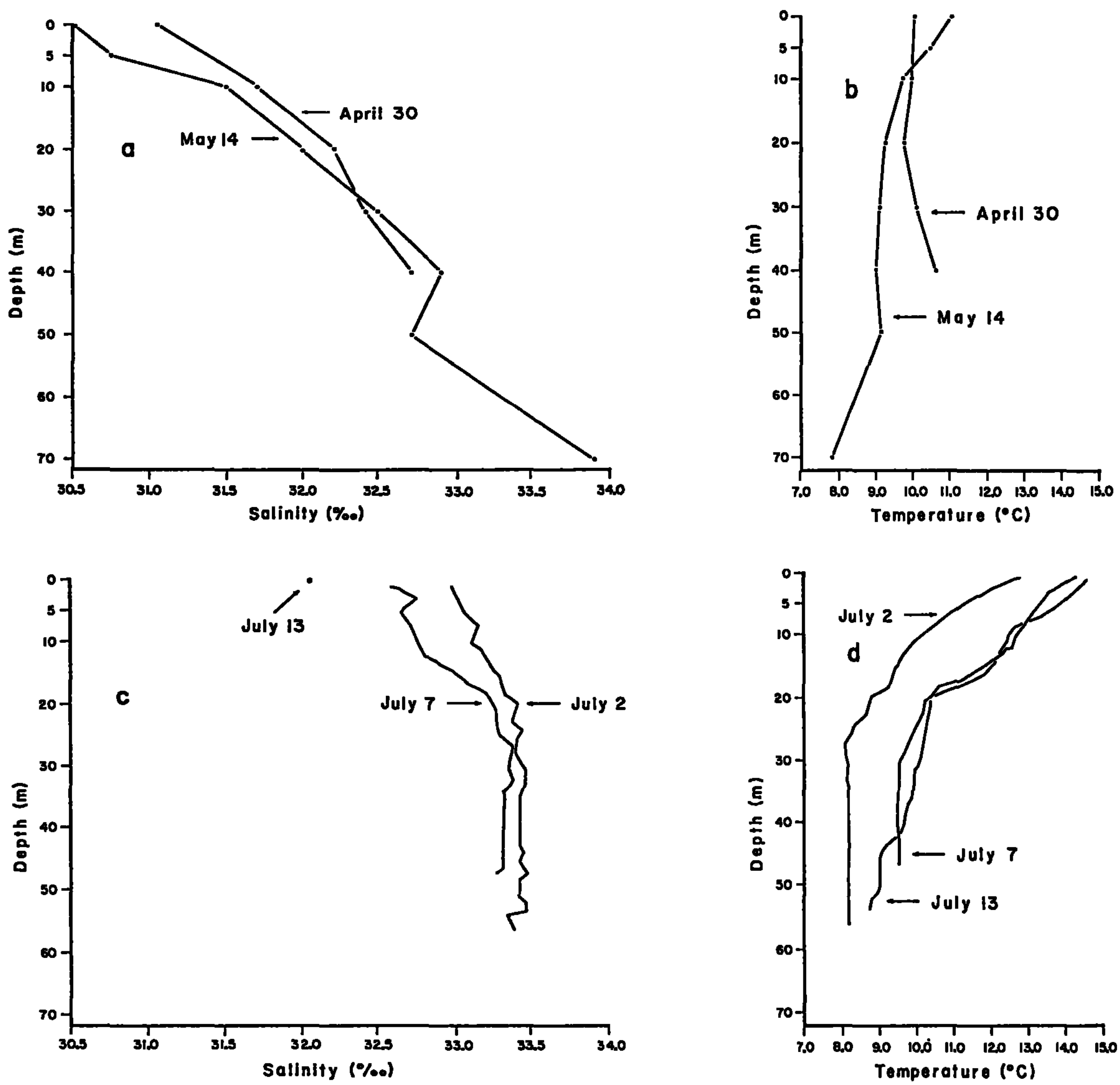

FIGURE 2.—Salinity and temperature profiles during the collections. a. Salinity profiles during the spring collections. b. Spring temperature profiles. c. Summer salinity profiles. d. Summer temperature profiles.

in April and May were about 9°-11°C (Fig. 2b). No thermocline was present. Thus, hydrographic regimes support grouping April and May samples together. Temperature and salinity profiles in April and May were typical for the winter Oregon hydrographic regime prior to the onset of late spring-early summer upwelling (Huyer 1977).

In July the salinity and temperature profiles differed from those in April and May (Figs. 2c, d). Salinities were more uniform in summer than spring throughout the water column, ranging from 32.0‰ at the surface to 33.4‰ below about 20 m (Fig. 2c). The temperature gradient in July was greater than in April and May due to warmer surface waters (Fig. 2d). Surface temperatures ranged from 12.8° to 14.6°C, decreasing with depth to about 8.2°-9.6°C at 40 m. A thermocline was present at about 10-20 m. Temperature and salinity profiles in July were typical of the summer Oregon hydrographic regime (Huyer 1977). Surface temperatures suggest that samples were not taken during active upwelling.

RESULTS

In this study, a total volume of 29,145.5 m^3 was filtered and 1,007 larvae, representing 33 taxa, were enumerated from 75 discrete depth tows. Larvae were most abundant in summer, with an abundance peak 10-30 m deep during daytime and 20-30 m deep during nighttime (Fig. 3). In spring, larvae were distributed relatively uniformly throughout the water column below 5 m with small abundance peaks at 10-20 and 40-50 m. During daytime in both spring and summer, larvae were least abundant at the surface (0-5 m), although abundance at the surface increased at night. The depth distribution at night also differed in having a secondary abundance peak near the bottom (50-60 m) and greater overall larval abundance than during the day.

The larval fish species were categorized as coastal (most abundance 2-28 km from the coast, see Tables 2, 3, and 4), or offshore (most abundant 37-111 km from the coast, see Tables 5, 6, and 7), according to larval assemblages described by Richardson and Pearcy (1977). Most larvae in this study were of the coastal assemblage because samples were collected at NH5 and NH10 (9.2 and 18.5 km from the coast, respectively). The spawning seasons of the dominant species off Oregon are discussed in Mundy (1984); most of the fall-winter spawning species were not represented in this study. Since many species were not abundant enough to demonstrate trends, only the dominant species will be discussed below.

Coastal Assemblage

Gadus macrocephalus, Microgadus proximus, Isopsetta isolepis, and *Psettichthys melanostictus* larvae were abundant in all three sampling periods (Tables 2, 3, 4, Fig. 4). *Gadus macrocephalus* larvae were most abundant during the day at 20-30 m in both spring and summer, but were very abundant in the deepest stratum (below 50 m) in night samples (Fig. 4). *Microgadus proximus* larvae do not show as clear a trend, but were most abundant in deeper water during summer, particularly at nighttime. In spring they were distributed throughout the water column. *Isopsetta isolepis* and *P. melanostictus* were also most abundant in nighttime samples. More *I. isolepis* larvae were found at 10-20 m in spring, whereas in summer they were collected throughout the water column, with abundance peaks near the bottom. *Psettichthys melanostictus* larvae were more abundant in summer than spring samples. During daytime in summer, *P. melanostictus* were most abundant below 10 m, whereas at nighttime, although found throughtout the water column, they were most abundant in waters shallower than 10 m (Fig. 4).

Seasonal abundance changes were observed for

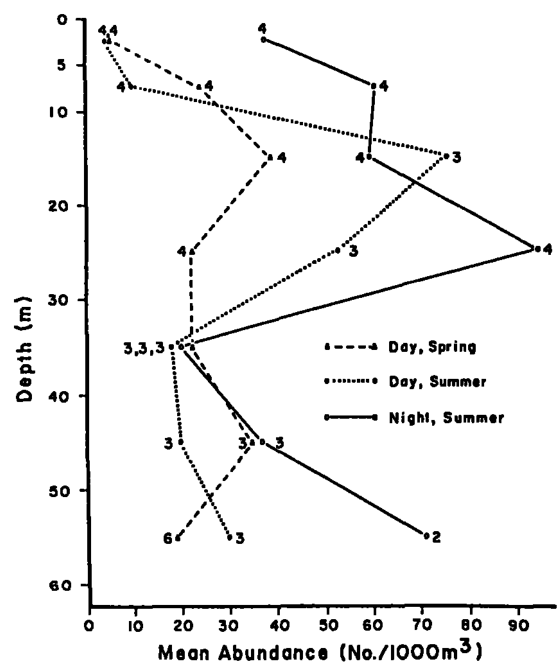

FIGURE 3.—Overall larval abundance (larvae per 1,000 m^3) for all collections. Numbers adjacent to data points indicate the number of samples taken.

TABLE 2.—Mean abundances (number per 1,000 m^3) for coastal larval species from spring (day only) samples.

	Depth (m)							
Species	0-5	5-10	10-20	20-30	30-40	40-50	>50	Mean
Clupeidae								
Clupea harengus	—	—	1.76	2.36	1.25	0.75	—	0.87
Osmeridae								
Undetermined spp.	—	1.85	5.02	1.22	1.51	1.16	0.23	1.57
Gadidae								
Gadus macrocephalus	1.14	0.53	5.69	7.59	2.91	—	0.89	2.68
Microgadus proximus	1.13	2.04	3.87	2.97	0.73	2.95	0.45	2.02
Cottidae								
Artedius fenestralis	—	—	—	—	—	—	—	—
Artedius harringtoni	—	—	—	—	—	0.75	0.41	0.17
Artedius meanyi	—	—	—	—	—	—	0.44	0.06
Clinocottus embryum	—	—	—	—	—	—	—	—
Cottus asper	—	0.53	—	—	—	—	—	0.08
Radulinus asprellus	—	—	—	—	—	—	2.60	0.37
Agonidae								
Odontopyxis trispinosa	—	—	—	—	—	—	0.23	0.03
Cyclopteridae spp. 1	—	—	—	0.74	2.29	3.64	0.45	1.02
Undetermined spp.	—	—	—	0.47	—	—	—	0.07
Bathymasteridae								
Ronquilus jordani	—	0.59	—	—	—	—	—	0.08
Ptilichthyidae								
Ptilichthys goodei	—	—	0.94	—	—	—	—	0.13
Bothidae								
Citharichthys stigmaeus	—	—	—	—	0.73	—	0.87	0.23
Pleuronectidae								
Isopsetta isolepis	0.49	1.79	7.78	2.86	—	1.29	0.66	2.12
Lepidopsetta bilineata	—	0.59	0.94	—	—	—	—	0.22
Parophrys vetulus	—	0.59	1.76	—	—	—	0.45	0.40
Psettichthys melanostictus	1.48	5.46	5.58	—	0.73	—	0.44	1.96

TABLE 3.—Mean abundances (number per 1,000 m^3) for coastal larval species from summer day samples.

	Depth (m)							
Species	0-5	5-10	10-20	20-30	30-40	40-50	>50	Mean
Clupeidae								
Clupea harengus	—	—	—	—	—	—	—	—
Osmeridae								
Undetermined spp.	—	—	—	—	—	—	3.69	0.53
Gadidae								
Gadus macrocephalus	—	—	1.38	12.01	1.08	1.09	—	2.22
Microgadus proximus	—	—	2.01	1.01	—	3.28	3.49	1.40
Cottidae								
Artedius fenestralis	—	—	1.00	1.15	—	—	—	0.31
Artedius harringtoni	—	0.68	4.54	3.30	2.18	2.19	3.39	2.33
Artedius meanyi	—	—	3.38	2.02	1.10	—	—	0.93
Clinocottus embryum	—	—	—	—	—	—	—	—
Cottus asper	—	0.53	—	—	—	—	—	0.08
Radulinus asprellus	—	—	—	—	—	—	—	—
Agonidae								
Odontopyxis trispinosa	—	—	—	1.01	—	—	—	0.14
Cyclopteridae spp. 1	—	—	—	2.22	2.16	—	—	0.63
Undetermined spp.	—	—	2.16	4.18	1.08	2.18	6.05	2.24
Bathymasteridae								
Ronquilus jordani	0.63	0.70	2.01	1.01	—	—	—	0.62
Ptilichthyidae								
Ptilichthys goodei	—	—	—	—	—	—	—	—
Bothidae								
Citharichthys stigmaeus	—	—	1.00	—	—	—	—	0.14
Pleuronectidae								
Isopsetta isolepis	—	—	2.07	1.01	2.20	—	4.82	1.44
Lepidopsetta bilineata	—	—	—	—	—	—	—	—
Parophrys vetulus	—	—	—	—	—	—	—	—
Psettichthys melanostictus	0.98	2.03	22.98	7.48	3.24	3.26	11.18	7.31

TABLE 4.—Mean abundances (number per 1,000 m^3) for coastal larval species from summer night samples.

Species	Depth (m) 0-5	5-10	10-20	20-30	30-40	40-50	>50	Mean
Clupeidae								
Clupea harengus	—	—	—	—	—	—	—	—
Osmeridae								
Undetermined spp.	—	4.42	15.15	4.56	—	0.75	1.12	3.71
Gadidae								
Gadus macrocephalus	—	—	—	0.82	3.16	8.11	22.98	5.01
Microgadus proximus	0.66	0.61	—	4.66	1.95	3.29	6.91	2.58
Cottidae								
Artedius fenestralis	3.20	—	0.78	1.57	—	0.75	2.60	1.27
Artedius harringtoni	1.35	4.41	5.44	11.30	0.73	1.27	1.40	3.70
Artedius meanyi	0.66	4.48	0.71	4.12	0.74	1.01	3.62	2.19
Clinocottus embryum	0.66	—	—	—	—	—	—	0.09
Cottus asper	—	—	—	—	—	—	—	—
Radulinus asprellus	—	—	—	—	—	—	—	—
Agonidae								
Odontopyxis trispinosa	—	—	—	—	—	—	2.50	0.36
Cyclopteridae spp. 1	—	—	0.77	0.79	—	—	—	0.22
Undetermined spp.	—	—	—	3.96	0.73	—	4.74	1.35
Bathymasteridae								
Ronquilus jordani	—	—	0.71	1.70	—	1.27	—	0.53
Ptilichthyidae								
Ptilichthys goodei	—	—	—	—	—	—	—	—
Bothidae								
Citharichthys stigmaeus	—	—	—	0.74	0.74	—	—	0.21
Pleuronectidae								
Isopsetta isolepis	—	2.57	1.63	6.50	2.64	10.90	1.12	3.62
Lepidopsetta bilineata	—	—	—	—	—	—	—	—
Parophrys vetulus	0.66	—	0.71	—	—	—	—	0.20
Psettichthys melanostictus	24.63	31.37	13.65	18.86	7.78	6.07	6.91	15.61

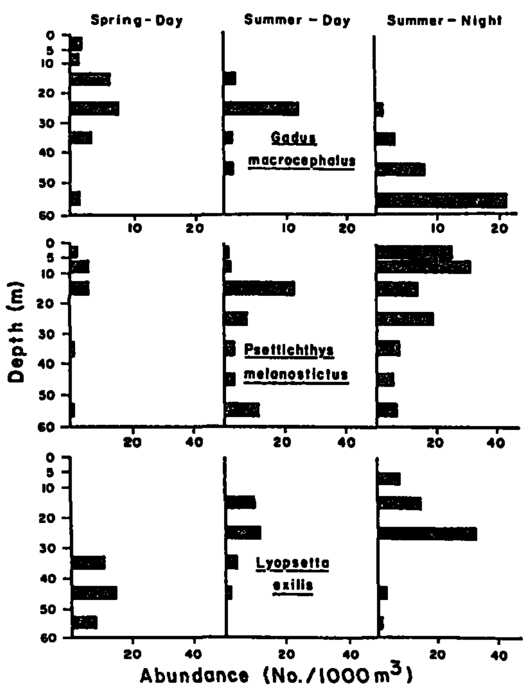

FIGURE 4.—Vertical abundance patterns of the three most abundant taxa (*Gadus macrocephalus*, *Psettichthys melanostictus*, and *Lyopsetta exilis*) during the three sampling periods.

Artedius and cyclopterid species. *Artedius fenestralis*, *A. harringtoni*, and *A. meanyi* were taken almost exclusively in the summer sampling period. All species were most abundant in nighttime samples. During the day, *A. harringtoni* larvae were distributed relatively uniformly throughout the water column from about 10 to 60 m, whereas at night most larvae were taken from the 5-30 m depth strata. Most cyclopterid larvae collected in spring were the larval type referred to as Cyclopteridae spp. 1 by Richardson and Pearcy (1977). Other cyclopterid species were more abundant in summer. Most cyclopterid larvae were collected below 20 m during both night and day, and in summer were abundant at the deepest sampling depths.

Osmerid larvae of undetermined species had a unique distribution pattern. They were abundant during spring, rare during summer daytime samples, and most abundant during summer nighttime samples. During both spring and summer, larvae were most abundant at the 10-20 m depth stratum.

Offshore Assemblage

Spring to summer differences in abundance patterns were more distinct for offshore larval species as compared with coastal species (Tables 5, 6, 7).

TABLE 5.—Mean abundances (number per 1,000 m³) for offshore larval species from spring (day only) samples.

Species	Depth (m) 0-5	5-10	10-20	20-30	30-40	40-50	>50	Mean
Offshore								
Engraulidae								
Engraulis mordax	—	—	—	—	—	—	—	—
Bathylagidae								
Bathylagus ochotensis	—	—	0.56	—	0.78	7.28	0.87	1.36
Bathylagus pacificus	—	—	—	—	—	—	0.22	0.03
Myctophidae								
Protomyctophum crockeri	—	—	—	—	—	0.75	—	0.11
Protomyctophum thompsoni	—	—	—	—	—	1.74	1.19	0.42
Stenobrachius leucopsarus	0.49	6.79	2.76	0.47	—	—	—	1.50
Bythitidae								
Brosmophycis marginata	—	—	—	—	—	—	—	—
Scorpaenidae								
Sebastes spp.	—	2.73	1.06	1.49	—	—	—	0.75
Bothidae								
Citharichthys sordidus	—	—	—	—	—	—	—	—
Pleuronectidae								
Glyptocephalus zachirus	—	—	1.06	—	—	—	—	0.15
Lyopsetta exilis	—	—	—	—	11.27	14.9	8.56	4.96
Coastal-Offshore								
Pleuronectidae								
Hippoglossoides elassodon	—	—	—	1.49	—	—	—	0.21

TABLE 6.—Mean abundances (number per 1,000 m³) for offshore larval species from summer day samples.

Species	Depth (m) 0-5	5-10	10-20	20-30	30-40	40-50	>50	Mean
Offshore								
Engraulidae								
Engraulis mordax	0.98	2.13	—	—	—	—	—	0.44
Bathylagidae								
Bathylagus ochotensis	—	—	—	—	—	—	—	—
Bathylagus pacificus	—	—	—	—	—	—	—	—
Myctophidae								
Protomyctophum crockeri	—	—	—	—	—	—	—	—
Protomyctophum thompsoni	—	—	—	—	—	—	—	—
Stenobrachius leucopsarus	—	—	—	—	—	—	—	—
Bythitidae								
Brosmophycis marginata	1.49	0.73	—	—	—	—	—	0.32
Scorpaenidae								
Sebastes spp.	—	0.65	3.03	1.08	1.10	—	—	0.84
Bothidae								
Citharichthys sordidus	—	0.73	—	—	—	—	—	0.10
Pleuronectidae								
Glyptocephalus zachirus	—	2.11	19.55	4.52	—	—	—	3.74
Lyopsetta exilis	—	—	10.03	11.53	4.38	2.13	—	4.01
Coastal-Offshore								
Pleuronectidae								
Hippoglossoides elassodon	—	—	—	—	—	1.10	—	0.16

Only *Sebastes* and *Lyopsetta exilis* larvae were abundant in all three sampling periods. *Sebastes* larvae were most abundant in nighttime samples, when they were mainly collected in shallow water (0-20 m). In both spring and summer daytime samples they were also in relatively shallow waters (5-40 m), although they were not abundant at the shallowest stratum (0-5 m). During day, *L. exilis* larvae were distributed in deeper water, particularly in spring, when all larvae were collected below 30 m (Fig. 3). At night, most *L. exilis* were shallower, between 5 and 30 m.

Two species, *Bathylagus ochotensis* and *Stenobrachius leucopsarus*, were collected only in spring samples. These two species were predominantly collected at different depths with *B. ochotensis* found

TABLE 7.—Mean abundances (number per 1,000 m^3) for offshore larval species from summer night samples.

Species	Depth (m) 0-5	5-10	10-20	20-30	30-40	40-50	>50	Mean
Offshore								
Engraulidae								
Engraulis mordax	4.09	3.76	—	—	—	—	—	1.12
Bathylagidae								
Bathylagus ochotensis	—	—	—	—	—	—	—	—
Bathylagus pacificus	—	—	—	—	—	—	—	—
Myctophidae								
Protomyctophum crockeri	—	—	—	—	—	—	—	—
Protomyctophum thompsoni	—	—	—	—	—	—	—	—
Stenobrachius leucopsarus	—	—	—	—	—	—	—	—
Bythitidae								
Brosmophycis marginata	—	—	—	—	—	—	—	—
Scorpaenidae								
Sebastes spp.	3.86	0.68	2.38	0.82	—	—	1.12	1.27
Bothidae								
Citharichthys sordidus	—	—	0.78	—	0.74	1.27	10.27	1.87
Pleuronectidae								
Glyptocephalus zachirus	0.66	0.68	0.77	0.91	—	—	—	0.43
Lyopsetta exilis	—	8.28	15.05	32.99	—	3.53	1.12	8.71
Coastal-Offshore								
Pleuronectidae								
Hippoglossoides elassodon	—	—	0.71	—	—	—	1.12	0.26

in deeper water (40-50 m) and *S. leucopsarus* in shallow water (5-20 m).

Two species of larval flatfishes and *Engraulis mordax* were collected only in summer samples. *Glyptocephalus zachirus* were most abundant during day at 5-30 m, and *Citharichthys sordidus* at night below 50 m. *Engraulis mordax* larvae were collected only above 10 m. *Engraulis mordax* were most abundant at night when more than half were in very shallow waters, <5 m. During the day, more *E. mordax* were found at 5-10 m than at 0-5 m.

A relationship between larval size and depth was not evident for any species. Because of the low abundances of larvae, however, this relationship could not be adequately considered for most species. A change in larval size with season was demonstrated for the most abundant species (Table 8), with mean larval standard lengths of all species greater in summer than in spring samples. There were no obvious differences between the size of larvae caught in day and night summer samples.

DISCUSSION

Peak abundances of all taxa combined occurred at 10-30 m on all sample dates (Fig. 3) and characterized several individual taxa during the day, including *Clupea harengus*, Osmeridae, *Gadus macrocephalus*, *Sebastes* spp., and *Parophrys vetulus*, as well as *Lyopsetta exilis* and *Psettichthys melanostictus* in the summer. The 10-30 m depth range bracketed the lower boundary of the seasonal thermocline in July, although no thermocline was present in April-May (Fig. 2). This trend for the peak abundance of fish larvae to be centered near the thermocline is similar to that found in other regions (Ahlstrom 1959; Miller et al. 1963; Kendall and Naplin 1981).

The trend for most larvae to be found in midwater was similar to that described by Brewer et al. (1981) for their deepest stations off southern California. We did not find large concentrations of larvae near the bottom as they did, except at night, when gadids, cottids, cyclopterids, and pleuronectids were abundant. Our sampling gear was ineffective just above the bottom as compared with the roller-equipped gear used by Brewer et al. (1981).

Richardson and Pearcy (1977) found larvae to be most abundant at 0-10 m and least abundant at 51-100 m during late May off Oregon. We found larvae to be most abundant at 10-30 m. This difference may be due to differences in hydrography and station locations. Their station was 18 km offshore, closer to the shelf break where the depth of water was over 150 m deep. The faunal composition in each study was also different. Richardson and Pearcy (1977) captured more specimens of several surface-associated taxa than we did, including large *Clupea harengus*, *Stenobrachius leucopsarus*, *Ronquilus jordani*, and *Ammodytes hexapterus*. We captured higher densities of deeper dwelling taxa, including gadids and cottids. Several taxa taken in both studies had different distributions in each, including *Sebastes*

TABLE 8.—Ranges and mean standard lengths (mm) for dominant fish larvae. *N* = number of larvae; Min. = minimum; Max. = maximum.

Species	Spring: Day				Summer: Day				Summer: Night			
	N	Min.	Mean	Max.	*N*	Min.	Mean	Max.	*N*	Min.	Mean	Max.
Coastal												
Clupea harengus	10	7	8.2	9	0	—	—	—	0	—	—	—
Osmerid	17	3	7.1	17	3	29	33.1	38	35	23	31.8	40
Gadus macrocephalus	29	8	10.8	20	17	9	13.6	17	28	9	13.3	19
Microgadus proximus	22	6	10.9	19	9	11	21.3	36	18	6	18.4	33
Artedius fenestralis	0	—	—	—	2	11	12.0	13	8	10	11.6	13
Artedius harringtoni	2	6	6.5	7	15	5	8.2	13	33	5	8.6	14
Artedius meanyi	1	—	4.9	—	6	7	9.9	16	19	7	9.4	18
Radulinus asprellus	10	6	7.6	9	0	—	—	—	0	—	—	—
Liparid type 1	12	4	5.7	6	4	3	3.1	3	2	3	3.5	4
Liparid unknown	1	—	10.2	—	14	5	16.7	25	10	15	20.4	23
Ronquilus jordani	1	—	6.6	—	5	22	27.1	33	5	24	24.1	25
Isopsetta isolepis	22	4	8.9	21	9	10	20.0	23	28	7	16.1	23
Psettichthys melanostictus	—	3	7.0	22	41	9	20.0	27	150	8	20.8	28
Offshore												
Engraulis mordax	0	—	—	—	4	12	13.5	15	12	7	13.1	16
Bathylagus ochotensis	16	5	8.1	19	0	—	—	—	0	—	—	—
Stenobrachius leucopsarus	19	3	5.2	9	0	—	—	—	0	—	—	—
Sebastes spp.	8	4	4.7	6	6	4	14.6	18	12	12	16.0	18
Citharichthys sordidus	0	—	—	—	1	—	20.5	—	11	17	37.8	40
Glyptocephalus zachirus	2	13	25	37	22	14	29.9	39	4	22	34.5	50
Lyopsetta exilis	71	4	8.4	15	27	11	13.2	16	79	7	12.2	20

spp., Cyclopteridae spp. 1, and *Isopsetta isolepis*. These differences indicate the need for more extensive sampling before the variability of vertical distributions off Oregon can be understood, particularly as they relate to hydrographic conditions.

We found *Engraulis mordax* larvae entirely at 0-10 m. Brewer et al. (1981) found greater concentrations of *Engraulis* below 10 m, while Ahlstrom (1959) found *Engraulis* to be concentrated in the upper 23 m with some specimens occurring to 105 m. Off Oregon, *Engraulis* larvae are found concentrated at 0-20 m (Richardson 1973), in association with the Columbia River plume, a lens of warm, low salinity water usually 20-40 m deep (Richardson 1980). Our limited data suggest that *Engraulis mordax* larvae occur at depths that would place them within the plume, rather than beneath it or at its boundary. The vertical distribution suggests restriction to the warmest part of the water column (Fig. 2d); northern anchovies rarely spawn in waters with surface temperatures below 14°C (Lasker et al. 1981).

The seasonal differences in species composition between the April-May and July samples were those that would be expected in samples from winter and summer hydrographic regimes, except that *Artedius fenestralis* and *A. meanyi* have been taken in April and May of other years (Mundy 1984). The presence of *Clupea harengus*, *Radulinus asprellus*, myctophid, and bathylagid larvae only in April-May, during a winter hydrographic regime, is expected from previous studies (Richardson and Pearcy 1977; Mundy 1984).

Studies of day/night differences in the distribution of fish larvae are confounded by daytime avoidance of nets by larvae (Ahlstrom 1959). Daytime avoidance of nets is suggested in our study by the greater numbers of larvae taken during the night than day at all but two depth strata. The lack of length differences between larvae caught in day and night, however, and the fact that no taxa were taken only in night samples during July suggests that diurnal net avoidance was not related to taxon or size. The same comparisons with 70 cm bongo net samples (Richardson and Pearcy 1977) suggest that diurnal avoidance by large larvae was greater for bongo nets than for the Tucker trawl.

Evidence for vertical migration exists for several species in this study (Tables 3, 4, 6, 7). *Psettichthys melanostictus* abundance in surface waters (0-10 m) increased greatly at night (Fig. 4). *Engraulis mordax* were most abundant at 5-10 m than 0-5 m during the day, but more evenly distributed at night. This could be due either to vertical migration or net avoidance in the shallowest stratum during the day. Ahlstrom (1959), however, presented evidence for negative phototaxis by anchovy larvae, and Hunter and Sanchez (1976) demonstrated nighttime migration to the surface in larvae larger than 10 mm SL. Thus larvae migrate upwards at night, but are constrained to shallower water in the day as compared with the southern subpopulation.

The clearest case of vertical migration was that of *Gadus macrocephalus* (Tables 3, 4), which was most abundant at 20-30 m in the day and deeper than 50 m at night. The migration of this species was primarily responsible for the increased total abundance of larvae near the bottom at night (Fig. 3). This pattern of movement is similar to that observed for larval *Ammodytes personatus* by Yamashita et al. (1985), who suggested that this reverse vertical migration allowed feeding in daytime and avoidance of migrating predators at night. This nocturnal descent, not previously reported for *Gadus* larvae, should be confirmed with further sampling. *Gadus morhua* larvae 3.8-4.9 mm long move from deeper water in the day to 0-2 m at night, and descend in the water column with growth (Hardy 1978). Larvae of another gadid, *Melanogrammus aeglefinus*, are most common in the thermocline and their depth of greatest abundance fluctuates as the thermocline depth changes with rotary tidal currents, causing occasional descent in the water column at night (Miller et al. 1963).

Offshore taxa in Oregon coastal waters should occur in greatest numbers during onshore surface water transport during winter and early spring. This was true in our study for the mesopelagic Myctophidae and Bathylagidae, but not for other offshore assemblage taxa (Tables 5, 6, 7). Almost all of the bathylagid and myctophid larvae except *Stenobrachius leucopsarus* were found below 30 m. Ahlstrom's (1959) work confirms these general distributions; he found most larvae of the genera taken in this study (*Electrona = Protomyctophum*; *Lampanyctus = Stenobrachius*) at depths >56 m, beneath the thermocline, except *Stenobrachius*. He found *Stenobrachius* to have the shallowest distribution of all myctophid larvae in his study (0-41 m). Richardson and Pearcy (1977) also found *Stenobrachius* larvae to be in shallow waters (0-50 m) with many at 0-10 m during the day. The distribution of larval mesopelagic fishes, or other offshore taxa, cannot be related to the depth of onshore transport because virtually nothing is known about the depth of winter onshore transport off Oregon (Peterson et al. 1979; Huyer[4]). Both deep and surface dwelling larvae of mesopelagic fishes collected in our study appear to be transported onshore, however, suggesting that transport occurs over a broad depth range off Oregon.

[4]A. Huyer, Associate Professor, Oregon State University, Corvallis, OR 97331, pers. commun. 29 September 1983.

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