NOAA Technical Report NMFS 20

Ichthyoplankton of the Continental Shelf Near Kodiak Island, Alaska

Arthur W. Kendall, Jr., and Jean R. Dunn

January 1985

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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ARTHUR W. KENDALL, JR., and JEAN R. DUNN[1]

ABSTRACT

Eleven ichthyoplankton surveys were conducted (1 in 1972 and 10 between 1977 and 1979) in the northeastern Pacific Ocean over the continental shelf off Kodiak Island, Alaska. In the 677 neuston and 632 bongo tows, eggs or larvae of more than 80 fish taxa were found. They were present in every season and throughout the survey area, although more taxa and more individuals were found in summer than in other seasons. Among the more abundant species were the gadid *Theragra chalcogramma* and several hexagrammids and pleuronectids. The hexagrammids and several cottids were abundant in the neustonic layer, where they spent close to a year as larvae and prejuveniles. Although the seasonal and geographic distribution of most taxa was complex, two patterns emerged: Late summer-fall spawners produce demersal eggs and have neustonic larvae that remain pelagic for several months (hexagrammids and some cottids), and spring-summer spawners have pelagic eggs and larvae that spend several weeks in the plankton but are not closely associated with the surface (*Theragra chalcogramma*, pleuronectids).

INTRODUCTION

The continental shelf off Kodiak Island, Alaska, supports large domestic and foreign fisheries for a number of fish species. Some species (e.g., *Anoplopoma fimbria* and *Sebastes alutus*) have been overfished, some are fully utilized (e.g., *Theragra chalcogramma* and *Hippoglossus stenolepis*), and others (e.g., *Gadus macrocephalus* and some pleuronectids) appear to be underutilized, particularly by the domestic fleet (G. Stauffer[2]). Management of these resources on a scientifically sound ecosystem basis, which is one of the goals of the National Marine Fisheries Service (NMFS), will require a substantial increase in information concerning all life history phases. In order to understand the recruitment mechanisms and variations in year-class strength, the ecology of the young planktonic stages must be studied. However, despite the long history of commercial exploitation and investigations of adult fishes (Ronholt et al. 1978[3]), virtually nothing has been published on the abundance, distribution, or species composition of the ichthyoplankton of the region. Attaining this information is the necessary first step toward applying early life history studies to fisheries problems.

Little was known about the composition of ichthyoplankton in waters contiguous to Kodiak Island prior to the initiation of OCSEAP (Outer Continental Shelf Environmental Assessment Program) supported studies (Table 1). Ichthyoplankton work was the primary objective in few previous studies in the area. The diversity of objectives, study methods, and lack of taxonomic resolution of results make it difficult to compare earlier studies or produce a comprehensive picture of ichthyoplankton distribution.

We report here on the seasonal and spatial distribution, abundance, and taxonomic composition of ichthyoplankton off Kodiak Island, and the recurring groups of larval fishes in this region. These data are derived from sampling on 11 cruises conducted by NMFS in 1972 and during 1977-79. Some of these cruises were partially supported by OCSEAP of the U.S. Bureau of Land Management, others were conducted cooperatively aboard Soviet research vessels, and still others were part of the NMFS Marine Resources, Monitoring, Assessment and Prediction (MARMAP) program. This time series of data on ichthyoplankton communities off Kodiak is the most comprehensive information available for anywhere in the eastern subarctic Pacific Ocean.

The offshore study area, generally bounded by lat. 55°30′-59°15′N and long. 148°30′-156°00′W, covers about 68,000 km^2 and encompasses the continental shelf mainly southeast of Kodiak Island from approximately the 40 to the 2,000 m contour (Fig. 1). Stations sampled during the study extended southwestward from Portlock Bank to just west of the Trinity Islands.

The topography of the Kodiak Island shelf on the southeastern side is rugged, consisting of relatively shallow banks separated by troughs running normal to the shelf edge. The shelf is 69-95 km wide, and is cut by four major troughs: Amatuli, Stevenson, Chiniak, and Kiliuda. These troughs, ranging in depth from about 110 to 240 m, are separated by four banks: Portlock to the east, followed to the west by North, Middle, and South Albatross banks, whose depths range from about 49 to 91 m. In general, the bottom is rugged and uneven, and substrate composition changes rapidly within short distances; bottom types range from soft mud and sand to rock. On the northwestern side of Kodiak Island the dominant feature is Shelikof Strait.

The cyclonic north Pacific subarctic gyre intensifies in the northwestern Gulf of Alaska as the Alaska Stream (Muench and Schumacher 1980). Northeast of Kodiak Island this current divides into a branch that flows through Shelikof Strait (the Kenai Current) and the main part of the stream which flows south-

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[2]G. Stauffer, Fishery Biologist, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112, pers. commun. May 1984.

[3]Ronholt, L. L., H. H. Shippen, and E. S. Brown. 1978. Demersal fish and shellfish resources of the Gulf of Alaska from Cape Spencer to Unimak Pass 1948-1976 (a historical review). Unpubl. manuscr., 4 vols., 955 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Table 1.—Summary of previous plankton sampling surveys relevant to the Kodiak Island shelf area.

Authors	Agency[1]	Years of sampling	Months sampled	General area of survey	No. stations near Kodiak	Sampling gear and type of tow	Kinds of data reported
Thompson and Van Cleve (1936)	IPHC	1926-34	Jan.-June	Gulf of Alaska	ca. 104	1 and 2 m nets, Petersen young fish trawls. Oblique tows (30°).	Distribution and abundance of Pacific halibut, *Hippoglossus stenolepis*, eggs and larvae.
North Pacific Committee (1960)	NORPAC	1955	June-Oct.	North Pacific Ocean	10	Clarke-Bumpus nets, oblique tow.	Station data; list of dominant zooplankton taxa; depth of haul: displacement volume.
LeBrasseur (1970)	FRBC	1956-59	Jan.-Aug.	Gulf of Alaska	19	NORPAC; IKMT; vertical and horizontal.	Identification of fish larvae by station.
Faculty of Fisheries Hokkaido Univ. (1979)	FFHU	1953-77	May-Aug.	North Pacific Ocean	7	Various: Ring net, NORPAC, neuston, vertical and horizontal.	Station data: variable other data on ichthyo-and zoo-plankton.
Aron (1960[2]; 1962)	UW	1957	July	North Pacific Ocean	5	3- and 6-ft IKMT, oblique tows.	Station data, plankton volume, dominant zooplankton, species composition of adult, juvenile, and larval fishes by station.
Lisovenko (1964)	VNIRO	1963	Apr.-July	Gulf of Alaska; Kodiak Island	50	80 cm conical, oblique (?) tows.	Distribution of rockfish, *Sebastes* sp., larvae.
Damkaer (1977)	PMEL	1975-76	Oct.-Nov. 75; Apr.-Aug. 76	Gulf of Alaska, Prince William Sound and Lower Cook Inlet	10	Vertical ring net. Oblique bongo net.	Distribution, composition, and abundance of zooplankton taxa.
Gosho (1977)	UW	1971	June-Aug.	Alitak and Kiliuda Bays, Kodiak Island	61	30 cm ring; horizontal tow.	Abundance and size composition of major zooplankton groups.
Harris and Hartt (1977)	UW	1976	May-Sept	Ugak, Kaiugnak, and Alitak Bays, Kodiak Island	ca. 170	Tow nets; herring trawl; beach seine trynet and Trammel net.	Distribution, abundance, age, and food habits of adult and juvenile fishes.
Rogers et al. (1979)	UW	1978	Mar.-Aug. and Nov. (11 cruises)	Kalsin-Chiniak, Kiliuda, Kaiugnak, Kodiak Island	ca. 286	Neuston nets, bongo nets, Tucker trawl, epibenthic sled.	Distribution and abundance of ichthyoplankton and euphausiids. Food habits of adult and juvenile fishes.
Rogers et al. (1979)	UW	1978-79	Mar.-Aug. Nov. 78 Mar. 79 (12 cruises)	As above	ca. 350	As above	As above
Kendall et al. (1980[3])	NWAFC	1977-79	Nov. 77 Apr.-Nov. 78 Feb.-Mar. 79 (5 cruises)	Kodiak Island Shelf	ca. 2,085	As above and IKMT	Distribution and abundance of ichthyoplankton and euphausiids; decapod larvae.
Kendall et al. (1980[4])	NWAFC	1977-79	Feb.-Nov. (17 cruises)	As above and Kodiak Shelf	ca. 762	As above	Comparison of inshore versus offshore distribution of ichthyoplankton. Structure of shelf larval fish community.

[1]IPHC - International Pacific Halibut Commission; NORPAC - North Pacific Committee; FRBC - Fisheries Research Board of Canada; FFHU - Faculty of Fisheries, Hokkaido University; UW - University of Washington; VNIRO - All-Union Research Institute of Marine Fisheries and Oceanography; PMEL - Pacific Marine Environmental Laboratory; NWAFC - Northwest and Alaska Fisheries Center.

[2]Aron, W. 1960. The distribution of animals in the eastern North Pacific and its relationship to physical and chemical conditions. Tech. Rep. 63, 65 p. College of Ocean and Fishery Sciences, University of Washington, Seattle, WA 98195.

[3]Kendall, A. W., Jr., J. R. Dunn, R. J. Wolotira, Jr., J. H. Bowerman, Jr., D. B. Dey, A. C. Matarese, and J. E. Munk. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak Shelf. NWAFC Processed Rep. 80-8, 393 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[4]Kendall, A. W., Jr., J. R. Dunn, D. E. Rogers, A. C. Matarese, and K. J. Garrison. 1980. Taxonomic composition, seasonal distribution, and abundance of ichthyoplankton in the nearshore zone of the Kodiak Archipelago, Alaska. NWAFC Processed Rep. 80-14, 62 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

westerly at the edge of the continental shelf off Kodiak Island and out 50 km from there, with mean speeds of 50-100 cm/s (Fig. 2). Between the coast and the stream, circulation on the shelf is complex as it is influenced by bottom topography, short-term wind events, seasonal cycles of freshwater input, tidal currents, and perturbations in the stream. Although long-term, mean-flow patterns can be recognized, acyclic processes often override the mean patterns making prediction of instantaneous flow impossible. On Portlock Bank a weak anticyclonic pattern exists. In the troughs, a shoreward flow occurs along the northeastern sides and a seaward flow along the southwestern sides. A coastal flow to the southwest along the island is probably due in part to freshwater input along the south coast to Kodiak Island.

Seasonal variability in oceanographic conditions in the area has not been adequately studied, but Kendall et al. (1980 see Table 1, footnote 3) reported on observations from ichthyoplankton cruises in 1977-79. In winter and spring the water column was rather homogeneous with temperatures generally between 3° and 5°C and salinity between 32.2 and 32.4$^0/_{00}$. In summer the water column was stratified due to low surface salinity from runoff and high surface temperatures from increased insulation. Warmer more saline water occurred offshore. Surface temperatures on the

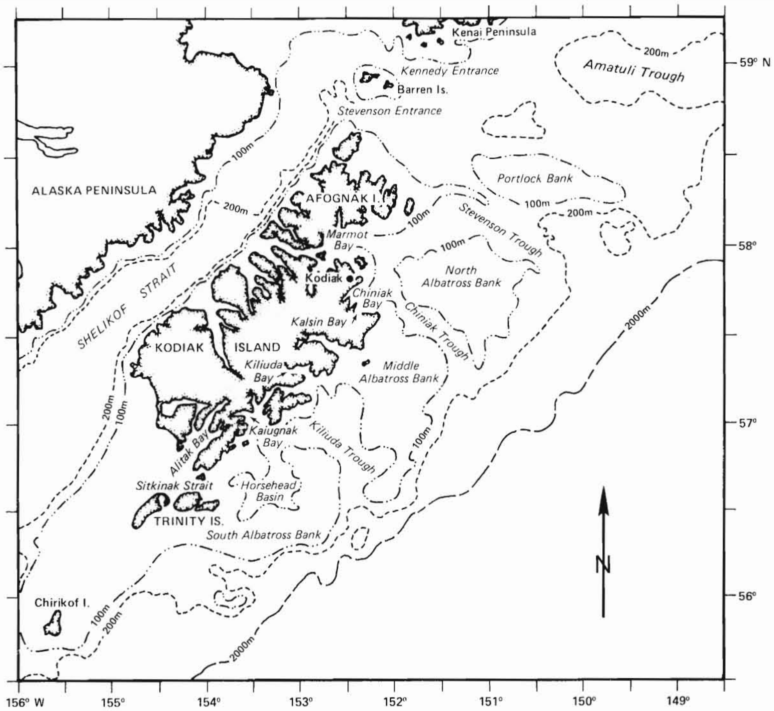

Figure 1.—Features associated with the study area off Kodiak Island.

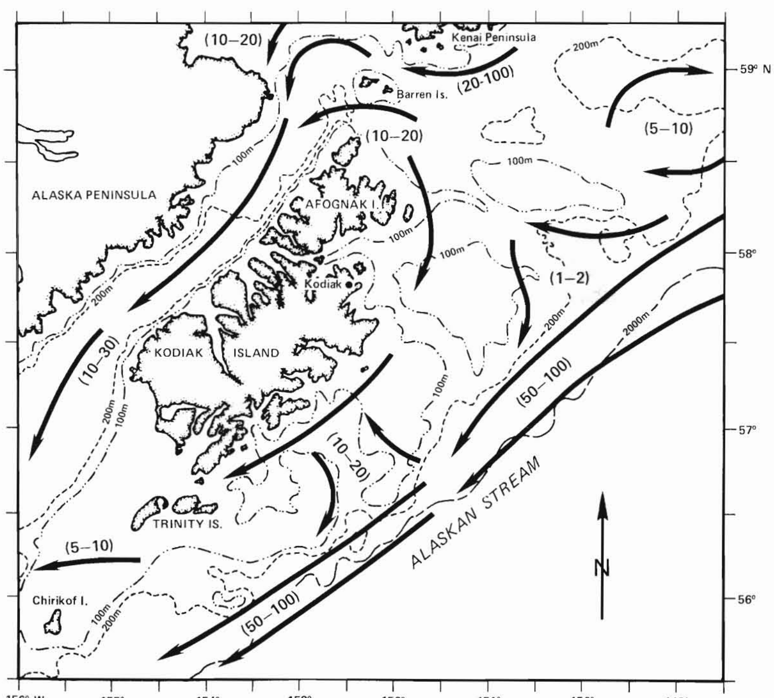

Figure 2.—Major water flow features of the study area off Kodiak Island.

shelf in summer were generally between 7° and 9°C, and salinities were between 32.0 and 32.4$^0/_{00}$, while at the bottom temperatures were 4.5°-7.0°C and salinities were 32.4-33.6$^0/_{00}$. By fall the stratification had broken down; shelf temperatures were generally 6°-8°C and salinities were 31.5-33.0$^0/_{00}$. Offshore the Alaska Stream had warmer, more saline water which intrudes onto the shelf, particularly at depth in the troughs throughout the year.

The Kodiak Island shelf area is an important region of commercial fishing. Important fisheries, both domestic and foreign, are directed toward *Hippoglossus stenolepis* and various other Pleuronectidae; *Gadus macrocephalus*, *Theragra chalcogramma*, and *Sebastes* spp., as well as king, *Paralithodes camtschatica*; snow (Tanner), *Chionoecetes bairdi*; and Dungeness, *Cancer magister*, crabs and pink shrimp, *Pandalus borealis* (Ronholt et al. footnote 3).

METHODS
(Table 2; App. Figs. 1,2)

A series of 11 offshore cruises was conducted in 1972 and from 1977 to 1979 (Table 2). The station pattern varied considerably

Table 2.—Number of ichthyoplankton samples collected on cruises conducted from April 1972 to September 1979.

Cruise	Vessel	Cruise dates	Stations occupied	Neuston (0.505 mm mesh)	Bongo (0.505 mm mesh)	Other (0.505 mm mesh)
2 KE 72	*George B. Kelez*	26 Apr.-5 May 1972	67	0	67	
4 MF 77	*Miller Freeman*	31 Oct.-14 Nov. 1977	61	83	59	
4 DI 78	*Discoverer*	28 Mar.-20 Apr. 1978	89	111	85	
2 MF 78	*Miller Freeman*	19 June-9 July 1978	91	111	89	
3 MF 78	*Miller Freeman*	9-21 Sept. 1978	28	28	28	
4 MF 78	*Miller Freeman*	26 Sept.-7 Oct. 1978	49	49	49	
5 MF 78	*Miller Freeman*	19 Oct.-1 Nov. 1978	19	19	19	
1 WE 78	*Wecoma*	25 Oct.-17 Nov. 1978	94	101	98	
1 MF 79	*Miller Freeman*	13 Feb.-11 Mar. 1979	88	89	88	
5 TI 79	*Tikookeansky*	16-24 May 1979	35	0	35	
1 PO 79	*Poseidon*	2-29 Sept. 1979	86	86	15	32 (bong)

over the years (App. Figs. 1,2), but a systematic centric design (Milne 1959) was used from 1978 to 1979.

Two types of gear were routinely used: 1) a Sameoto sampler (Sameoto and Jaroszynski 1969), with a mouth opening 0.3 m high by 0.5 m wide and an 0.505 mm mesh net, for collecting neuston samples; and 2) an aluminum MARMAP bongo sampler (Posegay and Marak 1980), 0.6 m inside diameter, with one net of 0.505 mm mesh and the other of 0.333 mm mesh.

Bongo nets were lowered at a rate of 50 m of wire/min and retrieved at a rate of 20 m/min, sampling from surface to within 5-10 m of the bottom, normally to a maximum depth of about 200 m, following standard MARMAP procedures (Smith and Richardson 1977). During lowering and retrieval, the ship's speed of 2.0 kn (1.03 m/s) was adjusted to maintain a 45° wire angle. Sampling depths were calculated based on actual wire angles.

Some exceptions to the routine use of bongo and neuston samplers occurred. Neuston was not sampled in 1972 (cruise 2 KE 72) nor on cruise 5 TI 79. The bongo array was lost on cruise 1 PO 79, and a single 60 cm diameter frame (called a "bong") was fabricated at sea and used to sample plankton. Occasionally, planned stations were deleted due to inclement weather or operational difficulties.

Plankton samples were preserved in the field in a 5% Formalin-seawater mixture buffered with sodium tetraborate and taken to the Seattle Laboratory of the NMFS Northwest and Alaska Fisheries Center (NWAFC). The settled volume was determined (Kramer et al. 1972) and all fish eggs and larvae (i.e., samples were not split) were removed from the neuston and 0.505 mm bongo samples. Fish eggs and larvae were identified to lowest taxon possible using standard procedures and life history stage was recorded.

Certain larval fishes were selected for length measurement (standard length to 0.1 mm) based on their abundance and/or economic value (i.e., *Mallotus villosus*; *Theragra chalcogramma*; Hexagrammidae; *Anoplopoma fimbria*; *Hemilepidotus* spp.; Stichaeidae, identified to type or species; *Ammodytes hexapterus*; and Pleuronectidae).

Numbers of eggs and larvae of each taxon from each tow were recorded. These numbers were converted to numbers per unit area or density as follows:

Unit area (number/10 m^2)

For bongo tows: $n \times d \times 10/[(r)^2 \times \pi \times l]$

For neuston tows: $n \times d \times 10/(h \times w \times l)$

Density (number/1,000 m^3)

For neuston tows: $n \times 1{,}000/(h \times w \times l)$

where n = number of organisms in sample,

r = radius of net opening in meters (0.3 m for bongo net),

h = effective fishing height of net opening in meters (0.15 m for neuston net),

w = width of net opening in meters (0.5 m for neuston net),

l = length of tow in meters (computed from calibrated flowmeter readings), and

d = depth of water sampled (calculated from wire angles for bongo tows; 0.15 m for neuston tows).

The percent occurrence (number of stations where taxon was collected/number of stations sampled × 100) of various taxa of fish eggs and larvae collected are illustrated by season. Relative abundance of each life history stage and taxon, expressed as $\log_{10}$ of the number in the survey area, is depicted for each season. For these estimates, the number per 10 m^2 of sea surface of each taxon collected in neuston and bongo nets was multiplied by the area of sea surface represented by each station, calculated as in Sette and Ahlstrom (1948). These figures were summed to estimate the total number of organisms in each taxon present in the study area at the time of the cruise.

Distribution of eggs and larvae of frequently occurring taxa is plotted for various solar seasons. The sampling area was divided into rectangles representing 0.25° latitude and 0.50° longitude. The number of tows (of neuston or bongo nets) made in each rectangle for each season is shown by six levels of shading. Superimposed on the rectangles are percent occurrence of the taxon in the rectangle represented by various sizes of dots.

The cooccurrence of larval fishes in the samples was analyzed using REGROUP and a support program CONNEX (based on Fager 1957). Although use of this method has been questioned (Richardson and Stephenson 1978), it has been applied to other ichthyoplankton investigations (Loeb et al. 1983). Since this method considers only joint occurrences, and does not deal with abundance, it was thought appropriate for the data examined here. After trying several affinity levels, a level of 0.4 was chosen as demonstrating the most reasonable groupings of larval fish. As discussed by Loeb et al. (1983), while the choice of affinity level is subjective, the rest of the procedure is objective.

Data on the relative abundance of adult fishes in the area were derived from NWAFC files on groundfish surveys and catches reported by the foreign fisheries operating in the area. Data from the same geographic area as used in the ichthyoplankton surveys (lat. 55°30′-59°15′N, long. 148°50′-156°00′W) and from all seasons were combined. Groundfish survey data was thus summarized from 2,293 trawl hauls taken between 1958 and 1982, with abundance reported both as kg/ha and number of fish/ha. Foreign catch data are available only from 1977 to 1981 and are reported in metric tons landed in the area of interest by species and by year. The arithmetic mean of the annual catch for the 5 yr of data was calculated to provide the estimate of relative abundance by species used for comparison with the other data bases. To estimate the relative abundance based on the egg and larval surveys, the number of larvae of a species in bongo catches in the survey area during the season of maximum abundance was used. Catches were averaged when more than one cruise occurred during a season.

Descriptions of early life-history stages of many fishes found off Kodiak Island are unavailable, although recent studies, based in part on material collected during this study, have made significant contributions. Identification of specimens in this study was based on characteristics of adults known from the area and published descriptions of eggs and larvae, as far as possible (Table 3). These allowed identification only to the familial or generic level when such descriptions were based on species not present off Kodiak Island. For specimens of unknown specific identity, series were established and referred to a "type" within the lowest certain category (i.e., Agonidae A, *Myoxocephalus* G), in hopes that the series could be assigned to a species as the study proceeded. This resulted in contributions toward description of several taxa [e.g., all the hexagrammids in the Kodiak Island area (Kendall and Vinter 1984)], although some series retain their type designations in this paper.

RESULTS
(Tables 4, 5)

The shelf off Kodiak Island was found to be a spawning and nursery area for numerous species of fish. Eggs and larvae of a number of the more than 80 taxa identified were found in every season. No area was found to lack young stages of fish. The water column (to at least 200 m) was used by ichthyoplankton and the neuston layer was particularly important to a number of species.

The seasonal cycles of occurrence of fish eggs and larvae are discussed first. Then an account of the geographical and seasonal distribution of the more abundant taxa collected is presented. Finally, we examine the community structure of larval fishes in the Kodiak Island shelf area.

Seasonal Cycle (App. Figs. 3-13)

Eggs.—Only 23 types of fish eggs were found; 13 of these were identified to species. Eggs of 11 species of pleuronectids were present. In winter six types of fish eggs were found and the dominant species were *Leuroglossus schmidti* and *Theragra chalcogramma* (App. Fig. 3). In spring a more diverse assemblage of eggs occurred that was dominated by *T. chalcogramma* and six species of pleuronectids (App. Figs. 4, 5). In summer almost the entire egg catch was made up of pleuronectids, with eight species present (App. Fig. 6). In fall the egg catch was considerably reduced, with only a few pleuronectids still present. *Leuroglossus schmidti* and *T. chalcogramma* entered the egg catches in late fall (App. Figs. 10-12). Macrourid eggs were present in summer and fall (App. Figs. 7-13).

Larvae.—The planktonic larval fish fauna was much more diverse than the eggs and contained many species of larvae originating from demersal eggs. In the bongo net, 82 types of larvae were found (Table 5) and in the neuston net 52 types (Table 4). Nearly all types of larvae caught in the neuston net were also caught in the bongo net.

In winter both the bongo and neuston catches were dominated numerically and in frequency of occurrence by larvae of *Hemilepidotus* spp. and several species of hexagrammids. *Mallotus villosus* larvae made up a large part of the catch in both nets, and *Leuroglossus schmidti* and *Stenobrachius leucopsarus* were also abundant in bongo catches (App. Fig. 3).

In spring the bongo catches contained considerable numbers of *Theragra chalcogramma*, *Ammodytes hexapterus*, and *Lepidopsetta bilineata* larvae. Larvae of *Bathymaster* spp. were abundant in late spring. Overall the larval fish assemblage seen in bongo catches in spring was quite diverse, with between 32 and 43 types caught on the three spring cruises. Neuston catches in spring were composed mainly of larvae of several hexagrammids, *Hemilepidotus* spp., and *Lyconectes aleutensis* (App. Figs. 4, 5).

Among the seasons, more taxa occurred in summer in both the bongo and neuston nets. In the bongo net *Sebastes* spp., *Bathymaster* spp., and several pleuronectids were commonly found. Several cottids were also present in low abundance. In the neuston net *Bathymaster* spp. and *Hexagrammos decagrammus* dominated the catches, but *Lyconectes aleutensis* and *Ammodytes hexapterus* were also abundant (App. Fig. 7). Altogether, 45 taxa of larvae were found in bongo samples and 35 in neuston samples in summer (Tables 4, 5).

In fall, *Mallotus villosus*, *Hemilepidotus* spp., and several hexagrammids were abundant in bongo catches. Larvae of *Stenobrachius leucopsarus* and *Sebastes* spp. were also abundant in some of the fall cruises. In the neuston catches in fall, larvae of *Hemilepidotus* spp., several hexagrammids, and *Bathymaster* spp. dominated (App. Figs. 8-11).

Distribution and Abundance of Selected Taxa (App. Figs. 14-84; Table 6)

Osmeridae (App. Figs. 14-17).—Unidentified osmerid larvae were taken in neuston nets in summer and fall and in bongo nets in spring through fall. Some of these larvae may have been small *Mallotus villosus*, although other species of osmerids occur in the Kodiak Island area. These unidentified osmerid larvae were most abundant in fall in neuston nets (App. Fig. 14) and in summer and fall in bongo nets (App. Fig. 15). They were collected in both kinds of sampling gear primarily in the nearshore and midshelf region.

Mallotus villosus larvae were identified in neuston and bongo tows in all cruises except summer. In summer, small larvae that could only be identified as osmerids were encountered; many of these may have been *M. villosus* larvae. Since this species seems to spawn primarily in summer near Kodiak Island, in order to follow their seasonal cycle of larval occurrences they will be discussed starting with the fall cruises. In fall *M. villosus* larvae, as reflected in neuston nets (App. Fig. 16), were widely distributed, extending eastward over Portlock Bank and westward to South Albatross Bank primarily over the inner and midshelf area; they were taken somewhat more widely in bongo tows (App. Fig. 17). In winter, these larvae were primarily taken in neuston tows in the nearshore area and northeastern end of the Kodiak Island shelf—they were more widely taken in bongo nets (App. Fig. 17). In spring, *M. villosus* larvae were taken primarily in neuston nets southwest of Kodiak Island over Horsehead Basin, South Albatross Bank, and west of the Trinity Islands.

Table 3.—Sources of information used in this study for identification of fish eggs (E) and larvae (L).

Scientific name	Common name	Stage	Reference
Clupea harengus pallasi	Pacific herring	L	Russell (1976)
Mallotus villosus	capelin	L	Templeman (1948)
Bathylagus milleri	stout blacksmelt	L	Ahlstrom (Unpubl.)[1]; Inhouse information
Bathylagus pacificus	Pacific blacksmelt	L	Ahlstrom (Unpubl.)[1]; Inhouse information
Leuroglossus schmidti	northern smoothtongue	E	Ahlstrom (1969)
Leuroglossus schmidti		L	Dunn (1983)
Protomyctophum thompsoni	bigeye lanternfish	L	Moser and Ahlstrom (1970)
Protomyctophum crockeri	flashlightfish	L	Moser and Ahlstrom (1970)
Stenobrachius leucopsarus	northern lampfish	L	Moser and Ahlstrom (1970)
Stenobrachius sp.		L	Inhouse information[2]
Microgadus proximus	Pacific tomcod	L	Matarese et al. (1981)
Gadus macrocephalus	Pacific cod	E,L	Mukhacheva and Zviagina (1960); Matarese et al. (1981)
Theragra chalcogramma	walleye pollock	E,L	Gorbunova (1954); Matarese et al. (1981); Inhouse information
Macrouridae	grenadiers	E,L	Ahlstrom and Moser (Unpubl.)[3]
Sebastes spp.	rockfishes	L	Moser et al. (1977)
Anoplopoma fimbria	sablefish	L	Ahlstrom and Stevens (1976)
Hexagrammidae	greenlings	L	Kendall and Vinter (1984)
Hexagrammos spp.		L	Kendall and Vinter (1984)
Hexagrammos decagrammus	kelp greenling	L	Kendall and Vinter (1984)
Hexagrammos lagocephalus	rock greenling	L	Kendall and Vinter (1984)
Hexagrammos octogrammus	masked greenling	L	Kendall and Vinter (1984)
Hexagrammos stelleri	whitespotted greenling	L	Kendall and Vinter (1984)
Ophiodon elongatus	lingcod	L	Kendall and Vinter (1984)
Pleurogrammus monopterygius	Atka mackerel	L	Kendall and Vinter (1984)
Cottidae	sculpins	L	Richardson and Washington (1980)
Artedius spp.		L	Richardson and Washington (1980)
Artedius meanyi	Puget Sound sculpin	L	Washington (1981)
Artedius harringtoni	scalyhead sculpin	L	Washington (1981)[4]
Artedius fenestralis	padded sculpin	L	Washington (1981)[4]
Clinocottus spp.		L	Richardson and Washington (1980)
Dasycottus setiger	spinyhead sculpin	L	Blackburn (1973); Richardson (1981)
Gymnocanthus spp.		L	Richardson (1981)
Gymnocanthus A		L	Inhouse information[5]
Hemilepidotus spp.	Irish lords	L	Richardson (1981)
Hemilepidotus hemilepidotus	red Irish lord	L	Richardson and Washington (1980)
Hemilepidotus jordani	yellow Irish lord	L	Peden (1978)
Hemitripterus villosus		L	Okiyama and Sando (1976)
Icelinus spp.		L	Richardson and Washington (1980)
Leptocottus armatus	Pacific staghorn sculpin	L	Richardson and Washington (1980)
Malacocottus zonurus 1		L	See Richardson (1981)
Myoxocephalus spp.		L	Inhouse information[6]
Myoxocephalus B		L	Inhouse information[6]
Myoxocephalus G		L	Inhouse information[6]
Radulinus spp.		L	Richardson (1981)
Radulinus asprellus	slim sculpin	L	Richardson and Washington (1980)
Triglops spp.		L	Richardson and Washington (1980)
Agonidae	poachers	L	Russell (1976)
Agonidae A	poachers	L	Inhouse information[7]
Agonidae C	poachers	L	Inhouse information[7]
Cyclopteridae	snailfishes	L	Russell (1976)
Aptocyclus ventricosus	smooth lumpsucker	L	Kobayashi (1962)
Trichodon trichodon	Pacific sandfish	L	Marliave (1981)
Bathymasteridae	ronquils	L	Matarese, In prep.[8]
Bathymaster spp.	searchers	L	Matarese, In prep.[8]
Ronquilus jordani	northern ronquil	L	Matarese, In prep.[8]
Anoplarchus insignis	slender cockscomb	L	Inhouse information; Misitano (Unpubl.)[9]
Chirolophis decoratus	decorated warbonnet	L	Waldron (Unpubl.)[10]
Lumpenella longirostris	longsnout prickleback	L	Inhouse information
Lumpenus maculatus	daubed shanny	L	Faber (1976)
Lumpenus sagitta	snake prickleback	L	Richardson (Unpubl.)[11]; Inhouse information
Stichaeus punctatus	Arctic shanny	L	Faber (1976)
Lyconectes aleutensis	dwarf wrymouth	L	Richardson (Unpubl.)[11]; Inhouse information
Pholis spp.	gunnels	L	Marliave (1975)
Zaprora silenus	prowfish	L	Chapman and Townsend (1938); Haryu and Nishiyama (1981)
Ammodytes hexapterus	Pacific sand lance	L	Kobayashi (1961)
Atheresthes stomias	arrowtooth flounder	E,L	Pertseva-Ostroumova (1960, 1961)
Glyptocephalus zachirus	rex sole	E,L	Ahlstrom and Moser (1975)

Table 3.—*Continued.*

Scientific name	Common name	Stage	Reference
Hippoglossoides elassodon	flathead sole	E,L	Pertseva-Ostroumova (1961); Miller (1969)
Hippoglossus stenolepis	Pacific halibut	L	Thompson and Van Cleve (1936)
Isopsetta isolepis	butter sole	E,L	Richardson, Dunn, and Naplin (1980)
Lepidopsetta bilineata	rock sole	L	Yusa (1957, 1958); Pertseva-Ostroumova (1961)
Limanda aspera	yellowfin sole	E,L	Pertseva-Ostroumova (1961)
Microstomus pacificus	Dover sole	L	Hagerman (1952)
Parophrys vetulus	English sole	L	Hickman (1959)
Pleuronectes quadrituberculatus	Alaska plaice	E,L	Pertseva-Ostroumova (1961)
Psettichthys melanostictus	sand sole	L	Sommani (1969)
Unidentified eggs:			
Type A (probably *Atheresthes stomias*)	arrowtooth flounder		Inhouse information[12]
Type C (demersal)			Inhouse information[13]
Type D (demersal)			Inhouse information[14]
Type M (Macrouridae type)	grenadiers		Inhouse information[15]

[1]E. H. Ahlstrom (deceased), Southwest Fisheries Center, NMFS, unpubl. data.

[2]Believed to be *S. nannochir.*

[3]E. H. Ahlstrom (deceased) and H. G. Moser, Southwest Fisheries Center, NMFS, unpubl. data.

[4]The specimens referred to these species had more preanal myomeres (ca. 3-4) than in the published descriptions but it is assumed that this is related to their development off Kodiak in water colder than off Oregon, the collection area that the descriptions were based on.

[5]At least two species of *Gymnocanthus* occur in the Kodiak area, however, the larvae of neither has been described. Among the preflexion larvae of this genus found in this study, a distinctive type based on larval pigment and morphology was found. This was designated *Gymnocanthus* A. Other specimens of *Gymnocanthus* that did not have these characteristics were designated *Gymnocanthus* spp.

[6]The taxonomy of *Myoxocephalus* in the northeast Pacific is poorly known. Two types of larvae were found: *Myoxocephalus* G, which had a characteristic pattern of dense melanophores uniformly covering the preanal part of the body, and *Myoxocephalus* B, a more variable type that might include more than one species with only light pigment mainly in the ventral postanal region. *Myoxocephalus* spp. are mainly larger specimens in which the larval pigment characters have been overgrown by juvenile pigment, although some smaller specimens which could not be referred to a type are also included.

[7]These were distinctive types of agonid larvae, based on morphology and pigment, which could not be assigned to any of the species occurring off Kodiak, due to incomplete developmental series and lack of study of larvae of this family.

[8]This family is represented by several nominal species off Kodiak, but the larvae of none of them have been described. Our samples contained specimens that formed a series of *Ronquilus jordani* and specimens that were referred to the other genus, *Bathymaster*, partly by elimination, as well as small and mutilated specimens that were identified only at the familial level.

[9]D. A. Misitano, Northwest and Alaska Fisheries Center, NMFS, unpubl. data.

[10]K. D. Waldron (retired), Northwest and Alaska Fisheries Center, NMFS, unpubl. data.

[11]S. L. Richardson, Gulf Coast Research Laboratory, Ocean Springs, MS, unpubl. data.

[12]Type A fish eggs are about 3.0 mm in diameter, have a smooth chorion, no oil globule, and homogeneous yolk. They may be eggs of *Atheresthes stomias.*

[13]Type C fish eggs appeared to be demersal eggs that were stirred into the water column by near-bottom currents, or were collected when the net inadvertently touched the bottom.

[14]Type D fish eggs are a distinctive type of demersal egg that is spherical with its surface covered with a few large points.

[15]Type M fish eggs appeared similar to macrourid eggs (Ahlstrom and Moser, unpubl.), but were not assigned to that family because unknown eggs of other families in the area may also have the characteristics of these eggs.

Average lengths of larvae collected in neuston nets appeared larger than those taken in bongo nets. In fall mean lengths in neuston nets were 33.4 mm and in bongo nets 23.5 mm (Table 6). Mean lengths of larvae in winter were 40.1 mm in neuston nets as opposed to 33.2 mm in bongo nets. The increase in mean length from fall to winter therefore ranged from 6.9 mm for neuston to 9.7 mm in bongo nets. Differences in mean lengths of specimens collected in the two kinds of gear may be attributed to avoidance and/or behavioral changes of the species with growth. Apparently *M. villosus* larvae are no longer available to our sampling gear after they reach about 55 mm.

Bathylagidae (App. Figs. 18-20).—*Bathylagus pacificus* larvae were taken in bongo nets in small numbers in spring through fall. They were most abundant in spring (App. Fig. 18) over slope waters.

Eggs of *Leuroglossus schmidti* were collected in fall through spring and larvae were collected in every season. Although a few eggs of this species were taken in neuston samples, most eggs were collected in bongo nets. Eggs of *L. schmidti* were found primarily over the slope region in fall and winter (App. Fig. 19). Larvae were also found in all seasons, primarily in slope waters (App. Fig. 20). Small numbers of larvae of *L. schmidti*, however, were found near Amatuli Trough in summer and fall and west of Trinity Islands in winter, suggesting intrusion of oceanic water to inshore areas, inasmuch as *L. schmidti* is considered a mesopelagic species.

Myctophidae (App. Figs. 21, 22).—Larvae of *Protomyctophum thompsoni* were collected primarily in bongo hauls in low numbers in all seasons. The larvae were mainly distributed over slope waters deeper than 200 m, but they were also found over Horsehead Basin and near Stevenson Entrance in fall.

Larvae of *P. crockeri* were collected in small numbers in summer only.

Stenobrachius sp. larvae, probably *S. nannochir*, were collected in low numbers in spring through fall (App. Fig. 21). This taxon was distributed primarily in midshelf and slope waters, but also was found nearshore.

Stenobrachius leucopsarus larvae were collected in bongo nets in all seasons sampled. They were widely distributed, occurring in nearshore, midshelf, and slope waters (App. Fig. 22). This species was most widely distributed in spring and summer.

Table 4.--Percent occurrence and mean density (number/1,000 m³) of fish eggs and larvae collected in neuston tows on cruises conducted from 1977-79.

STAGE AND SPECIES	CRUISE: 1MF79		CRUISE: 4D178		CRUISE: 2MF78		CRUISE: 3MF78		CRUISE: 1PO79		CRUISE: 4MF78		CRUISE: 5MF78		CRUISE: 4MF77		CRUISE: 1WE78	
	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³	OCCUR. %	MEAN NO. PER 1000m³
EGG																		
UNIDENTIFIED			1.12	12.00	2.27	50.89	3.57	9.52										
TELEOST TYPE A			5.62	48.77														
TELEOST TYPE C					1.14	19.45												
OSMERIDAE									2.08	145.86								
LEUROGLOSSUS SCHMIDTI									2.08	20.64							2.35	19.03
THERAGRA CHALCOGRAMMA	1.12	20.64	25.84	90.56	3.41	14.10									16.00	22.41	1.18	14.08
PLEURONECTIDAE			16.85	63.44	23.86	10[illegible].49	10.71	18.00	4.17	33.67								
GLYPTOCEPHALUS ZACHIRUS					32.95	32.57	3.57	11.92										
HIPPOGLOSSOIDES ELASSODON			7.87	31.89	19.32	29.13												
ISOPSETTA ISOLEPIS			2.25	22.47	5.68	55.42												
LIMANDA ASPERA					20.45	248.67	14.29	57.63	8.33	51.14								
MICROSTOMUS PACIFICUS			1.12	21.31	43.19	107.71												
PLATICHTHYS STELLATUS			1.12	43.29	1.14	52.12												
PLEURONECTES QUADRITUBERCULATUS			2.25	17.69														
PSETTICHTHYS MELANOSTICTUS					3.41	21.66	3.57	12.42										
LARVAE																		
UNIDENTIFIED	1.12	35.51	4.49	23.74	2.27	24.88	10.71	12.75							4.00	54.57		
DISINTEGRATED					7.95	26.00	17.86	20.95			2.22	13.49						
OSMERIDAE					2.27	299.00	3.57	88.33	27.08	74.25	15.56	37.02	18.18	80.84				
MALLOTUS VILLOSUS	13.48	22.44	6.74	26.92			42.86	52.98			11.11	29.68	45.45	77.35	12.00	30.98	28.24	48.87
MYCTOPHIDAE			1.12	13.89											1.33	19.19		
STENOBRACHIUS SP.					1.14	19.92												
PROTOMYCTOPHUM THOMPSONI									2.08	26.18					1.33	17.98		
GADIDAE					1.14	164.56												
THERAGRA CHALCOGRAMMA					4.55	21.64									2.67	20.37		
MACROURIDAE							3.57	36.03										
GASTEROSTEUS ACULEATUS											4.44	14.74						
SEBASTES SPP.	1.12	15.34			18.18	29.74	14.29	11.54	2.08	19.07							1.18	17.07
ANOPLOPOMA FIMBRIA					14.77	19.99												
HEXAGRAMMIDAE	6.74	26.48	5.62	57.34									9.09	67.88	4.00	43.03	2.35	15.51
HEXAGRAMMOS SPP.			8.99	39.28	3.41	64.66	28.57	57.61	4.17	34.02	22.22	38.29	45.45	70.31	13.33	25.82	9.41	28.19
HEXAGRAMMOS DECAGRAMMUS	83.15	157.19	84.27	171.58	64.77	53.01					15.56	18.85	36.36	25.14	64.00	79.67	36.47	85.60
HEXAGRAMMOS LAGOCEPHALUS							85.71	294.74	81.25	143.33	97.78	593.13	100.00	155.26	50.67	56.33	45.88	47.46
HEXAGRAMMOS OCTOGRAMMUS	12.36	20.34			5.68	23.81	64.29	111.69	50.00	89.51	91.11	120.83	100.00	117.17	45.33	31.90	45.88	54.23
HEXAGRAMMOS STELLERI	32.58	27.57	37.08	29.89	5.68	30.15	28.57	71.66	4.17	41.97	55.56	60.08	100.00	157.70	84.00	64.74	83.53	113.77
OPHIODON ELONGATUS					7.95	21.92												
PLEUROGRAMMUS MONOPTERYGIUS	47.19	77.33	31.46	89.95							13.33	72.56	81.82	35.70	46.67	88.49	42.35	118.29
COTTIDAE			2.25	24.19	2.27	21.42												
ARTEDIUS FENESTRALIS											4.44	18.36	9.09	11.78				
ARTEDIUS MEANYI					1.14	15.02												
GYMNOCANTHUS SPP.			1.12	36.26														
GYMNOCANTHUS A			1.12	14.00														
HEMILEPIDOTUS SPP.	57.30	105.21	35.96	166.65	5.68	22.29	25.00	26.58	6.25	16.52	48.89	91.26	100.00	81.88	76.00	163.22	61.18	104.52
HEMILEPIDOTUS HEMILEPIDOTUS			2.25	20.22	17.05	26.52												
HEMILEPIDOTUS JORDANI					5.68	36.16												
LEPTOCOTTUS ARMATUS									4.17	37.04			9.09	13.58				
MYOXOCEPHALUS SPP.					14.77	32.10												
MYOXOCEPHALUS B			1.12	34.55														
MYOXOCEPHALUS G			1.12	27.99														
CYCLOPTERIDAE			1.12	75.53	1.14	32.89	3.57	11.45										
APTOCYCLUS VENTRICOSUS											2.22	30.30	18.18	14.13	2.67	20.60		
BATHYMASTERIDAE					1.14	12.94												
BATHYMASTER SPP.	5.62	16.48	1.12	16.86	51.14	295.14	64.29	78.55	39.58	74.57	66.67	131.91	45.45	37.36	2.67	27.04	18.82	29.63
RONQUILUS JORDANI					2.27	14.75	14.29	11.53	4.17	16.98	2.22	15.10						
STICHAEIDAE			2.25	30.21	2.27	48.45												
ANOPLARCHUS INSIGNIS					1.14	21.08												
CHIROLOPHIS DECORATUS			5.62	49.94														
STICHAEUS PUNCTATUS					3.41	14.66												
LYCONECTES ALEUTENSIS			16.85	71.80	34.09	49.43												
PHOLIS SPP.					1.14	16.47												
PHOLIS LAETA					1.14	19.45												
ZAPRORA SILENUS			2.25	120.40														
AMMODYTES HEXAPTERUS			5.62	31.78	23.86	49.46												
GLYPTOCEPHALUS ZACHIRUS					2.27	25.46												
HIPPOGLOSSOIDES ELASSODON					2.27	13.99												
LEPIDOPSETTA BILINEATA			1.12	17.22	4.55	17.54												
MICROSTOMUS PACIFICUS					5.68	19.07												
PSETTICHTHYS MELANOSTICTUS					2.27	17.31												

Gadidae (App. Figs. 23-26).—Larvae of *Gadus macrocephalus* were collected in bongo nets in small numbers in spring and summer. The largest catches occurred in Shelikof Strait and west of Trinity Islands in spring (App. Fig. 23).

Theragra chalcogramma eggs were collected in both bongo and neuston nets in all seasons (App. Figs. 24, 25), but their greatest abundance occurred in spring. They were taken primarily in bongo nets and were distributed in nearshore, midshelf, and slope regions. The highest proportion of positive stations occurred in spring in the area north and west of Trinity Islands. *Theragra chalcogramma* larvae were taken mainly in bongo nets in fall, spring, and summer (Table 5), but greatest abundance occurred in the spring (App. Fig. 26). Like the eggs, larvae were found in nearshore, midshelf, and slope regions; however, greatest abundance was centered in the area near Trinity Islands. More recent studies have shown a major center of abundance of eggs and larvae in Shelikof Strait (Bates and Clark[4]).

In spring bongo catches, *T. chalcogramma* larvae were 2-8 mm (mean 5.5 mm) long; in summer, they ranged from 5 to 37 mm long (mean 19.1 mm), as shown in Table 6.

[4]Bates, R. D., and J. Clark. 1983. Ichthyoplankton off Kodiak Island and the Alaskan Peninsula during spring 1981. NWAFC Processed Rep. 83-09, 105 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Macrouridae (App. Fig. 27).—Unidentified macrourid eggs were collected in bongo tows mainly in summer and fall, primarily over slope waters (App. Fig. 27).

Scorpaenidae (App. Figs. 28, 29).—About 18 species of *Sebastes* are reported off Kodiak Island (Quast and Hall 1972); however, their larvae cannot be distinguished presently. Collections of *Sebastes* spp. larvae were made from late spring through early fall. They were caught primarily in the bongo net, although they also occurred in the neuston net, mostly in summer when they were at peak abundance, as indicated by the bongo net catches. There is evidence for a shift in distribution during the season from offshore near the edge of the continental shelf in late spring to over the continental shelf closer to shore in early fall. The distribution pattern seen for the genus may be confounded because several species are probably present in these collections and each likely has a distinct pattern, which only partially overlaps that of the other species.

Anoplopomatidae (App. Fig. 30).—*Anoplopoma fimbria* larvae occurred in neuston tows mainly near the edge of the shelf in summer. The few larvae caught had a mean length of 19.1 mm (Table 6).

Hexagrammidae (App. Figs. 31-40).—*Hexagrammos decagrammus* larvae occurred from fall through summer, primarily in

Table 5.--Percent occurrence and mean number per 10 m^2 of fish eggs and larvae collected in bongo tows on cruises conducted from April 1972 to September 1979.

STAGE AND SPECIES	CRUISE: 1MF79		CRUISE: 4DI78		CRUISE: 2KE72		CRUISE: 5TI79		CRUISE: 2MF78		CRUISE: 3MF78		CRUISE: 1PO79		CRUISE: 4MF78		CRUISE: 5MF78		CRUISE: 4MF77		CRUISE: 1WE78	
	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2	OCCUR. %	MEAN NO. PER 10 m^2
EGG																						
UNIDENTIFIED	2.27	18.62	1.18	3.37	26.53	6.07	5.56	6.87	4.55	9.29									3.92	10.74	1.18	5.59
TELEOST TYPE A			1.18	31.50																		
TELEOST TYPE C									1.14	29.07												
TELEOST TYPE D									1.14	10.93												
TELEOST TYPE M							27.78	49.50														
DISINTEGRATED													5.56	4.37								
BATHYLAGIDAE	2.27	6.52					2.78	6.68														
LEUROGLOSSUS SCHMIDTI	7.95	9.26							3.41	8.79	23.08	11.06	16.67	14.45	26.15	34.46	10.53	139.48	13.73	15.50	27.06	36.86
THERAGRA CHALCOGRAMMA	3.41	17.01	34.12	27.11	44.90	11.89	27.78	40.32	1.14	6.72							5.26	5.14	13.73	7.99	3.53	4.08
MACROURIDAE							2.78	6.73	19.32	28.69	7.69	16.16	16.67	19.79	4.62	8.45	5.26	6.69	3.92	19.62	9.41	8.42
PLEURONECTIDAE			25.88	13.39			13.89	20.33	35.23	20.84	3.85	4.42	5.56	12.26	1.54	16.43						
ATHERESTHES STOMIAS	4.55	9.80																				
GLYPTOCEPHALUS ZACHIRUS					16.33	3.29	38.89	19.13	26.14	10.90	3.85	6.29										
HIPPOGLOSSOIDES ELASODON	1.14	6.07	10.59	19.77	46.94	9.03	27.78	42.92	28.41	10.71												
ISOPSETTA ISOLEPIS			2.35	4.00					12.50	12.73												
LIMANDA ASPERA									17.05	25.22	30.77	8.63										
LYOPSETTA EXILIS									2.27	6.19												
MICROSTOMUS PACIFICUS							16.67	32.77	35.23	20.51												
PAROPHRYS VETULUS											3.85	4.42										
PLATICHTYS STELLATUS			4.71	5.28					1.14	16.16												
PLEURONECTES QUADRITUBERCULATUS					2.04	1.19	11.11	20.15														
PSETTICHYTHYS MELANOSTICTUS							2.78	6.06	1.14	5.62												
LARVAE																						
UNIDENTIFIED	1.14	7.13	7.06	4.67	2.04	13.18	2.78	6.04	3.41	14.55	7.69	6.29							5.88	4.85	1.18	4.21
DISINTEGRATED					22.45	2.04	16.67	12.61	4.55	4.99	7.69	4.49	11.11	30.53	1.54	6.14						
CLUPEA HARENGUS PALLASI									1.14	12.00												
OSMERIDAE					2.04	1.70	2.78	6.45	21.59	42.20	69.23	194.56	50.00	62.38	66.15	73.61	52.63	158.25				
MALLOTUS VILLOSUS	31.82	16.84	4.71	4.10							19.23	32.32	5.56	13.89	32.31	14.58	52.63	35.06	43.14	10.65	58.82	26.91
BATHYLAGUS MILLERI									2.27	7.06												
BATHYLAGUS PACIFICUS	3.41	6.83	2.35	4.51	18.37	2.33	11.11	7.80	4.55	8.11												
LEUROGLOSSUS SCHMIDTI	15.91	12.58	2.35	4.84	10.20	2.53	2.78	6.63	6.82	7.42	3.85	7.11	5.56	30.56	1.54	5.80	5.26	6.69	5.88	11.38	8.24	5.73
MYCTOPHIDAE					6.12	1.78			1.14	5.49												
STENOBRACHIUS SP.	1.14	6.43					11.11	11.30	13.64	16.72	3.85	21.34	5.56	7.77	18.46	17.11	5.26	6.38				
STENOBRACHIUS LEUCOPSARUS	6.82	13.61	10.59	5.46	34.69	3.54	16.67	11.69	28.41	7.74	26.92	19.04	22.22	15.08	24.62	12.47					5.88	5.90
PROTOMYCTOPHUM CROCKERI									1.14	7.04												
PROTOMYCTOPHUM THOMPSONI	3.41	6.49			8.16	1.65	2.78	6.49	1.14	6.95	3.85	5.43	5.56	7.65	3.08	8.41	5.26	6.38	9.80	4.69	8.24	3.21
GADIDAE					20.41	1.86			3.41	10.22												
GADUS MACROCEPHALUS			2.35	5.95	20.41	2.44	13.89	19.27	1.14	4.69												
MICROGADUS PROXIMUS					2.04	1.79																
THERAGRA CHALCOGRAMMA			20.00	15.04	26.53	5.86	22.22	227.39	17.05	7.71									5.88	4.87		
MERLUCCIUS PRODUCTUS							2.78	31.51														
MACROURIDAE	1.14	5.71	1.18	6.19	4.08	1.48			1.14	6.64												
SEBASTES SPP.					2.04	2.07	25.00	10.67	56.82	51.60	23.08	8.86	22.22	7.48	27.69	8.15					3.53	4.95
ANOPLOPOMA FIMBRIA					4.08	2.33																
HEXAGRAMMOS SPP.	1.14	6.71	1.18	3.77							3.85	397.28										
HEXAGRAMMOS DECAGRAMMUS	21.59	7.76	11.76	5.82	2.04	1.50			1.14	7.01							5.26	5.77	5.88	5.63	2.35	5.48
HEXAGRAMMOS LAGOCEPHALUS											61.54	21.02	5.56	5.70	60.00	12.22	15.79	8.79	3.92	4.08		
HEXAGRAMMOS OCTOGRAMMUS											34.62	26.50			24.62	9.71	15.79	6.24	3.92	5.46	2.35	6.51
HEXAGRAMMOS STELLERI	3.41	5.97	1.18	4.97					1.14	13.36	15.38	4.81			12.31	8.28	10.53	7.91	9.80	7.01	9.41	9.70
PLEUROGRAMMUS MONOPTERYGIUS	11.36	6.87	3.53	3.95															9.80	10.63	8.24	10.99
COTTIDAE	2.27	6.34	17.65	6.01	36.73	2.31	11.11	6.57	31.82	11.56	3.85	3.97									1.18	4.31
ARTEDIUS SPP.									2.27	10.45					1.54	5.76	5.26	5.14				
ARTEDIUS FENESTRALIS					2.04	1.72			6.82	5.55	19.23	6.82	11.11	9.20	7.69	5.41	5.26	11.59			4.71	4.04
ARTEDIUS HARRINGTONI									1.14	3.09					3.08	5.46	5.26	4.74				
ARTEDIUS MEANYI			1.18	2.35					12.50	8.99	3.85	5.75							1.96	4.77		
CLINOCOTTUS SPP.									1.14	5.74												
DASYCOTTUS SETIGER			1.18	6.19	2.04	1.70	2.78	6.50	1.14	22.51												
GYMNOCANTHUS SPP.					4.08	11.97																
GYMNOCANTHUS A			20.00	7.90	26.53	2.93																
HEMILEPIDOTUS SPP.	45.45	10.54	29.41	6.27	2.04	1.03					26.92	12.71			80.00	39.28	100.00	78.24	86.27	41.84	62.35	17.93
HEMILEPIDOTUS HEMILEPIDOTUS			1.18	5.18					1.14	5.49												
HEMITRIPTERUS VILLOSUS	1.14	6.07																				
ICELINUS SPP.					2.04	0.78							5.56	14.86	3.08	6.36						
MALACOCOTTUS ZONURUS	1.14	6.62			8.16	1.06	5.56	7.09														
MYOXOCEPHALUS SPP.			2.35	3.08	6.12	2.21	2.78	8.21														
MYOXOCEPHALUS B			8.24	9.23	14.29	7.23																
MYOXOCEPHALUS G			5.88	6.93	14.29	2.30																
RADULINUS SPP.					2.04	0.67																
RADULINUS ASPRELLUS									10.23	5.14	3.85	5.47										
TRIGLOPS SPP.	5.68	5.07	1.18	4.72	4.08	0.93																
AGONIDAE			3.53	5.15	14.29	1.24	2.78	5.78	11.36	6.45												
AGONIDAE A					10.20	1.13	2.78	4.10														
AGONIDAE C					6.12	1.27	2.78	6.50														
CYCLOPTERIDAE			10.59	6.84	22.45	1.78	8.33	7.91	13.64	6.80												
APTOCYCLUS VENTRICOSUS																					1.18	7.01
LIPARUS FLORAE									1.14	4.97							5.26	5.47				
TRICHODON TRICHODON	1.14	4.18																				
BATHYMASTER SPP.			1.18	18.25	4.08	4.25	58.33	35.32	93.18	67.36	26.92	17.62			21.54	8.68						
RONQUILUS JORDANI									22.73	8.09												
STICHAEIDAE			17.65	8.29	2.04	13.79	25.00	10.26	11.36	6.24												
ANOPLARCHUS INSIGNIS					2.04	0.67																
CHIROLOPHIS DECORATUS			3.53	8.45																		
LUMPENELLA LONGIROSTRIS									2.27	4.91												
LUMPENUS SAGITTA			8.24	5.35	12.24	1.05																
LUMPENUS MACULATUS					34.69	1.93	2.78	7.12														
STICHAEUS PUNCTATUS									1.14	3.33												
LYCONECTES ALEUTENSIS	2.27	6.10	3.53	4.96			2.78	6.06	6.82	6.80												
PHOLIDAE							2.78	12.31														
PHOLIS SPP.			3.53	6.46	2.04	0.57			1.14	6.66												
PTILICHTHYS GOODEI							2.78	7.42														
ZAPRORA SILENUS							8.33	6.92	3.41	6.67												
AMMODYTES HEXAPTERUS	5.68	5.89	65.88	28.43	59.18	6.80	19.44	17.68	2.27	7.11												
PLEURONECTIDAE									1.14	5.74												
ATHERESTHES STOMIAS	7.95	7.78	9.41	6.85	8.16	2.83																
GLYPTOCEPHALUS ZACHIRUS									30.68	8.67					1.54	6.03						
HIPPOGLOSSOIDES ELASSODON							13.89	19.27	46.59	9.00			5.56	10.19	3.08	6.08						
ISOPSETTA ISOLEPIS					2.04	0.78			18.18	10.14												
LEPIDOPSETTA BILINEATA			34.12	11.35	55.10	6.52	25.00	9.12	26.14	8.16	3.85	6.40			1.54	5.34						
LIMANDA ASPERA											30.77	7.22	5.56	5.70	3.08	5.79						
MICROSTOMUS PACIFICUS									21.59	9.70												
PAROPHRYS VETULUS															1.54	5.76						
PLATICHTHYS STELLATUS									2.27	7.24												
PLEURONECTES QUADRITUBERCULATUS							2.78	8.26														
PSETTICHTHYS MELANOSTICTUS							8.33	8.62	40.91	11.59	15.38	4.92	5.56	11.41								
HIPPOGLOSSUS STENOLEPIS			2.35	4.25			2.78	6.75	1.14	5.20							5.26	4.39				

the neuston net (App. Figs. 31, 32). They reached their maximum seasonal abundance in winter and spring, as opposed to the other hexagrammids found around Kodiak Island which are more abundant in fall. They were still present in over half of the neuston tows in summer when the other hexagrammids were in < 10% of the tows. The larvae were taken in bongo tows mainly in areas and at times when they were abundant in neuston tows. In neuston catches they were about 10-11 mm long in fall and winter, 11.8 mm in spring, and 19.7 mm in summer (Table 6). The larvae were caught mainly at nearshore and midshelf stations in fall, but became distributed all across the shelf in the other seasons.

Hexagrammos lagocephalus larvae occurred mainly in neuston samples during a relatively short portion of the year—fall (App. Figs. 33, 34), when they were 9-10 mm in mean length (Table 6). Apparently they become demersal at a smaller size and younger age than other hexagrammids, since none larger than 19 mm were caught and they were absent from samples after fall. They were widespread, occurring in more than 80% and up to 98% of the neuston samples from cruises in early fall, when their mean density was quite high (up to 593/1,000 m^3).

Hexagrammos octogrammus larvae were first present seasonally in the early fall cruises when specimens averaged 7.8 mm long (App. Figs. 35, 36, Table 6). They were at maximum abundance, occurring in 91% of the neuston tows, in October with abundance decreasing until in spring and summer when they were in fewer than 10% of the tows, had a mean length of 41.5 mm, and were distributed rather evenly throughout the study area.

Larvae of *Hexagrammos stelleri* were present in neuston samples throughout the year (App. Figs. 37, 38). The smallest larvae (7.3-8.5 mm mean length) were caught in early fall and the largest (51.1 mm) were caught in summer. They occurred in more than 50% of the neuston tows in October and November cruises. They occurred throughout the study area, but appeared to be more abundant at nearshore stations than were the other hexagrammids.

Pleurogrammus monopterygius larvae were caught primarily in neuston tows from fall through spring (App. Figs. 39, 40). Seasonally they reached maximum abundance in late October when they occurred in over 80% of the neuston tows. Although this species is reported to remain in the neuston until a larger size than other hexagrammids, in this study the larvae increased in

Table 6.—Means and standard deviations of standard lengths (mm) by season of the more commonly caught larvae.

	Winter				Spring				Summer				Fall			
	Neuston		Bongo		Neuston		Bongo		Neuston		Bongo		Neuston		Bongo	
Species	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Mallotus villosus	40.1	7.96	33.2	6.63									33.4	9.69	23.5	8.02
Theragra chalcogramma							5.5	1.05	22.2	5.41	19.1	7.69	4.2	0.21	5.0	0.61
Anoplopoma fimbria									19.1	4.52						
Hexagrammos decagrammus	10.7	1.33	10.7	1.62	11.8	2.65	12.5	2.35	19.7	6.81			9.9	1.07	10.0	0.95
H. lagocephalus													8.9	1.60	9.6	1.49
H. octogrammus	24.1	3.58											8.9	2.51	9.5	2.60
H. stelleri	19.3	2.64			23.0	3.98							10.8	2.53	10.4	1.66
Pleurogrammus monopterygius	14.3	1.70			17.6	2.98							10.3	0.79	10.6	0.34
Hemilepidotus spp.	8.3	1.18	7.2	1.20	10.7	2.24	10.9	1.63	22.1	2.56			5.9	1.12	5.1	0.88
Hemilepidotus hemilepidotus									19.3	1.78						
Lyconectes aleutensis					16.4	2.48			26.0	5.18						
Ammodytes hexapterus			5.5	0.57			7.9	1.76	45.0	8.92						
Atheresthes stomias			7.6	0.53			6.8	1.27								
Glyptocephalus zachirus											11.8	3.25				
Hippoglossoides elassodon							6.1	2.34			10.8	5.34				
Isopsetta isolepis											7.3	3.34				
Lepidopsetta bilineata							4.3	0.74			11.8	4.19				
Limanda aspera															6.7	1.80
Microstomus pacificus											7.5	1.00				
Psettichthys melanostictus											5.5	1.61			10.0	6.90

mean length from 10.3 mm in fall to only 17.6 mm by spring (Table 6). They were taken primarily over the outer shelf and slope with fingers of occurrence extending shoreward associated with the troughs.

Cottidae (App. Figs. 41-51).—About 35 species of cottids occur in the Gulf of Alaska (Howe and Richardson 1978[5]). Most have demersal eggs, but the larval stage varies considerably among the species in duration, appearance, and apparent importance as a dispersal mechanism (Richardson and Washington 1980). Several types of cottid larvae were recognized in our samples and they could be identified to various taxonomic levels (family, genus, type within a genus, species). Those that were identified only as cottids were found during every season in bongo catches. They were most abundant in spring and summer when they were widespread in nearshore and midshelf waters (App. Fig. 41).

Larvae of *Artedius harringtoni* were collected in bongo tows in every season except winter, but were most frequently found in fall (App. Fig. 42). Then they were frequent parts of the catch, mainly at some nearshore stations, and occurred less often at midshelf stations.

In bongo catches in summer, *Artedius meanyi* larvae were found at scattered locations throughout the study area (App. Fig. 43). They did not appear to be as concentrated in nearshore areas as did some other cottids.

In bongo catches in spring, *Gymnocanthus* A larvae were found mainly in areas adjacent to land, although some were found at midshelf stations (App. Fig. 44).

Up to four species of *Hemilepidotus* may occur in the Kodiak Island area, and it was not possible to identify the species of larvae <18 mm. These larvae occurred in all seasons and were about equal in percent occurrence and mean length in both bongo and neuston tows (App. Figs. 45, 46). They were most frequently caught in mid-fall, but were in more than 25% of the tows from September through mid-April. Their mean lengths increased from 4.3 to 4.6 mm in September to 22.1 mm in July (Table 6). They occurred throughout the study area, and no definite pattern of distribution was evident. This may have resulted partly from the presence of larvae of more than one species with overlapping distribution.

In summer some *Hemilepidotus* larvae were large enough to identify by adult meristic characters. Most numerous were the *Hemilepidotus hemilepidotus* which occurred at several widely scattered locations throughout the study area, mainly in neuston collections (App. Fig. 47).

Larvae identified as *Myoxocephalus* spp. occurred primarily in neuston samples during the summer (App. Fig. 48). They were widely scattered from nearshore to slope stations mainly in the northern part of the study area.

Larvae of *Myoxocephalus* B occurred mainly nearshore off the southern part of Kodiak Island in bongo tows in spring (App. Fig. 49).

Myoxocephalus G larvae were present in nearshore areas in bongo collections in spring. They were mainly off the southeast coast of Kodiak Island, but some were also caught at the northern end of the study area off the tip of the Kenai Peninsula (App. Fig. 50).

In summer, *Radulinus asprellus* larvae occurred in bongo catches primarily south of the center of Kodiak Island in nearshore and midshelf areas (App. Fig. 51).

Agonidae (App. Fig. 52).—In bongo catches in spring and summer, unidentified agonid larvae were scattered over the sampling area. No distinct pattern of occurrence was noted, except that they were absent from the outer shelf and slope areas. Although the patterns in the two seasons are dissimilar, the differences are probably insignificant, because the larvae were so sparse and their specific identity was not determined.

Agonidae A larvae were present in bongo tows in spring at scattered midshelf areas (App. Fig. 53).

[5]Howe, K. M., and S. L. Richardson. 1978. Taxonomic review and meristic variation in marine sculpins (Osteichthyes: Cottidae) of the northeast Pacific Ocean. Unpubl. manuscr., 142 p. School of Oceanography, Oregon State University, Corvallis, OR 97331.

Cyclopteridae (App. Figs. 54, 55).—Larvae of unidentified cyclopterids were caught in bongo tows mainly in nearshore and midshelf areas in spring and summer (App. Fig. 54).

Larvae of *Aptocyclus ventricosus* were found in neuston collections in fall in a few scattered midshelf areas (App. Fig. 55).

Bathymasteridae (App. Figs. 56-59).—*Bathymaster* spp. larvae were abundant in both neuston and bongo tows from spring into fall. A complex pattern was seen with vast differences in frequency of occurrence between the two nets during the same season (App. Figs. 56, 57). These differences may be due in part to the presence of larvae of more than one species of *Bathymaster* in the samples with different behavior patterns and spawning seasons. Except in summer, when caught throughout the study area, they were rarely caught at the most shoreward stations. These larvae seem to become more neustonic with development, since in spring they were more abundant in bongo than in neuston catches, while the reverse was true in fall. They seemed to be most abundant in waters over the troughs that cut into the shelf off Kodiak Island.

Larvae of *Ronquilus jordani* were caught widely in bongo samples in summer (App. Figs. 58, 59). They occurred from the nearshore area to beyond the edge of the shelf. In fall neuston tows were more localized in the area of Kiliuda Trough and Horsehead Basin.

Stichaeidae (App. Figs. 60-62).—A number of larvae identified only as stichaeids were collected primarily in spring (App. Fig. 60). Because several species were involved, no obvious pattern in their distribution could be ascertained.

Larvae of *Lumpenus maculatus* were collected in bongo nets in spring (App. Fig. 61). These larvae were taken in nearshore and midshelf areas and in northeast Shelikof Strait.

Larvae of *L. sagitta* were collected in bongo nets in spring (App. Fig. 62). This species was found almost entirely in nearshore waters.

Other identified stichaeid larvae collected in small numbers (Tables 4, 5) included *Anoplarchus insignis*, *Chirolophis decoratus*, *C. nugator*, *Lumpenella longirostris*, and *Stichaeus punctatus*.

Cryptocanthodidae (App. Fig. 63).—Larvae of *Lyconectes aleutensis* were collected primarily in neuston nets in spring and summer. In spring larvae were concentrated mainly near the southern end of Kodiak Island and around the Trinity Islands. In summer they were more widespread and caught more frequently offshore than in spring, and tended to be concentrated in waters over Kiliuda and Stevenson Troughs. The mean length of the larvae in neuston catches in spring was 16.4 mm (range 12-25 mm) and in summer it was 26.0 mm with a range of 12-34 mm (Table 6).

Ammodytidae (App. Figs. 64, 65).—*Ammodytes hexapterus* larvae were found in winter, spring, and summer cruises (Tables 4, 5). In winter they occurred only in the bongo net, whereas in the spring and summer they were collected in both bongo and neuston nets. These larvae were taken in neuston nets primarily in the summer (App. Fig. 64) at nearshore and midshelf stations. They averaged 45.0 mm in length (Table 6).

Larvae were widespread and abundant in bongo catches in spring when they occurred throughout the study area. They were most concentrated in the nearshore zone and highest catches occurred off the southwest end of Kodiak Island and averaged 7.9 mm in length (Table 6).

Pleuronectidae (App. Figs. 66-84).—Unidentified pleuronectid eggs were taken in neuston and bongo nets mainly during spring and summer (App. Figs. 66, 67). The majority were early and middle stage eggs, about 1.0 mm in diameter, and are most likely of four possible species: *Platichthys stellatus*, *Psettichthys melanostictus*, *Parophrys vetulus*, or *Isopsetta isolepis*. In spring the distribution of these eggs, as reflected by catches in both kinds of gear, was essentially the same. They were found nearshore and midshelf, primarily from Portlock Bank westward to Middle Albatross Bank, although relatively isolated catches were made over South Albatross Bank and west of Trinity Islands.

In summer catches of unidentified pleuronectid eggs were made at nearshore and midshelf stations as in spring, but they were found primarily from North Albatross Bank southwestward to South Albatross Bank and west of Trinity Islands (App. Figs. 66, 67).

Eggs of *Atheresthes stomias* were collected only in winter 1979. They were taken in bongo nets in small numbers at four stations over slope waters. Larvae of *A. stomias* were captured in bongo nets over slope waters in winter and spring (App. Fig. 68). Mean length in winter was 7.6 mm (range 7-8 mm) and in spring their mean length was 6.8 mm (range 5-10 mm) as shown in Table 6.

Glyptocephalus zachirus eggs were collected in neuston nets mainly in summer (App. Fig. 69) and in bongo nets in spring and summer (App. Fig. 70). In both kinds of gear, eggs were found primarily over the outer shelf and slope areas; little difference was apparent in the distribution of *G. zachirus* eggs among the two kinds of gear.

Larvae of *G. zachirus* were captured in bongo nets only in the summer (App. Fig. 71). They were found over midshelf and slope areas, but largest catches were made primarily in the latter area. Larvae ranged in length from 6 to 20 mm (mean 11.8 mm) as shown in Table 6.

Eggs of *Hippoglossoides elassodon* were collected in neuston nets mainly in summer and in bongo nets in spring and summer. Neuston catches of eggs were primarily in nearshore and midshelf areas (App. Fig. 72).

Catches of *H. elassodon* eggs in bongo nets in the spring and summer were widely distributed. In spring they were collected in nearshore and midshelf areas as well as in Shelikof Strait. In summer they were collected primarily in nearshore and midshelf areas and west of Trinity Islands (App. Fig. 73). Larvae in spring were collected only west of the Trinity Islands whereas in summer they were widely distributed primarily in midshelf and slope waters (App. Fig. 74). In spring larvae ranged from 4.5 to 15.5 mm (mean 6.1 mm), and in summer they ranged from 4 to 24 mm (mean 10.8 mm), as shown in Table 6.

Only late stage eggs of *Isopsetta isolepis* were identified. They were found primarily in bongo nets in the summer (App. Fig. 75) when they were taken mainly over Middle Albatross Bank. Larvae were captured in bongo nets in summer at 15 stations over Middle and North Albatross banks (App. Fig. 76). Lengths ranged from 3 to 13 mm, with a mean of 7.3 mm (Table 6).

Lepidopsetta bilineata larvae were taken in bongo nets in spring and summer (App. Fig. 77). In both seasons they tended to occur primarily in nearshore and midshelf areas, although they were also taken near the slope. Lengths in spring ranged from 2.9 to 9.3 mm (mean 4.3 mm), and in summer they ranged from 3 to 20 mm and averaged 11.8 mm (Table 6).

Larvae of *Limanda aspera* were collected primarily in summer in both bongo and neuston nets (App. Figs. 78, 79). In both kinds of gear, eggs were collected primarily in the nearshore zone. They tended to be concentrated over North, Middle, and South Albatross banks.

Limanda aspera larvae were taken primarily in bongo nets in fall (App. Fig. 80). Larvae were also found primarily in the nearshore zone and principally over South Albatross Bank and near the Trinity Islands. In fall they ranged from 3.6 to 10.0 mm in length and averaged 6.7 mm (Table 6).

Eggs of *Microstomus pacificus* were collected in neuston and bongo nets mainly in summer (App. Figs. 81, 82). Most *M. pacificus* eggs were found at the edge of the shelf and over slope waters. The geographical distribution of the eggs in the two kinds of gear was similar.

Larvae of *M. pacificus* were taken only in summer, and then primarily in bongo nets (App. Fig. 83). They were taken most frequently over Kiliuda Trough, but were also taken over the slope. Larvae ranged in length from 5 to 10 mm and averaged 7.5 mm (Table 6).

Only late stage eggs of *Psettichthys melanostictus* were identified to species. Eggs were captured in low numbers in neuston nets in summer (Table 4) and in bongo nets in spring and summer (Table 5). They were taken primarily at nearshore and midshelf stations. Larvae of *P. melanostictus* were taken in bongo nets primarily in the summer and in the midshelf region (App. Fig. 84). They averaged 5.5 mm in length in summer and 10.0 mm in fall (Table 6).

Pleuronectes quadrituberculatus eggs and larvae were taken in small numbers in neuston and bongo nets in spring (Tables 4, 5). Eggs were collected in nearshore and shelf edge waters, and in Shelikof Strait, while a single larvae was taken in Shelikof Strait.

Recurrent Groups (App. Figs. 85-87)

Results of recurrent group analysis using a 0.4 affinity level (Fager 1957) on the larval fish occurrences by gear and season, and all seasons and all data combined, show a complex community structure.

In neuston catches *Hexagrammos decagrammus* and *Hemilepidotus* spp. were associated with each other, or other species, during every season (App. Fig. 85). In fall and winter, other hexagrammids were associated with these two species to form a single group, to which *Bathymaster* spp. were associated in the fall. In spring *Lyconectes aleutensis* was a member of the *Hemilepidotus* spp.-hexagrammid group. In summer the composition had changed with a group consisting of *Bathymaster* spp., *Lyconectes aleutensis*, and *Ammodytes hexapterus* present. *Sebastes* spp. and *Hemilepidotus* spp. formed a second group that was associated with *Bathymaster* spp. in the first group. *Hexagrammos decagrammus* was also associated with *Bathymaster* spp. and *Myoxocephalus* spp. was associated with *Lyconectes aleutensis*.

In bongo catches a more complex pattern was seen in most seasons (App. Fig. 86). *Hemilepidotus* spp. and some of the hexagrammids were part of the groups in fall and winter. Various pleuronectids were members of groups in every season but winter. The gadids, *Theragra chalcogramma* and *Gadus macrocephalus*, as well as three of the cottids, were part of the structure in spring. In summer five pleuronectids were part of the structure and *Bathymaster* spp. and *Sebastes* spp., along with two pleuronectids, were members of the main group. In addition to the pleuronectids, *Stenobrachius leucopsarus* and *Ronquilus jordani* were associated with some members of that group.

When the neuston data from all cruises were combined, two groups were recognized (App. Fig. 87). The larger group, with four members and three associates, was composed of five hexagrammid species, *Hemilepidotus* spp. and *Bathymaster* spp. The other group contained only *Lyconectes aleutensis* and *Ammodytes hexapterus*.

When data from bongo samples from all cruises were combined, a pattern of 5 groups with 15 taxa emerged (App. Fig. 87). One group contained *Bathymaster* spp. and *Sebastes* spp., along with three pleuronectids as members or associates. Another group contained three cottids and was associated with a group composed of *Ammodytes hexapterus* and *Lepidopsetta bilineata*. Another group contained *Hemilepidotus* spp. and *Mallotus villosus*, and still another *Hexagrammos lagocephalus* and *H. octogrammus*.

When data from all cruises and both the bongo and neuston nets were combined, a group of frequently cooccurring species consisting of the hexagrammids, *Hemilepidotus* spp., and *Mallotus villosus* was seen (App. Fig. 87). From the analysis of individual seasons and nets, it was shown that this group was most strongly represented in neuston catches in fall and winter. Only *M. villosus* was associated mainly with bongo catches. Other groups present in the combined data were *Bathymaster* spp. and *Sebastes* spp. (mainly summer in both neuston and bongo catches), *Ammodytes hexapterus* and *Lepidopsetta bilineata* (spring bongo catches), and three cottids: *Gymnocanthus* A, *Myoxocephalus* B, and *Myoxocephalus* G (spring bongo samples).

Summary of Occurrences of Abundant Taxa

From the cruise results presented here, the annual cycle of occurrence of fish eggs and larvae off Kodiak Island can be summarized by season and area (Table 7). The onshore-offshore patterns of distribution of ichthyoplankton were roughly characterized as nearshore (< 60 km from shore), midshelf (40-80 km from shore), and slope (75-≥130 km from shore). The ichthyoplankton was dominated by the generally ubiquitous hexagrammids and *Hemilepidotus* spp. in fall and winter. Between fall and winter, larvae of *Mallotus villosus* shifted from nearshore to midshelf waters. By spring, *Theragra chalcogramma* and some pleuronectids were present, and in summer, several pleuronectids dominated throughout the area. Eggs of *Theragra chalcogramma* were caught mainly nearshore, while the larvae were widespread throughout the area. Other larvae abundant mainly in spring-summer were *Ammodytes hexapterus*, *Lyconectes aleutensis*, and *Bathymaster* spp. Larvae of the mesopelagic species *Stenobrachius leucopsarus* and *Leuroglossus schmidti* were concentrated in slope waters, as were eggs of Macrouridae where they showed little seasonality.

DISCUSSION

Extensive faunal surveys of ichthyoplankton have been reported from relatively few areas of the world ocean, and such studies in subarctic waters are even rarer. In the eastern Pacific, Ahlstrom (1971, 1972) reported larval fish distributions in tropical, mainly oceanic, waters and in the California Current (Ahlstrom 1965). Although a number of ichthyoplankton studies have been conducted off Oregon (see Richardson, Laroche, and Richardson 1980), they have not been reported in such a way as to document the seasonal cycle over a large area. Waldron (1981) summarized ichthyoplankton studies in the eastern Bering Sea, and found that data had to be accumulated from a number of studies using different gear and methods to derive an annual cycle of ichthyoplankton occurrence, and, in general, no estimates of abundance could be made. The present study will allow comparisons of occurrence, and relative and seasonal abundance of ichthyoplankton as studies in other areas are conducted. It will

Table 7.—Season and areas of major occurrences of the most abundant taxa of fish eggs (E) and larvae (L) off Kodiak Island.

	Fall	Winter	Spring	Summer
Nearshore (<60 km from shore)	*Mallotus villosus* - L *Theragra chalcogramma* - E		*Theragra chalcogramma* - E[1] *Ammodytes hexapterus* - L[1] Pleuronectidae - E	Pleuronectidae - E *Isopsetta isolepis* - E *Limanda aspera* - E
Midshelf (40-80 km from shore)	Osmeridae - L *Hexagrammos decagrammus* - L *Bathymaster* spp. - L[1]	*Mallotus villosus* - L *Hexagrammos octogrammus* - L *H. stelleri* - L	*Bathymaster* spp. - L *Hippoglossoides elassodon* - E *Lepidopsetta bilineata* - L[1]	*Hexagrammos stelleri* - L *Glyptocephalus zachirus* - L *Hippoglossoides elassodon* - E&L *Psettichthys melanostictus* - L *Isopsetta isolepis* - L *Lepidopsetta bilineata* - L[1] *Microstomus pacificus* - L
Slope (75–≥130 km from shore)	*Leuroglossus schmidti* - E *Stenobrachius leucopsarus* - L[1] Macrouridae - E	*Leuroglossus schmidti* - E&L *Atheresthes stomias* - L	*Stenobrachius leucopsarus* - L[1] *Pleurogrammus monopterygius* - L	*Stenobrachius leucopsarus* - L[1] Macrouridae - E *Glyptocephalus zachirus* - E *Microstomus pacificus* - E
Ubiquitous	*Hexagrammos lagocephalus* - L *H. octogrammus* - L *H. stelleri* - L *Pleurogrammus monopterygius* - L *Hemilepidotus* spp. - L	*Hexagrammos decagrammus* - L *Pleurogrammus monopterygius* - L *Hemilepidotus* spp. - L	*Theragra chalcogramma* - L *Hexagrammos decagrammus* - L *H. stelleri* - L *Hemilepidotus* spp. - L *Lyconectes aleutensis* - L	*Theragra chalcogramma* - L *Sebastes* spp. - L *Hexagrammos decagrammus* - L *Bathymaster* spp. - L *Lyconectes aleutensis* - L *Ammodytes hexapterus* - L

[1]Frequents other geographic regions also.

also allow comparisons with other years in the Kodiak Island area. Interannual changes in the relative abundance of eggs and larvae of various taxa could signal changes in biomass or other population parameters of adults of those taxa.

Measurement of Kinds and Abundance of Fishes

One of the frequently stated goals of ichthyoplankton studies is to provide information on the species composition of the fish fauna of an area (Ahlstrom and Moser 1976). The supposition is that the plankton net is less species-selective than any one other single type of sampling equipment and that the eggs and larvae are far more abundant than the adults. Ahlstrom (1965) demonstrated the applicability of egg and larval surveys in determining the kinds of fish inhabiting the California Current. This technique has not been applied elsewhere, partially because the extensive data base required is not available. Many of the fishes of the California Current system are pelagic in all their life history stages (eggs, larvae, juveniles, adults). In the Kodiak Island area, the fish community is composed of species that are pelagic during fewer of their life history stages. There are few species that produce pelagic eggs; *Theragra chalcogramma* and the pleuronectids are the major exceptions. The juveniles and adults of many of the species are demersal. Thus, although the data base from ichthyoplankton surveys near Kodiak Island is not as extensive as that in the California Current, it is of interest to compare the species composition and relative abundance as reflected in these surveys with that reflected from information based on adults.

Comparison of three measures of species composition and abundance (two based on adult catches, one based on larval catches) reveals differences that can be attributed to a number of causes. The fisheries catch data give a biased view of the assemblage due to selection based on economic value of the species and legal restrictions (Fig. 3). Compared with the other measures, the fisheries catch indicates greater abundance of larger bodied species. *Theragra chalcogramma* ranks first in both the fisheries and the groundfish survey data, and it ranks third in the ichthyoplankton data (Figs. 4, 5). The fisheries and groundfish survey data reported by weight show similar rankings of species; some exceptions are *Pleurogrammus monopterygius*, *Anoplopoma fimbria*, and *Sebastes* spp. which compose a substantial part of the fisheries catch, but are rare in the groundfish survey data. There is some similarity between the groundfish survey data reported by numbers of fish and the ichthyoplankton survey data. Both show osmerids and pleuronectids as abundant members of the fish fauna. However, the ichthyoplankton data indicate an abundance of several smaller or cryptic fishes (e.g., *Bathymaster* spp., *Stenobrachius leucopsarus*, *Ammodytes hexapterus*, and *Hemilepidotus* spp.) that are probably not sampled adequately by the groundfish trawls. Ichthyoplankton data were not considered extensive enough to allow interannual comparisons.

These comparisons indicate that the plankton net is probably less selective than bottom trawls since larval fish as part of plankton are in a physically less heterogeneous environment than the adults. Vertically oblique plankton tows, such as those used for these comparisons, produce samples that integrate through much of the heterogeneity of the planktonic environment. However, life history characteristics of the species complicate correlations be-

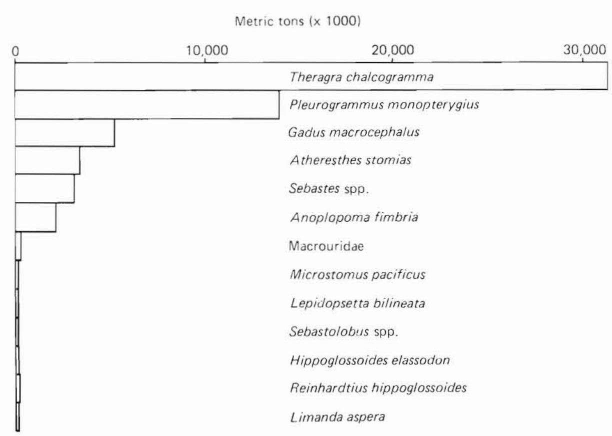

Figure 3.—Reported foreign nation trawl catches of fish in the Kodiak study area, 1977-81, averaged for the 5 yr, reported and ranked by metric tons.

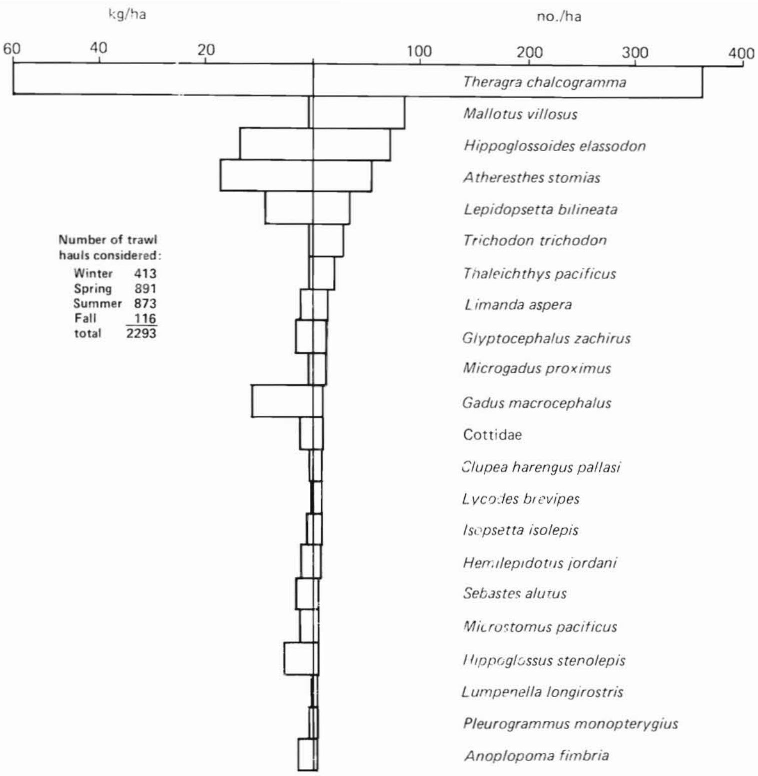

Figure 4.—Abundance of fishes in the Kodiak study area as indicated by groundfish survey catches, reported and ranked as numbers of fish per hectare (ha) and also reported as kilograms per hectare.

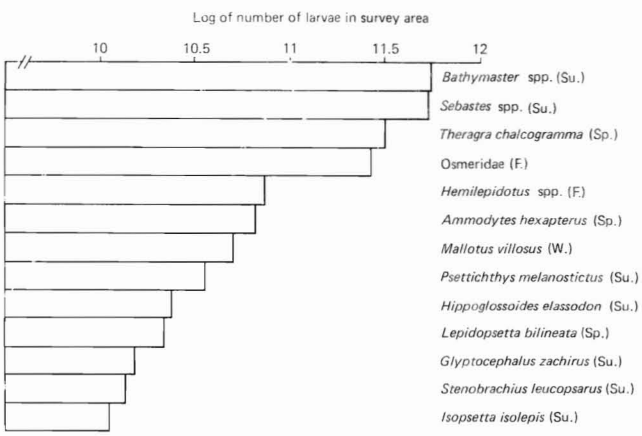

Figure 5.—Estimated numbers of fish larvae produced annually in the Kodiak study area. (Su. = summer, F. = fall, W. = winter, Sp. = spring.)

tween numbers of fish larvae caught and numbers of adults present. Life history parameters such as fecundity, longevity, type and size of egg, extent of parental care, and duration of larval life must be considered in making correlations between abundances based on plankton surveys and those based on adult populations.

Comparative Early Life History Patterns

There are several postulates concerning reproduction of marine animals at high latitudes as opposed to low latitudes that can be examined by comparing the early life history patterns observed off Kodiak Island with those of fishes from more temperate or tropical areas. Marshall (1953) put forward the idea that fishes reproducing at high latitudes and in the deep sea would produce relatively few, large, yolky eggs that would hatch into comparatively advanced larvae. This seems to be related to the advantages larger larvae would have in securing food in the seasonally varying environment. Marshall (1953) also noted the tendency of fish at high latitudes to dispense with the planktonic egg and larval stages. In summarizing breeding patterns of fishes near the British Isles, Qasim (1956) concluded that northern forms breed in winter or early spring, and their breeding season lasts 3-4 mo, during which individuals spawn only once. Breeding in southern forms is during spring or summer, lasts 5-6 mo, and individuals spawn several times during the season. Off Kodiak Island, pelagic eggs of relatively few species are found since most fishes in the area produce demersal eggs (Kendall 1981). Pleuronectidae is the only family in the area that is represented by several species that produce pelagic eggs. *Theragra chalcogramma*, a gadid, is also an important member of the fish fauna off Kodiak Island that produces pelagic eggs. Most other pelagic fish eggs found off Kodiak Island are produced by mesopelagic fishes that probably have their centers of abundance well off the shelf. *Theragra chalcogramma* eggs are found beginning in fall with peak abundance in spring. The pleuronectid eggs are found primarily in spring and summer. These features correspond to Marshall's (1953) idea that at high latitudes most fish produce large, yolky eggs (demersal eggs tend to be larger and are denser than pelagic eggs). Following Qasim's (1956) ideas, the pleuronectids, breeding in spring and summer, would have their centers of distribution south of Kodiak Island, while *T. chalcogramma*, breeding in the colder parts of the year, would have its center of abundance further north.

Most of the pleuronectids off Kodiak Island are wide ranging and occur from California to the Bering Sea, but their abundances in different parts of their range are not known accurately. However, some difficulties arise in applying Qasim's (1956) principles to the observed spawning seasons of these fish. The breeding season of several of the pleuronectids further south, off Oregon, is winter (Richardson, Laroche, and Richardson 1980). Thus it seems that, in general, the pleuronectids off Kodiak Island spawn later in the year than they do further south, which indicates that off Kodiak Island they are north of their center of abundance. However, *Atheresthes stomias*, *Limanda aspera*, and *Reinhardtius hippoglossoides* are most abundant in the Kodiak Island area or further north. Also, among the pleuronectids *Lepidopsetta bilineata*, with demersal eggs, and *Atheresthes stomias*, with pelagic eggs, spawn earlier (primarily in spring) than the others and *Limanda aspera* spawns later (extending into early fall). *Lepidopsetta bilineata* is abundant throughout the north Pacific rim, while *L. aspera* is the dominant pleuronectid in the Bering Sea, where eggs are caught in summer (Waldron 1981). *Atheresthes stomias* is also abundant in the Bering Sea. The seasonal spawning pattern of these fish would thus indicate that *L. bilineata* and *A. stomias* are more abundant north of Kodiak Island and *L. aspera* is more abundant south of Kodiak Island, when, in fact, this is the case only for *A. stomias*.

Theragra chalcogramma, whose eggs are found in the plankton off Kodiak Island from fall through spring, occurs in abundance in the northern Gulf of Alaska and in the Bering Sea where it dominates the fish fauna. It ranges from off central California in the eastern Pacific to the southern Sea of Japan in the western Pacific. With its spawning season during the colder part of the year, according to Qasim (1956) its center of abundance should be north of Kodiak Island. This seems to be the case, although there appear to be localized spawning stocks throughout its range which may be quite abundant, and adapted for local hydrographic conditions. Spawning seems to take place primarily in winter and spring throughout its range.

Turning to the bulk of the fish off Kodiak Island, the fauna is dominated by fish that lay demersal eggs, and these are mainly of the order Scorpaeniformes. The larvae of these fishes, representing several species of hexagrammids and cottids, were abundant in all seasons. Fish other than scorpaeniforms that lay demersal eggs and whose larvae were frequently caught included osmerids, bathymasterids, and several stichaeids. Most of these taxa enter the plankton in spring or summer, and some remain pelagic for up to a year before assuming demersal habits (Garrison and Miller 1982[6]). *Ammodytes hexapterus* is exceptional in that it spawns demersal eggs apparently in winter with most small larvae found in spring and large larvae found in summer.

The many fish off Kodiak Island that arise from demersal eggs enter the plankton at a larger size than larvae from pelagic eggs. This is particularly true of the larvae that enter the plankton in late summer and fall to spend the winter there. The larvae originating from pelagic eggs are generally from species that spawn in spring or summer. In accord with Marshall (1953), the fish with larger larvae would be better suited for the high latitude environment than those with smaller larvae. The difference in spawning season between fish with demersal and pelagic eggs may allow both types to maintain populations in this subarctic regime.

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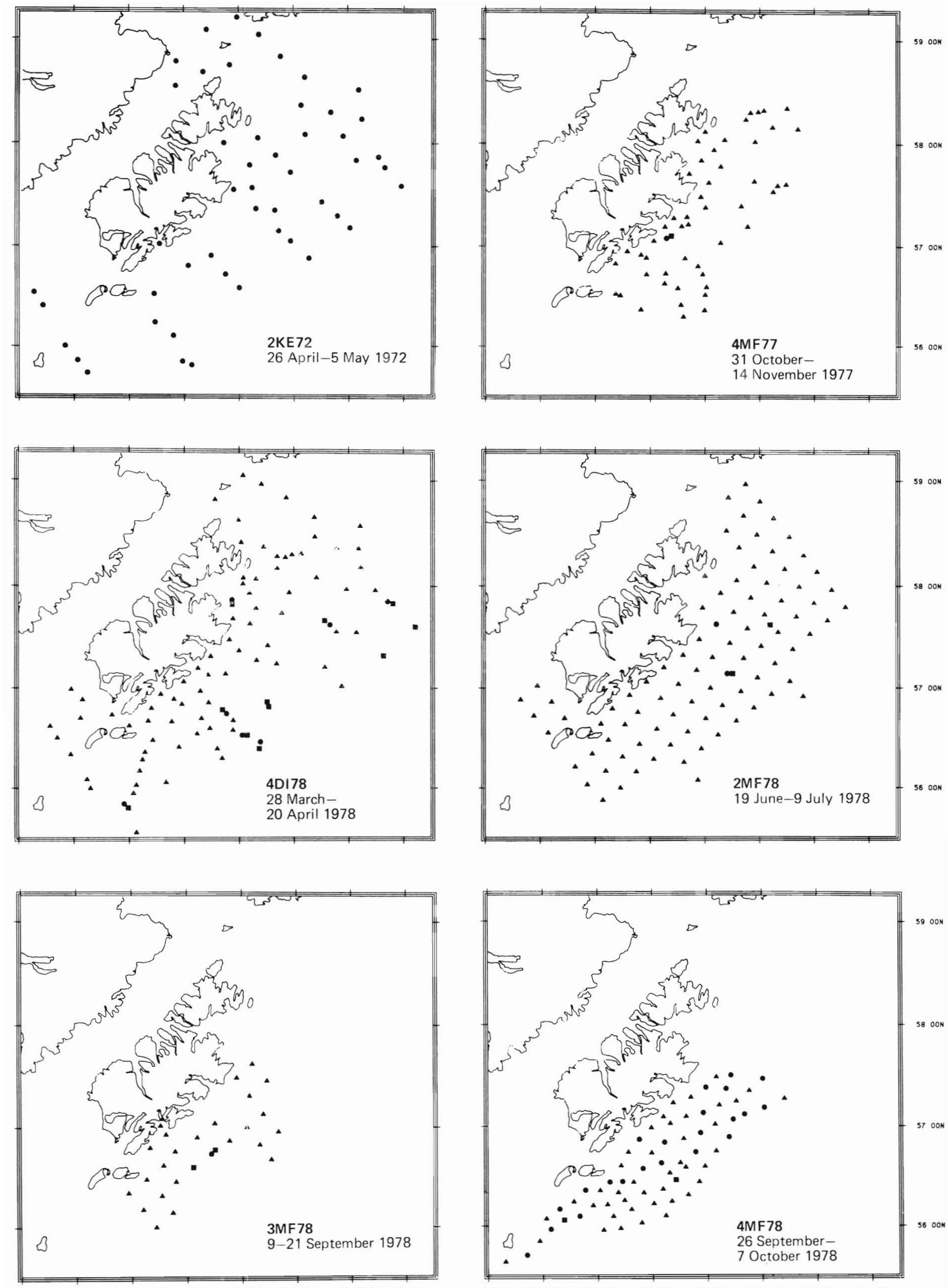
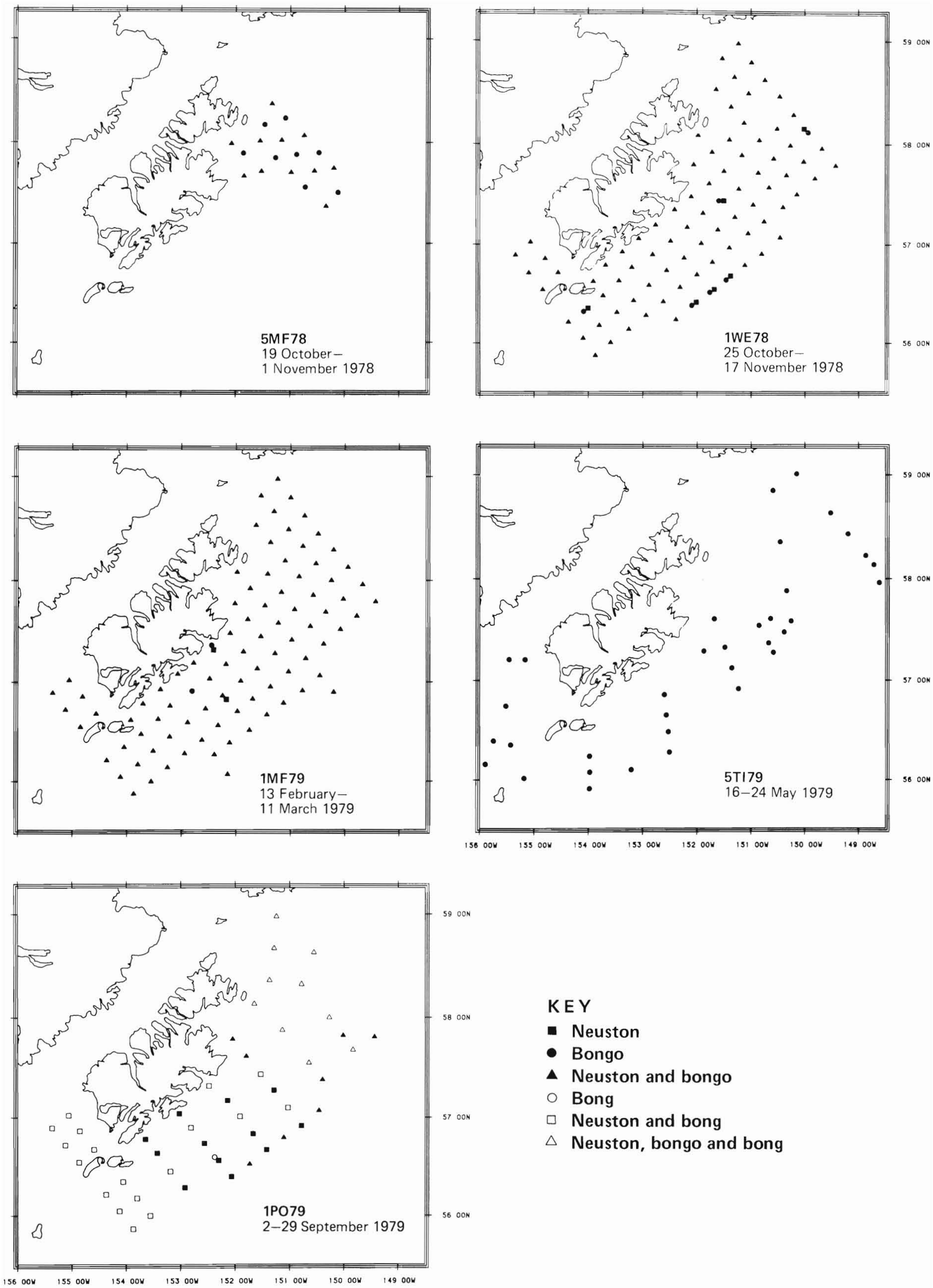
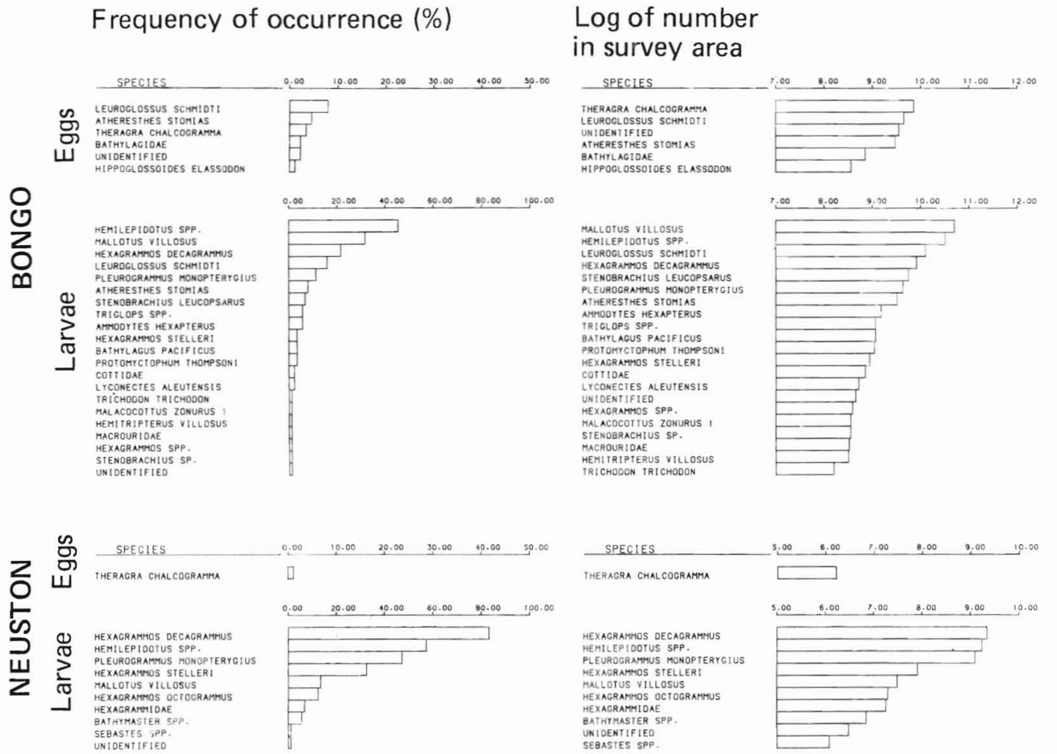


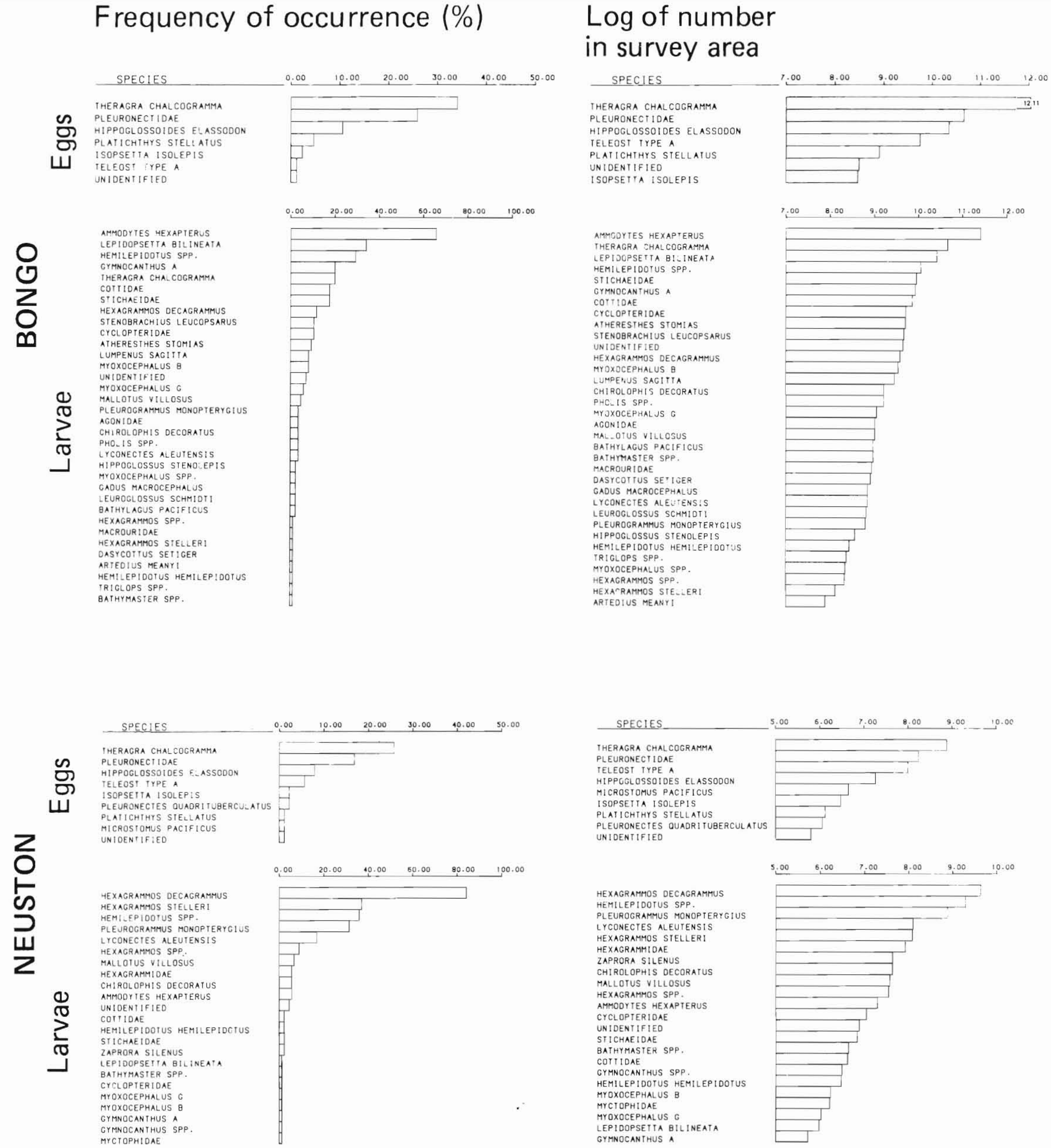
Appendix Figure 1.—Ichthyoplankton sampling stations, cruises 2KE72, 4MF77, 4DI78, 2MF78, 3MF78, and 4MF78.



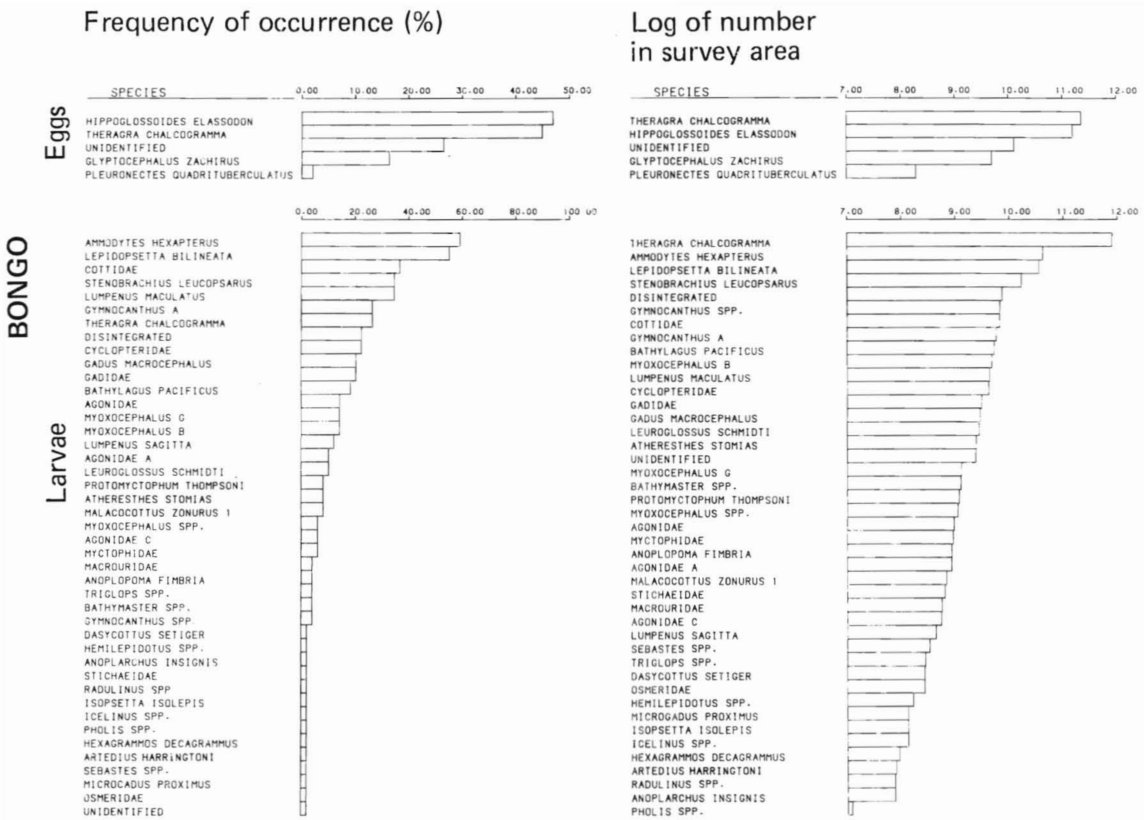
Appendix Figure 2.—Ichthyoplankton sampling stations, cruises 5MF78, 1WE78, 1MF79, 5TI79, and 1PO79.



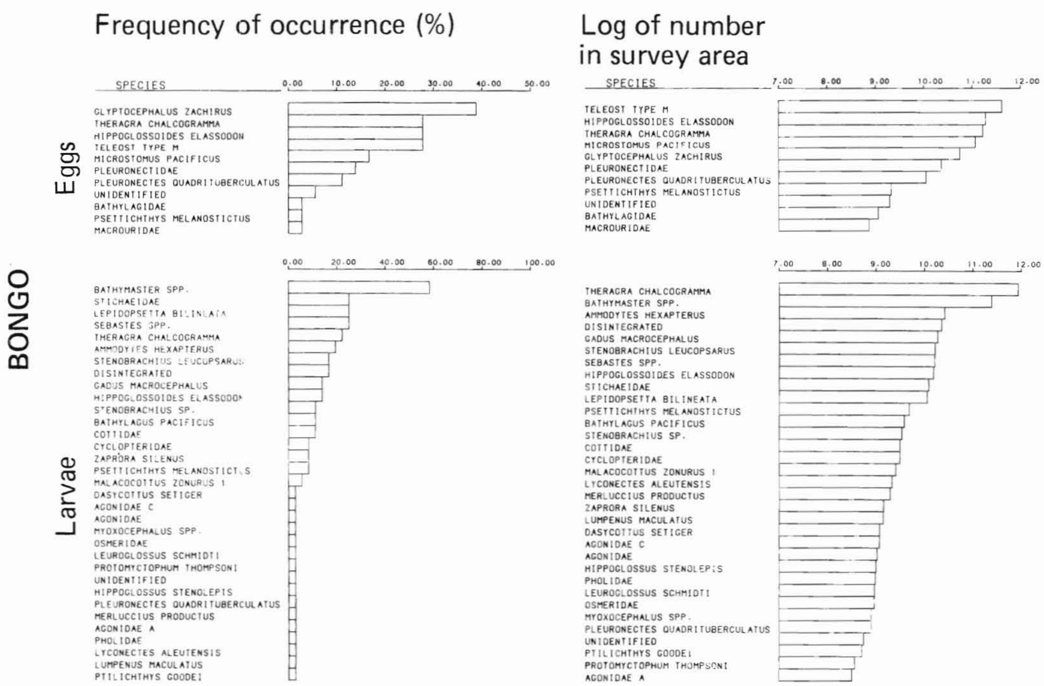
Appendix Figure 3.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 88 bongo and 89 neuston tows on cruise 1MF79, winter 1979.



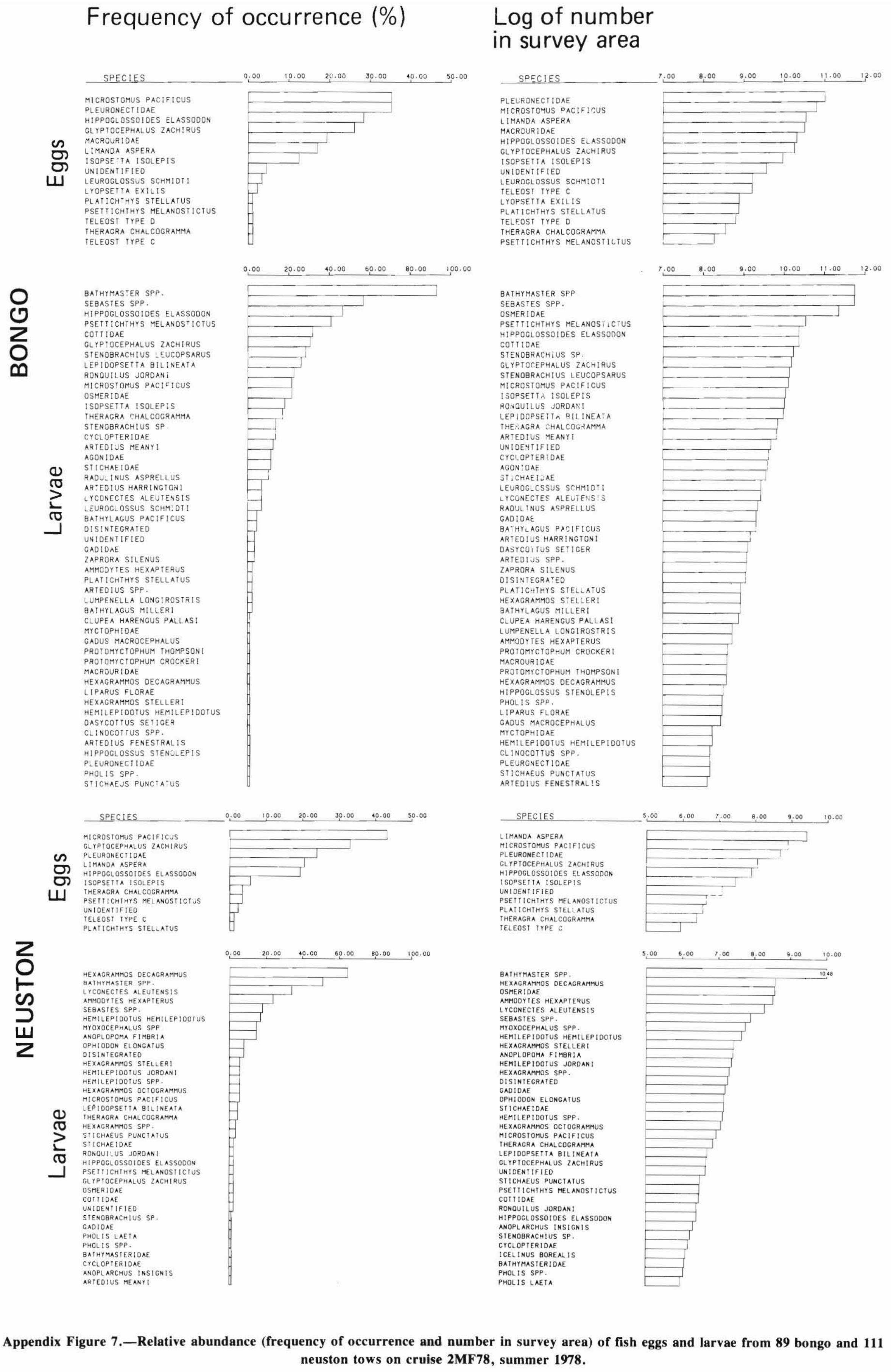
Appendix Figure 4.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 85 bongo and 111 neuston tows on cruise 4DI78, spring 1978.



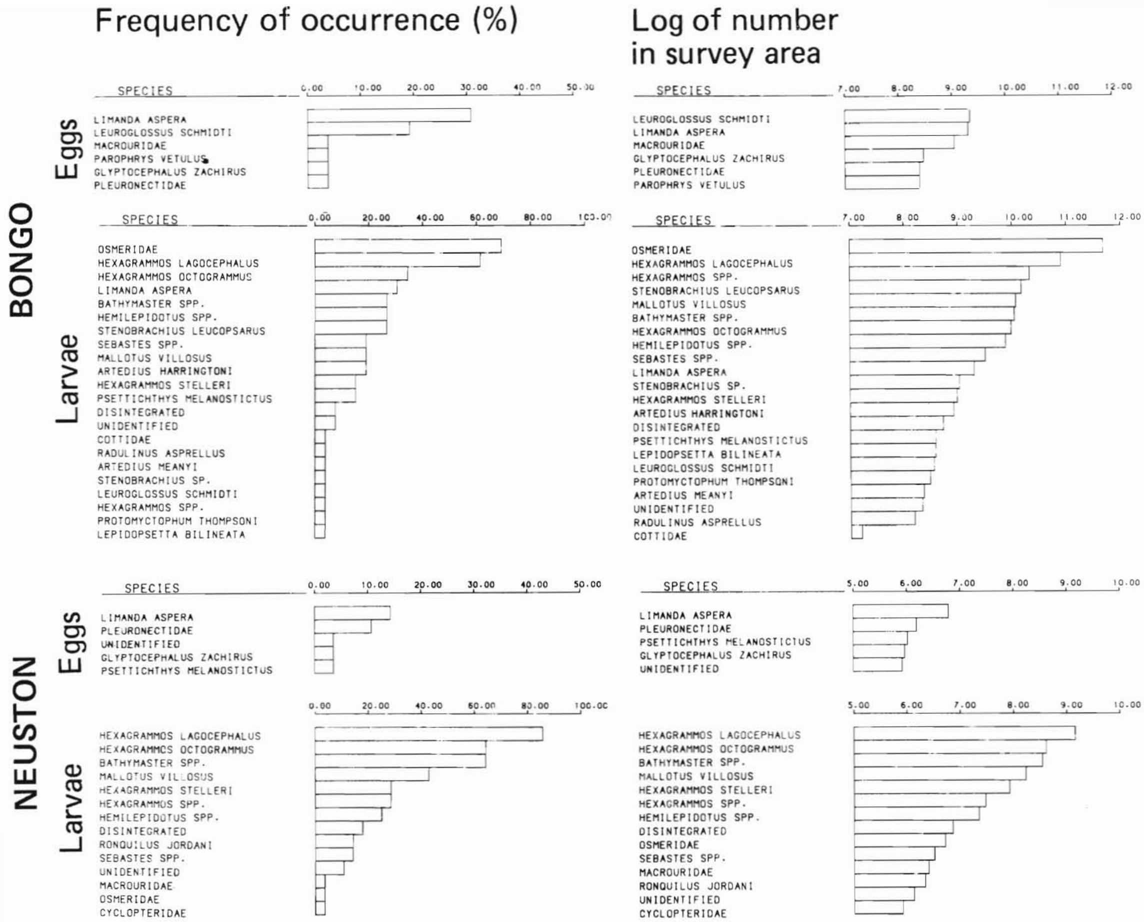
Appendix Figure 5.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 67 bongo tows on cruise 2KE72, spring 1972.



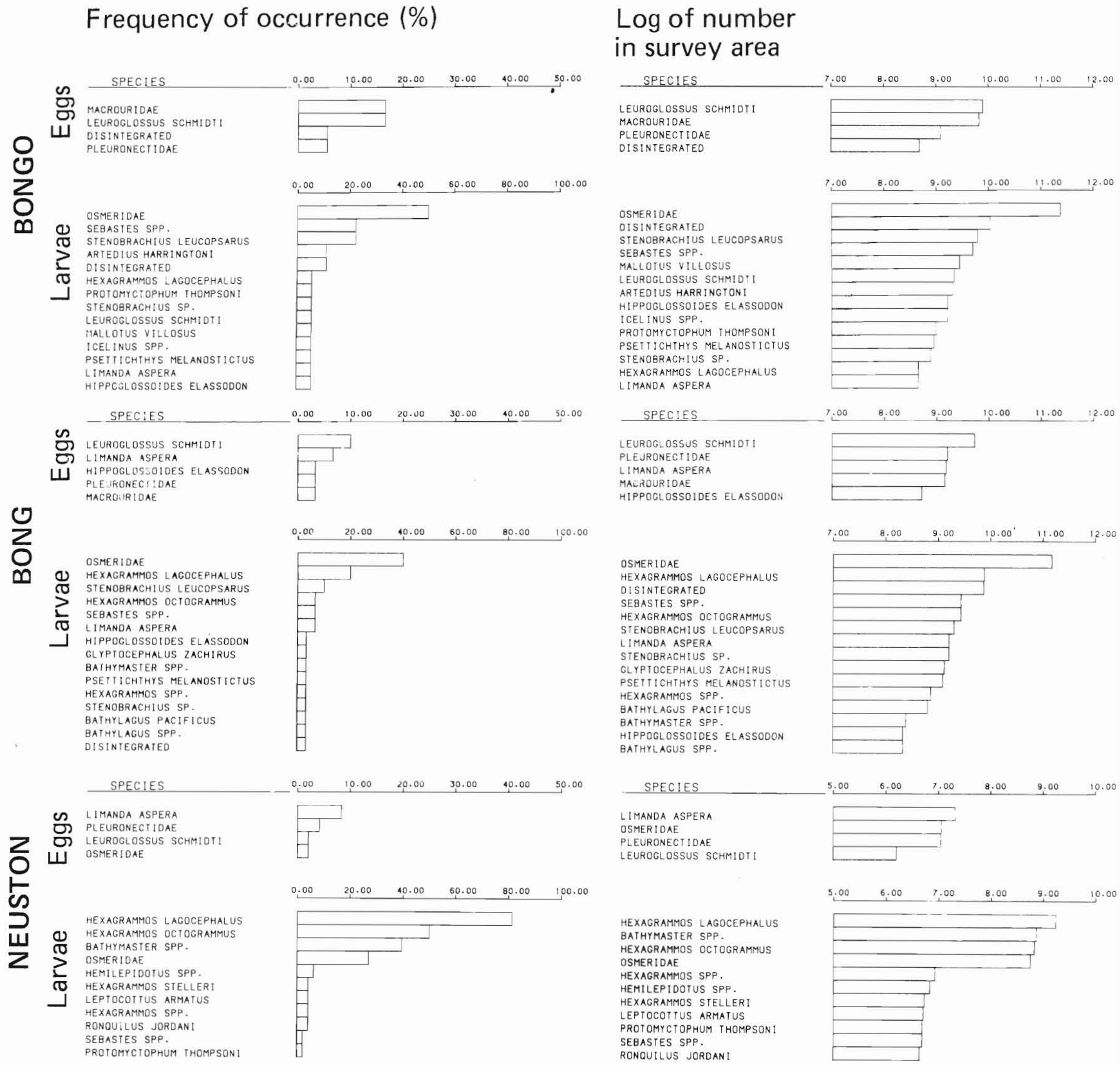
Appendix Figure 6.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 35 bongo tows on cruise 5TI79, spring 1979.



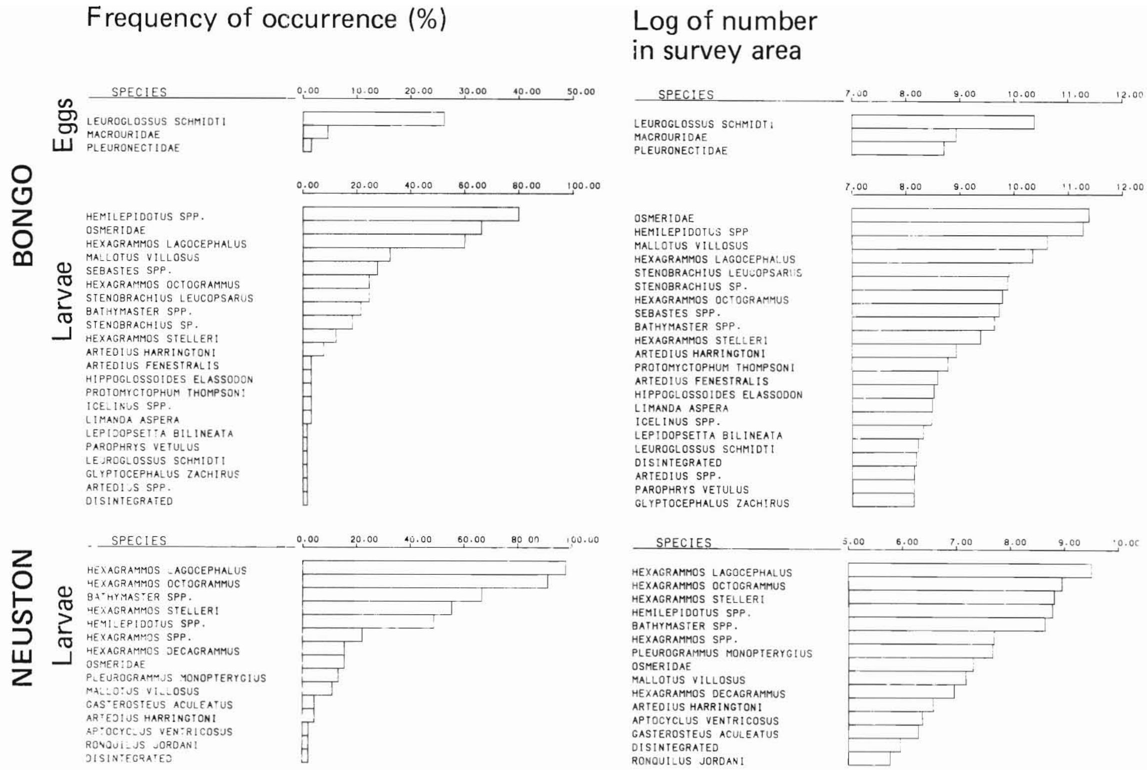
Appendix Figure 7.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 89 bongo and 111 neuston tows on cruise 2MF78, summer 1978.



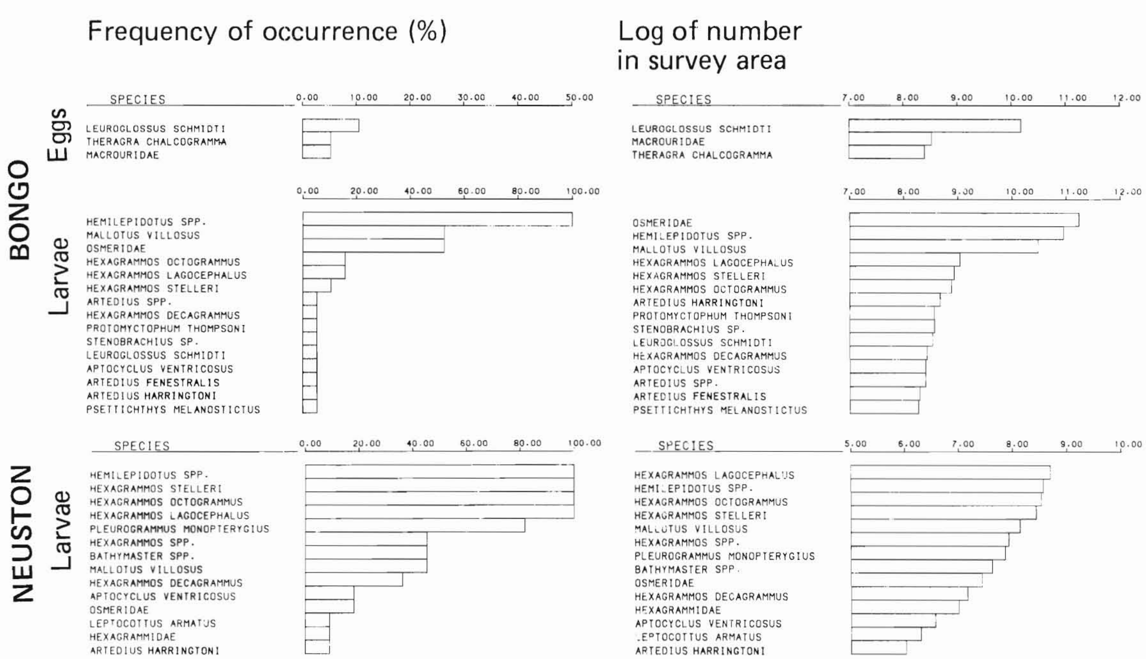
Appendix Figure 8.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 28 bongo and 28 neuston tows on cruise 3MF78, summer-fall 1978.



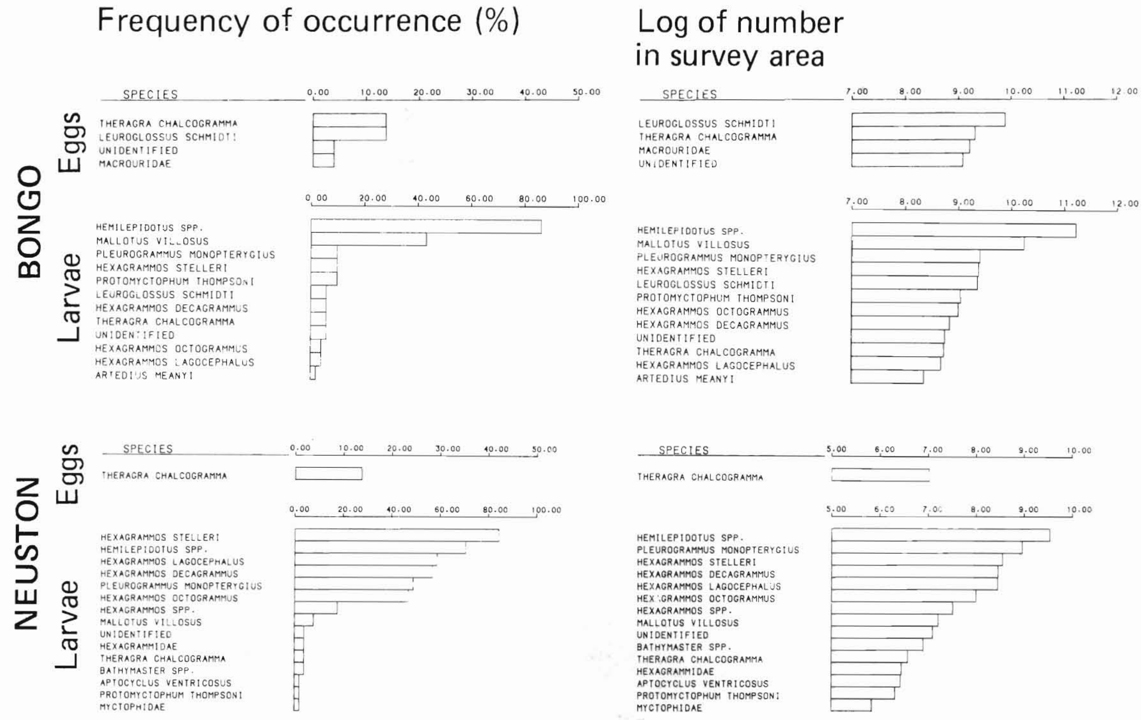
Appendix Figure 9.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 15 bongo, 32 bong, and 86 neuston tows on cruise 1PO79, summer-fall 1979.



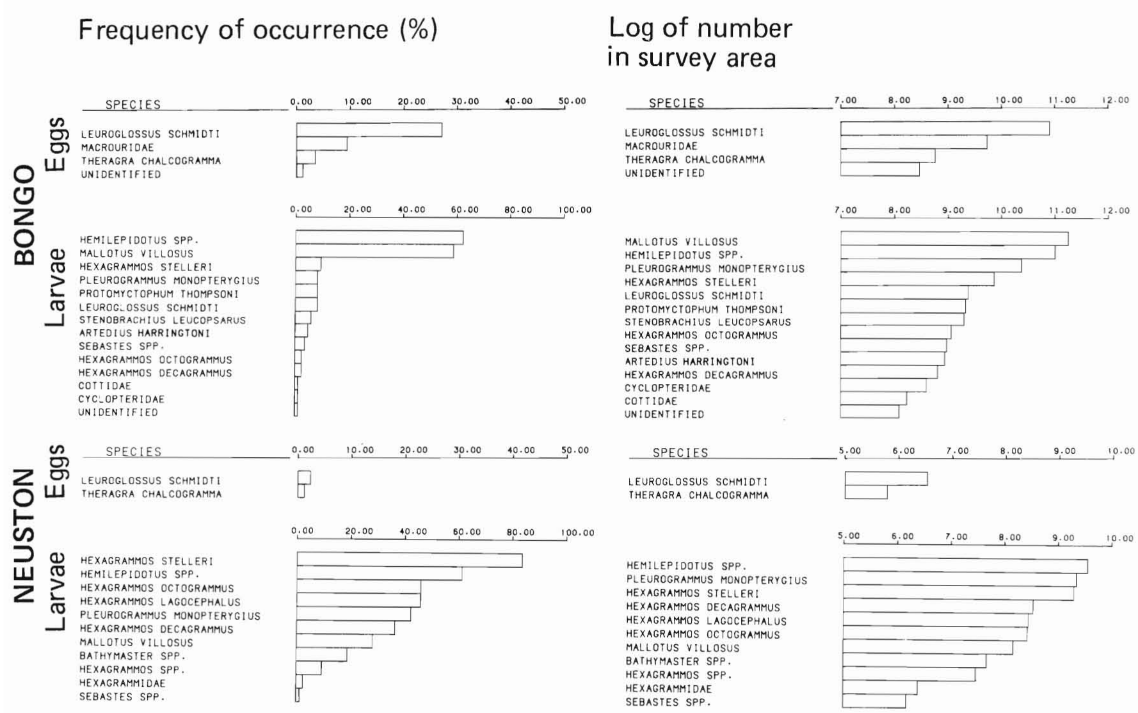
Appendix Figure 10.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 49 bongo and 49 neuston tows on cruise 4MF78, fall 1978.



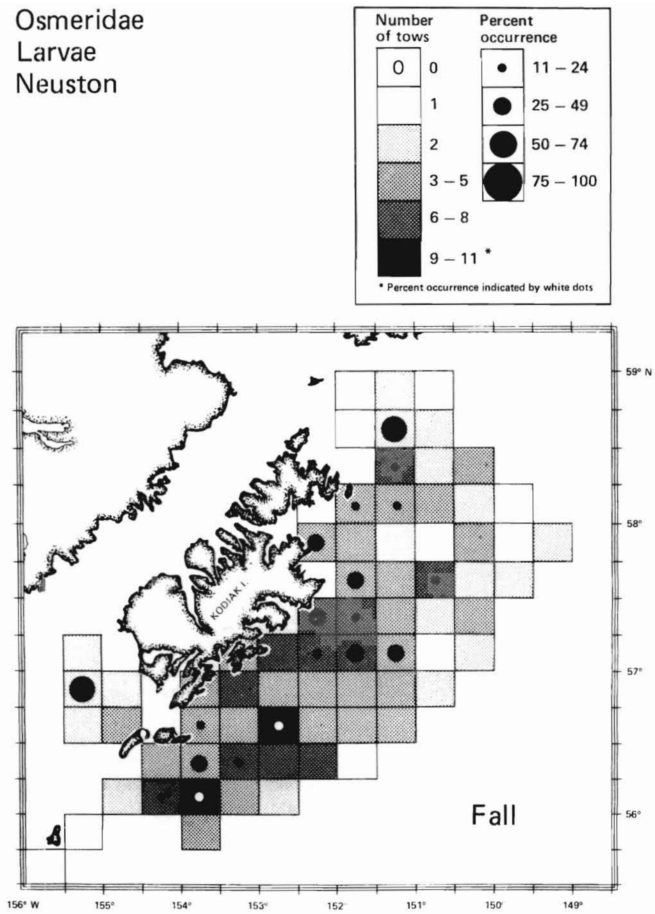
Appendix Figure 11.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 19 bongo and 19 neuston tows on cruise 5MF78, fall 1978.



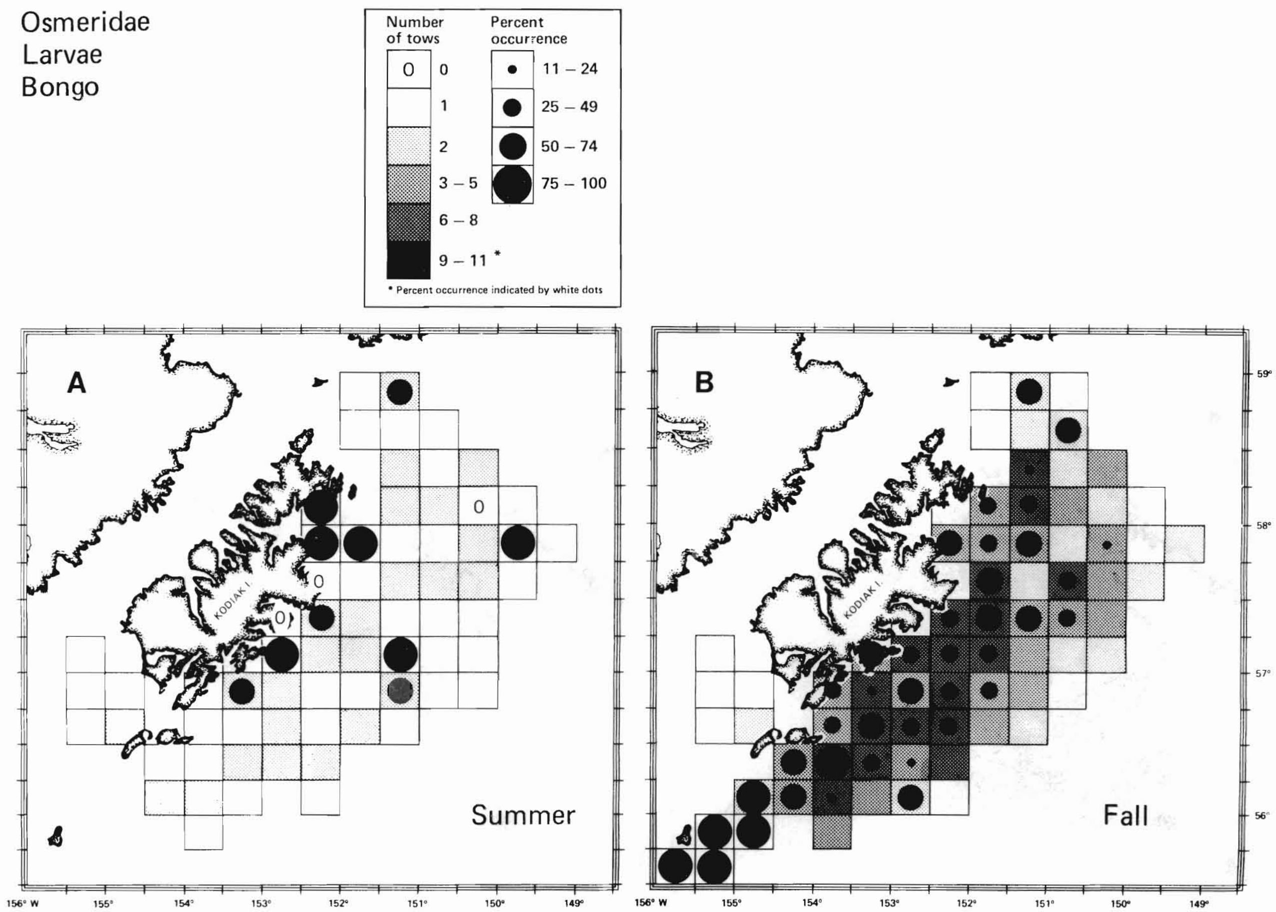
Appendix Figure 12.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 59 bongo and 83 neuston tows on cruise 4MF77, fall 1977.



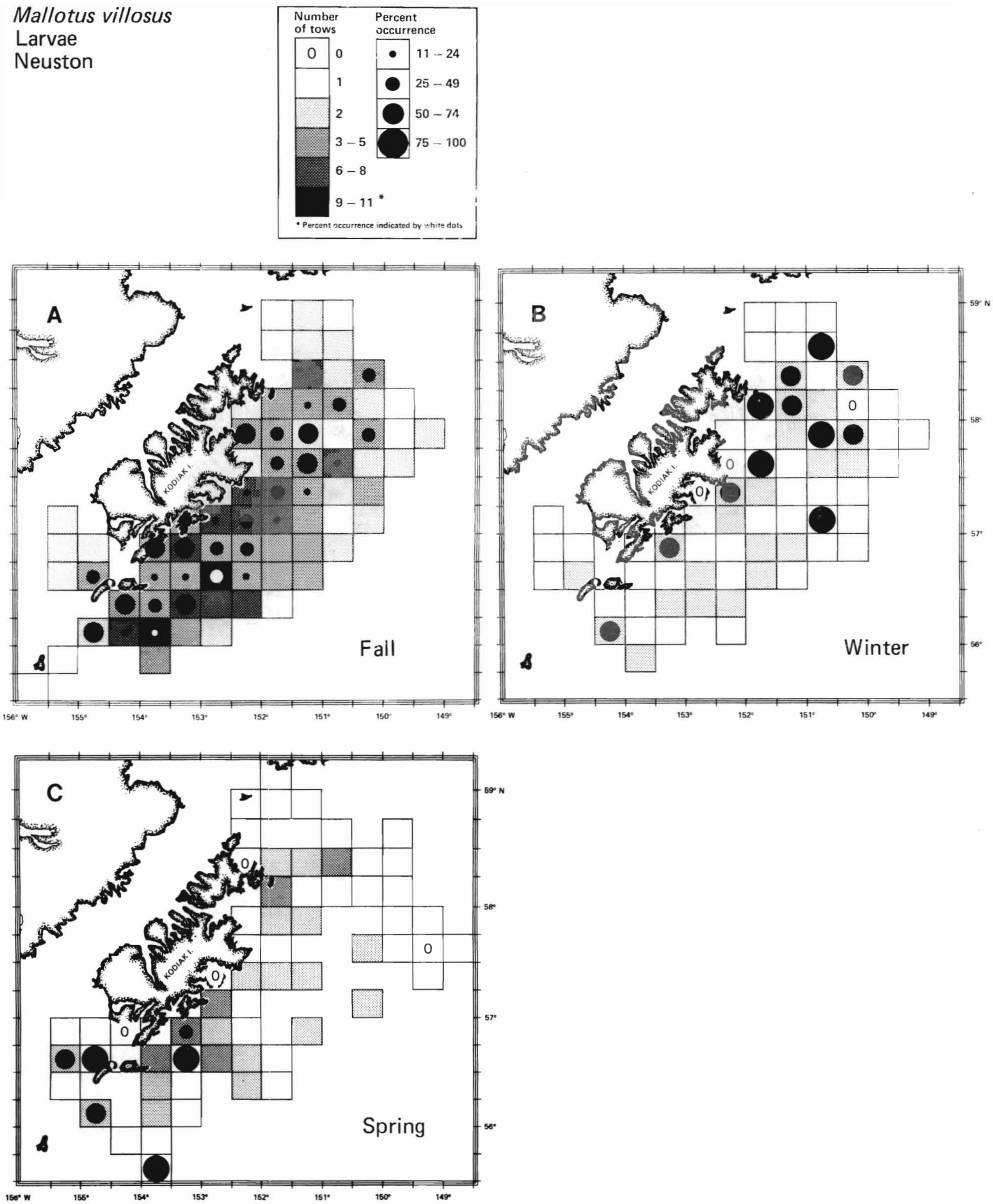
Appendix Figure 13.—Relative abundance (frequency of occurrence and number in survey area) of fish eggs and larvae from 98 bongo and 101 neuston tows on cruise 1WE78, fall 1978.



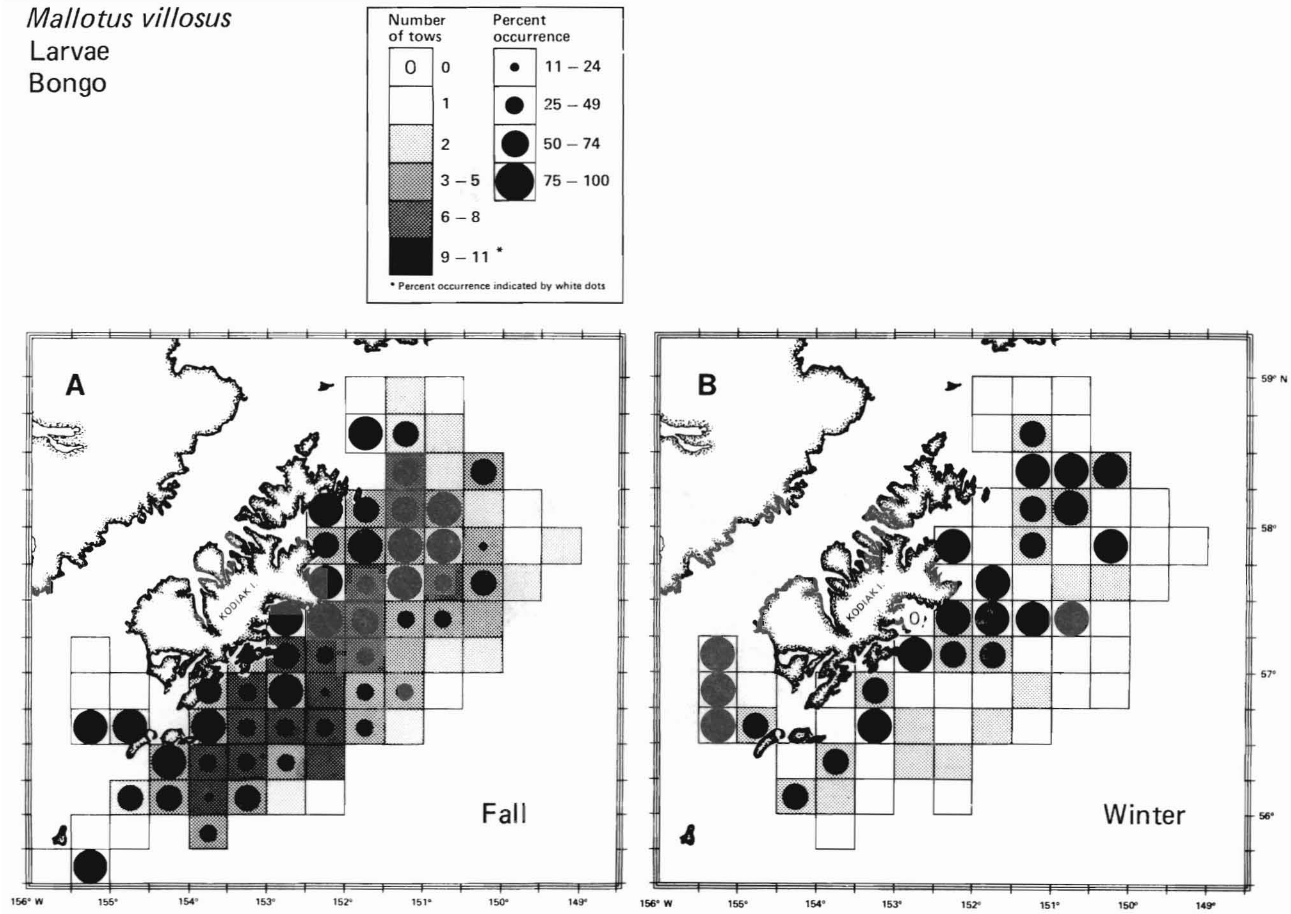
Appendix Figure 14.—Distribution of Osmeridae larvae in neuston tows in fall.



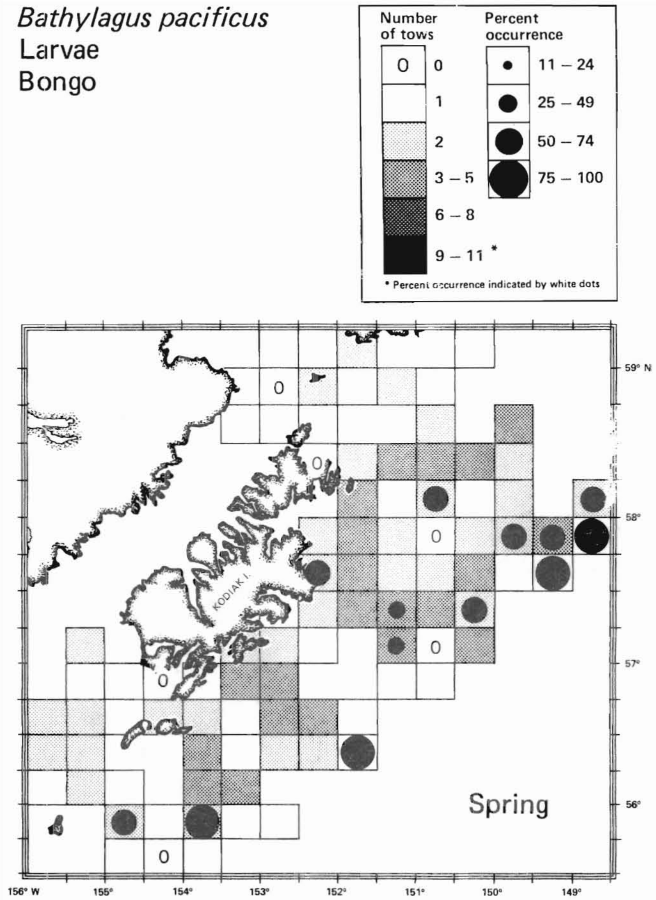
Appendix Figure 15.—Distribution of Osmeridae larvae in bongo tows. A. summer and B. fall.



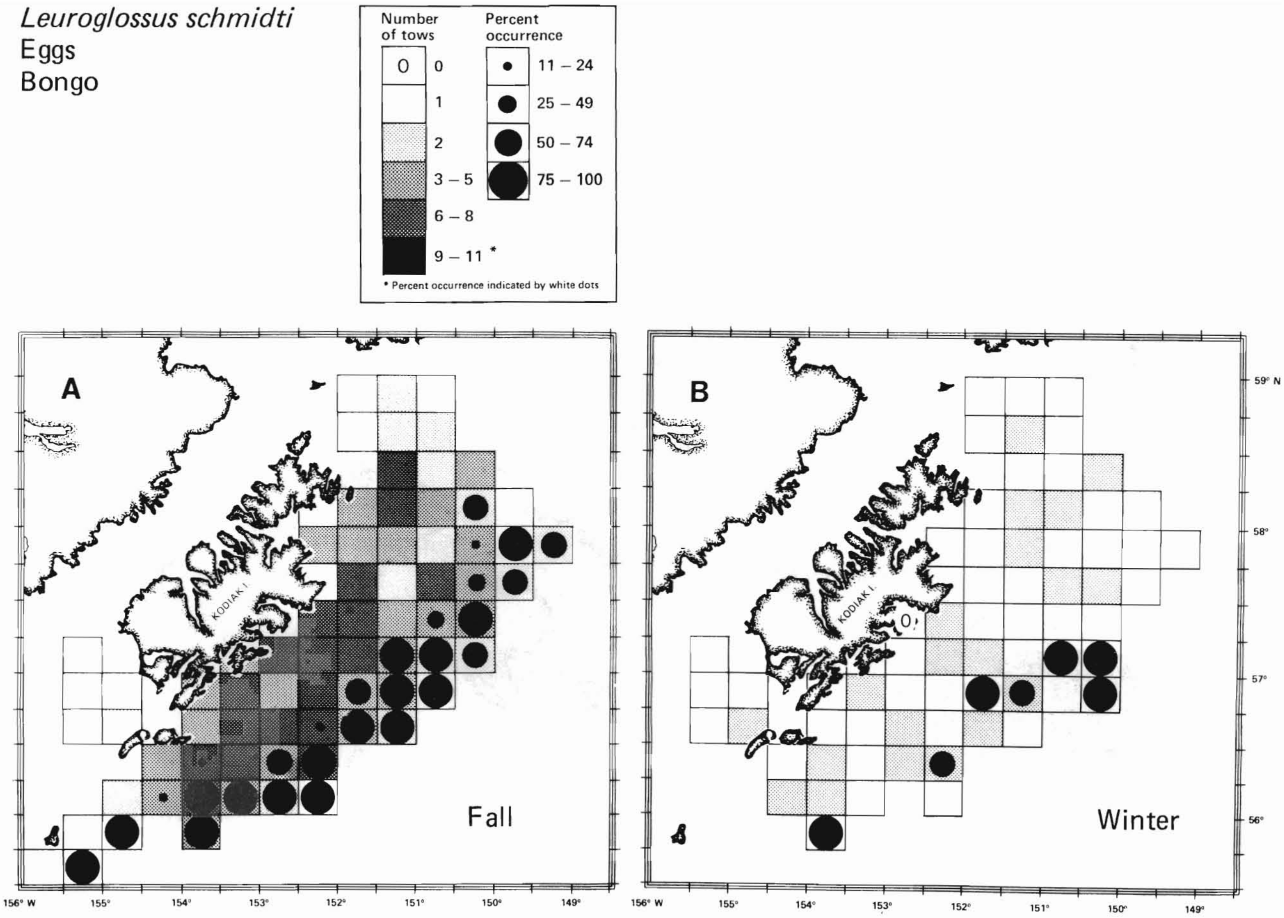
Appendix Figure 16.—Distribution of *Mallotus villosus* larvae in neuston tows. A. fall, B. winter, and C. spring.



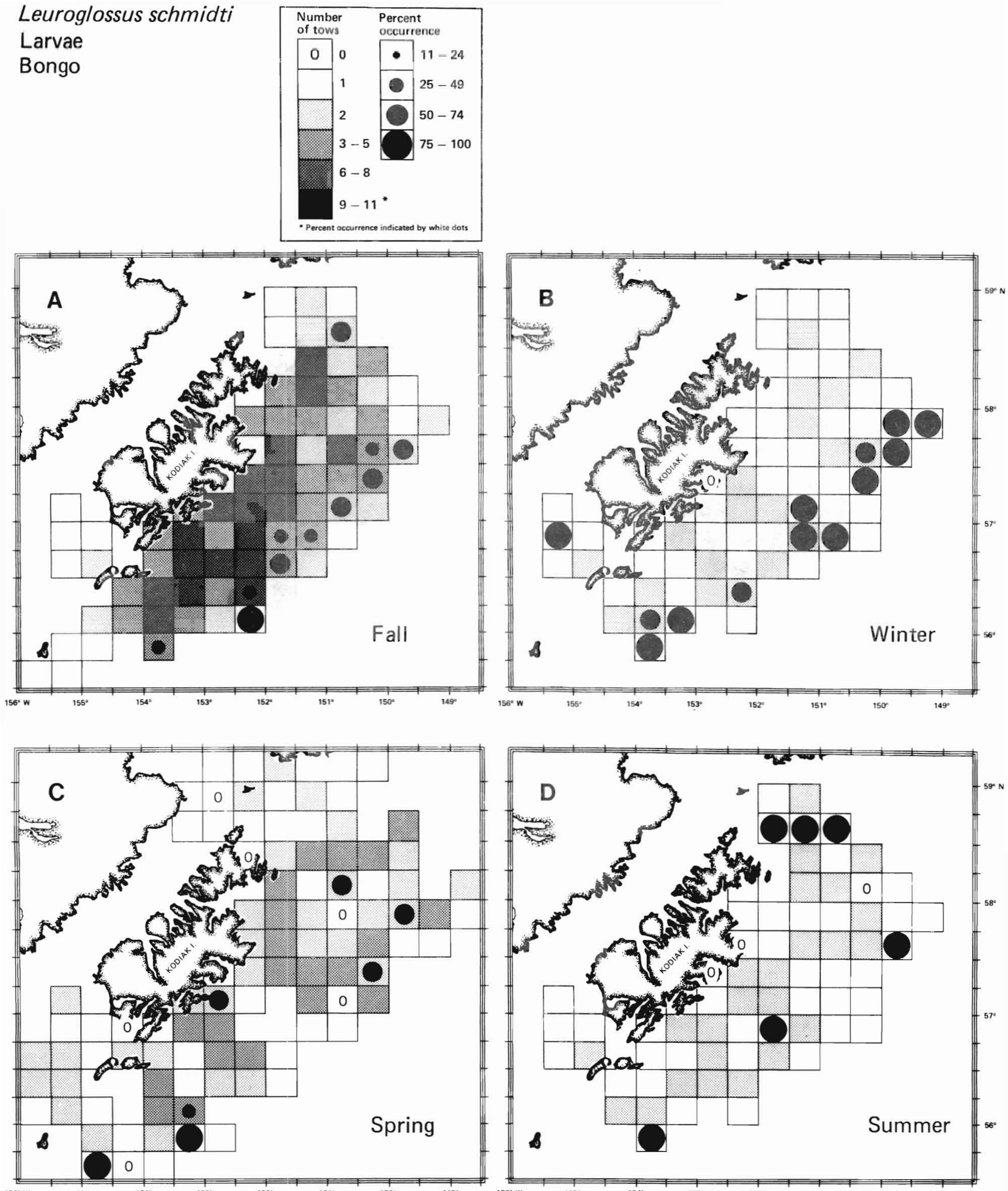
Appendix Figure 17.—Distribution of *Mallotus villosus* larvae in bongo tows. A. fall and B. winter.



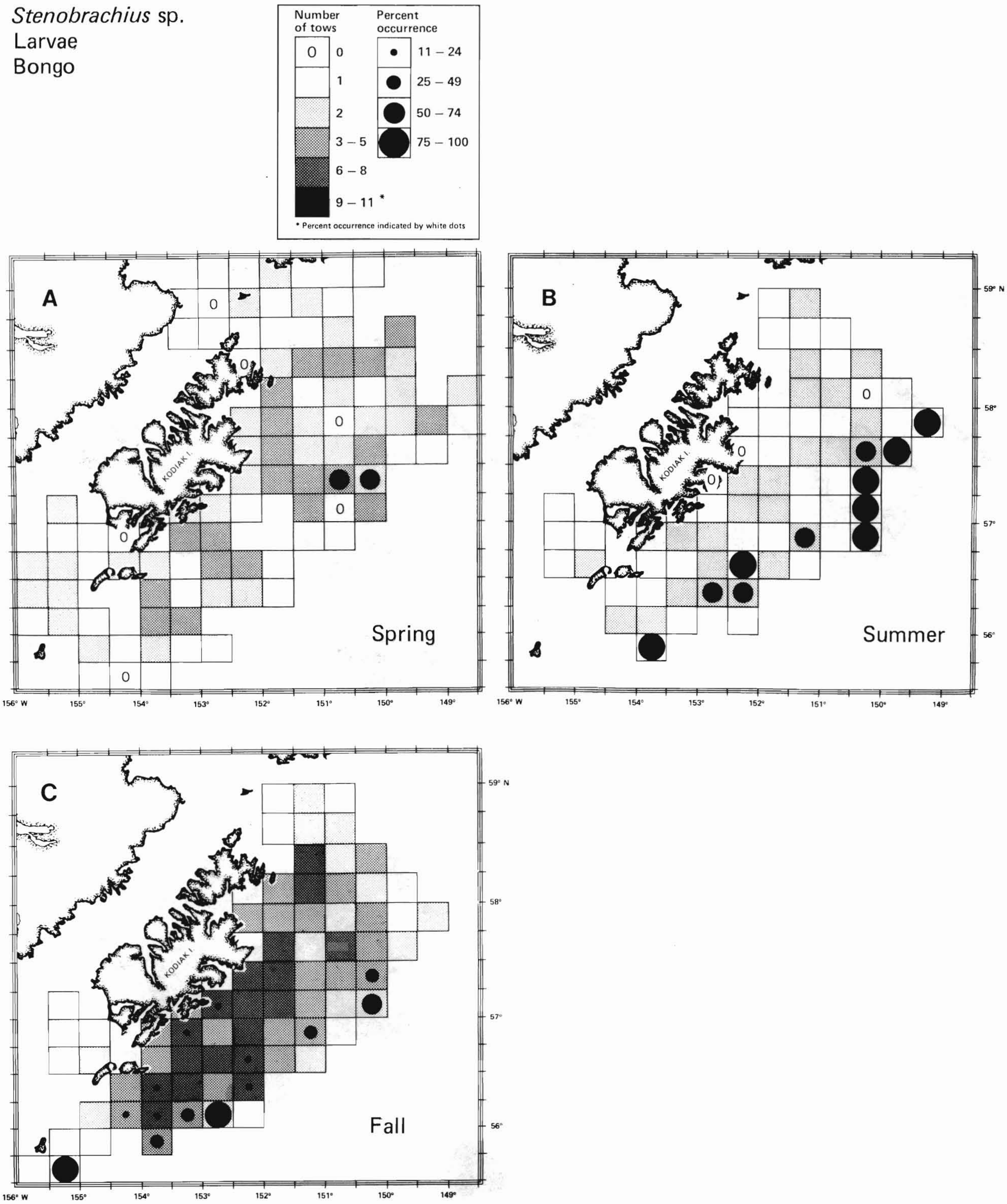
Appendix Figure 18.—Distribution of *Bathylagus pacificus* larvae in bongo tows in spring.



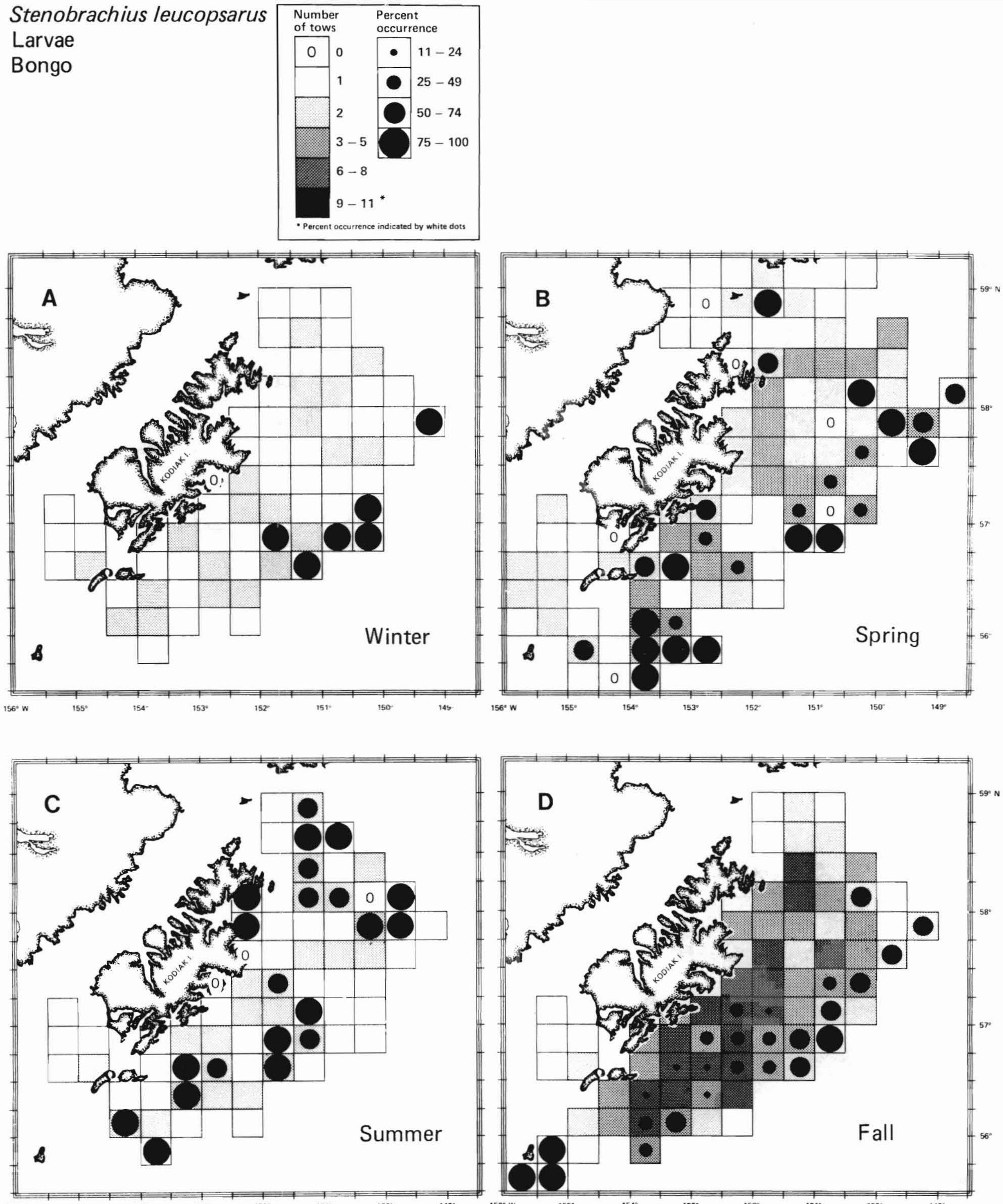
Appendix Figure 19.—Distribution of *Leuroglossus schmidti* eggs in bongo tows. A. fall and B. winter.



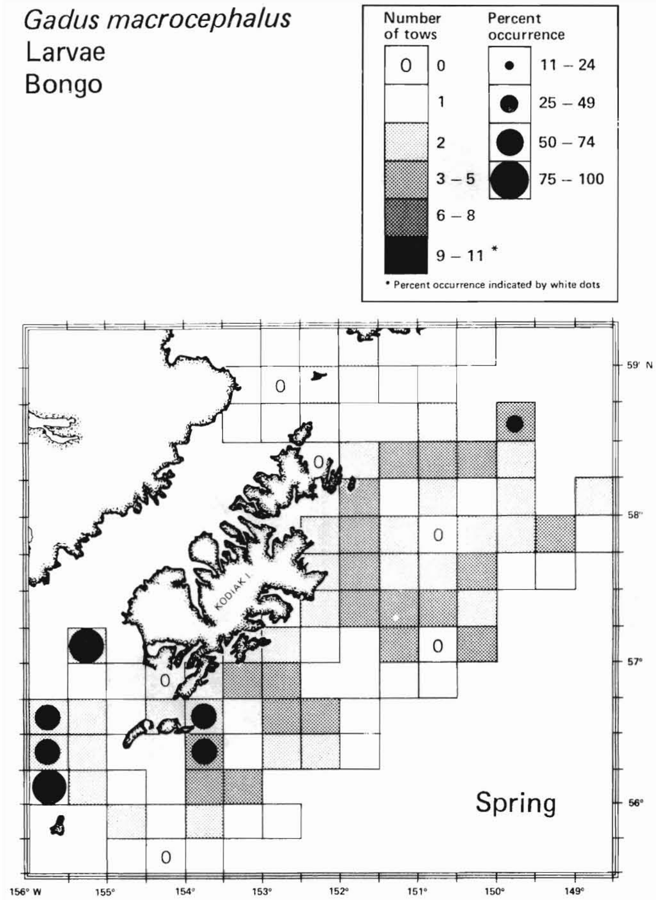
Appendix Figure 20.—Distribution of *Leuroglossus schmidti* larvae in bongo tows. A. fall, B. winter, C. spring, and D. summer.



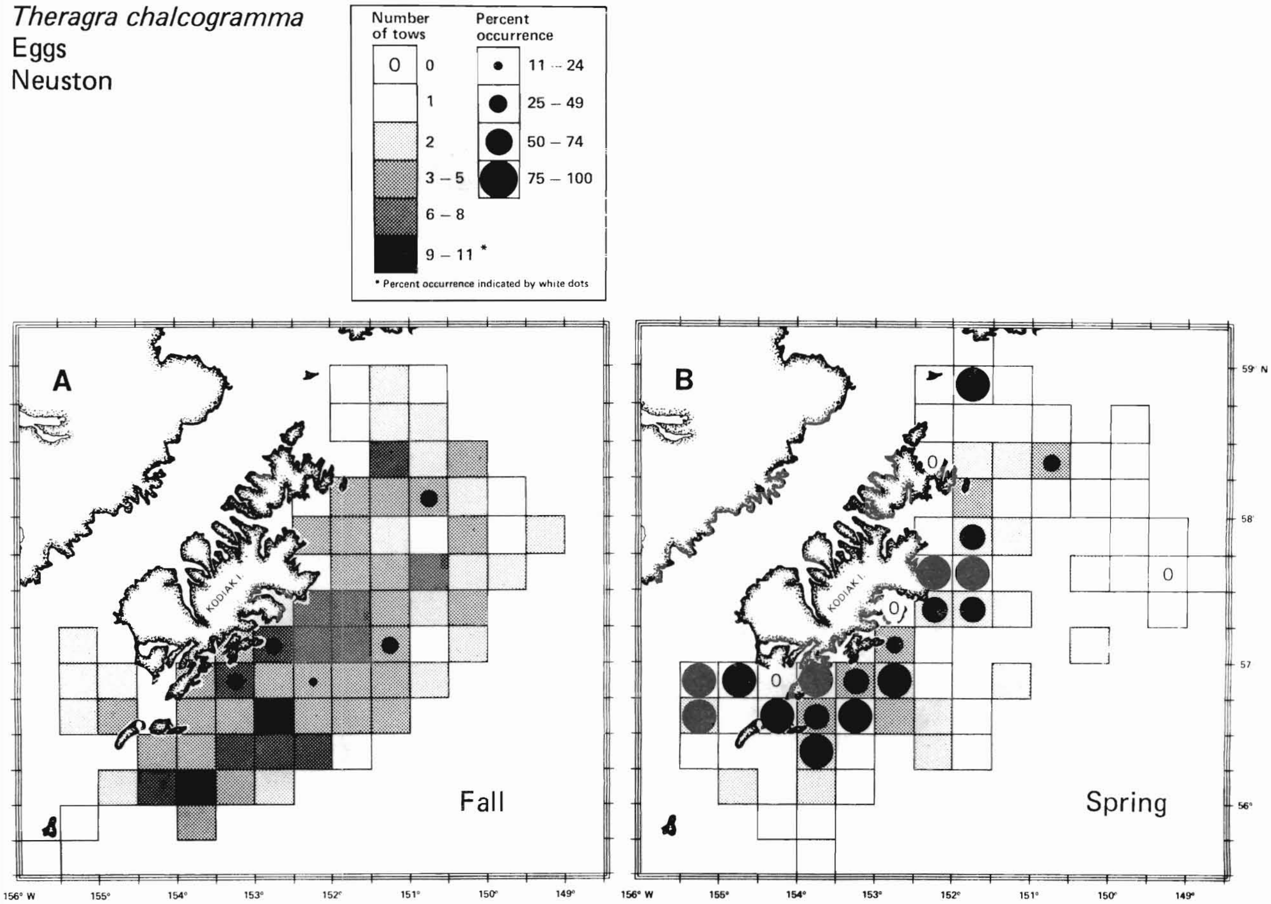
Appendix Figure 21.—Distribution of *Stenobrachius* sp. larvae in bongo tows. A. spring, B. summer, and C. fall.



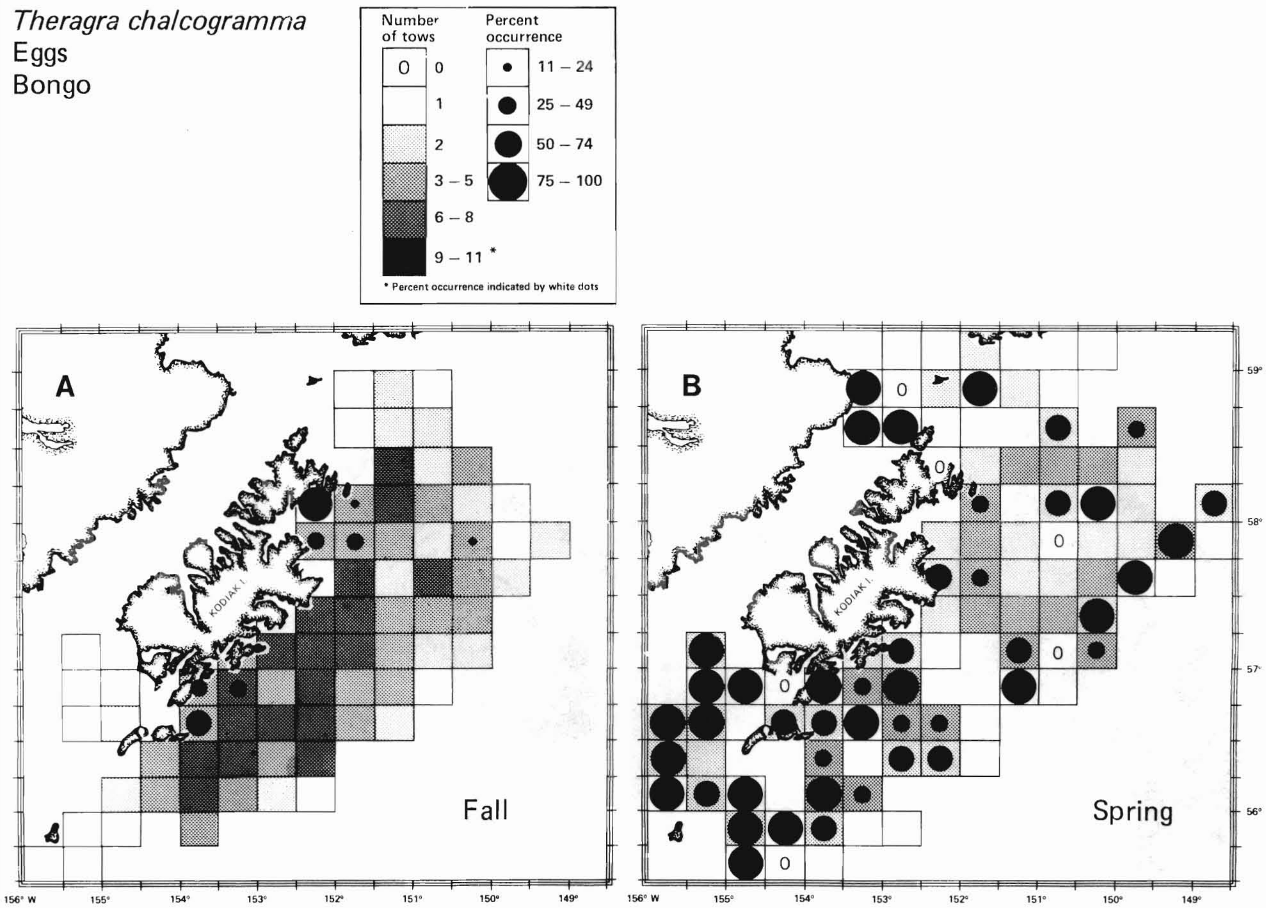
Appendix Figure 22.—Distribution of *Stenobrachius leucopsarus* larvae in bongo tows. A. winter, B. spring, C. summer, and D. fall.



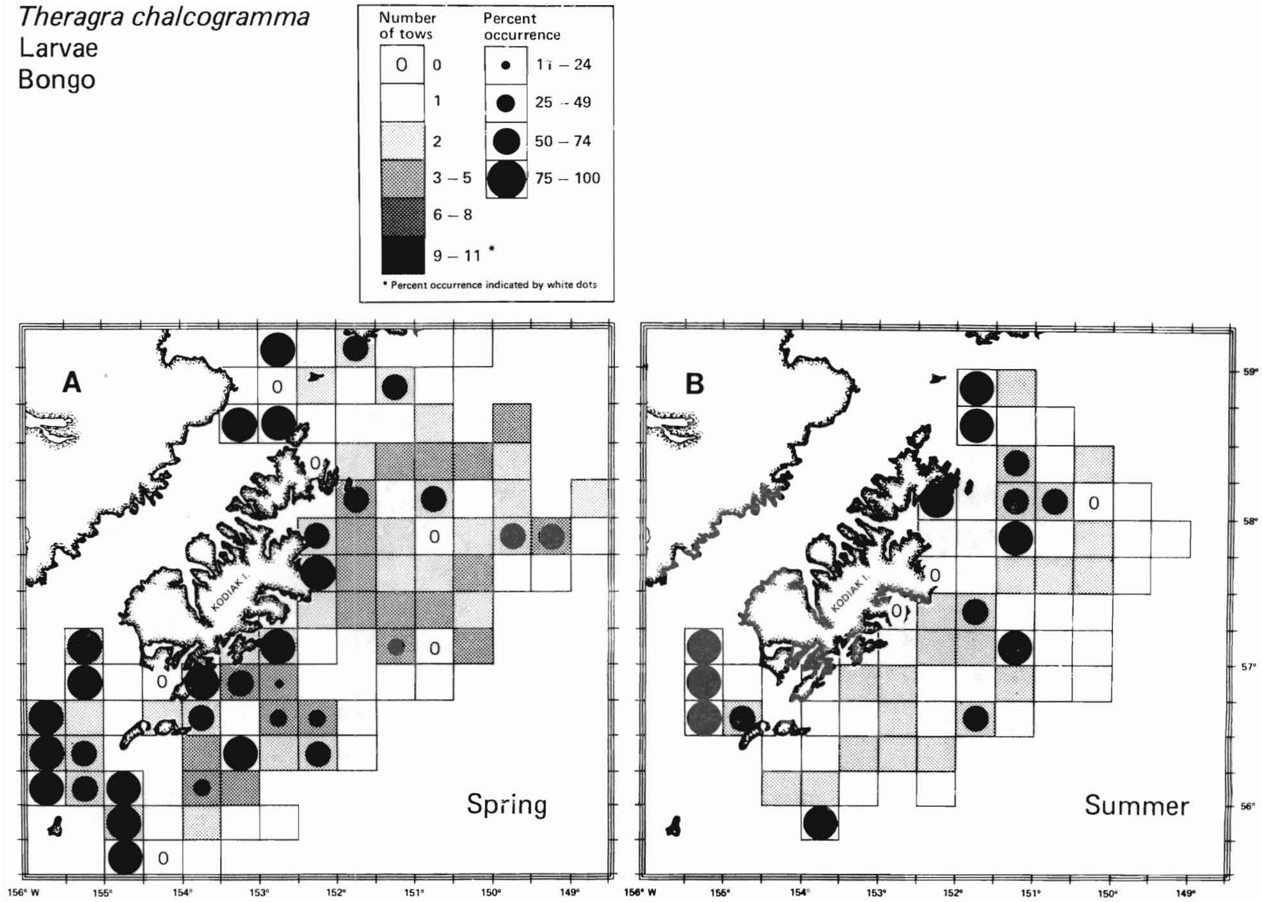
Appendix Figure 23.—Distribution of *Gadus macrocephalus* larvae in bongo tows in spring.



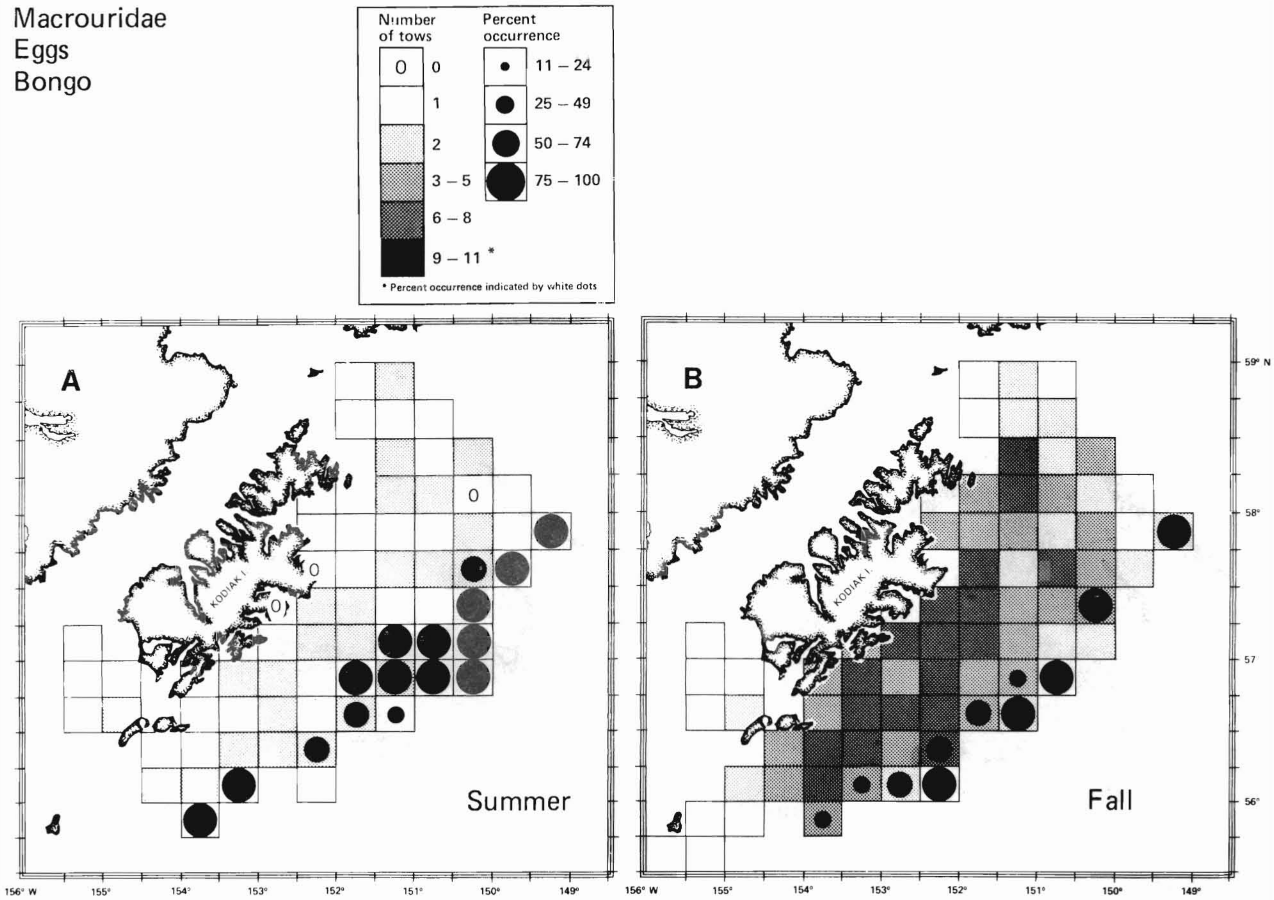
Appendix Figure 24.—Distribution of *Theragra chalcogramma* eggs in neuston tows. A. fall and B. spring.



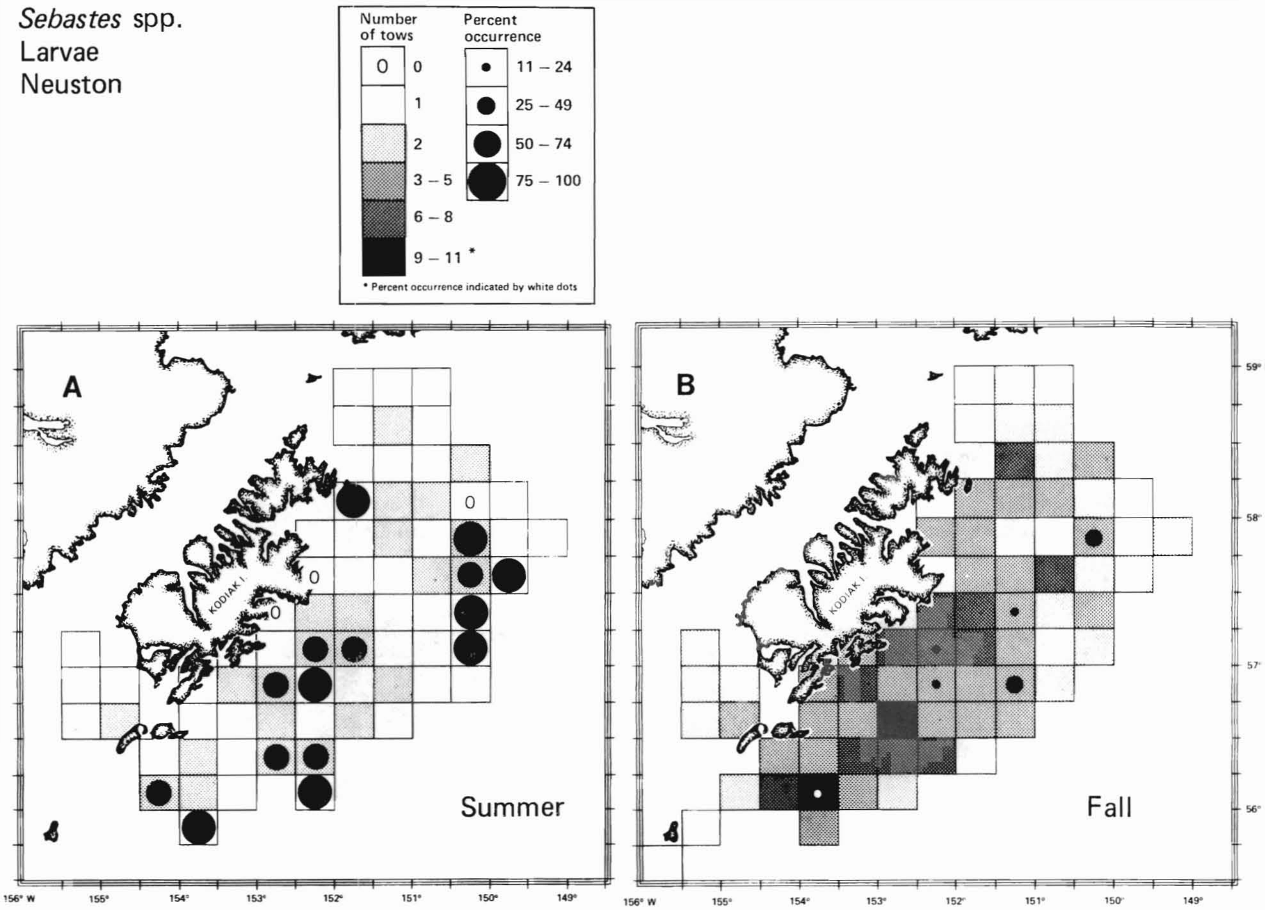
Appendix Figure 25.—Distribution of *Theragra chalcogramma* eggs in bongo tows. A. fall and B. spring.



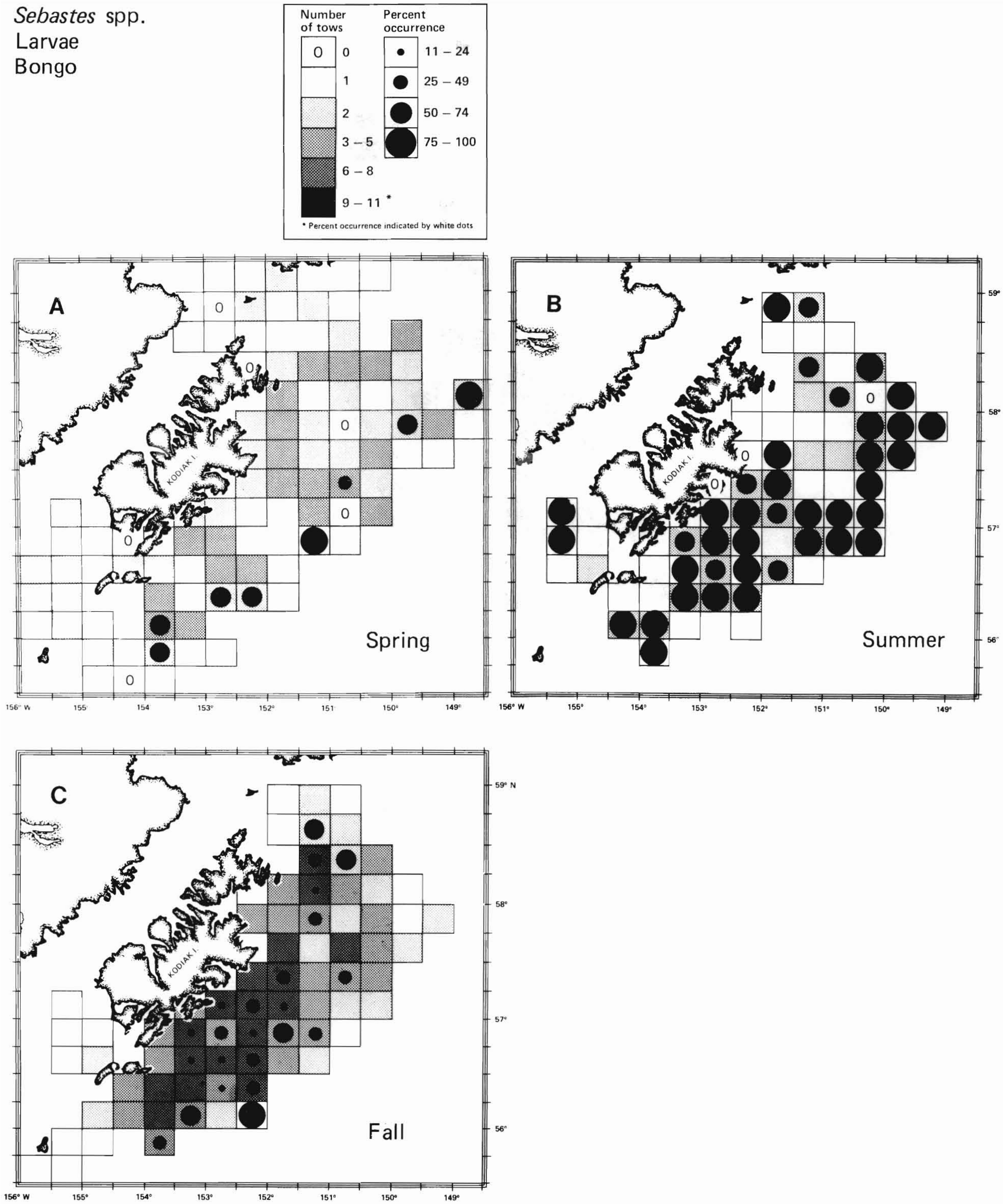
Appendix Figure 26.—Distribution of *Theragra chalcogramma* larvae in bongo tows. A. spring and B. summer.



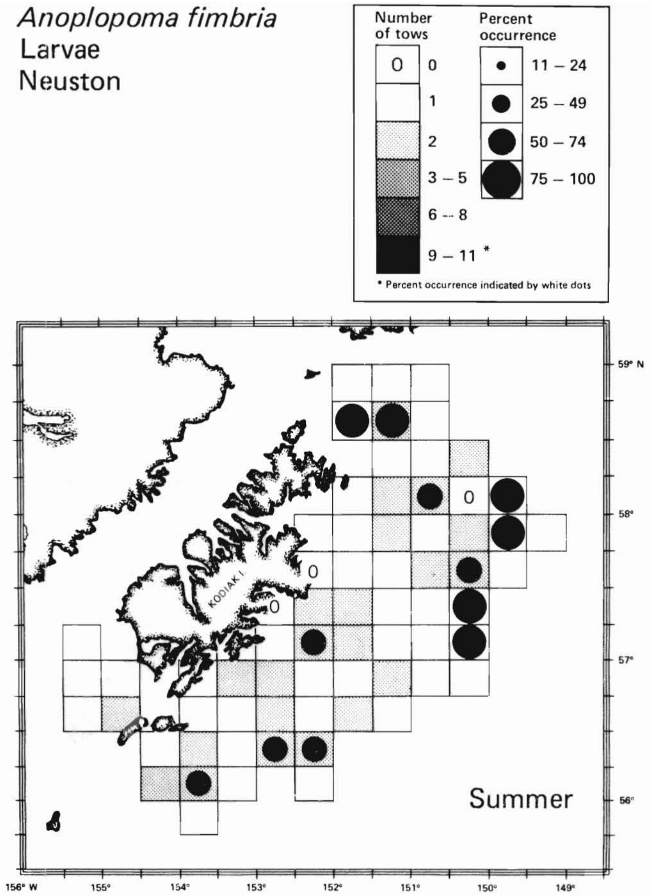
Appendix Figure 27.—Distribution of Macrouridae eggs in bongo tows. A. summer and B. fall.



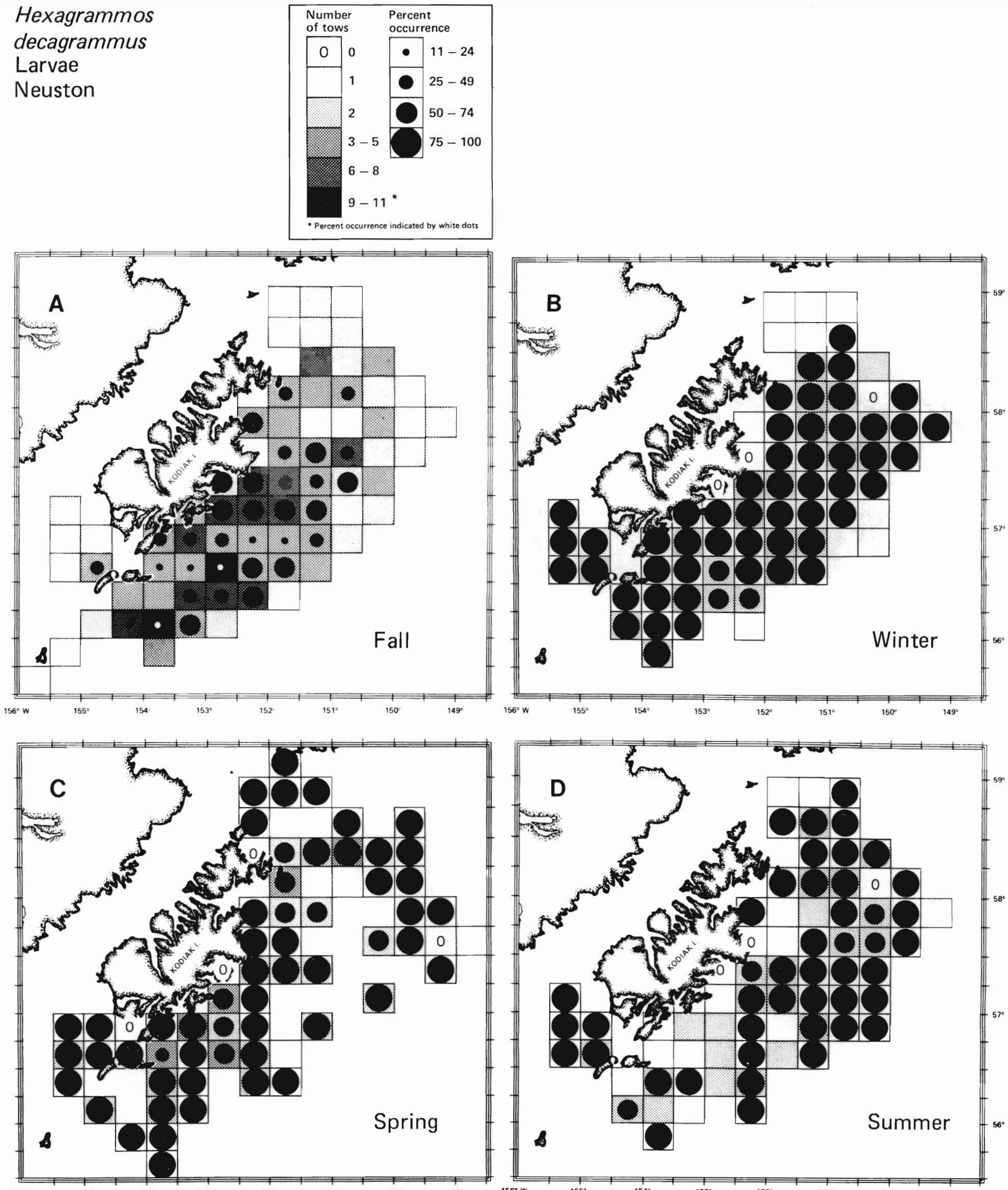
Appendix Figure 28.—Distribution of *Sebastes* spp. larvae in neuston tows. A. summer and B. fall.



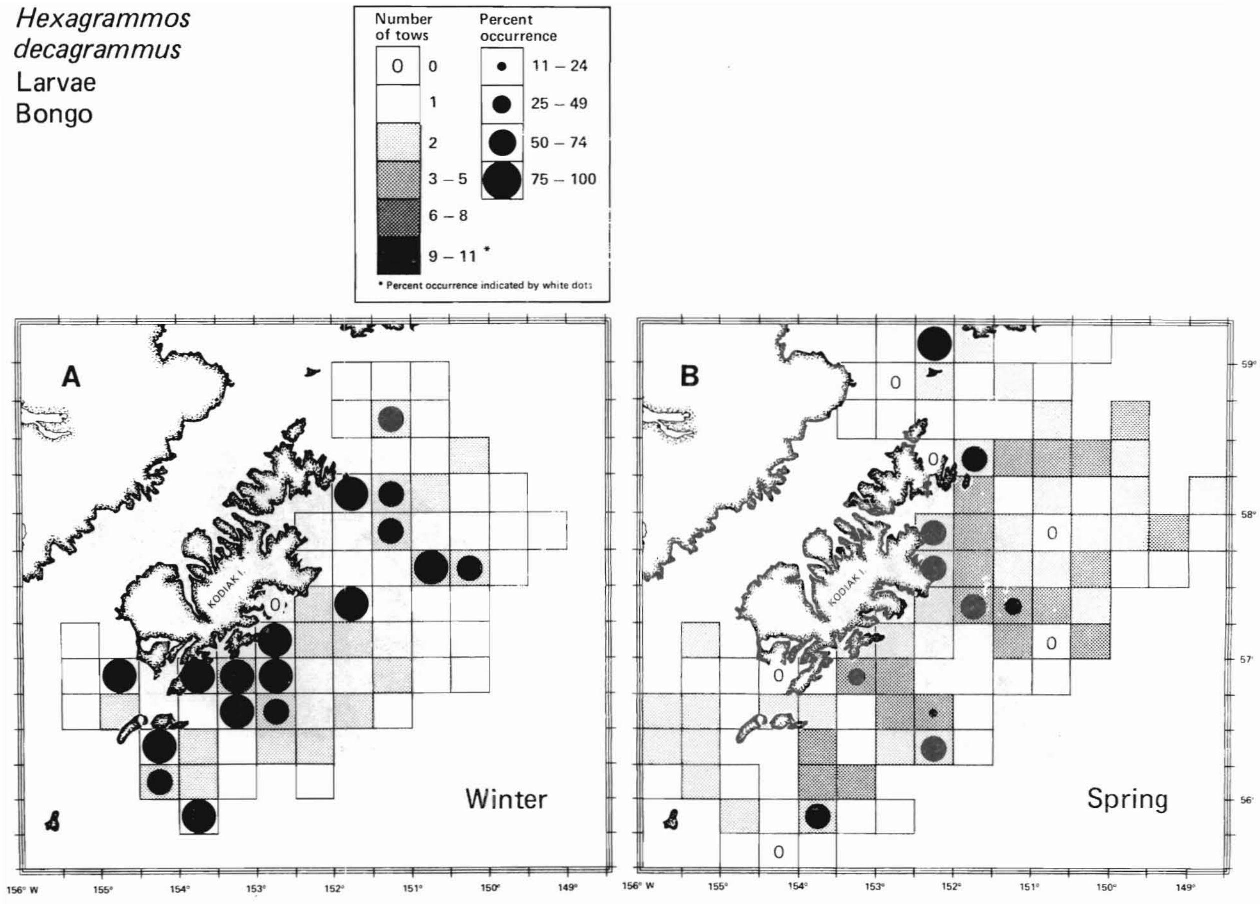
Appendix Figure 29.—Distribution of *Sebastes* spp. larvae in bongo tows. A. spring, B. summer, and C. fall.



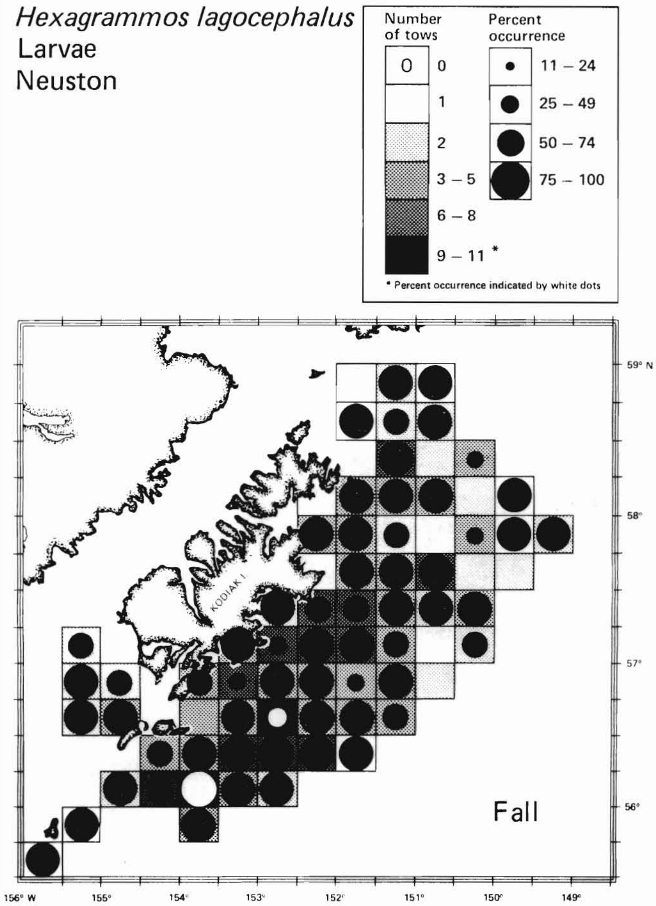
Appendix Figure 30.—Distribution of *Anoplopoma fimbria* larvae in neuston tows in summer.



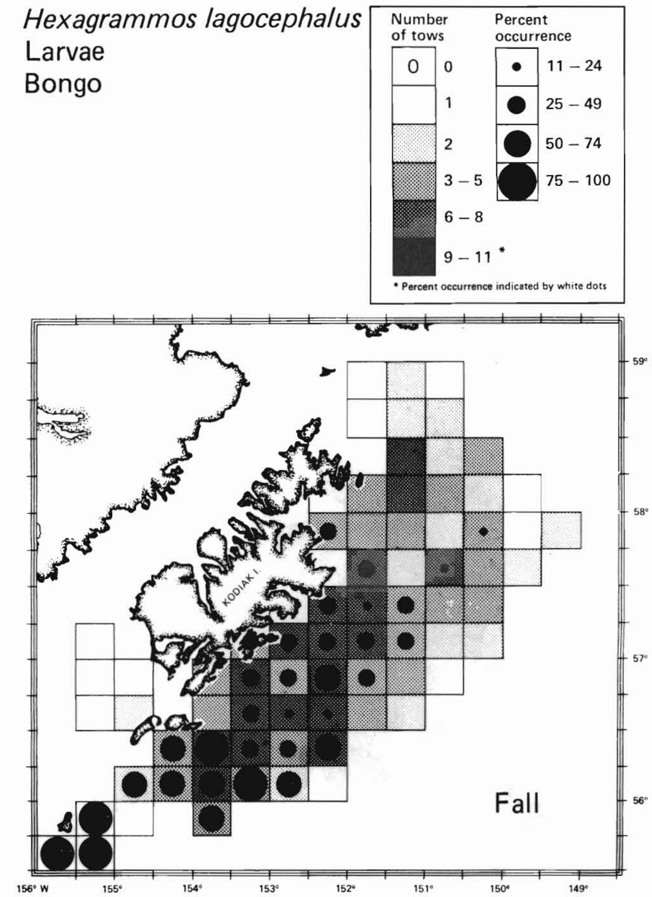
Appendix Figure 31.—Distribution of *Hexagrammos decagrammus* larvae in neuston tows. A. fall, B. winter, C. spring, and D. summer.



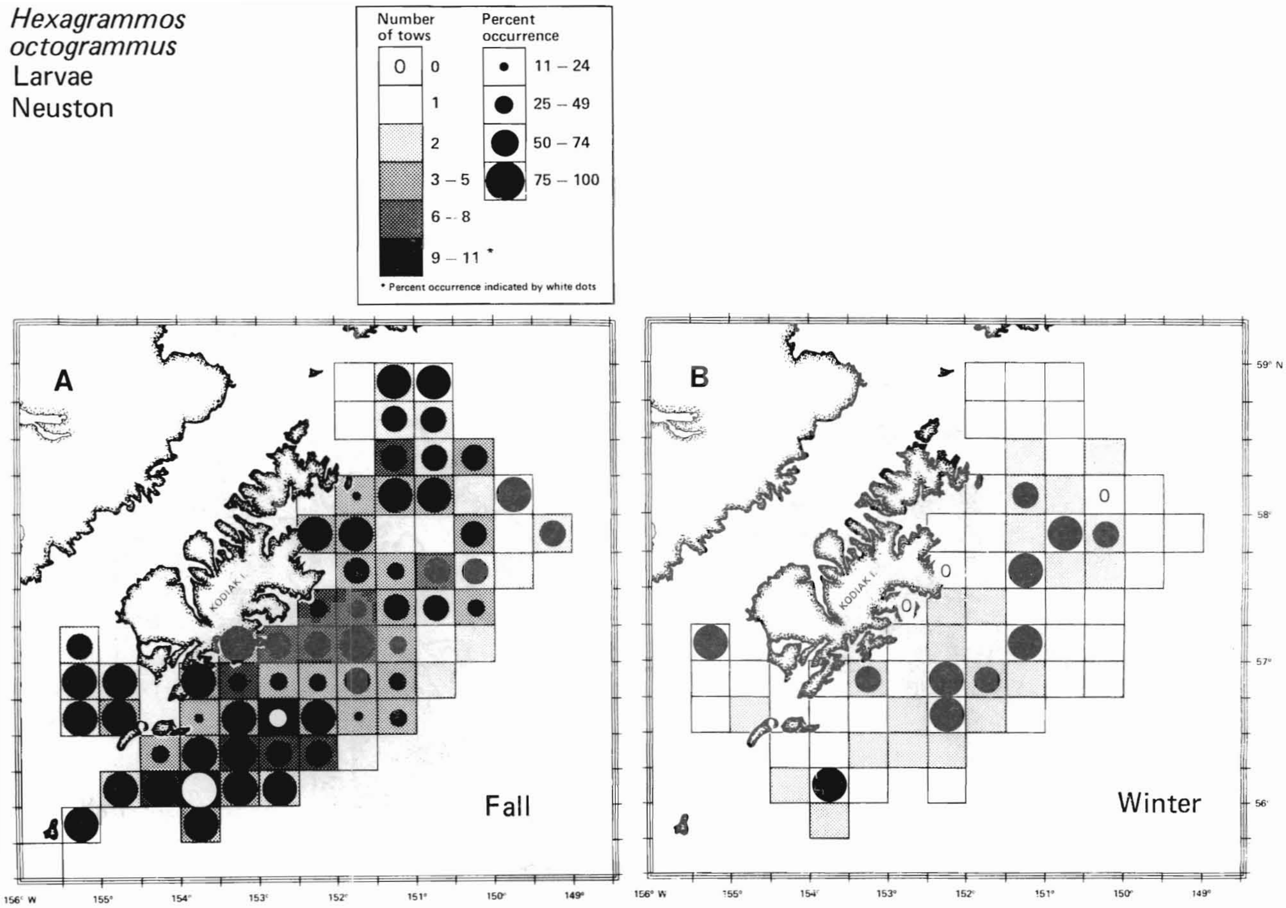
Appendix Figure 32.—Distribution of *Hexagrammos decagrammus* larvae in bongo tows. A. winter and B. spring.



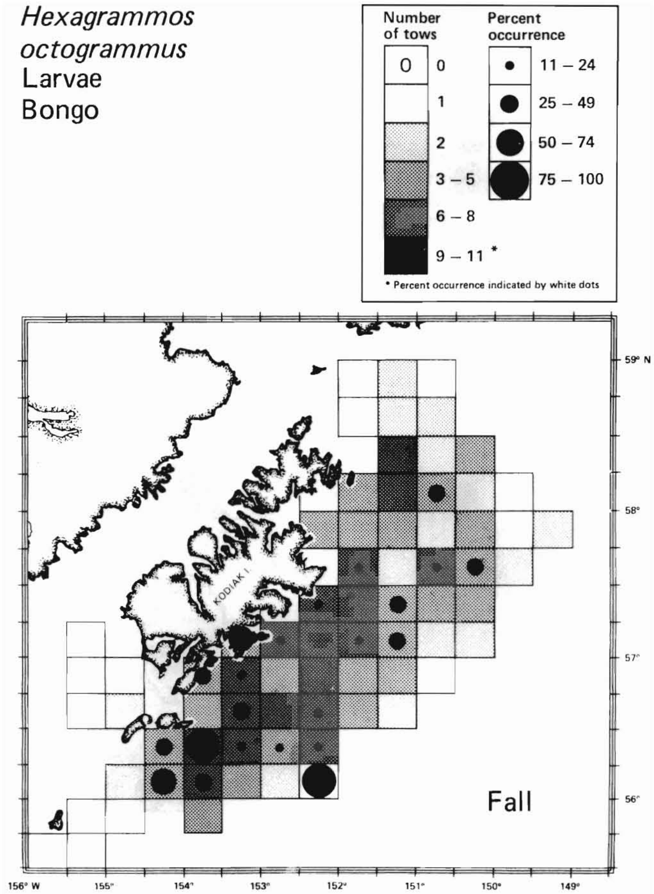
Appendix Figure 33.—Distribution of *Hexagrammos lagocephalus* larvae in neuston tows in fall.



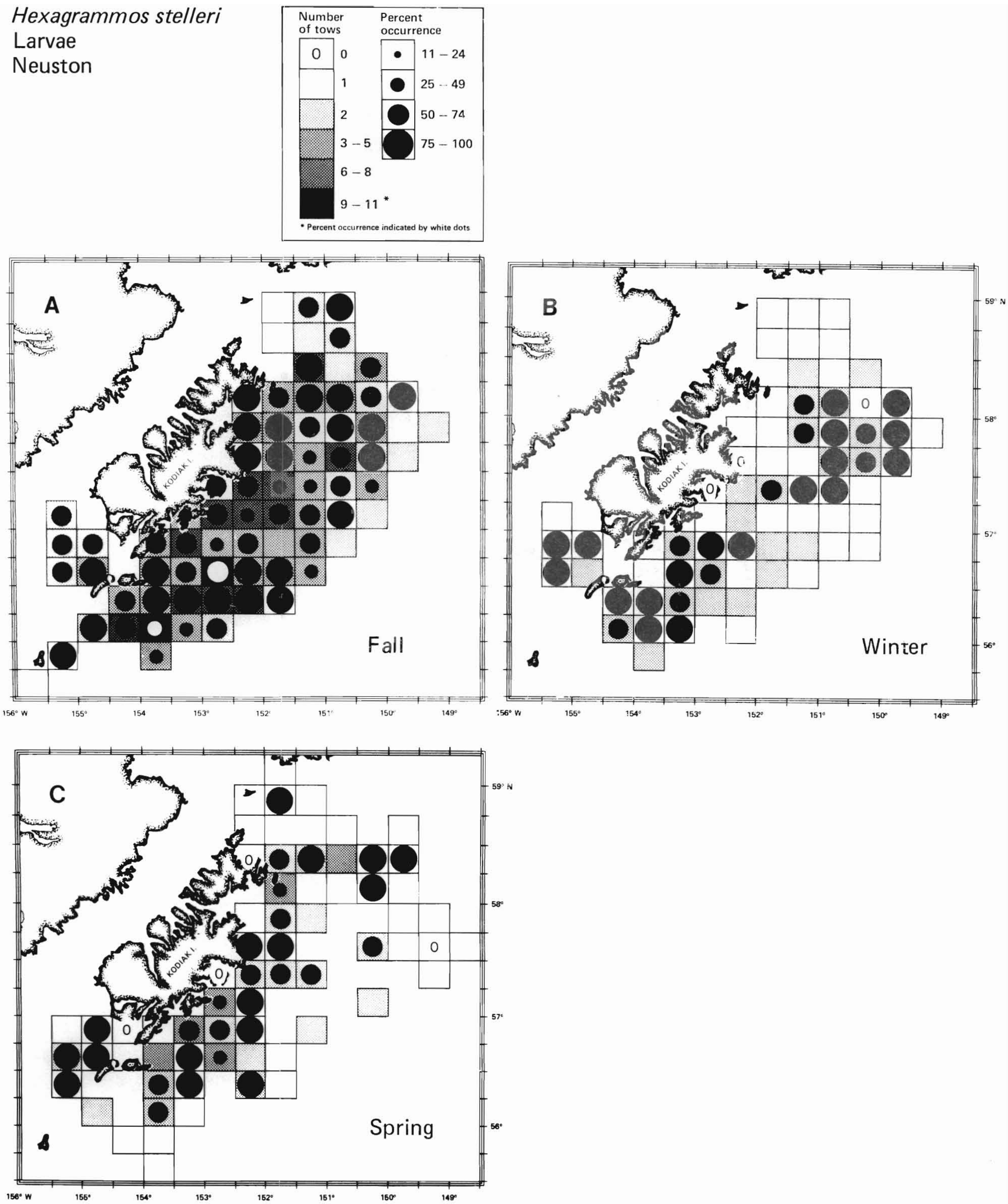
Appendix Figure 34.—Distribution of *Hexagrammos lagocephalus* larvae in bongo tows in fall.



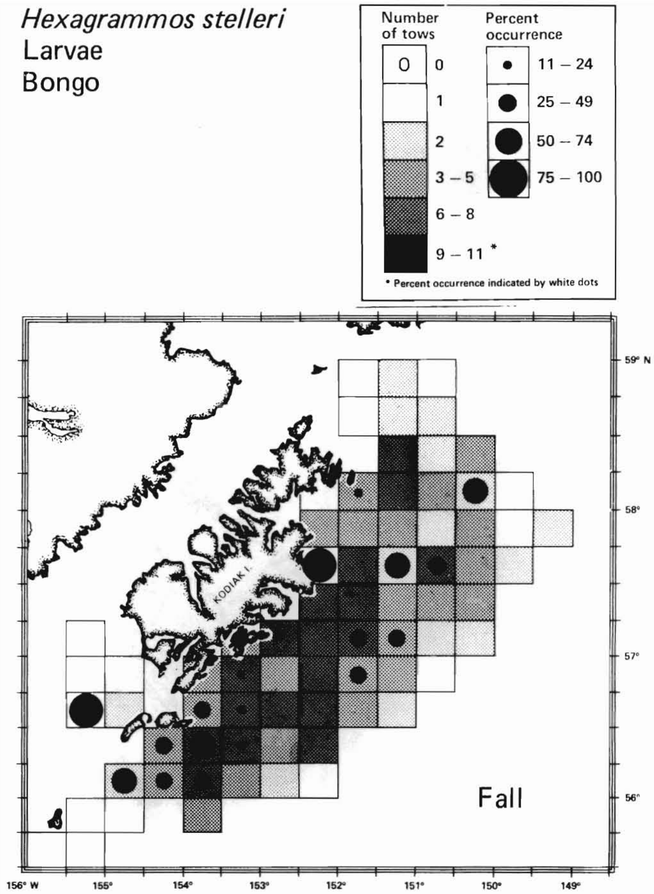
Appendix Figure 35.—Distribution of *Hexagrammos octogrammus* larvae in neuston tows, A. fall and B. winter.



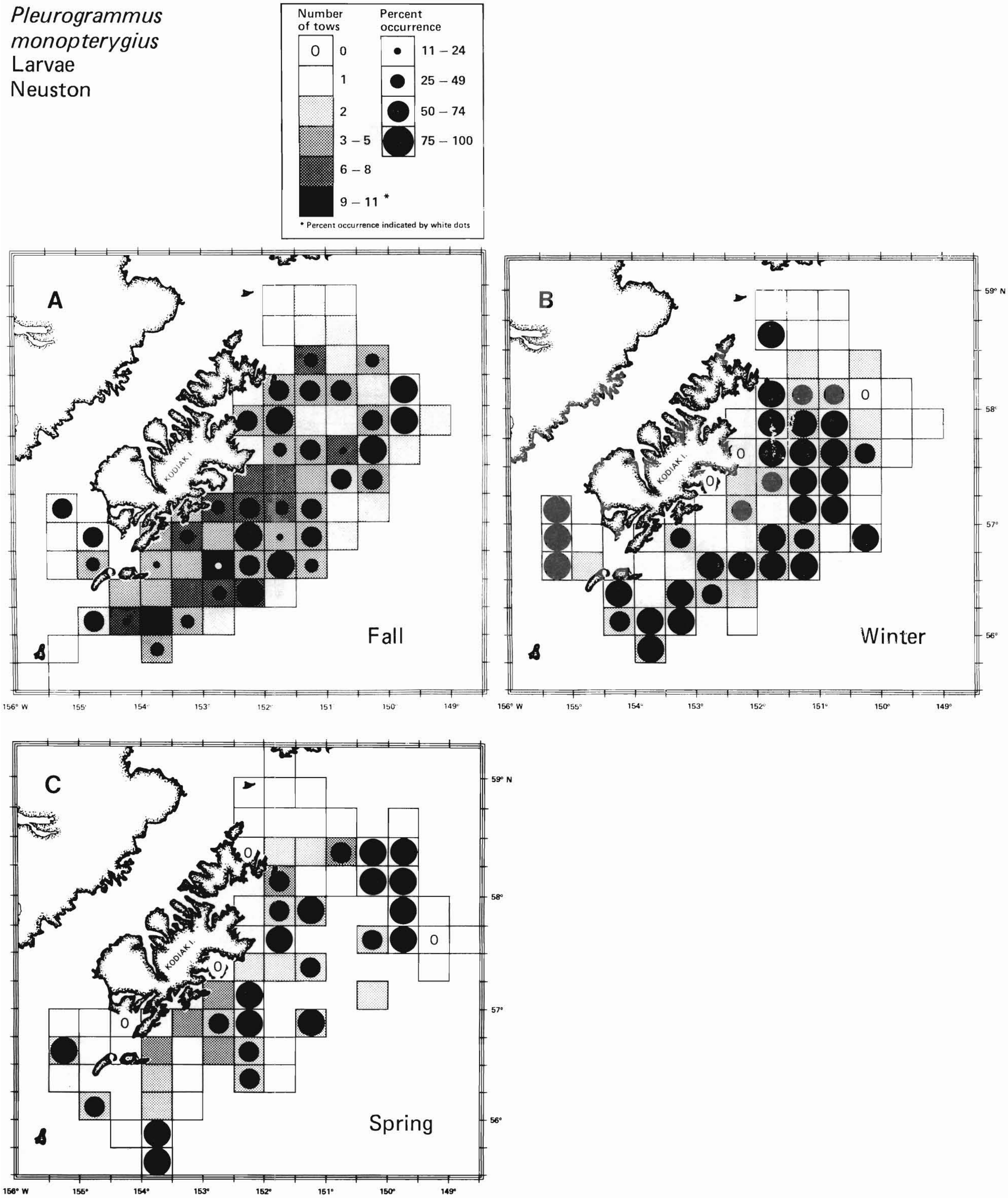
Appendix Figure 36.—Distribution of *Hexagrammos octogrammus* larvae in bongo tows in fall.



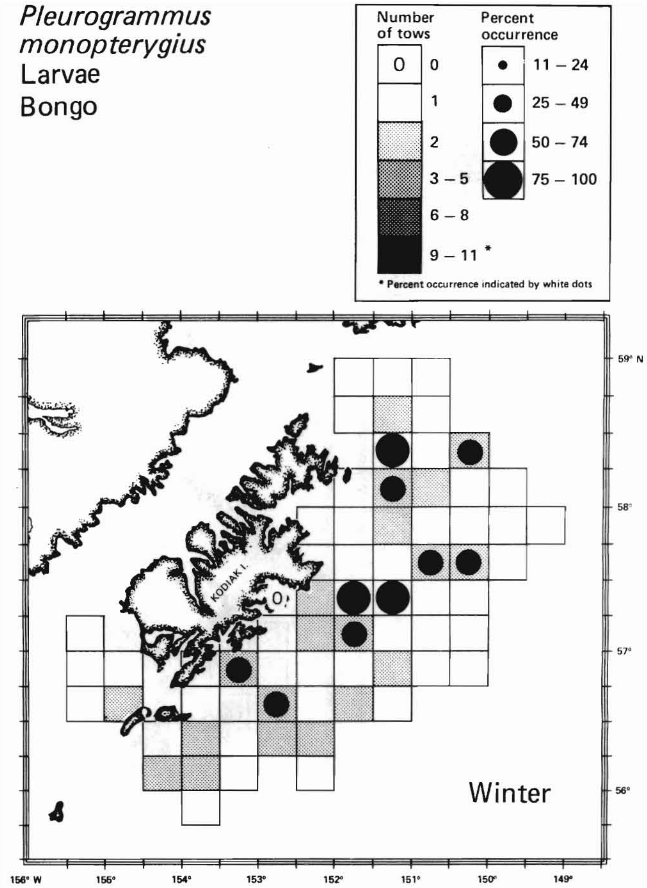
Appendix Figure 37.—Distribution of *Hexagrammos stelleri* larvae in neuston tows. A. fall, B. winter, and C. spring.



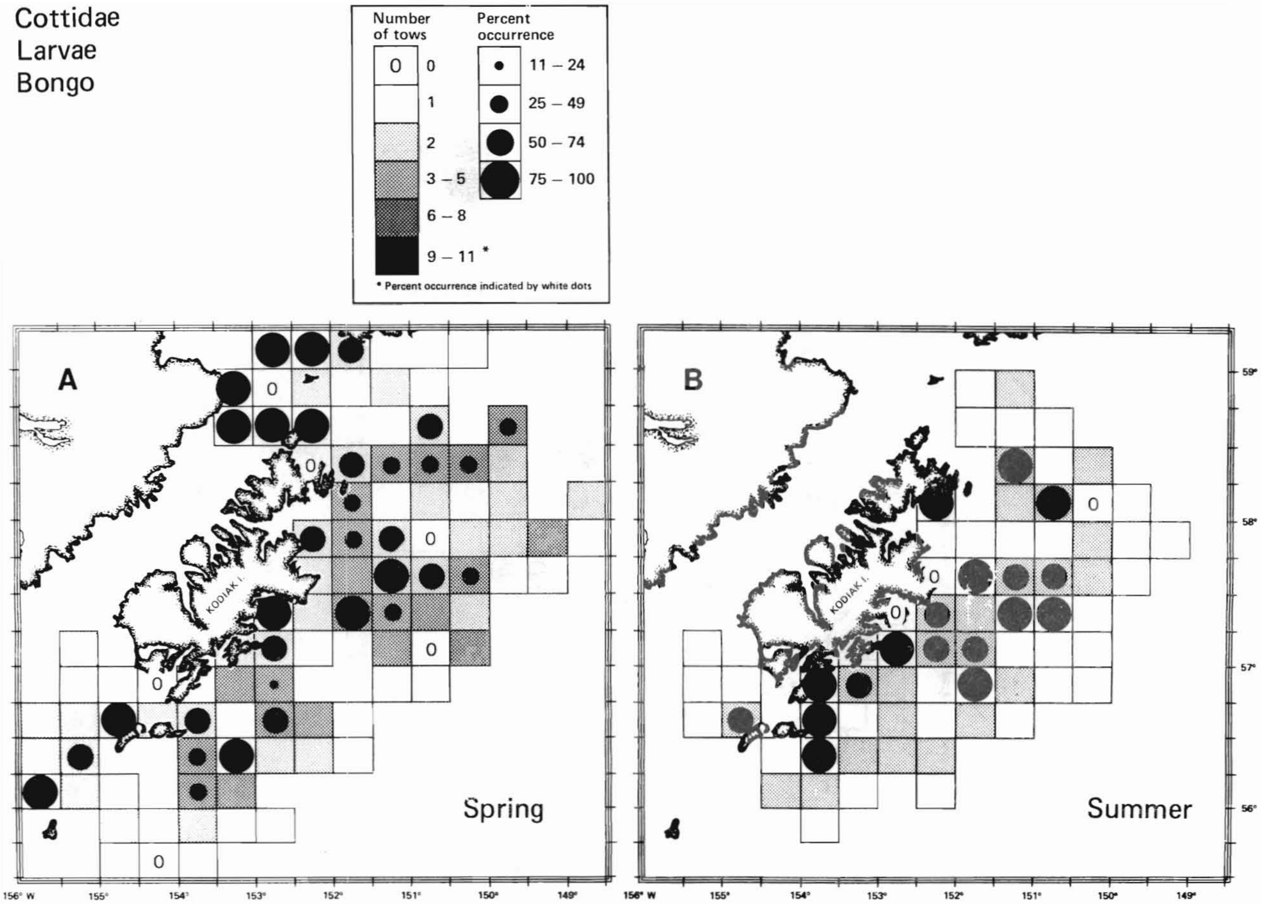
Appendix Figure 38.—Distribution of *Hexagrammos stelleri* larvae in bongo tows in fall.



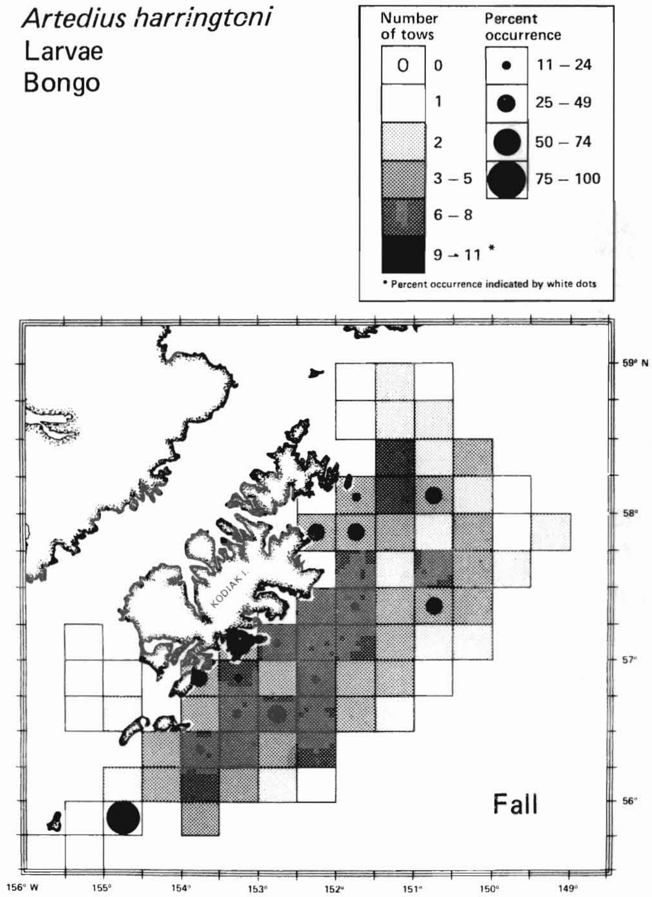
Appendix Figure 39.—Distribution of *Pleurogrammus monopterygius* larvae in neuston tows. A. fall, B. winter, and C. spring.



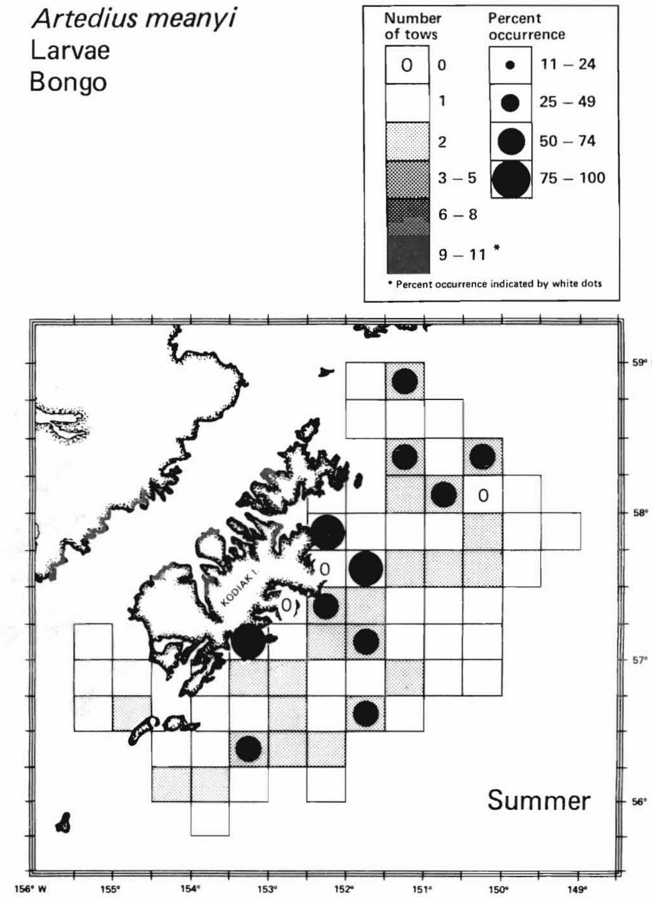
Appendix Figure 40.—Distribution of *Pleurogrammus monopterygius* larvae in bongo tows in winter.



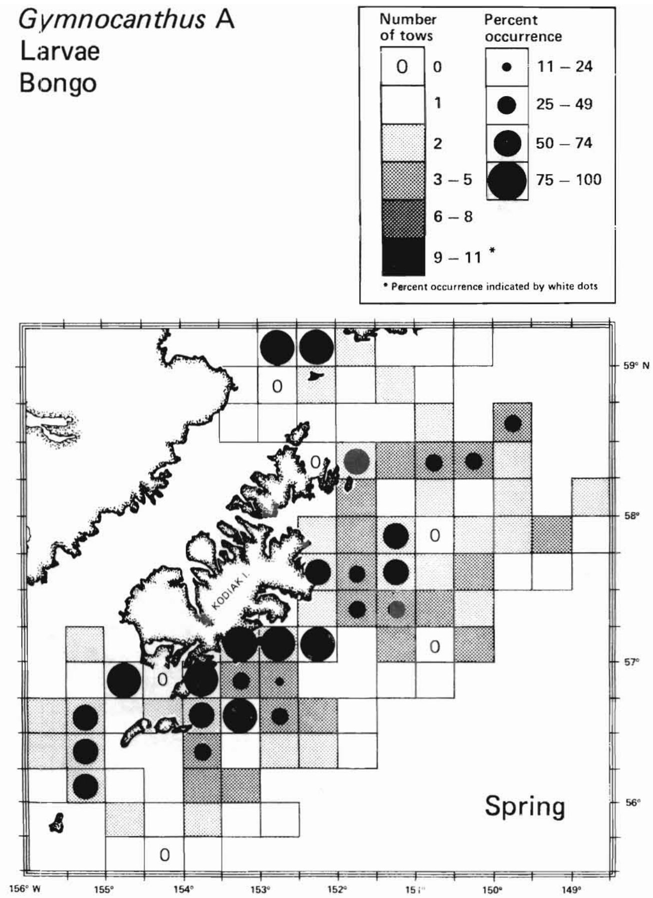
Appendix Figure 41.—Distribution of Cottidae larvae in bongo tows. A. spring and B. summer.



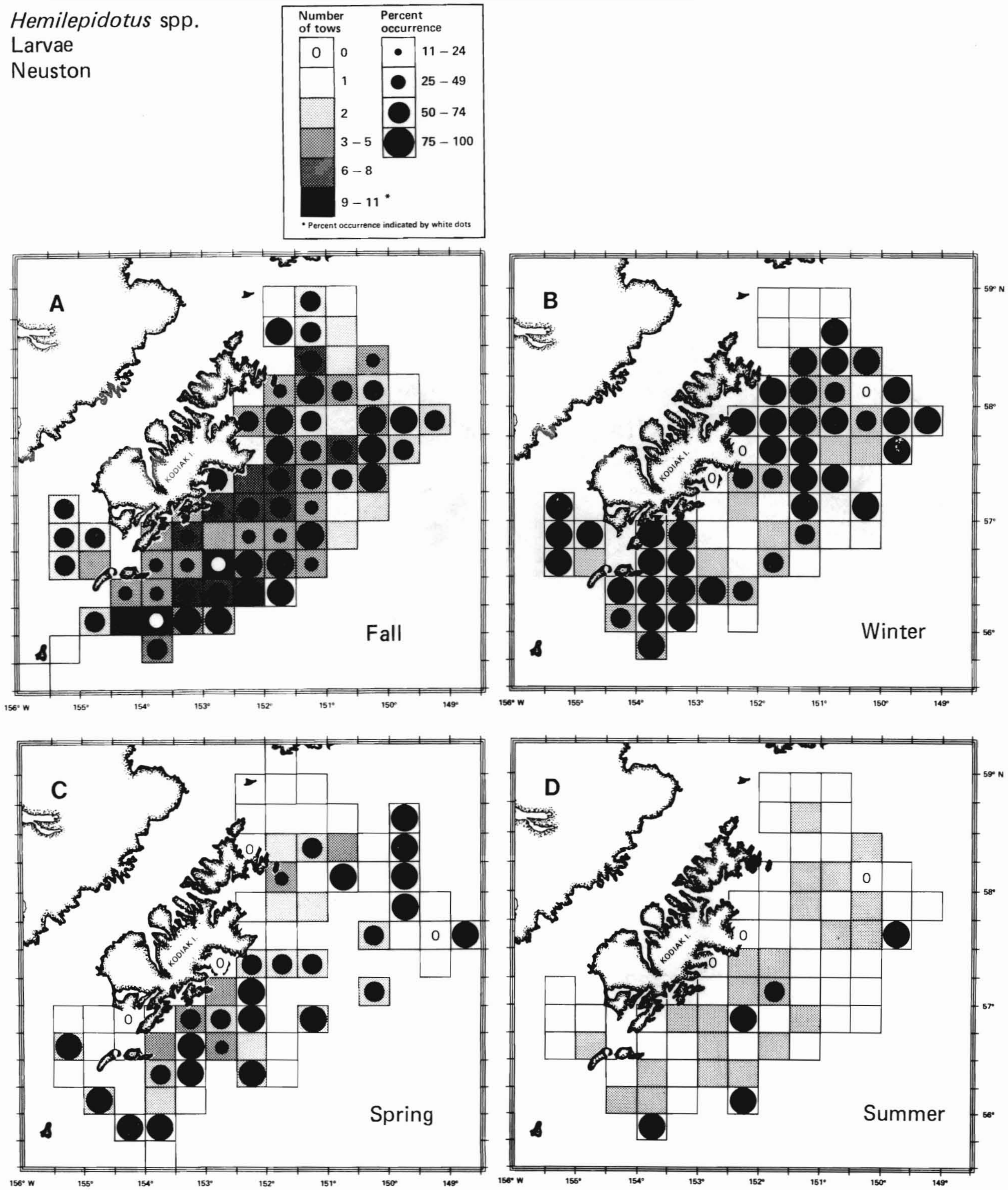
Appendix Figure 42.—Distribution of *Artedius harringtoni* larvae in bongo tows in fall.



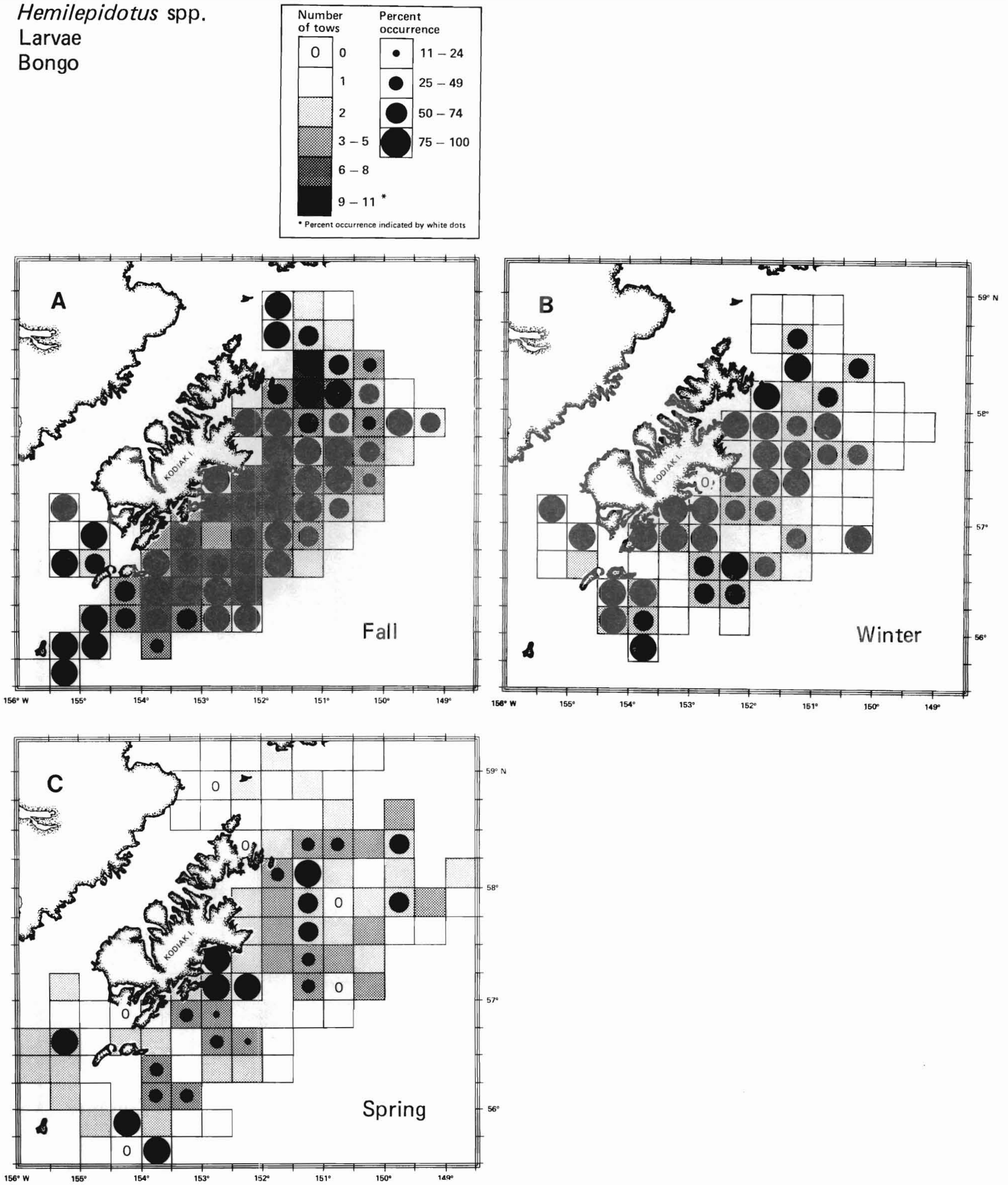
Appendix Figure 43.—Distribution of *Artedius meanyi* larvae in bongo tows in summer.



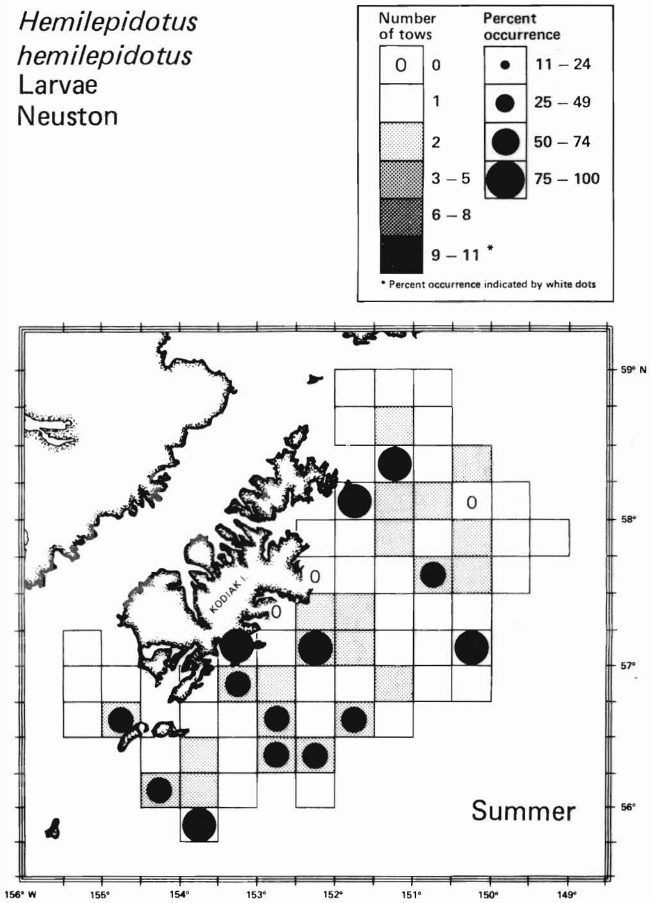
Appendix Figure 44.—Distribution of *Gymnocanthus* A larvae in bongo tows in spring.



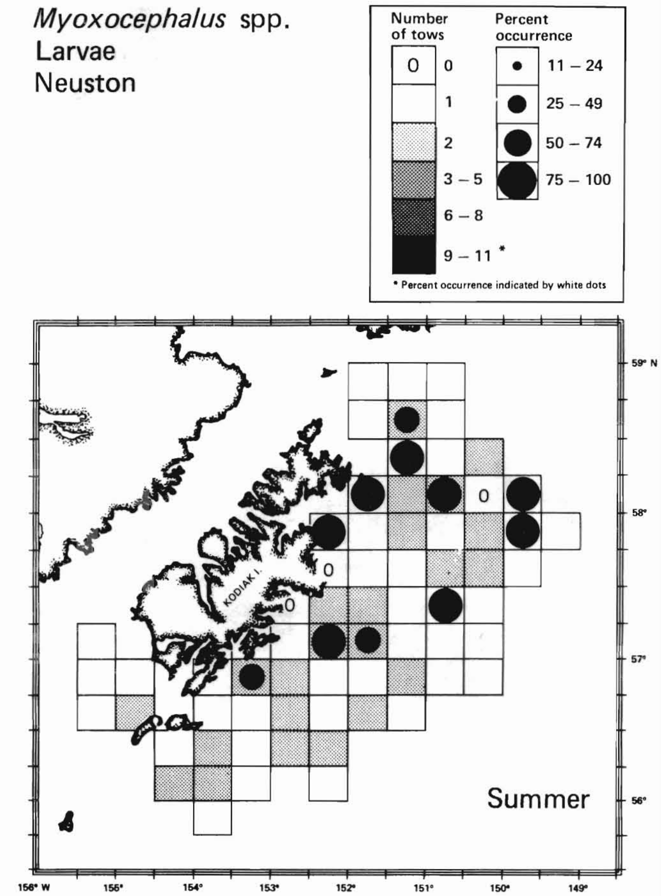
Appendix Figure 45.—Distribution of *Hemilepidotus* spp. larvae in neuston tows. A. fall, B. winter, C. spring, and D. summer.



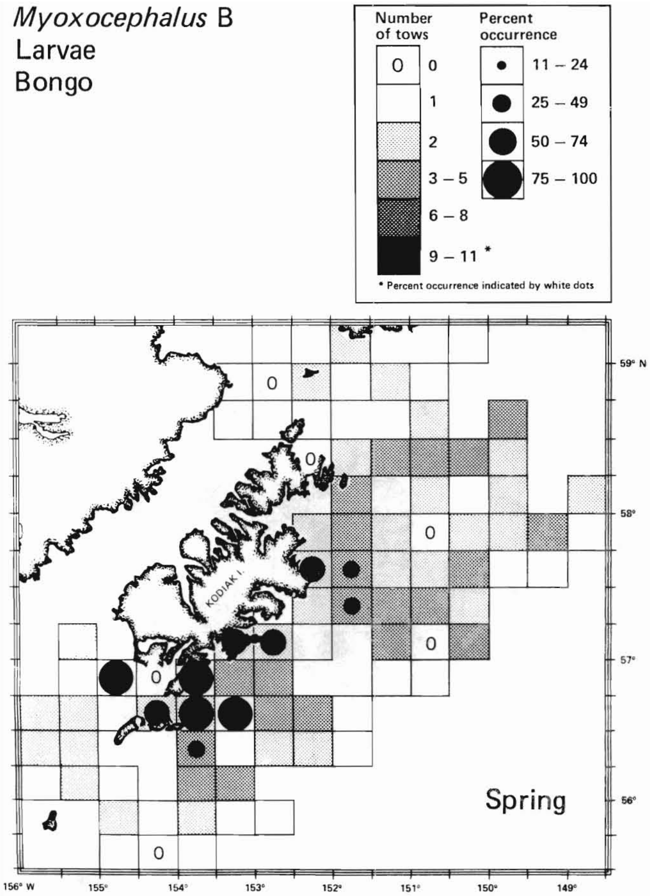
Appendix Figure 46.—Distribution of *Hemilepidotus* spp. larvae in bongo tows. A. fall, B. winter, and C. spring.



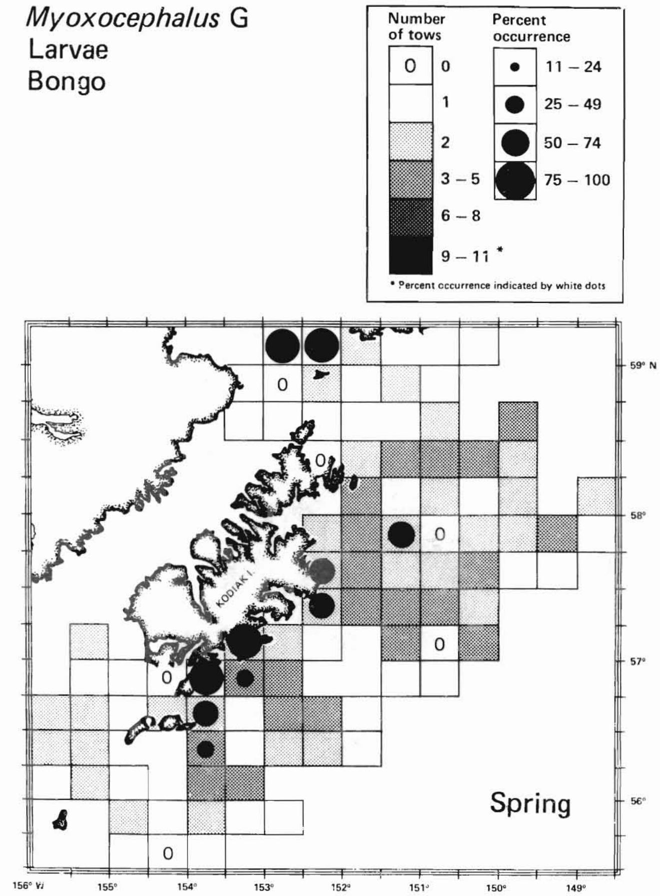
Appendix Figure 47.—Distribution of *Hemilepidotus hemilepidotus* larvae in neuston tows in summer.



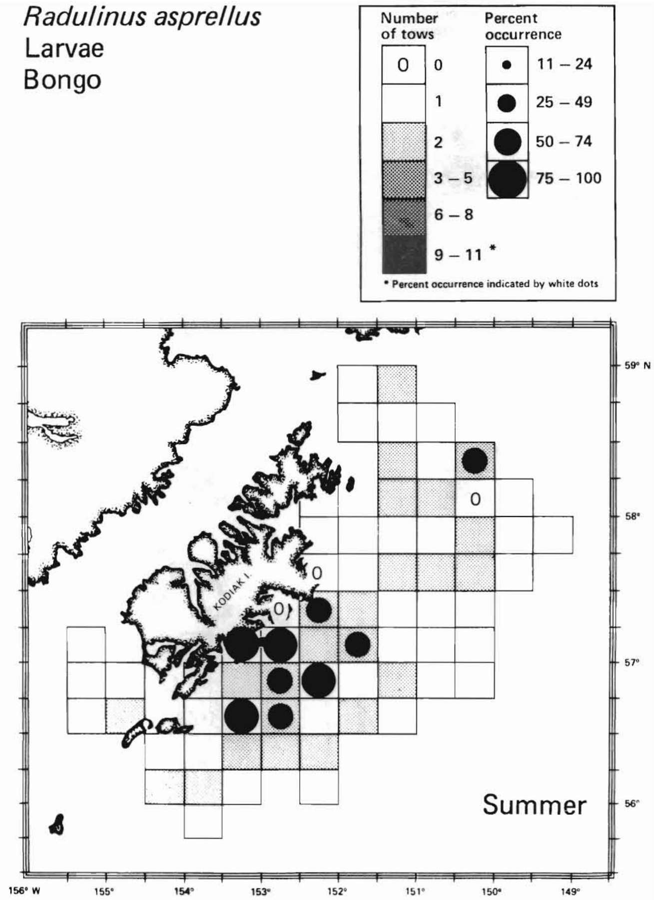
Appendix Figure 48.—Distribution of *Myoxocephalus* spp. larvae in neuston tows in summer.



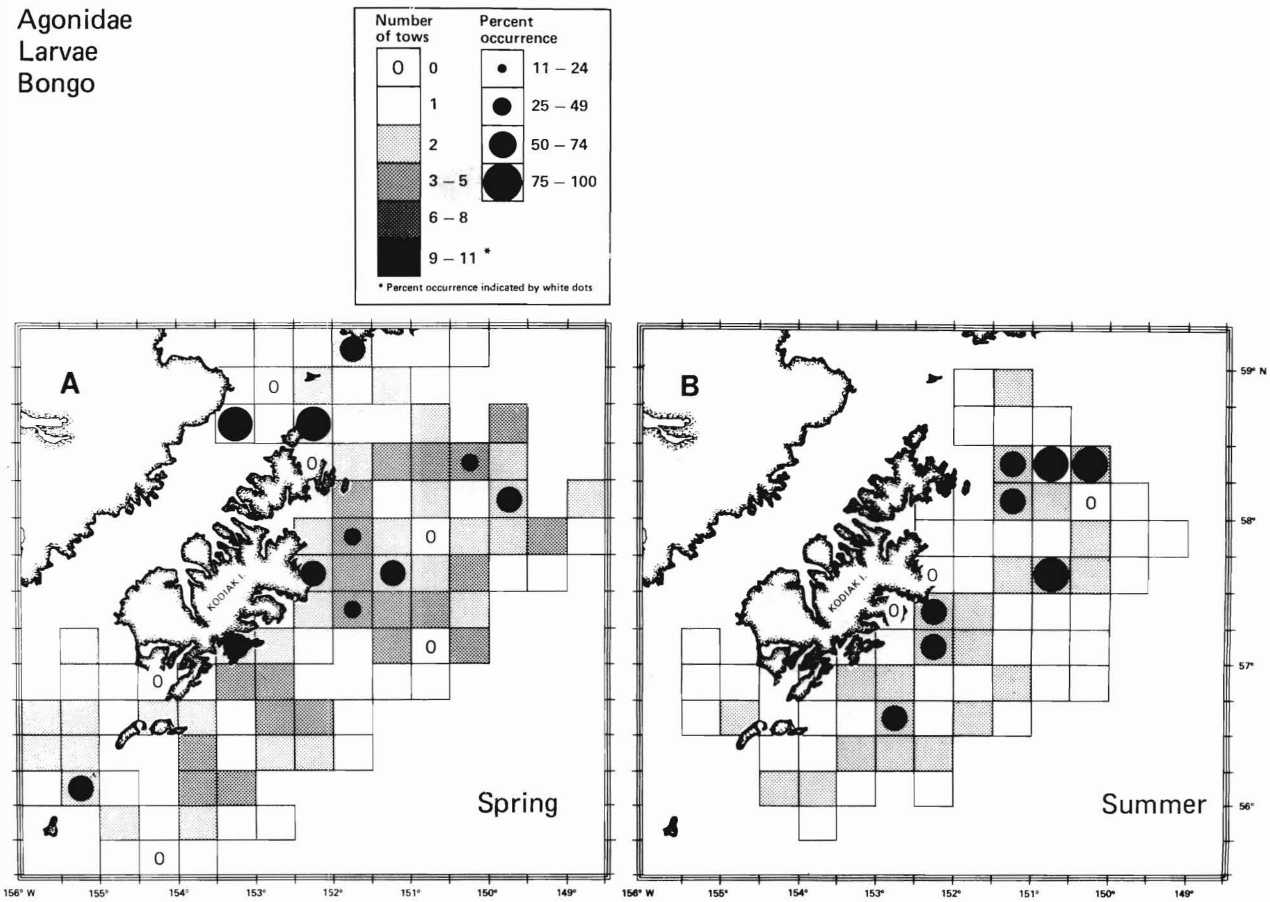
Appendix Figure 49.—Distribution of *Myoxocephalus* B larvae in bongo tows in spring.



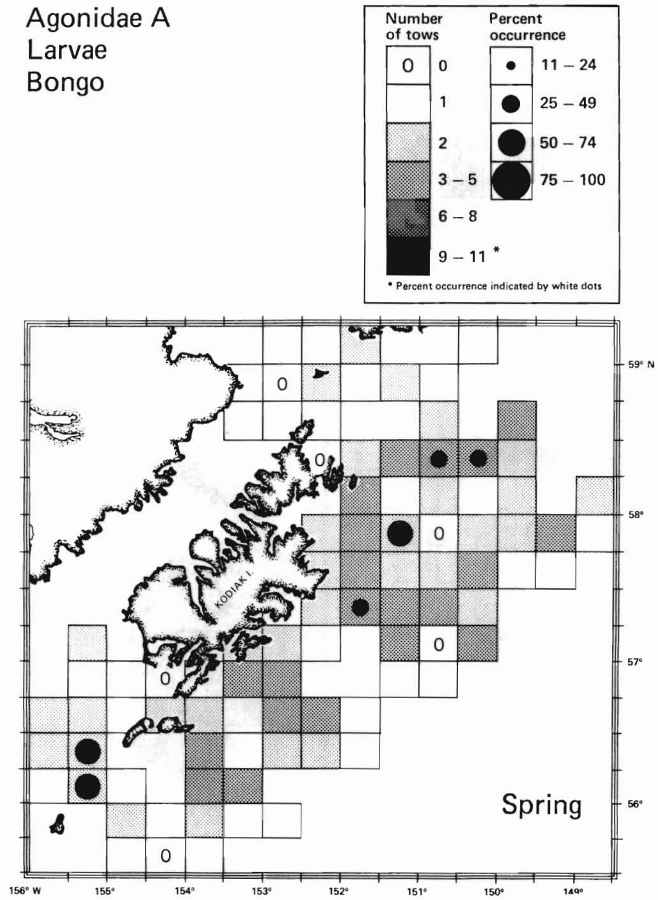
Appendix Figure 50.—Distribution of *Myoxocephalus* G larvae in bongo tows in spring.



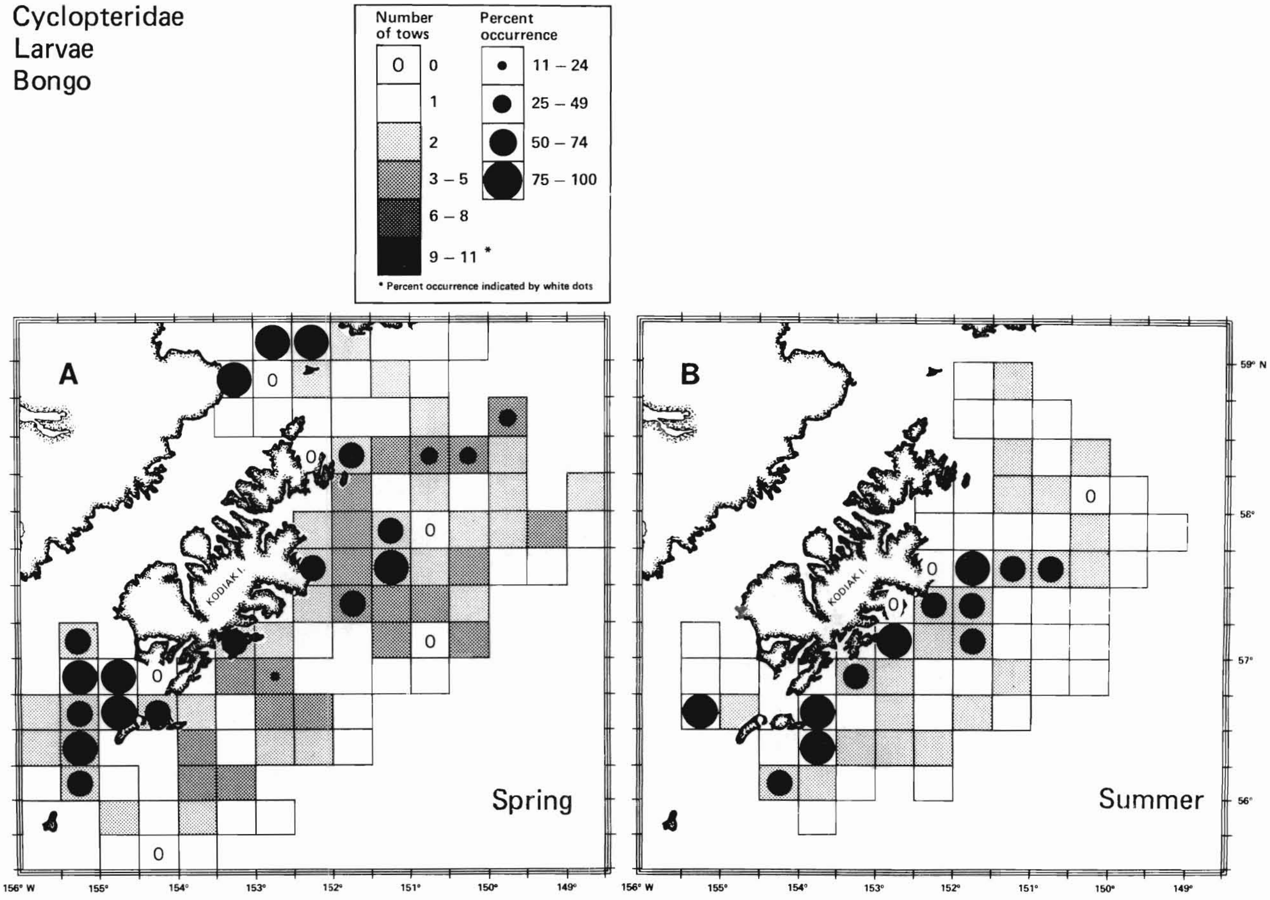
Appendix Figure 51.—Distribution of *Radulinus asprellus* larvae in bongo tows in summer.



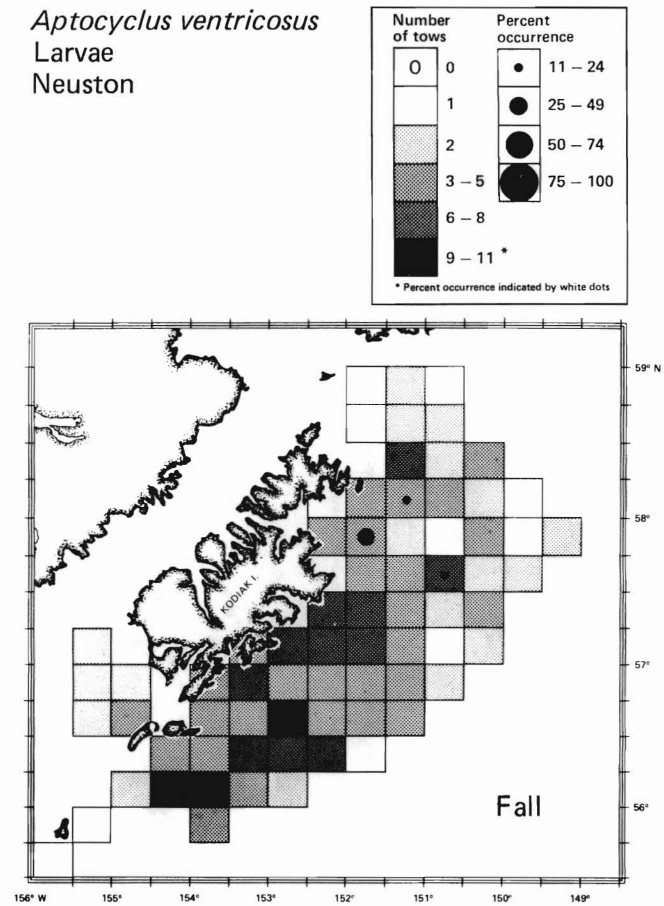
Appendix Figure 52.—Distribution of Agonidae larvae in bongo tows. A. spring and B. summer.



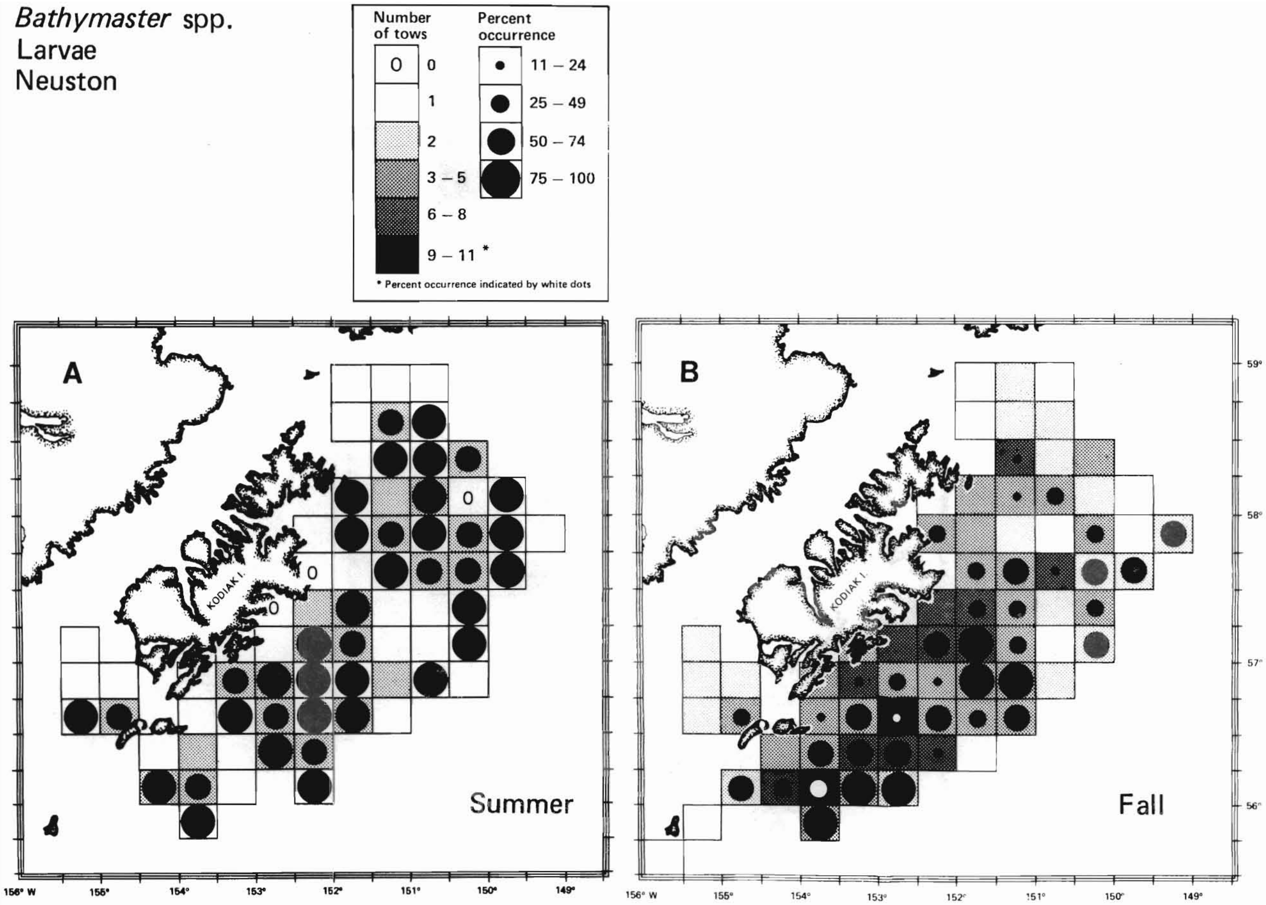
Appendix Figure 53.—Distribution of Agonidae A larvae in bongo tows in spring.



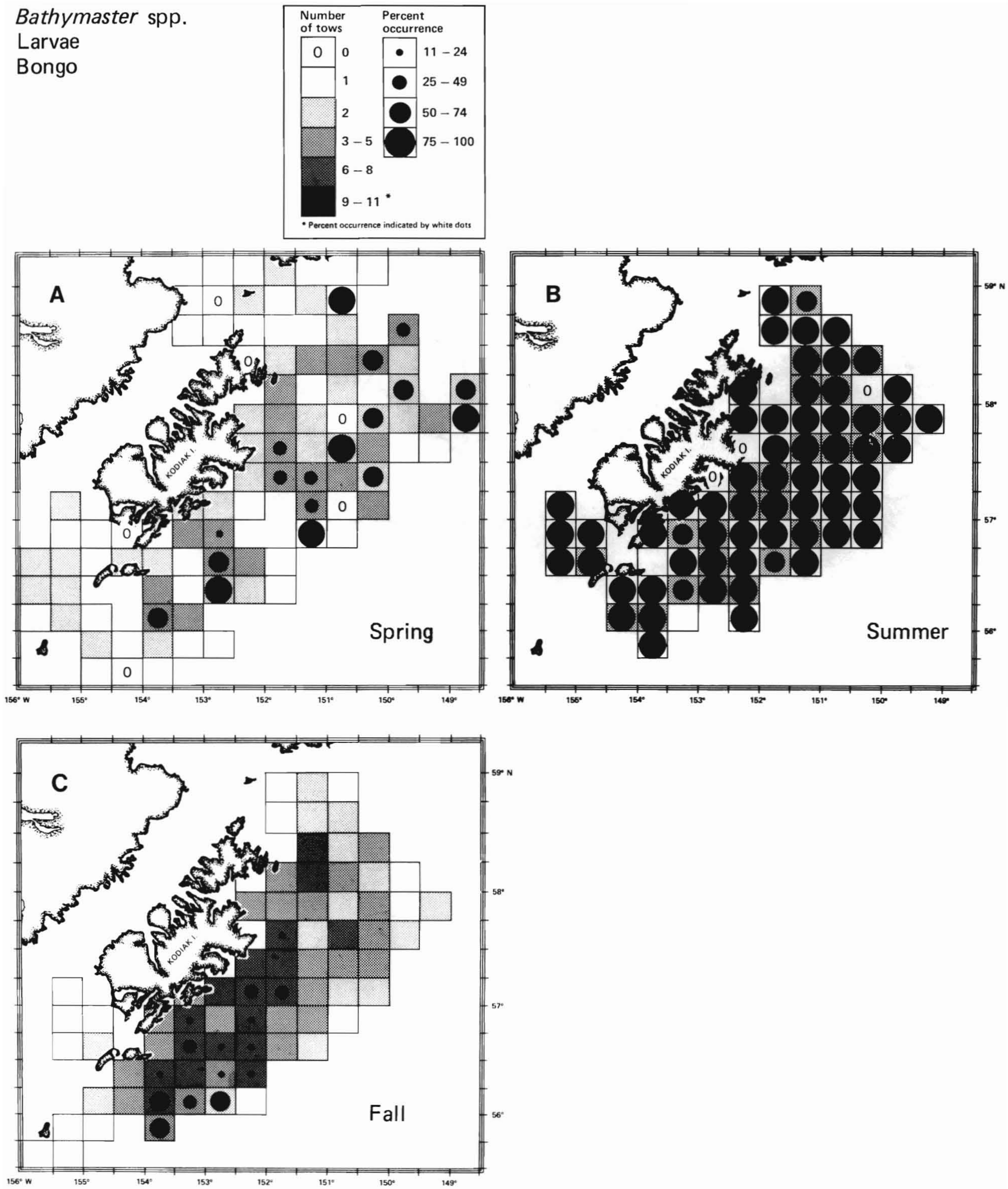
Appendix Figure 54.—Distribution of Cyclopteridae larvae in bongo tows. A. spring and B. summer.



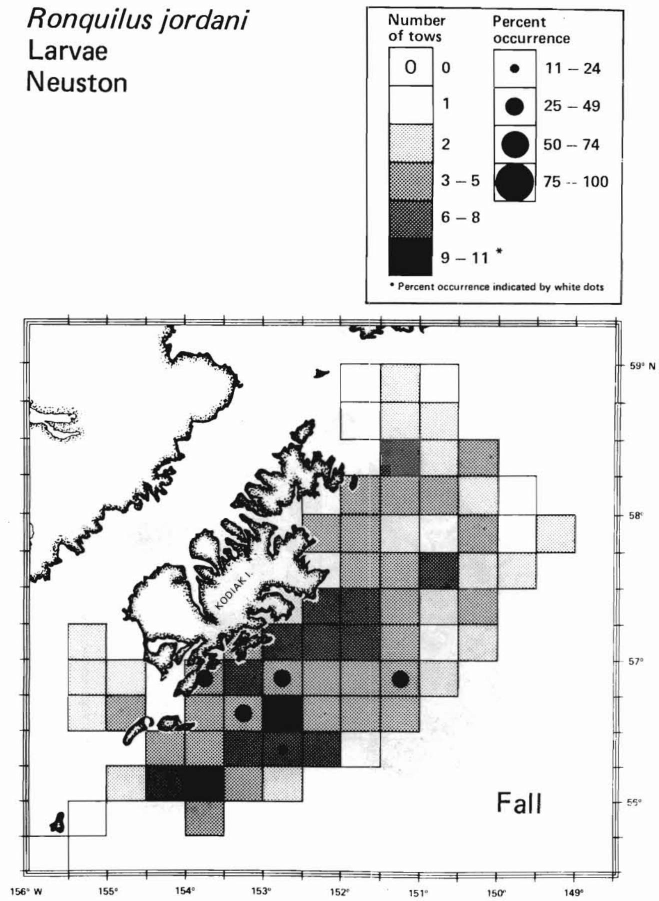
Appendix Figure 55.—Distribution of *Aptocyclus ventricosus* larvae in neuston tows in fall.



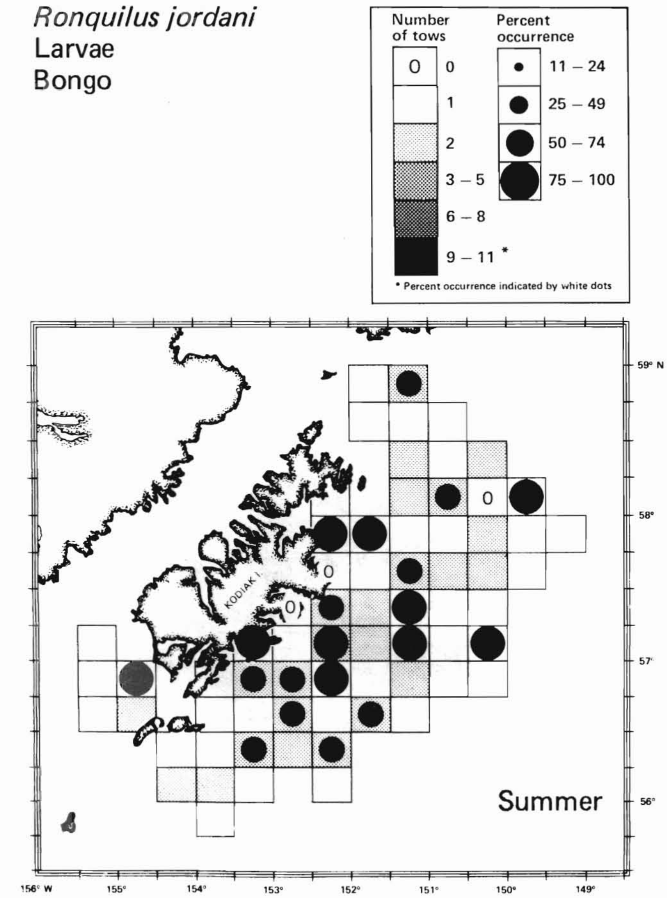
Appendix Figure 56.—Distribution of *Bathymaster* spp. larvae in neuston tows. A. summer and B. fall.



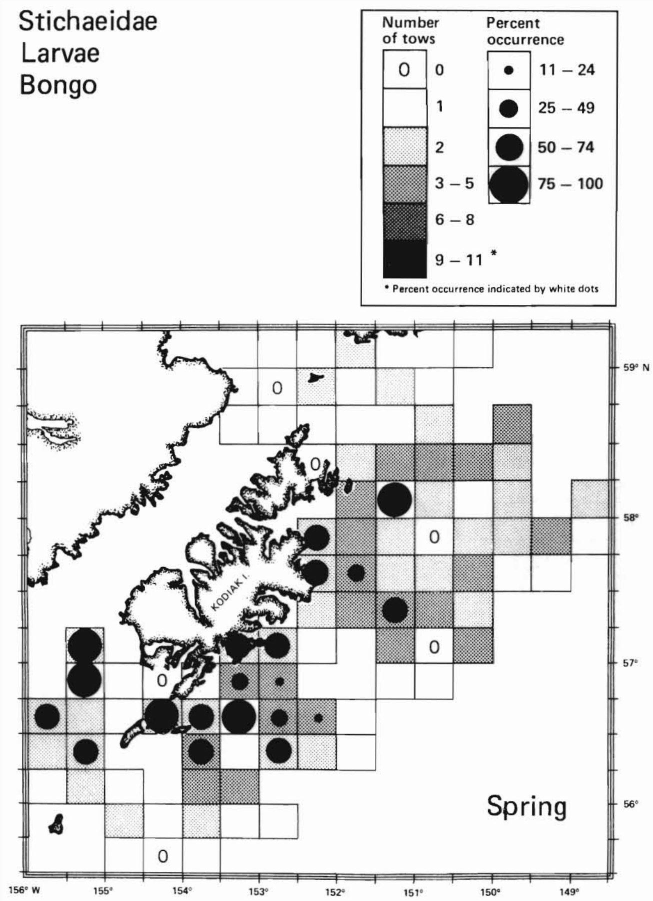
Appendix Figure 57.—Distribution of *Bathymaster* spp. larvae in bongo tows. A. spring, B. summer, and C. fall.



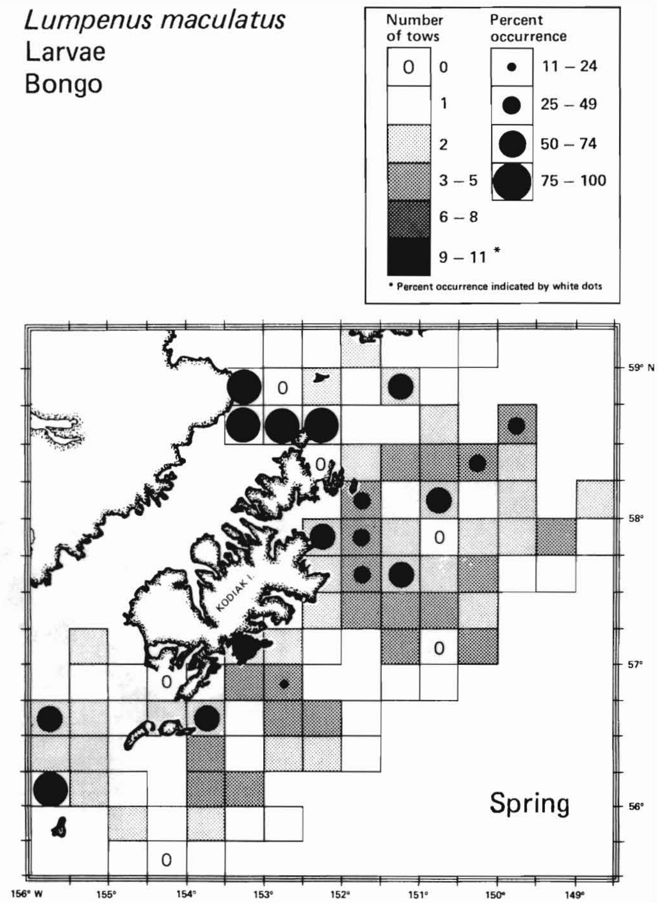
Appendix Figure 58.—Distribution of *Ronquilus jordani* larvae in neuston tows in fall.



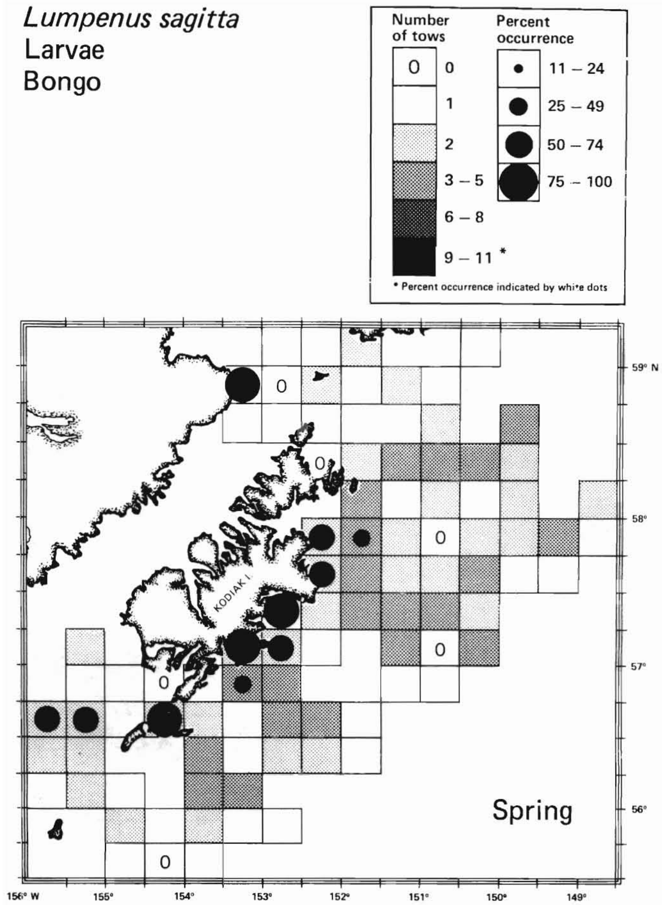
Appendix Figure 59.—Distribution of *Ronquilus jordani* larvae in bongo tows in summer.



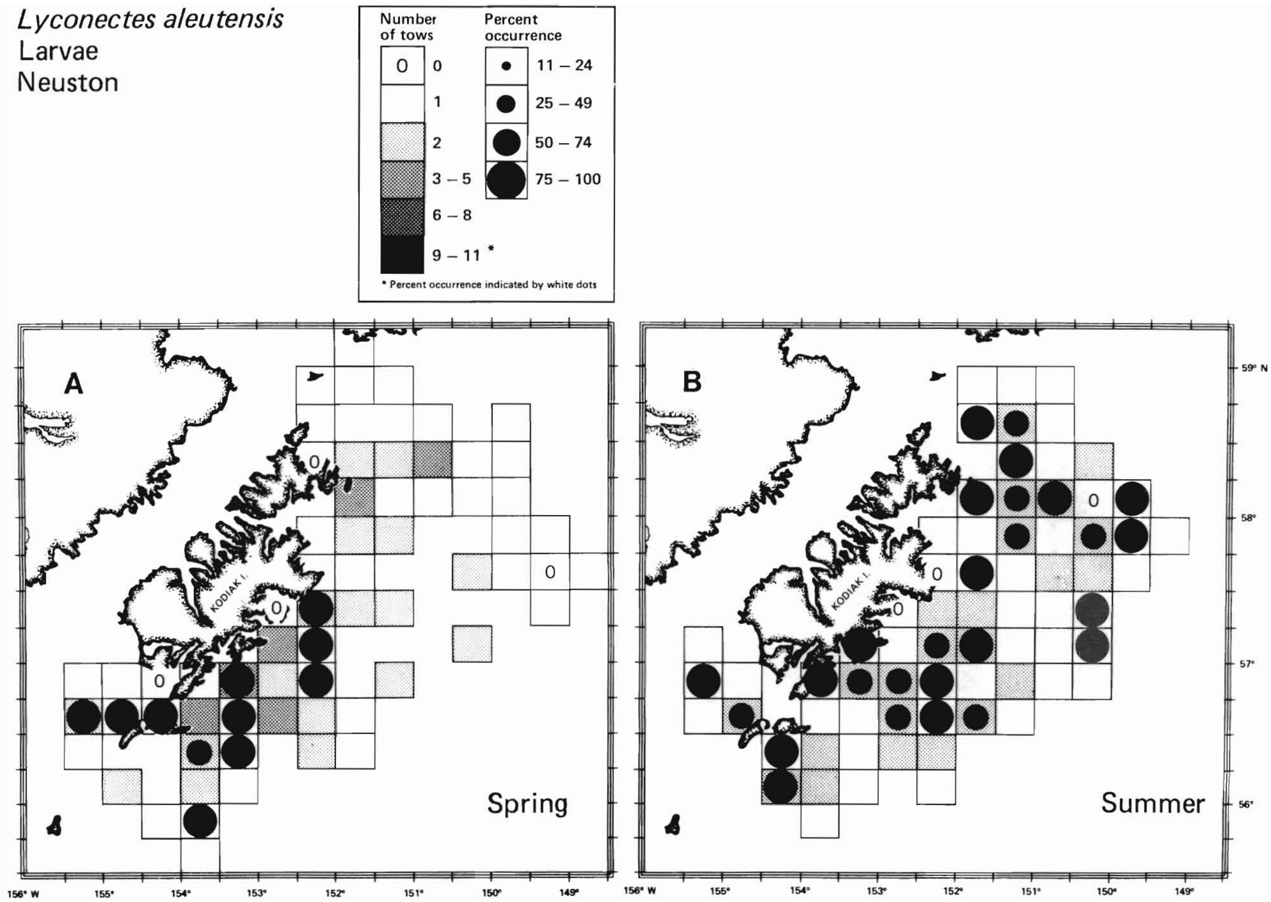
Appendix Figure 60.—Distribution of Stichaeidae larvae in bongo tows in spring.



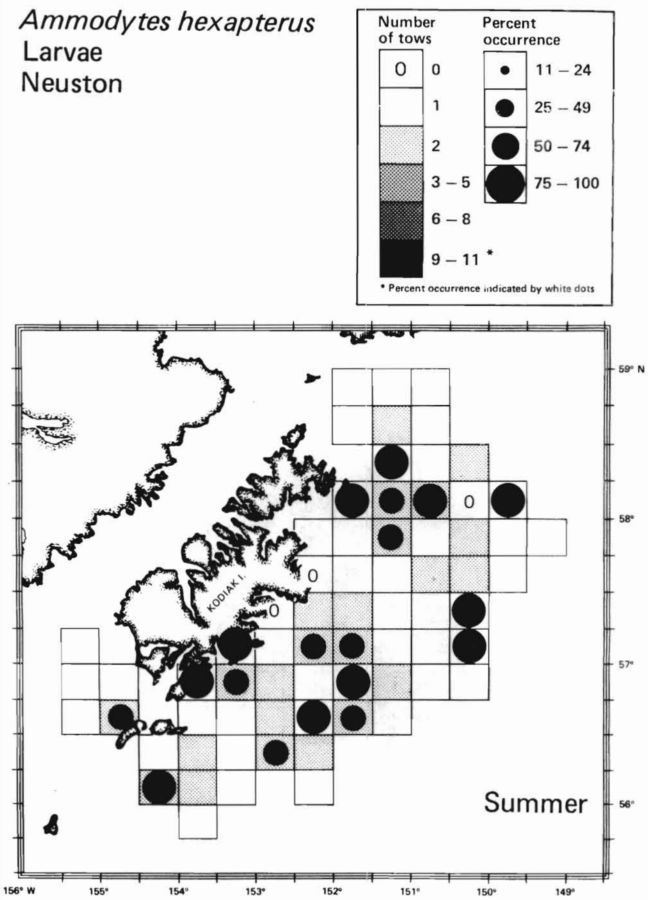
Appendix Figure 61.—Distribution of *Lumpenus maculatus* larvae in bongo tows in spring.



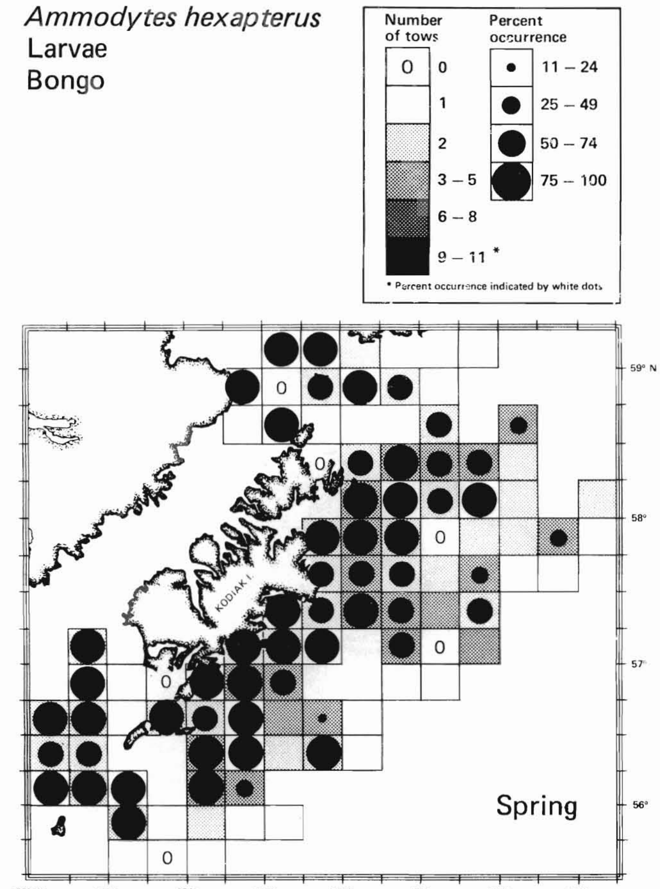
Appendix Figure 62.—Distribution of *Lumpenus sagitta* larvae in bongo tows in spring.



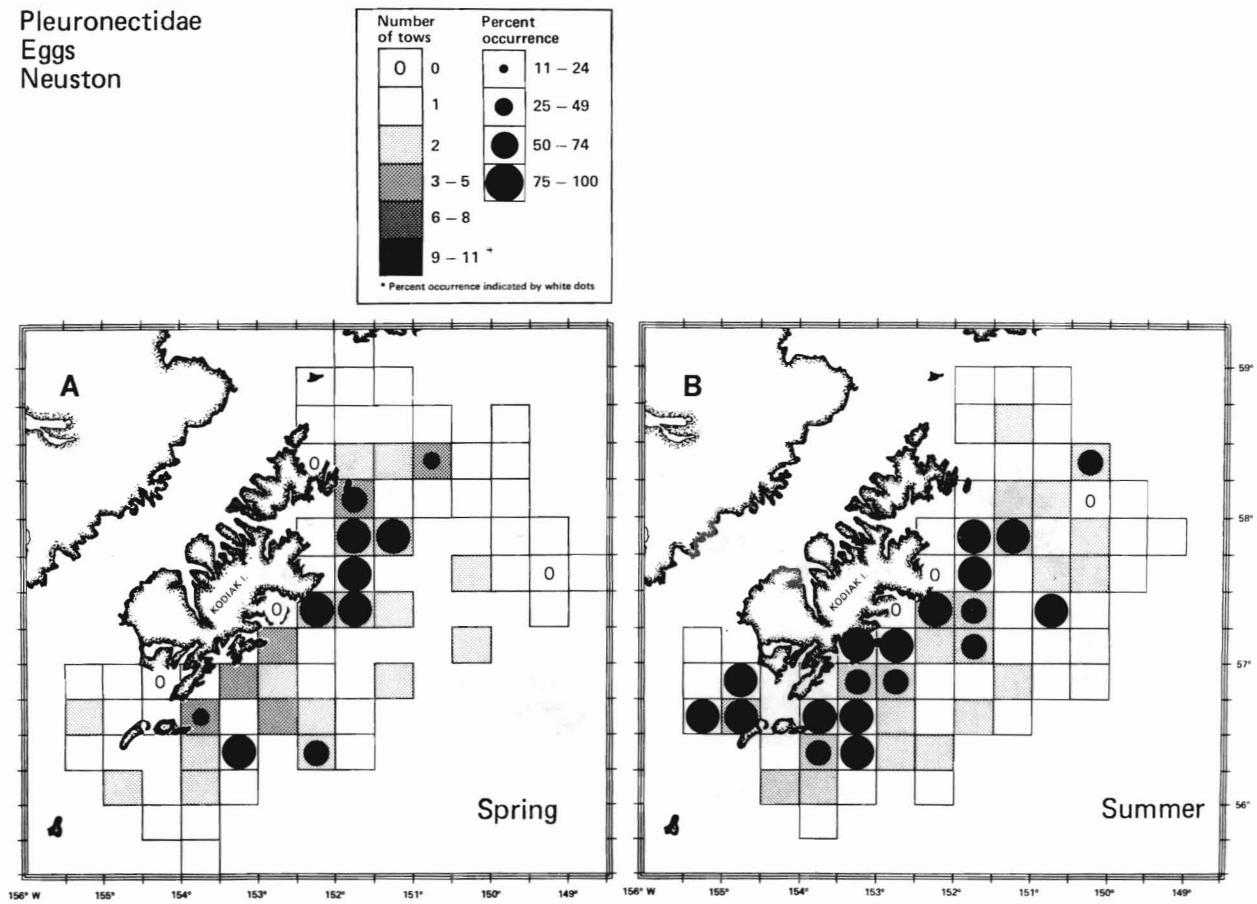
Appendix Figure 63.—Distribution of *Lyconectes aleutensis* larvae in neuston tows. A. spring and B. summer.



Appendix Figure 64.—Distribution of *Ammodytes hexapterus* larvae in neuston tows in summer.

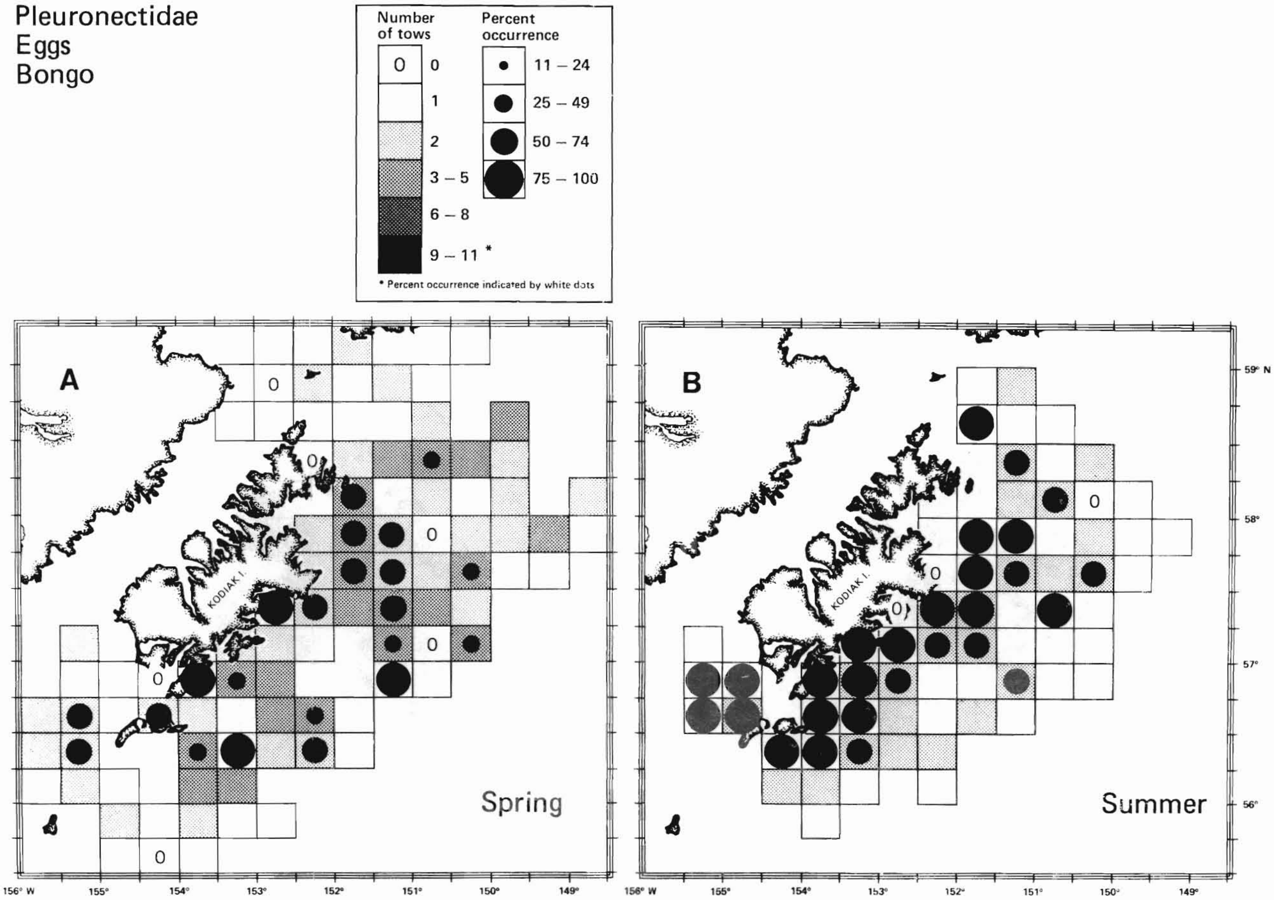


Appendix Figure 65.—Distribution of *Ammodytes hexapterus* larvae in bongo tows in spring.

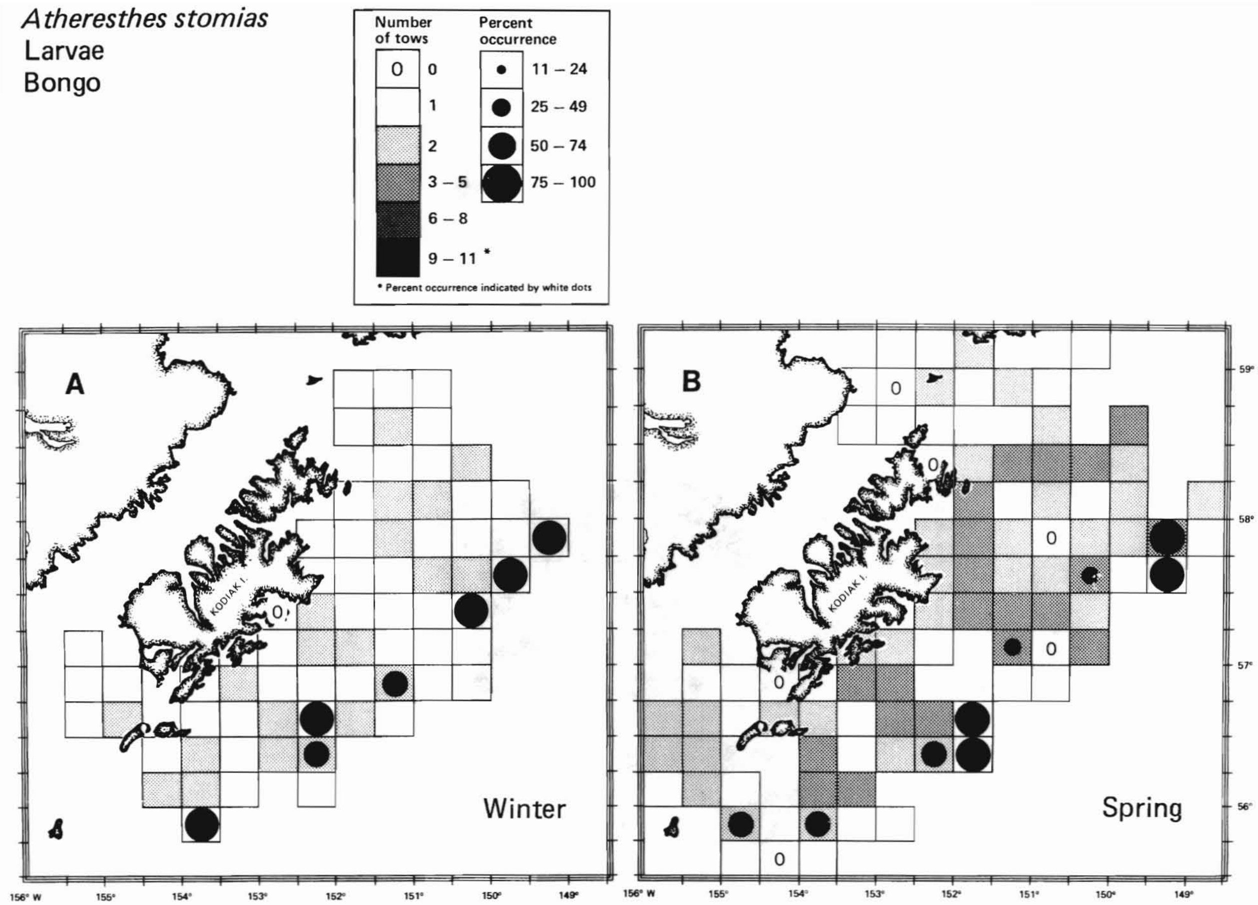


Appendix Figure 66.—Distribution of Pleuronectidae eggs in neuston tows. A. spring and B. summer.

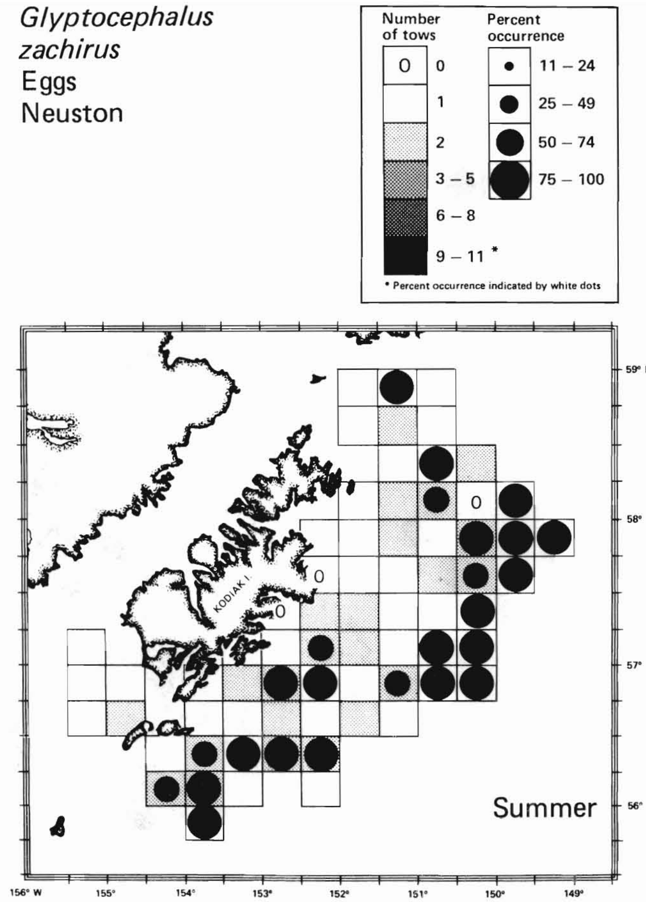
Pleuronectidae
Eggs
Bongo



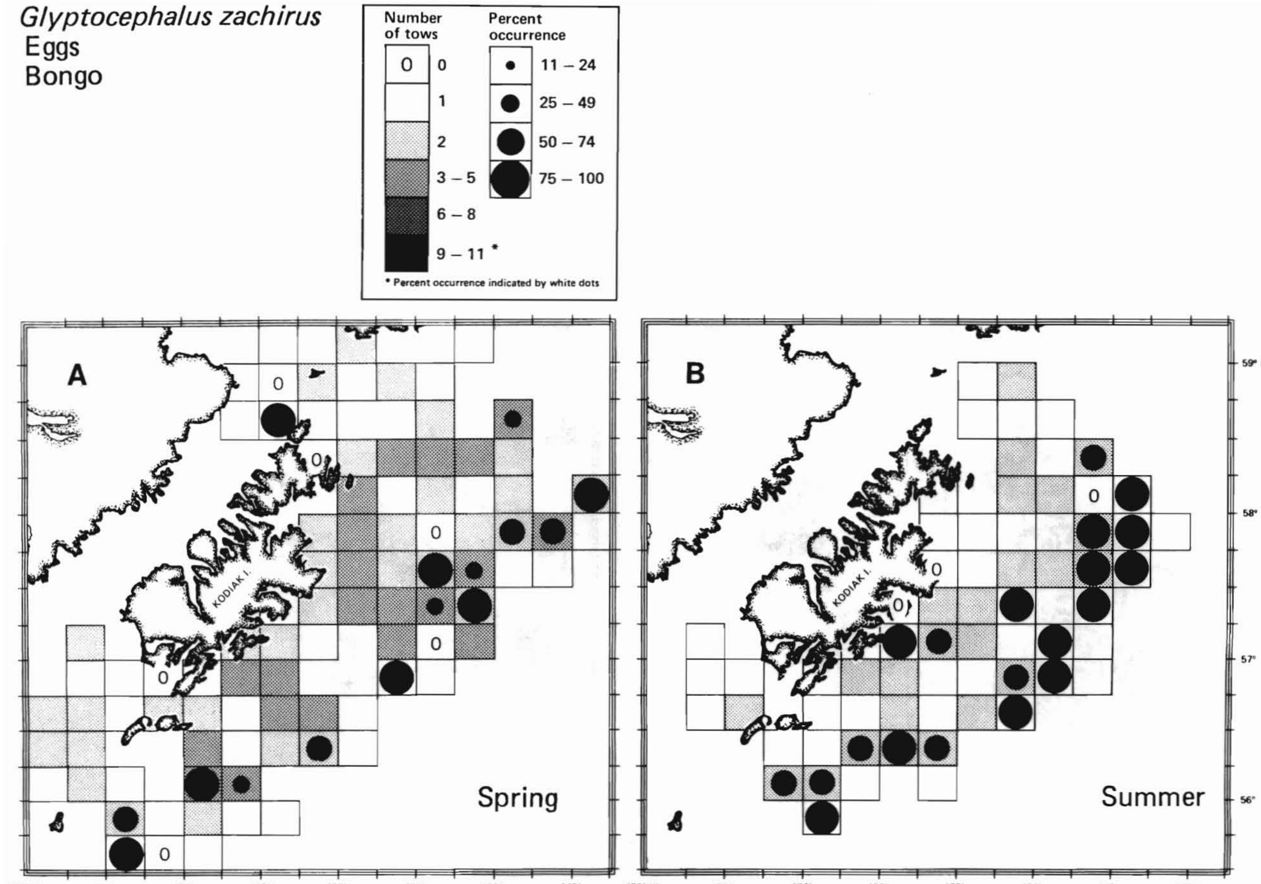
Appendix Figure 67.—Distribution of Pleuronectidae eggs in bongo tows. A. spring and B. summer.



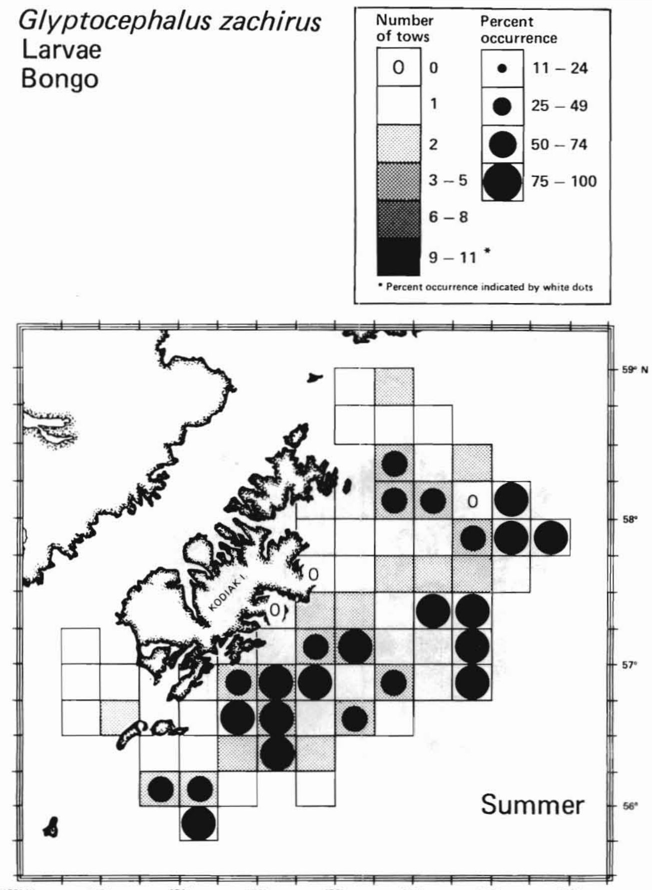
Appendix Figure 68.—Distribution of *Atheresthes stomias* larvae in bongo tows. A. winter and B. spring.



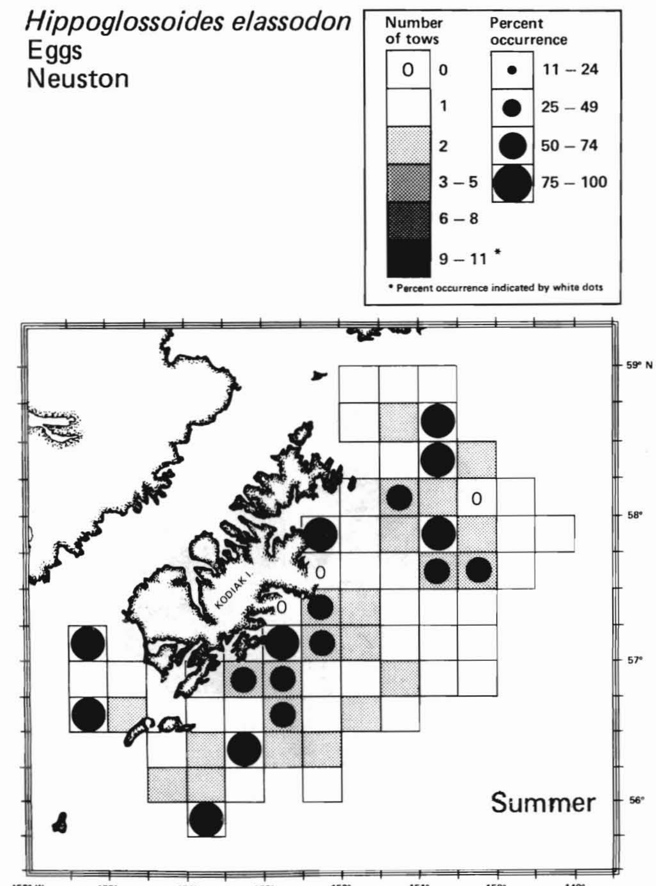
Appendix Figure 69.—Distribution of *Glyptocephalus zachirus* eggs in neuston tows in summer.



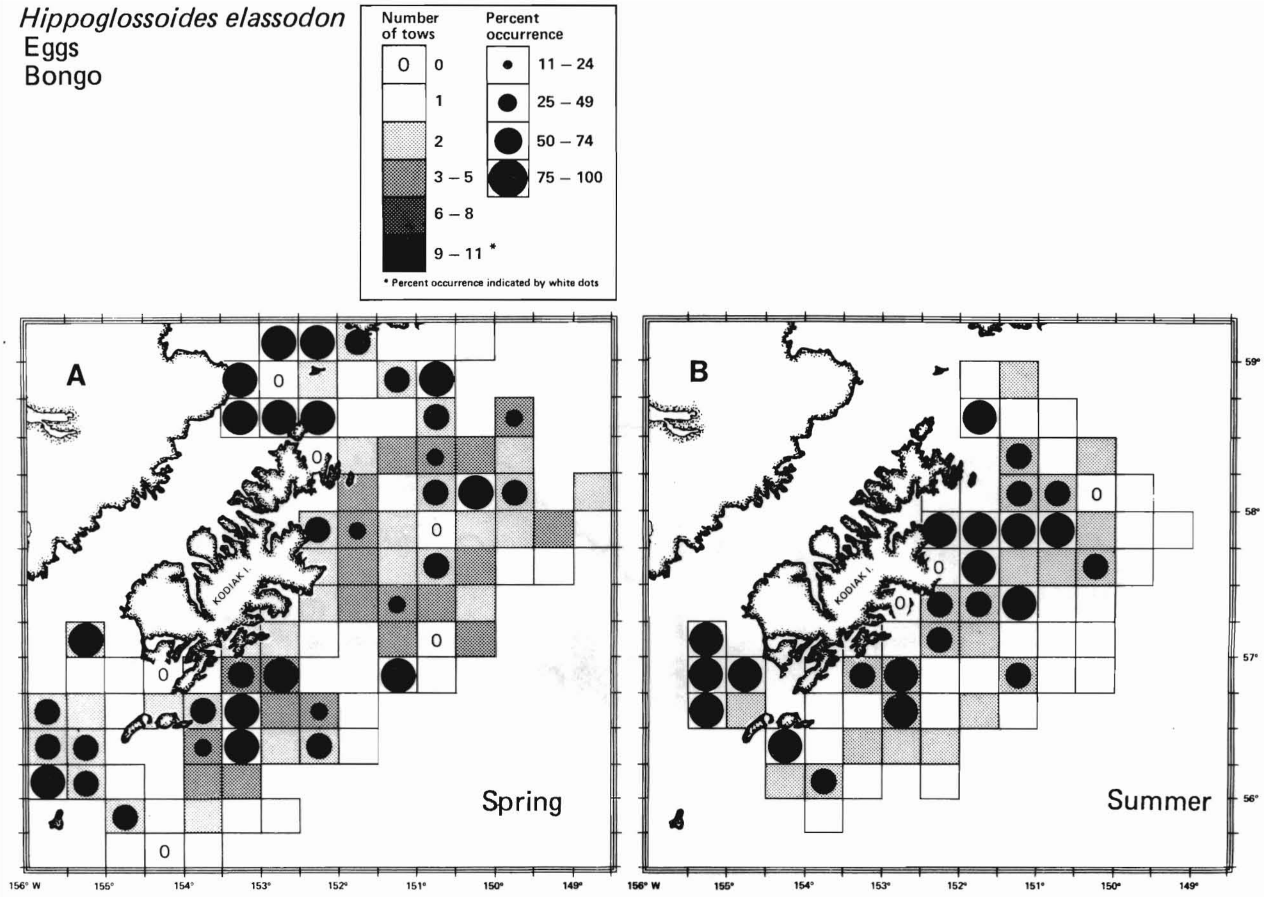
Appendix Figure 70.—Distribution of *Glyptocephalus zachirus* eggs in bongo tows. A. spring and B. summer.



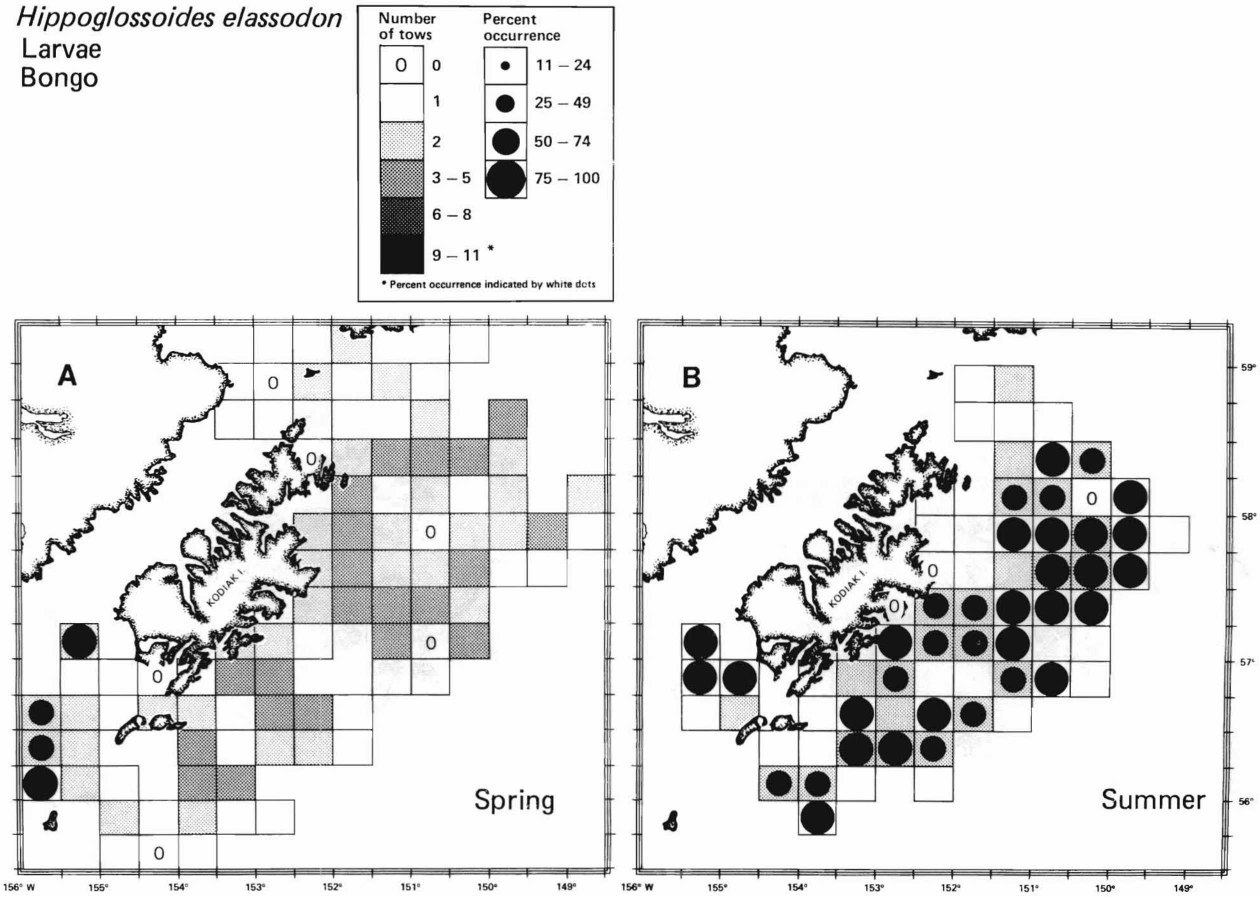
Appendix Figure 71.—Distribution of *Glyptocephalus zachirus* larvae in bongo tows in summer.



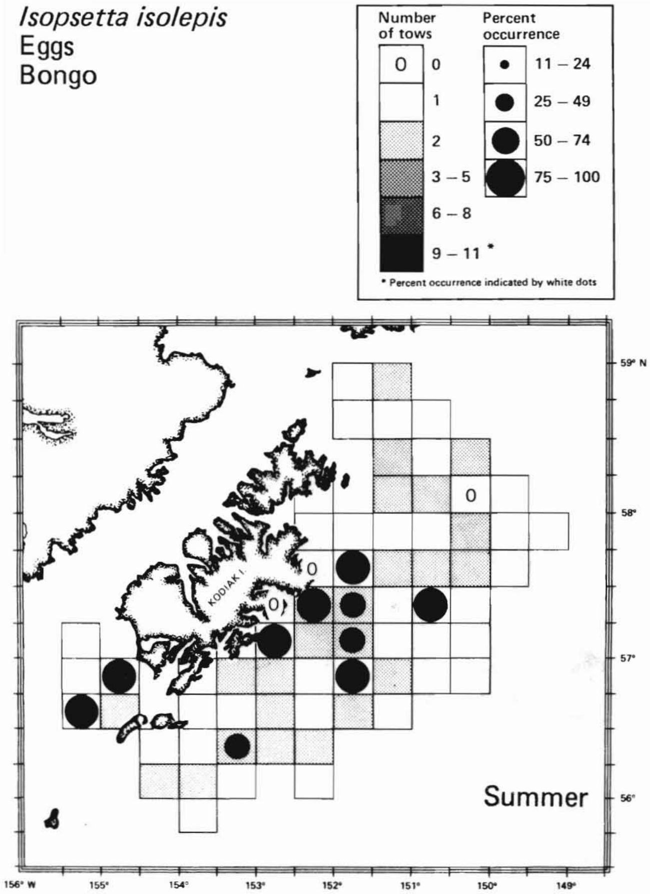
Appendix Figure 72.—Distribution of *Hippoglossoides elassodon* eggs in neuston tows in summer.



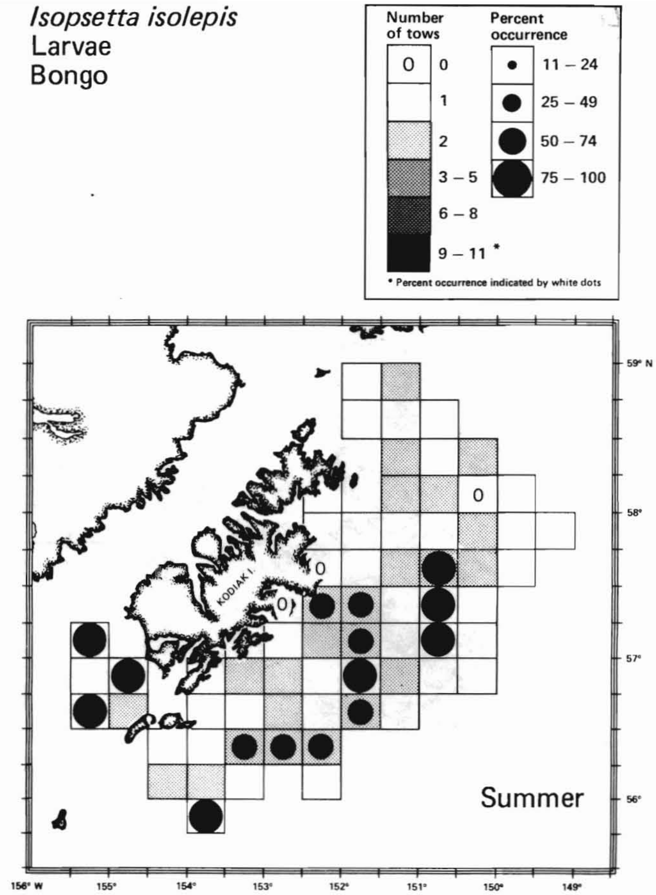
Appendix Figure 73.—Distribution of *Hippoglossoides elassodon* eggs in bongo tows. A. spring and B. summer.



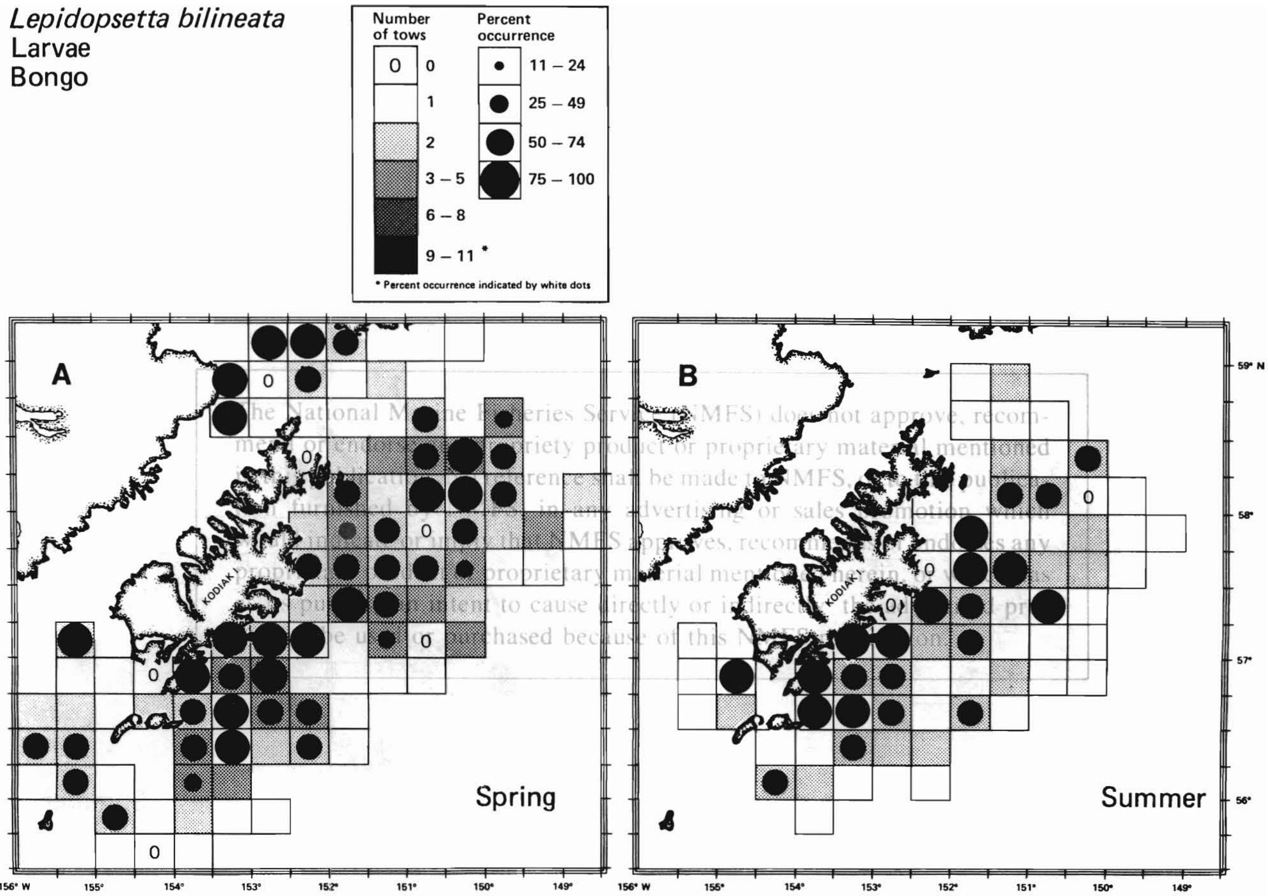
Appendix Figure 74.—Distribution of *Hippoglossoides elassodon* larvae in bongo tows. A. spring and B. summer.



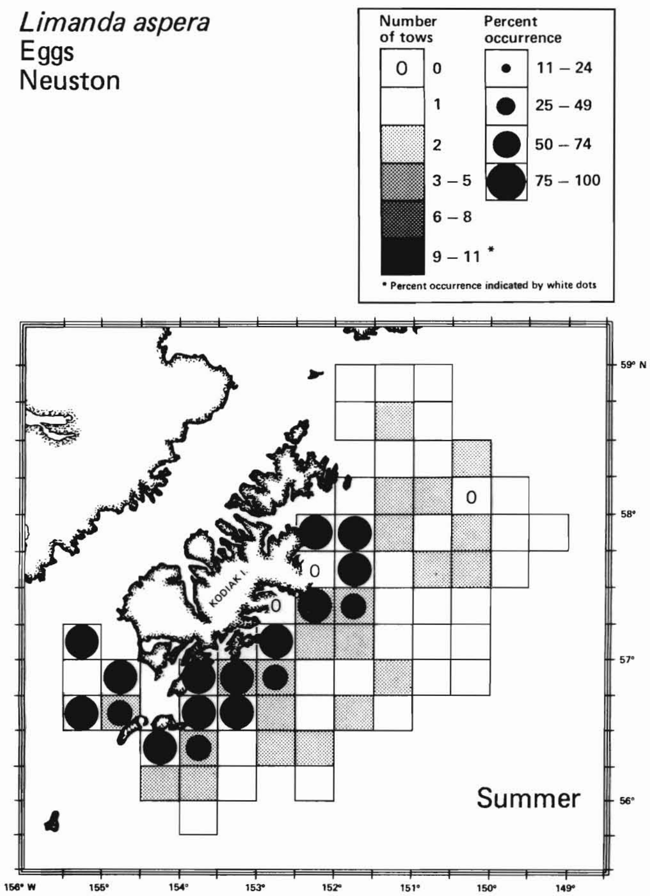
Appendix Figure 75.—Distribution of *Isopsetta isolepis* eggs in bongo tows in summer.



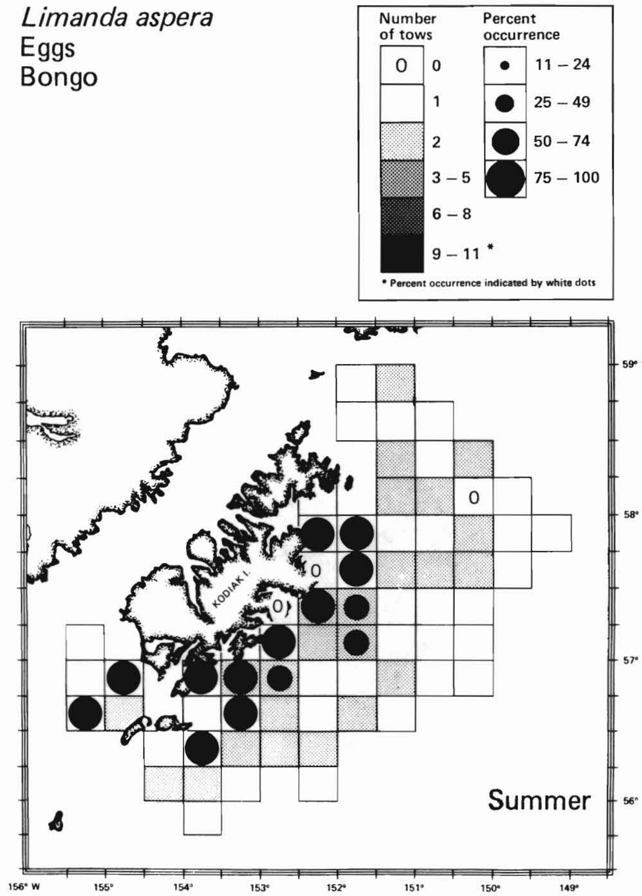
Appendix Figure 76.—Distribution of *Isopsetta isolepis* larvae in bongo tows in summer.



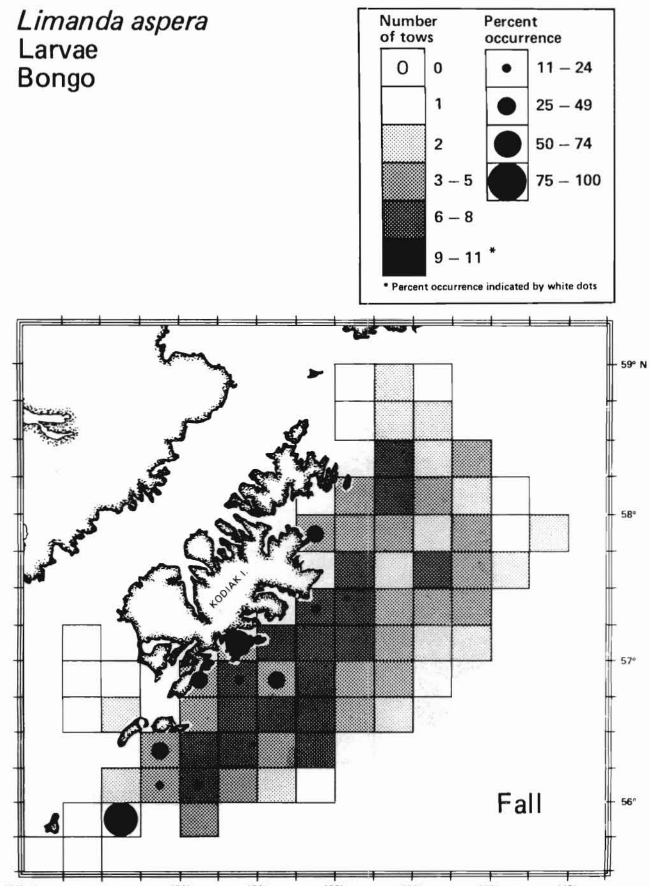
Appendix Figure 77.—Distribution of *Lepidopsetta bilineata* larvae in bongo tows. A. spring and B. summer.



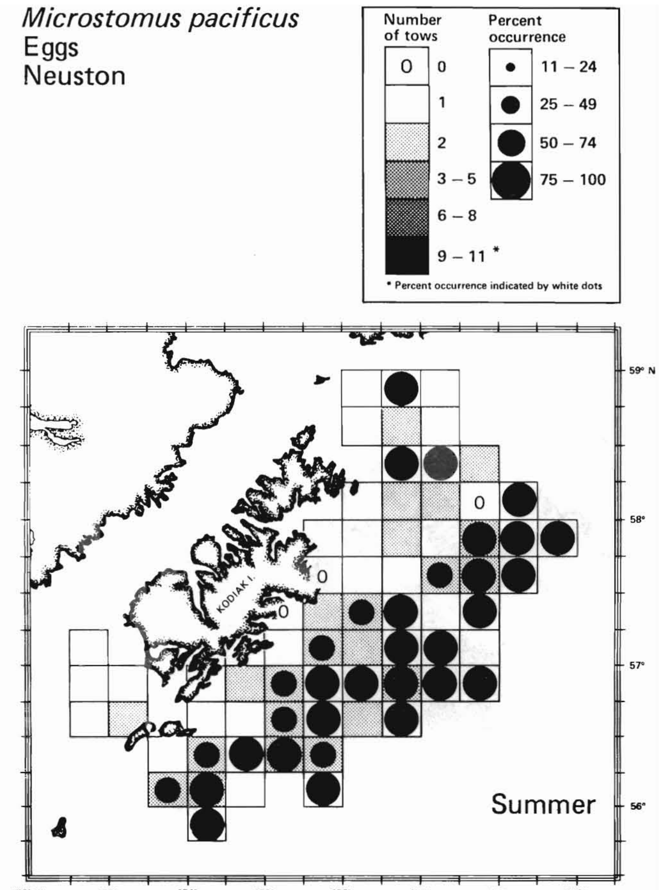
Appendix Figure 78.—Distribution of *Limanda aspera* eggs in neuston tows in summer.



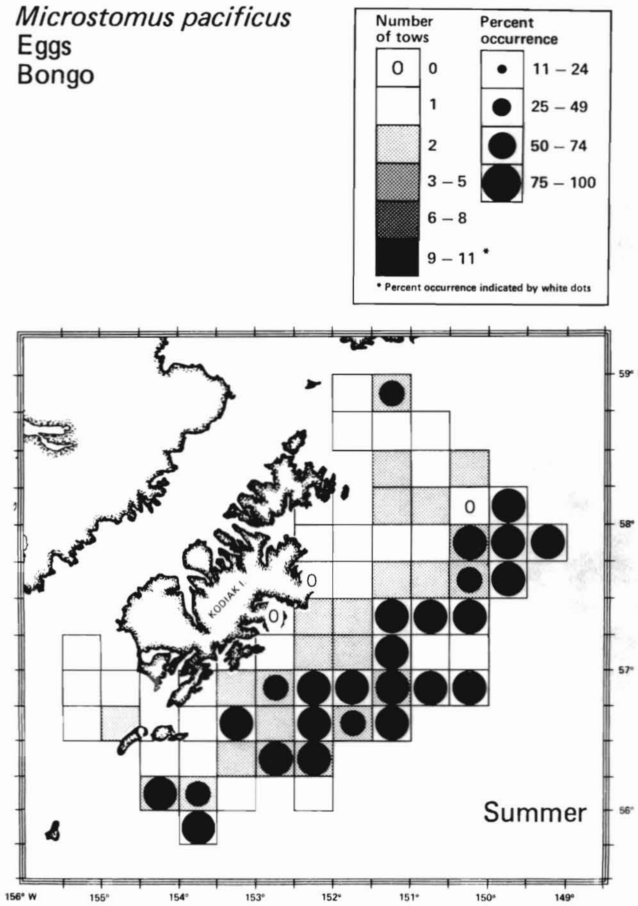
Appendix Figure 79.—Distribution of *Limanda aspera* eggs in bongo tows in summer.



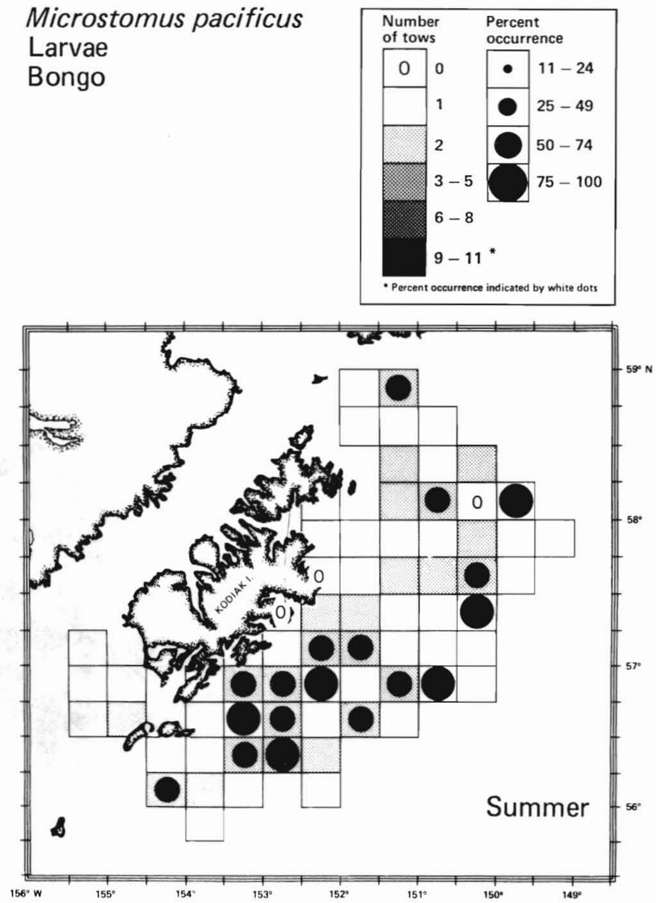
Appendix Figure 80.—Distribution of *Limanda aspera* larvae in bongo tows in fall.



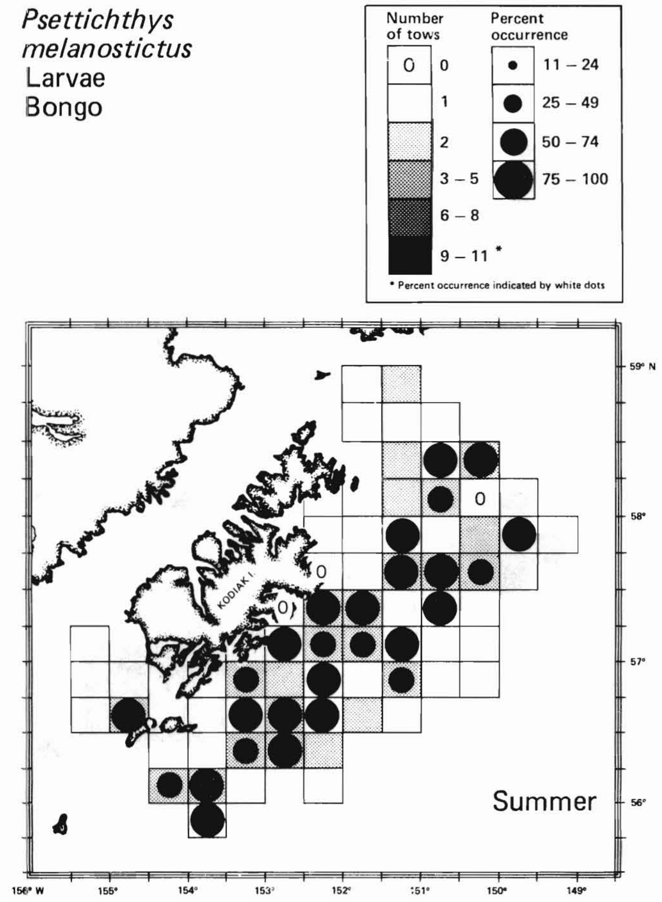
Appendix Figure 81.—Distribution of *Microstomus pacificus* eggs in neuston tows in summer.



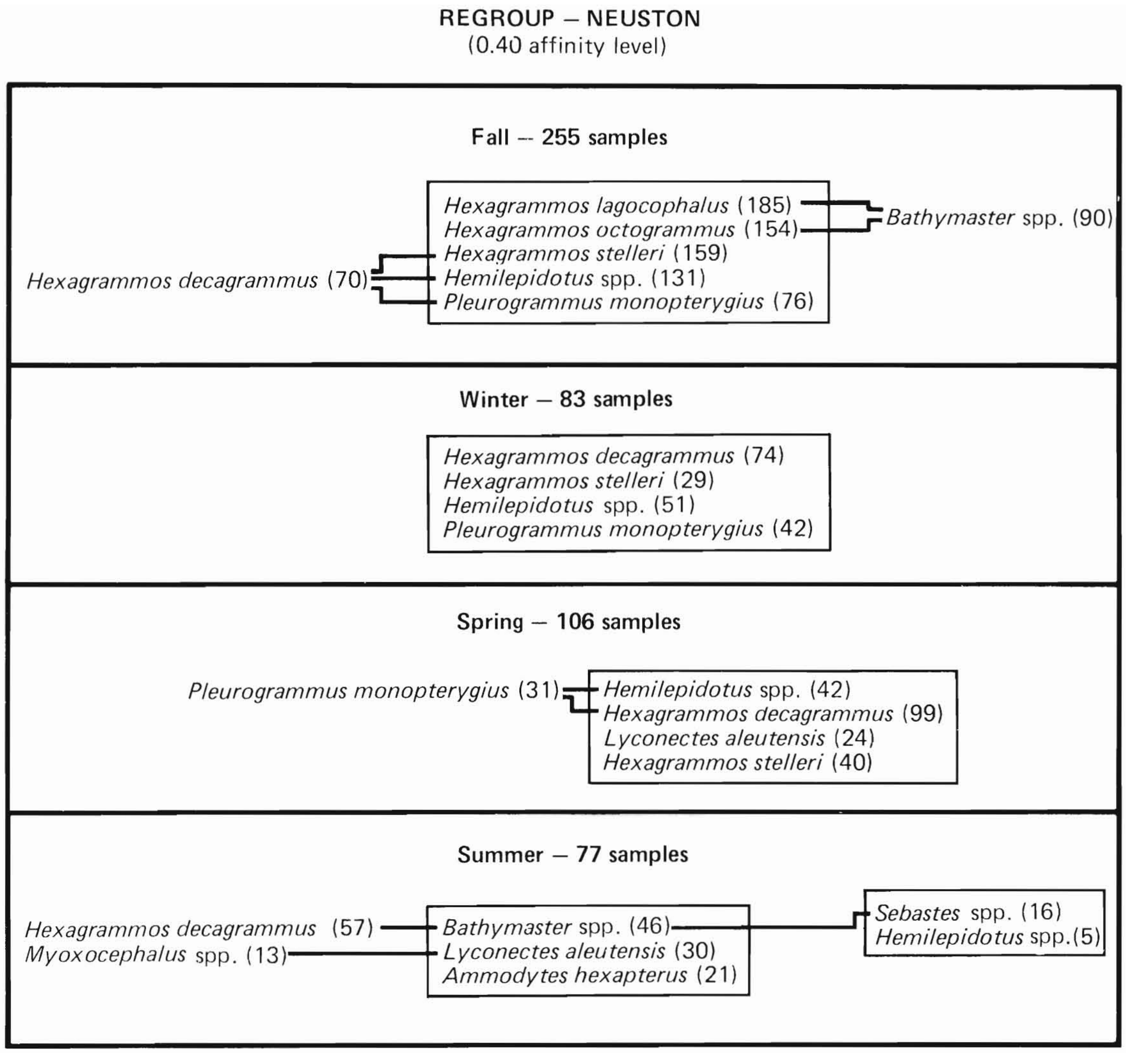
Appendix Figure 82.—Distribution of *Microstomus pacificus* eggs in bongo tows in summer.



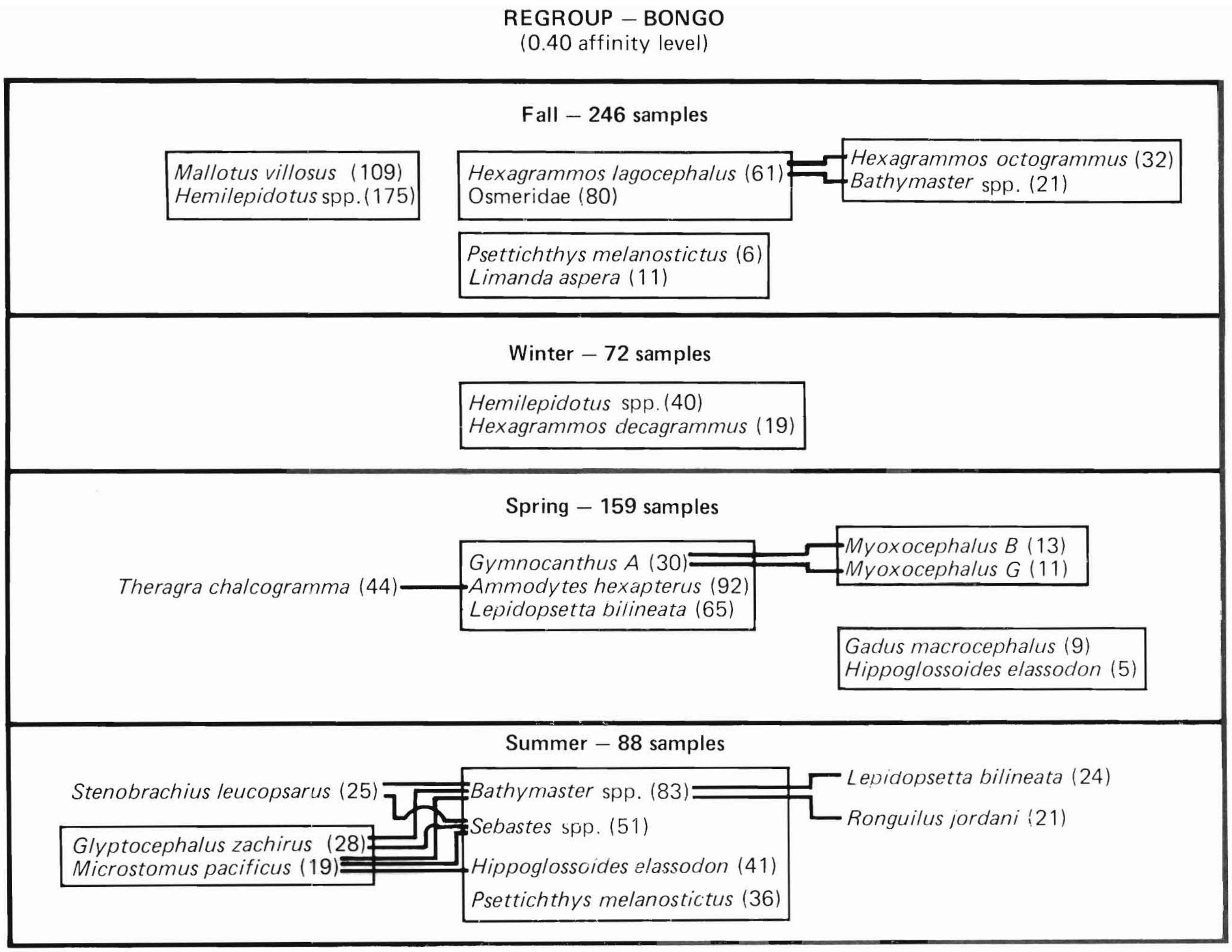
Appendix Figure 83.—Distribution of *Microstomus pacificus* larvae in bongo tows in summer.



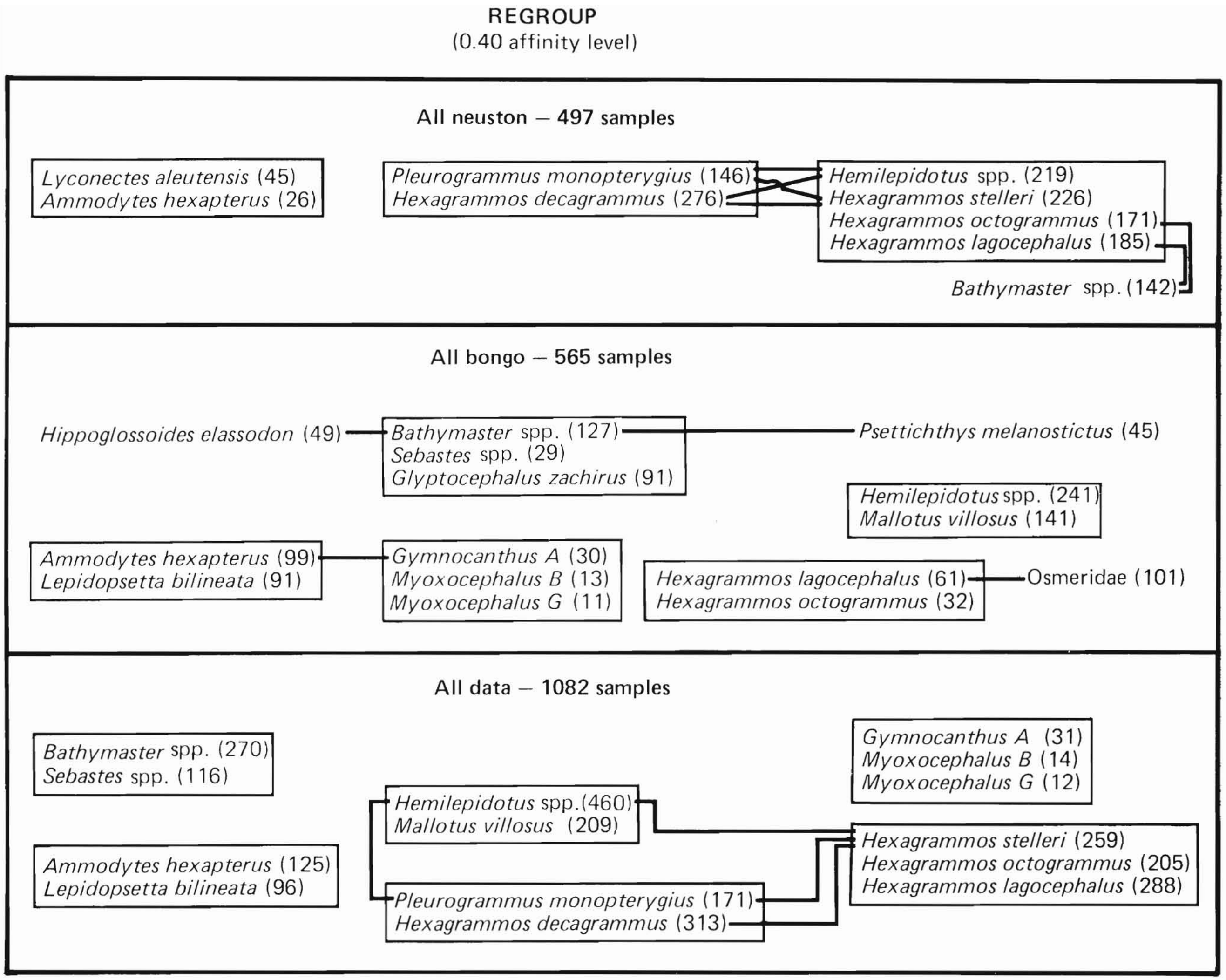
Appendix Figure 84.—Distribution of *Psettichthys melanostictus* larvae in bongo tows in summer.



Appendix Figure 85.—Results of recurrent group analysis of neuston catches by season. Boxes enclose members of recurrent groups. Lines connect taxa with affinities outside their groups. Numbers of occurrences are in parentheses after taxa names.



Appendix Figure 86.—Results of recurrent group analysis of bongo catches by season. Boxes enclose members of recurrent groups. Lines connect taxa with affinities outside their groups. Numbers of occurrences are in parentheses after taxa names.



Appendix Figure 87.—Results of recurrent group analysis of all data, regardless of net or season; all bongo data, regardless of season; and all neuston data, regardless of season. Boxes enclose members of recurrent groups. Lines connect taxa with affinities outside their groups. Numbers of occurrences are in parentheses after taxa names.