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National Marine Fisheries Service

Larval Fish Survey of Humboldt Bay, California

MAXWELL B. ELDRIDGE and CHARLES F. BRYAN

SEATTLE, WA
December 1972

National Marine Fisheries Service, Special Scientific Report--Fisheries Series

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Larval Fish Survey of Humboldt Bay, California

By

MAXWELL B. ELDRIDGE

National Marine Fisheries Service
Tiburon Fisheries Laboratory
Tiburon, CA 94920

and

CHARLES F. BRYAN

Cooperative Fisheries Unit
Louisiana State University
Baton Rouge, LA 70803

ABSTRACT

As part of a series of investigations of the marine resources of Humboldt Bay, Calif., a larval fish survey was conducted from January to December 1969. Bottom and oblique tows were made at five sampling stations with 1-m plankton nets on alternate biweekly intervals. Thirty-seven species of larval and juvenile fishes representing 17 families were collected. In terms of larval abundance, the dominant fish was the bay goby, *Lepidogobius lepidus*, followed by Pacific herring (*Clupea harengus pallasi*), Pacific staghorn sculpin (*Leptocottus armatus*), longfin smelt (*Spirinchus thaleichthys*), and the arrow goby (*Clevelandia ios*). These five species constituted 95% of all larvae captured.

The number of larvae captured increased with increasing distance from the mouth of the Bay. The lowest number of species captured was at a station which experienced the widest range of salinities and temperatures. Peaks of seasonal abundance occurred in January and February and in April and May. Relatively few fish were captured after June. Some notable appearances of offshore spawned fishes were found in Humboldt Bay.

INTRODUCTION

Pacific coast estuaries are important spawning and nursery grounds for fishes, but the extent of this utilization has received little attention from fishery scientists. In northern California waters, several biologists have conducted investigations. Porter (1964) studied the larval and juvenile pleuronectids and bothids in the waters adjacent to the entrance of Humboldt Bay, Calif. Further pleuronectid research was carried on when Misitano (1970) captured premetamorphosed and juvenile English sole (*Parophrys vetulus*) during the course of his early life history study. Some incidental catches of fish larvae were made in a zooplankton survey recently completed in the northern part of Humboldt Bay (Eichenberry, 1970). The most current research involves a larval cottid study which was begun in the spring of 1971.

This larval fish survey was conducted as part of a series of studies to evaluate the resources of Humboldt Bay. From January to December 1969, an intensive effort was made to determine the seasonal and areal distribution of the larval fishes.

METHODS

Humboldt Bay is located on the north coast of California (Fig. 1). It is 14 miles long, shallow with extensive mudflats, and is mostly bordered by marshlands and sandy beaches. Arcata and South Bays are uniformly shallow and unnavigable outside the narrow channels, except at high tide. Limited freshwater entry is provided by one small river, three creeks, and minor tributaries.

Five sampling stations, each 153 m (500 ft) long, were selected (Fig. 1). Stations 1 and 4 were similar in depth (5-8 m) and were located in major drainage channels adjoining expansive eelgrass mudflats. Station 2, adjacent to a rock jetty, experienced the strongest tidal currents and was the deepest station (12-15 m). Station 3 was relatively shallow (3-5 m) and bordered by a gently sloping sandy beach. Station 5 was the shallowest (2-3 m) and experienced the greatest variation in salinity and temperature.

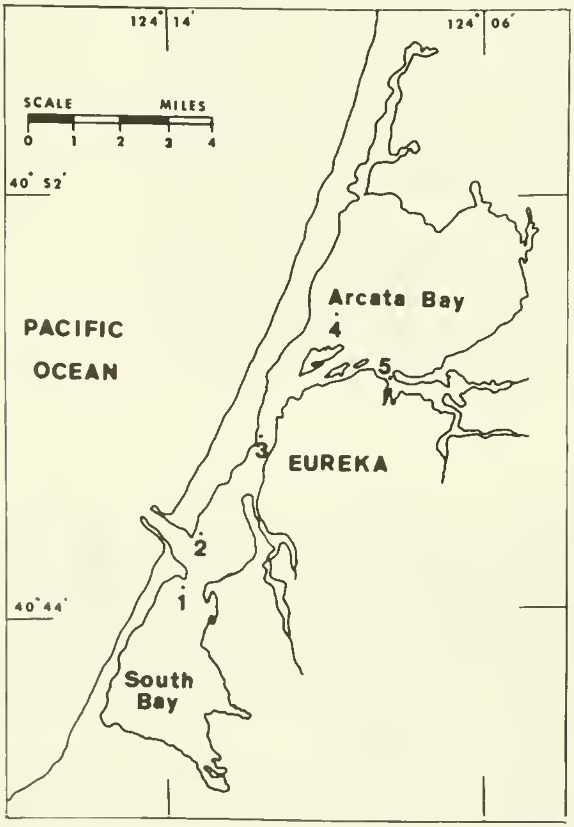

Figure 1. — Humboldt Bay, Calif., and the five sampling stations.

An attempt was made to sample the entire water column at each station, making alternate bottom and oblique tows at biweekly intervals. A 1-m plankton net of No. 0 mesh (aperture size 0.57 mm) was used with a centrally located flowmeter. For bottom samples, a macroplankton sled (Fig. 2) was towed at 1-3 knots. The sampling gear was retrieved, using a variable-speed winch apparatus powered by a 4-hp engine with a 4-speed automobile transmission.

Larval and juvenile fishes were collected in 118 tows over a 12-month period. All samples were fixed and held in 5% formaldehyde in seawater. Fishes were sorted, identified, enumerated, and measured, using an ocular micrometer mounted in a stereozoom dissecting microscope. Identifications were made with the assistance of E. H. Ahlstrom (personal communication) and by using several keys and descriptions, the most useful of which were: Ahlstrom (1965), Bolin (1944), Breder and Rosen (1966), Budd (1944), Clothier (1950), Hart and McHugh (1944), Hickman (1959), Jones (1962), Orcutt (1950), and Orsi (1965).

Surface and bottom temperatures and salinities were taken with each sampling. Temperatures were recorded using a standard nonreversing mercury thermometer while salinities were determined with an induction salinometer in the laboratory.

RESULTS

Environment

In general, vertical similarities in temperature and salinity reflect the extent of mixing and low freshwater inflow into the Bay (Fig. 3 and 4). Water temperatures from January to December 1969, ranged from 7.5° to 19.6°C (Fig. 3). The temperature began to increase in February and reached a maximum in late May, remaining high until September. Stations 1, 2, and 3 exhibited the lowest overall combined surface and bottom temperature means (11.4°, 11.0°, and 11.3°C, respectively), while stations 4 and 5 had relatively high

Figure 2. — Sampling boat showing macroplankton sampling appartus.

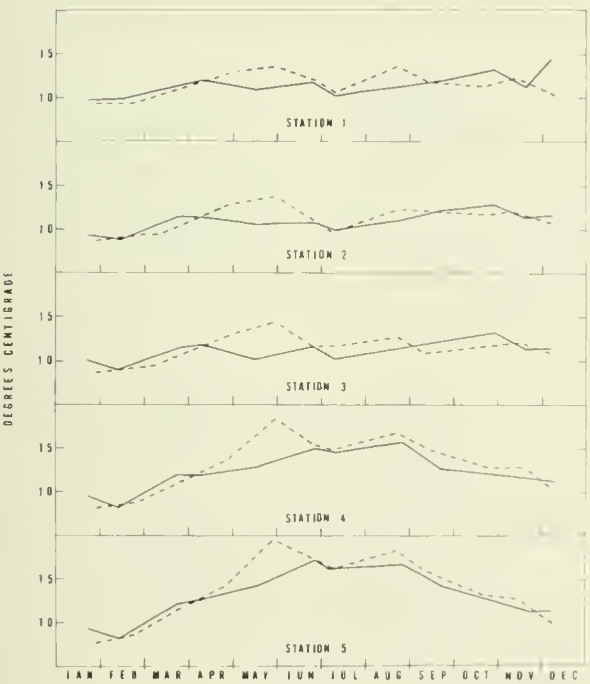

Figure 3. — Surface (---) and bottom (—) temperatures recorded in Humboldt Bay during 1969.

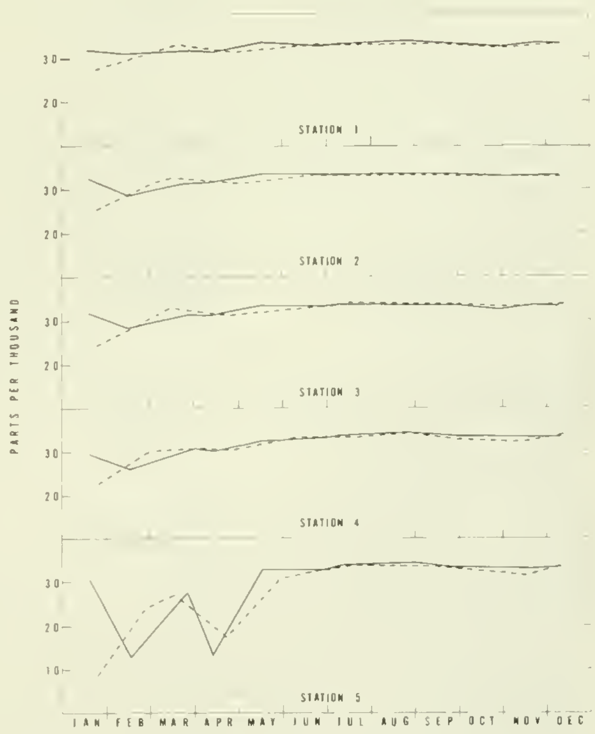

Figure 4. — Surface (---) and bottom (—) salinities recorded in Humboldt Bay during 1969.

overall means (12.8° and 13.3°C, respectively). The greatest fluctuation in bottom and surface salinities occurred between January and May (Fig. 4), then they stabilized throughout the remainder of the year. Because station 5 was located within the mouth of a freshwater tributary, the greatest range and vertical variation in salinities were found here. The overall mean for all stations was 31.5‰ and the range 8.5-34.1‰.

Species Composition

Thirty-seven species of larval and juvenile fishes representing 17 families were collected during the 12-month sampling period (Table 1). Of these, nine forms were not identifiable beyond family and two only to superorder. Two were classified to genus and 24 to species. The total catch of larvae and juveniles was 9,766, yielding an average of 0.13 larvae per cubic meter of water sampled.

The most speciose family was the Cottidae with six species. Only two were identifiable; the rest were present in too few numbers or were not found in developmental series to allow identification. In terms of abundance, the bay goby, *Lepidogobius lepidus*, dominated the catch and Pacific herring, *Clupea harengus pallasi*, were almost as abundant; together they comprised 82% of the total catch. The bay goby, Pacific herring, Pacific staghorn sculpin (*Leptocottus armatus*), longfin smelt (*Spirinchus thaleichthys*), and the arrow goby (*Clevelandia ios*) constituted 95% of all larvae collected.

Table 1. Species, month, size and numbers of fish larvae and juveniles collected in Humboldt Bay, Calif.

Taxon	Common name	Size range (mm)	No. of larvae OT[1]	No. of larvae BT[2]	No. of juveniles OT[1]	No. of juveniles BT[2]	Month collected
Clupeidae:							
Clupea harengus pallasi	Pacific herring	4-32	2,814	864	3	278	Jan.-May
Engraulidae:							
Engraulis mordax	Northern anchovy	5-37	1	3	3	12	Mar., Aug., Sept., Dec.
Osmeridae:							
Hypomesus pretiosus	Surf smelt	23-51	--	--	10	23	Nov.-Mar.
Spirinchus starksi	Night smelt	55-69	--	--	--	25	Jan.
Spirinchus thaleichthys	Longfin smelt	4-51	525	186	--	2	Jan.-Dec.
Osmerid	Unknown	4-13	20	140	--	--	Mar.-June
Sciaenidae:							
Cynoscion nobilis	White seabass	4-6	1	8	--	--	Jan., Dec.
Myctophidae:							
Stenobrachius leucopsarus	Northern lampfish	3-5	4	3	--	--	Jan.-Mar., May
Tarltonbeania crenularis	Blue lampfish	4-7	4	2	--	--	Sept.-Nov.
Gonostomatidae:							
Cyclothone acclinidens	Benttooth bristlemouth	4	1	--	--	--	Dec.
Gobiidae:							
Lepidogobius lepidus	Bay goby	3-33	790	3,260	3	19	Apr.-Sept.
Eucyclogobius newberryi	Tidewater goby	10-12	--	--	2	--	Nov.
Clevelandia ios	Arrow goby	3-6	41	216	--	--	Aug.-Dec.
Scorpaenidae:							
Sebastodes spp.	Rockfish	4-6	6	5	--	--	Dec.-Mar.
Hexagrammidae:							
Hexagrammos decagrammus	Kelp greenling	8	--	11	--	--	Feb.
Ophiodon elongatus	Lingcod	4-9	2	4	--	--	Jan.-Feb.
Hexagrammid	Unknown	8	--	1	--	--	May

Comparatively few juveniles (386) were captured with 11 species represented. Herring were very numerous making up 73% of the total catch of juveniles (Table 1).

Areal Distribution

Larval abundance increased with distance from the Bay entrance (Fig. 5) and an analysis of variance comparing catch means of all larvae produced an F ratio 0.5871/0.0255 = 23.0235, with 4 and 44 df which was significant at the 1% level. The comparatively large catches from stations 4 and 5 were composed

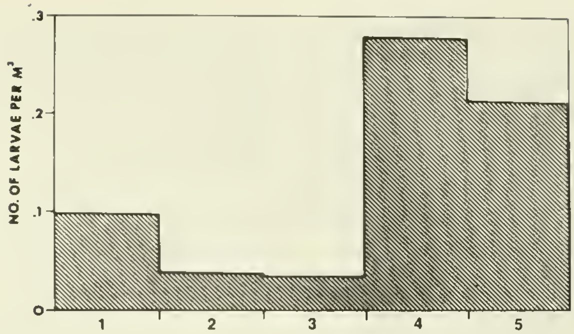

Figure 5. — The mean larval fish catch per cubic meter of water sampled collected in each station during 1969.

Table 1. — Species, month, size and numbers of fish larvae and juveniles collected in Humboldt Bay, Calif — Continued.

Taxon	Common name	Size range (mm)	No. of larvae OT[1]	No. of larvae BT[2]	No. of juveniles OT[1]	No. of juveniles BT[2]	Month collected
Cottidae:							
Artedius sp.		4-9	--	1	--	1	Feb., Oct.
Leptocottus armatus	Pacific staghorn sculpin	3-8	40	213	--	--	Jan.-Apr., Sept.-Dec.
Cottid (4 types)	Unknowns	3-8	33	88	--	--	Jan.-May, July
Agonidae:							
Odontopyxis trispinosa	Pigmy poacher	14	--	--	--	1	Dec.
Stellerina xyosterna	Pricklebreast poacher	4-17	--	3	--	3	June, July, Oct.
Cyclopteridae:							
Cyclopterid (2 types)	Unknowns	3-4	1	1	--	--	Jan., May
Ammodytidae:							
Ammodytes hexapterus	Pacific sand lance	3-7	7	36	--	--	Jan.-Apr.
Blennioidei:							
(2 types)	Unknowns	3-14	1	5	--	--	Jan.-Apr.
Atherinidae:							
Atherinopsis californiensis	Jacksmelt	8-10	3	5	--	--	Apr.-June
Bothidae:							
Citharichthys stigmaeus	Speckled sanddab	3	1	--	--	--	Dec.
Paralichthys californicus	California halibut	3	1	--	--	--	Mar.
Pleuronectidae:							
Parophrys vetulus	English sole	7	--	1	--	--	Dec.
Platichthys stellatus	Starry flounder	5-9	--	7	--	--	June-Aug.
Psettichthys melanostictus	Sand sole	18	--	--	--	1	Jan.
Pleuronectid	Unknown	3-4	4	17	--	--	Jan.-Apr.

[1] Oblique tow.

[2] Bottom tow.

primarily of Pacific herring and bay goby. They comprised 88% of the larvae collected in station 4 and 89% in station 5. On the other hand, the two least productive stations, 2 and 3, were located near the mouth of the Bay and they differed from stations 1, 4, and 5 in that they had no eelgrass or mudflats in close proximity. In addition, the water currents were visually noted to be the greatest in stations 2 and 3.

Although station 5 had the second highest catch rate, it exhibited the lowest number of species (Fig. 6). This may be linked to the comparatively wide range in temperature and salinity found in station 5. The Pacific herring, northern anchovy, longfin smelt, an unknown smelt, bay goby, arrow goby, and the Pacific staghorn sculpin were most ubiquitous during the course of the study. Whereas offshore species, bothids, and plueronectids were largely confined to the stations nearest the Bay entrance, resident demersal groups (cottids and gobiids) were concentrated in Arcata Bay.

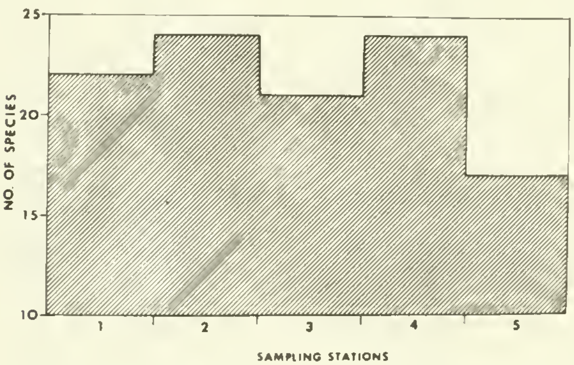

Figure 6. — The number of species of fish larvae and juveniles collected in each station during 1969.

Seasonal Distribution

Two periods of abundance are evident in the seasonal distribution of the average monthly larval fish catch per cubic meter (Fig. 7). The peak in January and February is primarily due to Pacific herring, and the high in April and May is a result of large bay goby catches. A slight increase in catch was noted in October because of an increase in the number of arrow gobies; however, fish larvae were comparatively scarce after June. The

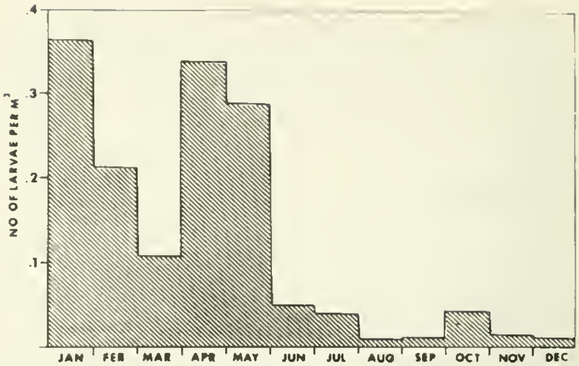

Figure 7. — The mean fish catch per cubic meter of water sampled each month during 1969.

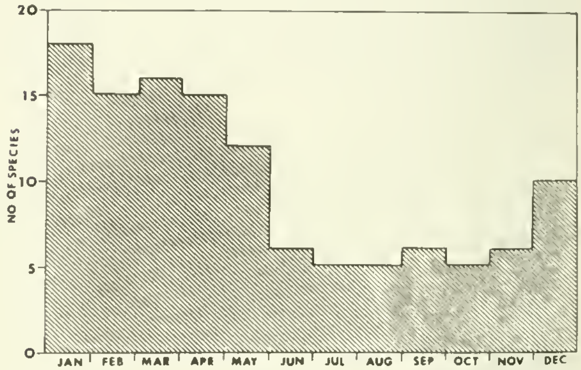

Figure 8. — The number of species of fish larvae and juveniles captured each month during 1969.

period from January to May yielded the highest average number of species caught (Fig. 8). They consisted primarily of resident inshore species, *Sebastes* spp., hexagrammids, cottids, and the Pacific sand lance. The longfin smelt was collected throughout the year with the largest numbers in January. Interestingly, the December catch exhibited a marked increase in the number of species while the catch remained low. This was the effect of an influx of larvae spawned offshore. The Northern anchovy was collected sporadically during four different times of the year.

DISCUSSION

The ichthyoplankton population of Humboldt Bay appears to follow a pattern in which the majority of species are endemic to the immediate area. In this survey 32 of the 37 collected species are commonly found in nearshore areas.

Four fish species (*Cynoscion nobilis*, *Stenobrachius leucopsarus*, *Tarltonbeania crenularis*, and *Cyclothone acclinidens*) were not previously known to exist in the Bay and represent new introductions to the list of Bay fauna (Gotshall and Allen, in preparation).[1] The latter three species are classified as mesopelagic fishes and exhibit diel migration in offshore waters (Pearcy and Laurs, 1966). *Cyclothone acclinidens* is recorded as abundant and is commonly found at a depth of 100 ft or more (Fitch and Lavenburg, 1968). The occurrence of these fishes in shallow inshore areas is most likely due to fortuitous drifting of larvae into Humboldt Bay. Fast (1960) believed seasonal oceanographic conditions involving changes in current directions were responsible for large catches of *Stenobrachius leucopsarus* in Monterey Bay. Likewise, for Humboldt Bay, onshore currents resulting from southerly winds combined with tidal movements could bring these mesopelagic larvae into the Bay. Wind direction data from near the Bay for the periods of capture of these fishes generally indicate either mixed conditions or predominate southerly winds. It has also been noted (Ahlstrom, 1959) that most fish larvae, including the three mesopelagic species in this survey, were found in the upper part of the thermocline to approximately 125 m. This would place the fish larvae in the waters most influenced by surface winds. A concluding factor is that all but two of the specimens representing four species were captured near the Bay entrance.

Localization in distribution was evidenced with the bothids, pleuronectids, and offshore species near the Bay entrance, and cottids and gobies in Arcata Bay. Their limited distribution were most likely due to being spawned and surviving in large numbers only within certain areas. For many species the small numbers captured obviate a discussion of their distribution.

Winter freshwater runoff and shallow depth were responsible for the wide range in salinity and temperature in station 5. Concurrently, the number of species found at station 5 was the lowest which may reflect the limiting environmental conditions. The estuarine waters at the other four stations were mixed well from surface to bottom by virtue of the large tidal prism relative to the volume of the Bay and the turbulence on both the flood and ebb tide stages.

In the pelagic larval fish surveys along the California coast, most notably the California Cooperative Fisheries Investigations, larval fish abundance is measured in numbers of individuals below 1 square meter of sea surface. This analysis is confined to results of oblique plankton net hauls. For surveys in estuarine areas, this method becomes more complicated because of the shallowness of the stations which often necessitates development of specialized sampling gear as in this study. In order to compare the results of the sled and the oblique tows, we chose to use larvae per cubic meter strained. This and similar values have been commonly used in studies along the east coast of the United States (Lewis and Mann, 1971; Pearcy and Richards, 1962; Richards, 1959). It should be noted, however, that numbers of fish larvae per volume of water strained are not strictly comparable values but density measurements. If the total number of larvae in an area are used for the analysis of horizontal distribution, more meaningful conclusions of the relative productivity of different areas can be formed.

The Pacific coast of the United States (excluding Alaska) has remarkably few estuaries. Consequently, those that do exist are focal points for population concentrations and commercial and industrial developments. The extent to which these marine environments have been modified by man's activities is not fully known. Yet the rate of activity is increasing and the need to understand and evaluate the effects of these activities on the ecosystem has become important. Estuarine larval fish surveys can provide information relating to the utilization of inshore areas for spawning and nursery grounds both in space and time. By monitoring the larval fish population over long periods of time, it is also possible to determine the rate and extent of change in the abundance and species

[1] Gotshall, D., and G. H. Allen. Annotated checklist of Humboldt Bay. Manuscript in preparation.

composition of these fishes. This larval fish survey offers some basic information relating to the larval fish population in Humboldt Bay. Further research is presently needed for development of more efficient sampling methods, for gathering information on the distribution of fish larvae within the estuary and how it changes with time, and for understanding how physical-chemical conditions affect distribution.

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LITERATURE CITED

AHLSTROM, E. H.
1959. Vertical distribution of pelagic fish eggs and larvae off California and Baja California. U.S. Fish Wildl. Serv., Fish. Bull. 60:107-146.
1965. Kinds and abundance of fishes in the California Current region based on egg and larval surveys. Calif. Coop. Oceanic Fish. Invest. Rep. 10:31-52.

BOLIN, R. L.
1944. A review of the marine cottid fishes of California. Stanford Ichthy. Bull. 3:1-135.

BREDER, C. M., JR., and D. E. ROSEN.
1966. Modes of reproduction in fishes. Nat. Hist. Press, Garden City, N.Y., 941 p.

BUDD, P. L.
1940. Development of the eggs and early larvae of six California fishes. Calif. Dep. Fish Game, Fish Bull. 56, 53 p.

CLEMENS, W. A., and G. V. WILBY.
1961. Fishes of the Pacific coast of Canada. Fish. Res. Board Can., Bull. 68, 443 p.

CLOTHIER, C. R.
1950. A key to some southern California fishes based on vertebral characters. Calif. Dep. Fish Game, Fish Bull. 79, 83 p.

EICHENBERRY, J.
1971. Seasonal and spatial distribution of meroplankton in north Humboldt Bay. M.S. Thesis, Humboldt State College, Arcata, Calif., 48 p.

FAST, T. N.
1960. Some aspects of the natural history of *Stenobranchius leucopsarus* Eigenmann and Eigenmann. Ph.D Thesis, Stanford Univ. (Libr. Congr. Card No. Mic. 60-6729) 107 p. Univ. Microfilms. Ann Arbor, Mich. (Diss. Abstr. 21:2833-2834.)

FITCH, J. E., and R. J. LAVENBERG.
1968. Deep-water teleostean fishes of California. Univ. Calif. Press, Berkely, 155 p.

HART, J. L., and J. L. McHUGH.
1944. The smelts (Osmeridae) of British Columbia. Fish. Res. Board Can., Bull 64, 27 p.

HICKMAN, C. P., JR.
1959. The larval development of the sand sole (Psettichthys melanostictus). Wash. Dep. Fish., Fish. Res. Pap. 2(2):38-47.

JONES, A. C.
1962. The biology of the euryhaline fish, *Leptocottus armatus armatus* Girard. Univ. Calif. Publ. Zool. 67:321-368.

LEWIS, R. M., and W. C. MANN.
1971. Occurrence and abundance of larval Atlantic menhaden, *Brevoortia tyrannus*, at two North Carolina inlets with notes on associated species. Trans. Am. Fish. Soc. 100:296-301.

MISITANO, D.
1970. The early life history of English sole (*Parophrys vetulus*) in Humboldt Bay. M.S. Thesis, Humboldt State College, Arcata, Calif., 54 p.

ORCUTT, H. G.
1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Calif. Dep. Fish Game, Fish Bull. 78, 64 p.

ORSI, J. J.
1965. The embryology of the English sole, *Parophrys vetulus*. Calif. Dept. Fish Game 54:133-155.

PEARCY, W. G., and R. M. LAURS.
1966. Vertical migration and distribution of mesopelagic fishes off Oregon. Deep-Sea Res. 13:153-165.

PEARCY, W. G., and S. W. RICHARDS.
1962. Distribution and ecology of fishes of the Mystic River estuary, Connecticut. Ecology 43:248-259.

PORTER, P.
1964. Notes on fecundity, spawning and early life history of Petrale sole (*Eopsetta jordani*), with descriptions of flatfish larvae collected in the Pacific Ocean off Humboldt Bay, California. M.S. Thesis, Humboldt State College, Arcata, Calif., 98 p.

RICHARDS, S. W.
1959. Pelagic fish eggs and larvae of Long Island Sound. *In* Oceanography of Long Island Sound and Guide for Preparing Figures, p. 95-124. Yale Univ., Bull. Bingham Oceanogr. Collect. 17 (artic. 1).

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