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Distribution and abundance of carangid larvae in the southeastern Brazilian Bight during 1975-1981

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• *Abstract*: Distribution and abundance of the carangid larvae collected during ten survey cruises in the southeastern Brazilian Bight were analyzed. *Trachurus lathami* was the most abundant species in the surveyed area with 58.54 % of total carangids taken, followed by *Chloroscombrus chrysurus* with 15.22 % and *Decapterus punctatus* with 12.17 %. Larvae of *T. lathami* and *D. punctatus* were found all over the continental shelf while the distribution of *C. chrysurus* larvae was limited to the coastal region. Most of the species occurred all year-around but remarkably during spring and summer. This intensive spawning period of most carangid species seems to be related to the seasonal variation of the hydrographic structure of the southeastern coast of Brazil.

• *Descriptors:* Carangidae, Ichthyoplankton surveys, Fish larvae, Population number, Seasonal distribution, Abiotic factors, R/V "Prof. W. Besnard", Southeastern Brazilian coast.

• *Descritores*: Carangidae, Levantamentos ictioplanctônicos, Larvas de peixe, Número da população, Distribuição sazonal, Fatores abióticos, N/Oc. "Prof. W. Besnard", Brasil: costa sudeste.

Introduction

Carangid fishes inhabit marine and estuarine waters in tropical, subtropical and temperate regions of the world ocean (Bannikov, 1987). They are active swimmers and live in school or small groups (Berry & Smith-Vaniz, 1978). The group is heterogeneous, including genera of quite different shapes and appearances, from elongated and fusiform to high and laterally compressed body (Ginsburg, 1952). The carangids are constituted by approximately 32 genera and 140 species (Smith-Vaniz, 1984; Gushiken, 1988), from which 15 genera occur in the southeastern Brazilian waters (Menezes & Figueiredo,1980) : *Trachinotus*, *Oligoplites*, *Parona*, *Naucrates*, *Seriola*, *Alectis*, *Caranx*, *Chloroscombrus*, *Decapterus*, *Hemicaranx*, *Pseudocaranx*, *Selar*, *Selene*, *Trachurus*, and *Uraspis*.

Many of them are commercially exploited, specially those of the genera *Trachurus*, *Caranx*, *Decapterus* and *Trachinotus*. Global nominal catches of the carangids in 1987 was about 240.93 thousand tons (FAO, 1989). They are also important for sport fishing (*Seriola* spp.) in California (Sumida *et al.*, 1985) or for fishculture (*Seriola quinqueradiata*) in Japan (Fukuhara, 1987). In the marine ecosystem they are important prey species of many predators such as tunas and tuna-like species (Bailey, 1989; Shaw & Drullinger, 1990).

In Brazilian waters the study on distribution and abundance of carangids is scarce. Menezes & Figueiredo (1980) elaborated an identification manual of marine fishes which includes information of occurrences and distribution of 30 carangid species. Saccardo (1980; 1987) investigated the morphology, reproduction, distribution, and the abundance of *Trachurus lathami* in southern Brazil. Zavala-Camin (1981; 1986) showed occurrences of carangids species in stomach contents of tunas and related species in southern Brazilian waters. Cunha (1987) described the occurrence, distribution, and bioecology of *Trachinotus* species in intertidal zones from Rio Grande do Sul to Espírito Santo. Scorvo-Filho *et al.* (1987) described an occurrence of juveniles *Trachinotus* species

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in the Ubatuba region. Very little is known about egg and larval abundance and distribution patterns of carangids in Brazil with exception the distribution and abundance of *Chloroscombrus chrysurus* larvae along the southern Brazilian coast described by Weiss *et al.* (1976).

Knowledge obtained from ichthyoplankton survey can provide important information about the fishery potential of a species (Richards, 1985). Presence of a large number of eggs and larvae in a certain area indicate the presence of adult schools. Thus, the study of distribution and abundance of eggs and larvae can provide estimate on the fluctuation of adult stocks as well as changes in spawning area and season due to changes in oceanographic conditions (Ciechomski, 1981).

In this paper we present informations on occurrence of carangid larval groups, the seasonal distribution patterns of the most abundant species, and the influence of abiotic factors on them in the southeastern Brazilian Bight.

Material and methods

Surveyed area

The samples of carangid larvae were collected during ten survey cruises carried out in the southeastern Brazilian Bight (SEBB) with the R/V "Prof. W. Besnard" of the Instituto Oceanográfico da Universidade de São Paulo and with the R/V "Cruz del Sur" of PDP-SUDEPE (Table 1). The survey area extended from Cabo Frio (23 °S) to Cabo Santa Marta Grande (29 °S), covering entire continental shelf up to 200 m isobath (Fig. 1). In the cruises 1, 2, 3, 4, 5 and 7, we extended two observation lines for 260 km from the coast in Cabo Frio and in Cabo Santa Marta Grande to cover the main axis of the Brazil Current along the shelf break. In the cruises 10 and 12, the survey area was limited up to the 100 m isobath line on the continental shelf.

Sampling methods

Plankton samples were collected by Bongo nets with digital flowmeters mounted at the center of mouth (Posgay *et al.*, 1968). The sampling method used was that described by Smith & Richardson (1977). Two nets with different mesh sizes (0.333 mm and 0.505 mm) were used, but only the plankton samples collected with the 0.505 mm net were considered in this study. Double oblique hauls were made and sampling depth varied according to station depth, but maximum for 200 m depth. In stations shallower than than 60 m the net was lowered twice close to the bottom to increase the volume of water filtered. The ship speed was maintained in 1.5 to 2.0 knots to keep the wire angle in about 45°. The zooplankton samples collected with the nets were preserved in a buffered formalin 10 % solution.

At each sampling station a routine hydrographic observations were made using the Nansen bottle with reversing thermometers, and temperature and salinity of discrete depth were measured. Temperature and salinity at 10 m depth of each station were considered as representative of the upper mixing layer, where most of fish eggs and larvae were found.

Laboratory procedures

In the laboratory, the zooplankton volume was measured by displacement method (Kramer *et al.*, 1972). All fish eggs and larvae were firstly sorted out from plankton samples using Bogorov plate, and then the larvae were classified into family group. The carangid larvae were identified into species level according to the morphological characters of each species (Katsuragawa, 1990).

Larval abundance was estimated using the following equation:

$$Y = \frac{D \cdot X}{V} \quad ,$$

Table 1. Summary of the oceanographic cruises conducted between 1975 and 1981 in the southeastern Brazilian Bight

CRUISES	DATES	VESSEL	No. OF STATIONS	SAMPLING AREA
FINEP 1	NOV-DEC/1975	R/V "Prof. W. Besnard"	140	Cabo Frio (RJ) - Cabo de Santa Marta Grande (SC)
FINEP 2	JAN/1976	R/V "Prof. W. Besnard"	140	Cabo Frio (RJ) - Cabo de Santa Marta Grande (SC)
FINEP 3	MAY/1976	R/V "Prof. W. Besnard"	140	Cabo Frio (RJ) - Cabo de Santa Marta Grande (SC)
FINEP 4	SEP-OCT/1976	R/V "Prof. W. Besnard"	140	Cabo Frio (RJ) - Cabo de Santa Marta Grande (SC)
FINEP 5	DEC/1976	R/V "Prof. W. Besnard"	140	Cabo Frio (RJ) - Cabo de Santa Marta Grande (SC)
FINEP 6	JAN-FEB/1977	R/V "Prof. W. Besnard"	112	Cabo Frio (RJ) - S. Francisco do Sul (SC)
FINEP 7	JAN/1978	R/V "Prof. W. Besnard"	134	Cabo Frio (RJ) - Cabo de Santa Marta Grande (SC)
FINEP 10	JAN-FEB/1979	R/V "Cruz del Sur"	90	Cabo de S. Tomé (RJ) - Cananéia (SP)
FINEP 11	JAN/1980	R/V "Prof. W. Besnard"	42	Cabo Frio (RJ) - Florianópolis (SC)
FINEP 12	JAN/1981	R/V "Prof. W. Besnard"	46	Cabo Frio (RJ) - Florianópolis (SC)

where Y = number of larvae per square meter of sea surface, D = maximum sampling depth (m), X = number of fish larvae taken, and V = volume of water filtered (m^3). But, V = a.n.c, where a = area of mouth opening (0.2827 m^2), n = number of rotations of flowmeter and c = calibration factor of flowmeter.

Results

Table 2 shows the number of carangid larvae and juveniles collected during ten survey cruises in the southeastern Brazilian Bight. Five taxon were identified at species level (*Trachurus lathami*, *Chloroscombrus chrysurus*, *Decapterus punctatus*, *Selene setapinnis* and *Selene vomer*) and four at genus level (*Oligoplites*, *Caranx*, *Seriola* and *Trachinotus*). From a total of 12,600 carangids, *Trachurus lathami*, *Chloroscombrus chrysurus* and *Decapterus punctatus* were predominant, representing 83.9 %. Eleven percent of larvae and juveniles were not identified to any taxon.

Rough scad, *Trachurus lathami*

Larvae and juveniles of rough scad, *T. lathami*, were the most abundant (58.5 %) among all carangids studied in this report. The distribution of this species extended from the coast (16 m depth) to the shelf break, covering the entire continental shelf (Fig. 2). However, we can notice that the highest density of larvae (more than 20 larvae m^2) was localized in the neritic region. A relation between the occurrence and station depth showed that 64.5 % of positive stations and 85.5 % of *T. lathami* larvae were found in the 40-100 m depth zone (Fig. 4a). Occurrence of larvae and juveniles in waters off the continental shelf was rare. A similar tendency was observed for other carangid larvae.

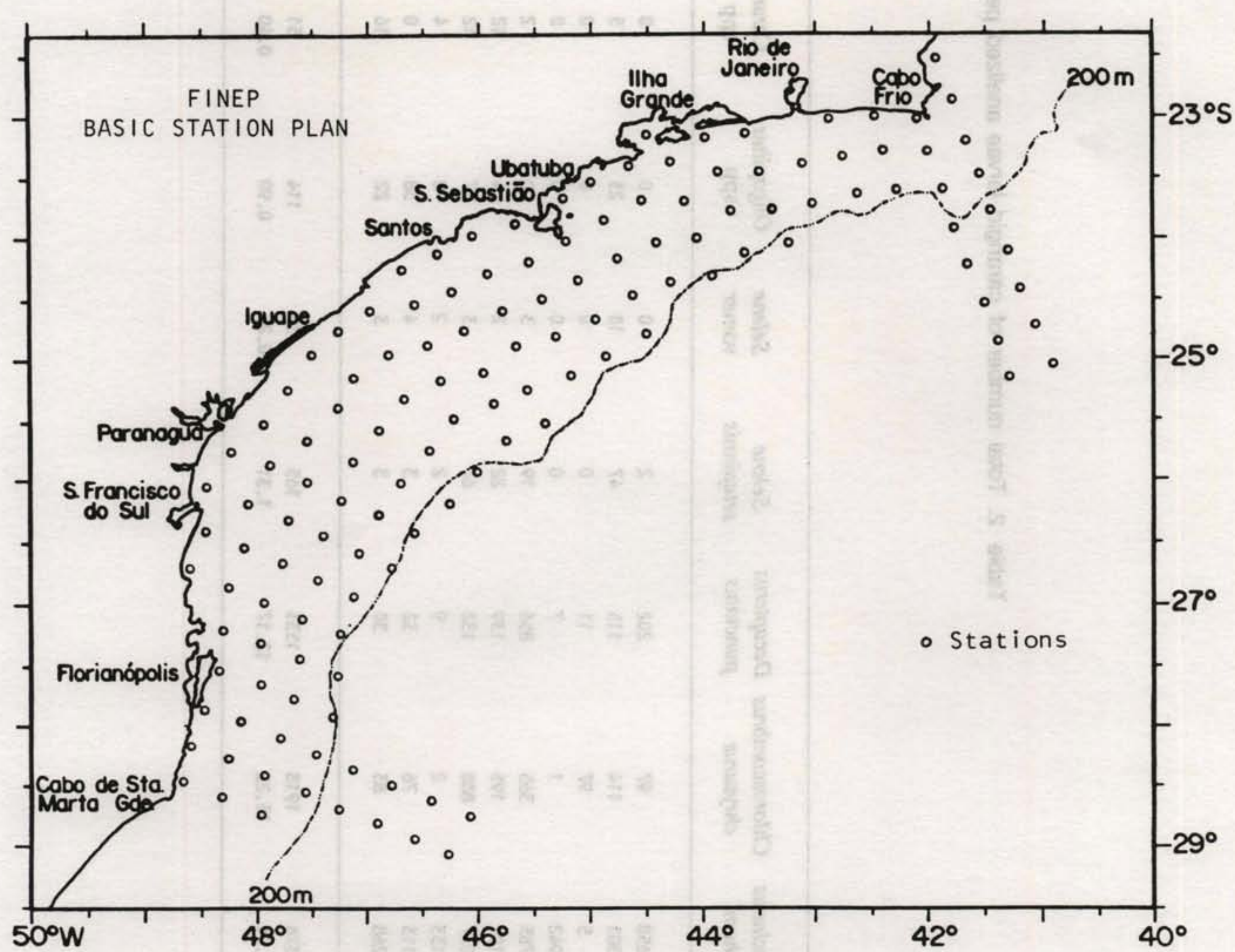


Fig. 1. FINEP basic station plan, ranging from Cabo Frio (23°S) to Cabo de Santa Marta Grande (29°S) in the southeastern Brazilian Bight.

Table 2. Total number of carangid larvae analized per cruize

CRUISES	*Trachurus lathami*	*Chloroscombrus chrysurus*	*Decapterus punctatus*	*Selene setapinnis*	*Selene vomer*	*Oligoplites* spp	*Caranx* spp	*Seriola* spp	*Trachinotus* spp	Others carangids	TOTAL
FINEP 1	658	97	202	2	0	0	0	0	1	459	1446
FINEP 2	301	114	115	47	18	23	5	1	0	153	777
FINEP 3	5	97	11	0	0	0	0	0	0	21	134
FINEP 4	3942	1	7	0	0	0	0	2	0	123	4075
FINEP 5	785	365	856	19	3	0	2	0	0	206	2236
FINEP 6	107	195	139	22	2	4	12	0	0	145	626
FINEP 7	1037	888	132	67	3	27	12	0	0	199	2365
FINEP 10	133	2	9	2	2	0	4	0	0	1	153
FINEP 11	113	76	32	3	4	38	0	2	0	20	288
FINEP 12	268	83	30	3	3	22	16	0	0	75	500
TOTAL	7376	1918	1533	165	35	114	51	5	1	1402	12600
% TOTAL	58.54	15.22	12.17	1.31	0.28	0.90	0.40	0.04	0.01	11.13	

In November-December 1975 two large concentrations of larvae were found: one near Florianópolis and another in São Sebastião-Ubatuba region (Fig.2a). In January 1976 only one large concentration was found along Ilha Grande coast. In May 1976 no large aggregation was found, and the distribution was restricted to small number of larvae in the region between Santos and São Francisco do Sul (Fig. 2c).

In the early spring cruise (Sep-Oct. 1976) four large concentrations of larvae were found along the coast from São Sebastião to Cabo Santa Marta Grande and the abundance of *T. lathami* larvae was the largest of the ten cruises (Fig. 2d). In the following cruise (Dec. 1976) total abundance decreased and two areas of larval concentration were found: one in northeast of Florianópolis and another along Ilha Grande coast (Fig. 2e). During the cruise of January-February 1977 no large concentration was recorded. Only small numbers of larvae were found over the continental shelf. In January 1978 a large concentration of larvae was recorded along the coast of Ilha Grande, but no significant number of larvae was found in southern part of the surveyed area (Fig. 2g).

For the last three cruises conducted in January-February 1979, January 1980, and January 1981, only the area inside the 100 m isobath line has been investigated. In January-February 1979 (Fig. 2h) no large concentration was observed but larvae were present in all surveyed area. In January 1980 the number of positive stations decreased further and a large amount of larvae were found along the coast of Rio de Janeiro State (Fig. 2i). In 1981 the distribution pattern of larvae was similar to that observed in 1979 but a large concentration of larvae was found in front of Rio de Janeiro in offshore waters (Fig. 2j).

T. lathami larvae were found in a wide temperature range between 11.5 °C and 27.5 °C (Fig. 3a), the mean temperature at 10 m depth of all positive stations was 22.2 °C (s = 2.67). The majority of positive stations (85.8%) and of the total catch (94%) were observed within the temperature range of 18-25 °C. The salinity at 10 m depth of all positive stations varied from 32.86 to 37.67 psu but 88.2 % of positive stations and 95.9 % of larvae were found in salinity range of 33.5-36.0 psu.

Atlantic bumper, *Chloroscombrus chrysurus*

The atlantic bumper, *Chloroscombrus chrysurus*, was the second most abundant species representing 15.5 % of all carangids collected (Table 2). Larvae of this species were found in all cruises but their distribution was limited exclusively to coastal stations (Fig. 5). They were collected at depth range from 15 to 75 m (Fig. 4b) and mean depth of all positive stations was 31.5 m (s = 14.9). Most of positive stations were found in the 15-30 m depth zone, in which 92.3 % of larvae were collected. Only 1.4 % of larvae were found in stations with more than 50 m.

Distribution of *C. chrysurus* larvae extended from Cabo Frio to Florianópolis with large variation in distribution patterns among different cruises (Fig. 5). *C. chrysurus* larvae were found mainly in the coastal stations between São Sebastião and São Francisco do Sul in all late-spring and summer cruises. Exceptions to this pattern occurred in both January 1976, when the occurrence extended further north, and Jan-Feb. 1979, when no significant occurrence was found. In autumn (May 1976) the larval distribution was limited to the coastal region between Cabo Frio and Paranaguá. In September-October 1976 only one positive station was found close to Rio de Janeiro, indicating that no significant spawning activities were going on during late spring and summer that year.

Temperature variation in positive stations of *C. chrysurus* was between 16.1 and 28.7 °C with mean temperature of 24.8 °C (s = 2.10). Most of positive stations had temperature higher than 22°C, 73.9 % of them were found between 24° and 27 °C, in which 90.0 % of larvae were taken (Fig. 3b). This result shows a slightly higher temperature range of this species in relation to *T. lathami*.

Salinity variation was between 32.75 and 36.89 psu with mean salinity of 34.70 psu (s = 0.92). Most positive stations stayed between 33.50 and 36.00 psu, in which 86.5 % of larvae were taken (Fig. 3b).

Round scad, *Decapterus punctatus*

Decapterus punctatus was also abundant and accounted for 12.2 % of total carangids collected (Table 2). This species showed a wide distribution over the continental shelf, similar to that observed for *T. lathami*, but including some positive stations out of shelf break off Cabo Frio. Occurrence of positive stations was concentrated in depth zone between 20 m and 60 m, in which 94.4 % of larvae were taken (Fig. 4c).

The occurrence of *Decapterus punctatus* larvae showed a large variation in terms of abundance and horizontal distribution (Fig. 5). They were more abundant during austral summer (from December to February) cruises and less abundant in autumn and early spring cruises. Their horizontal distribution patterns during late-spring and summer cruises were similar to those observed for *T. lathami*, but more sporadic over the continental shelf. *D. punctatus* larvae were always abundant in coastal areas off Paranaguá during eight summer cruises. They were also found in coastal areas off Santos and São Sebastião. The largest concentration of *D. punctatus* larvae was observed in coastal areas off Paranaguá between Santos and São Francisco do Sul in December 1976.

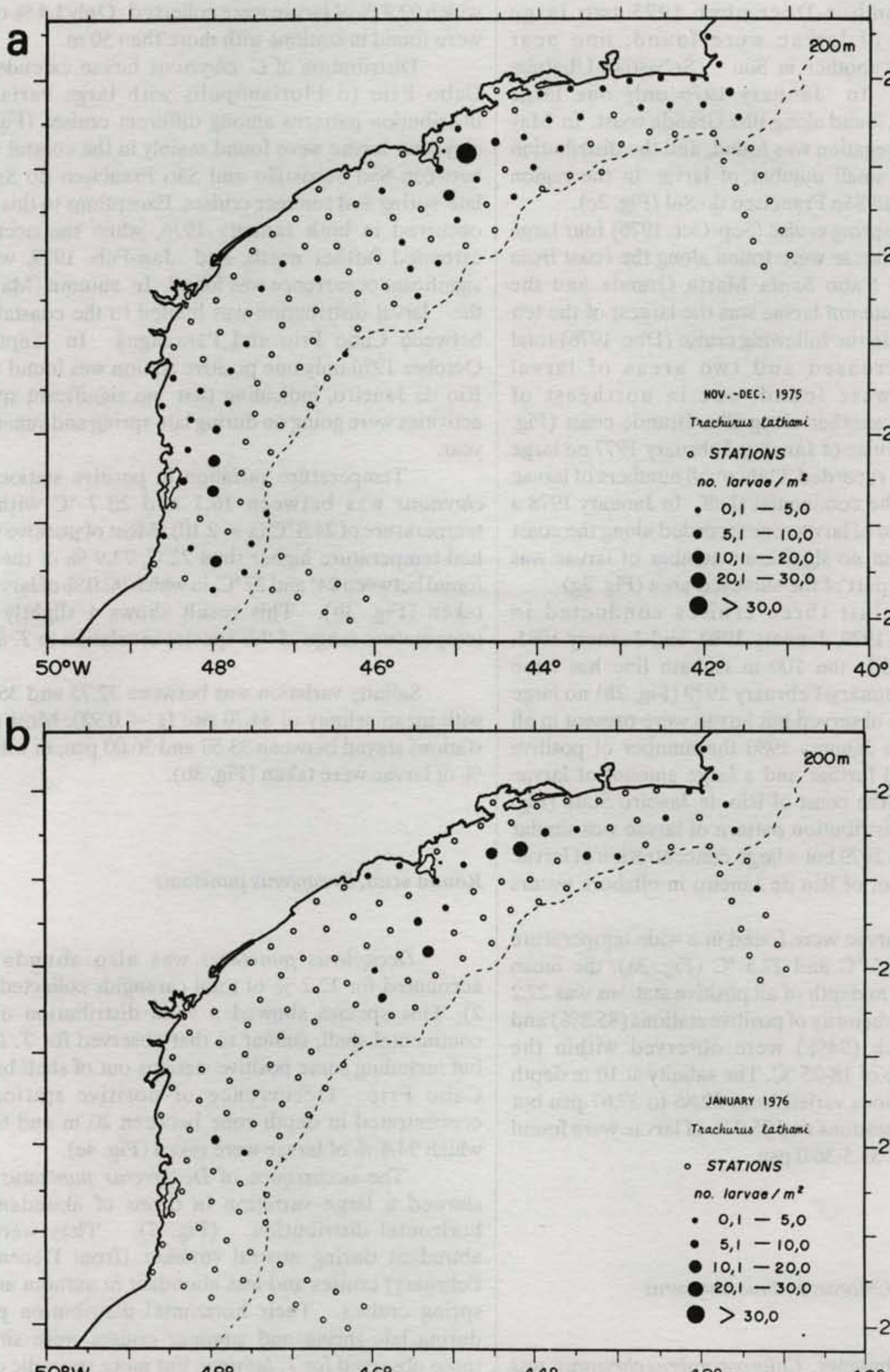
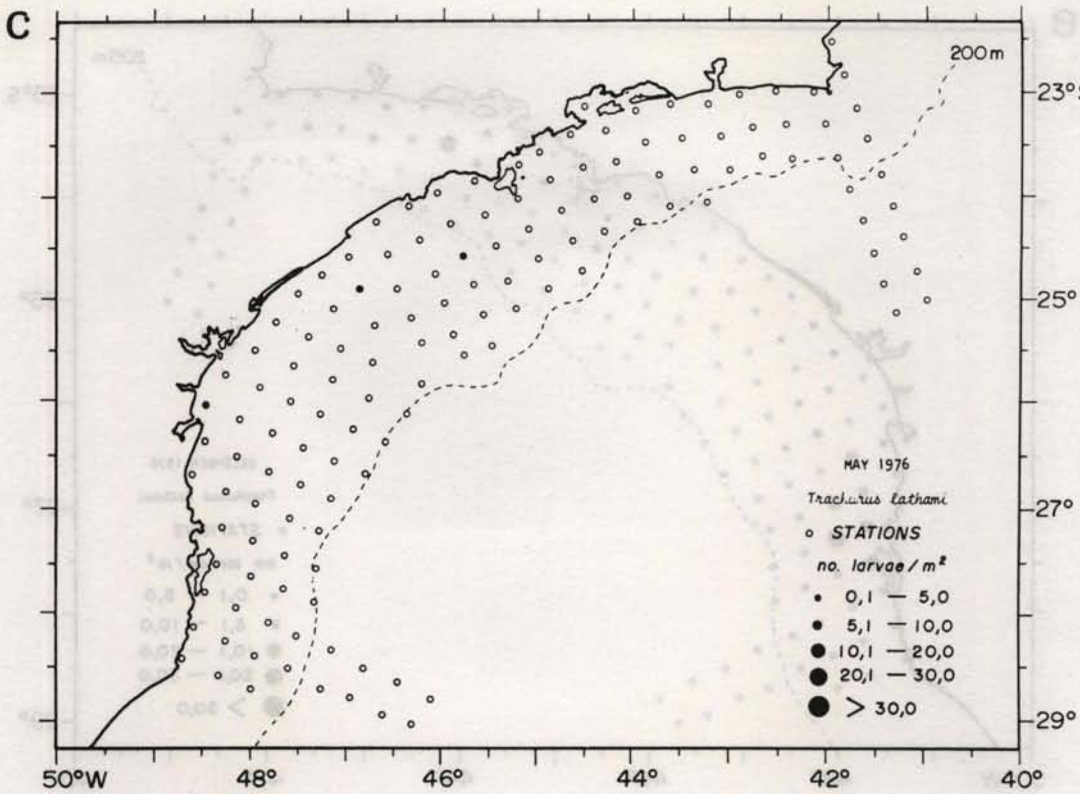


Fig. 2. Distribution and abundance (no. of larvae/m^2) of *Trachurus lathami* larvae. a) November and December 1975; b) January 1976.



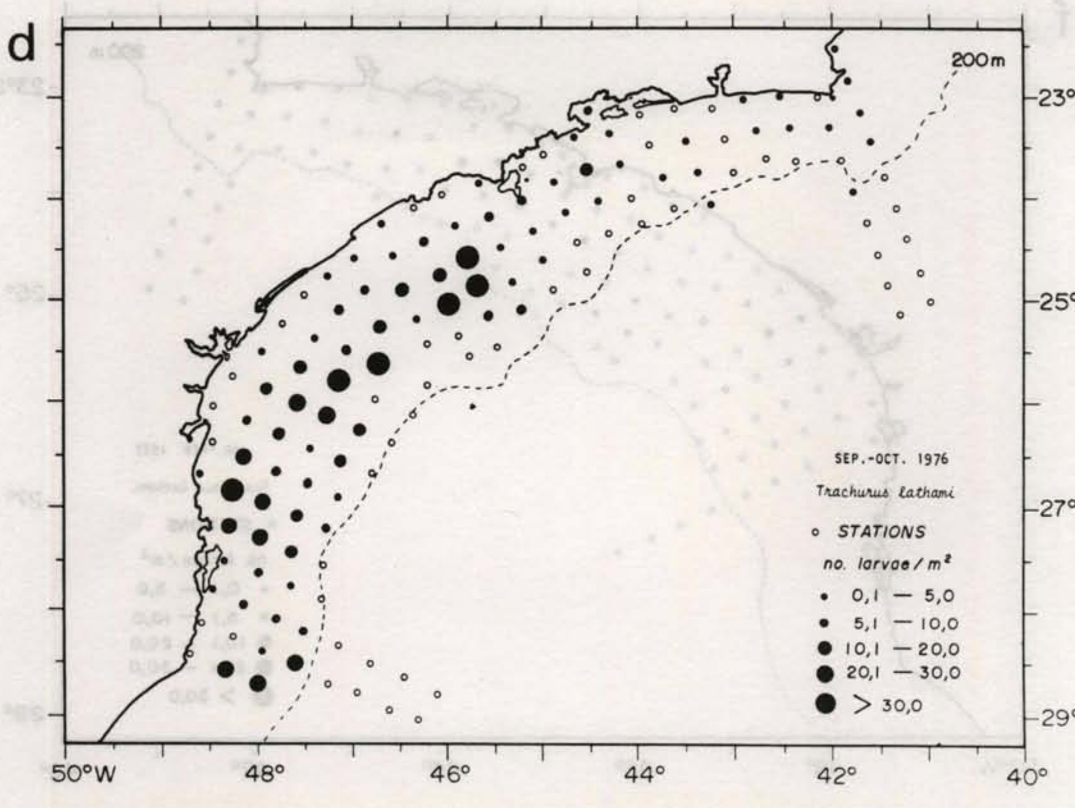
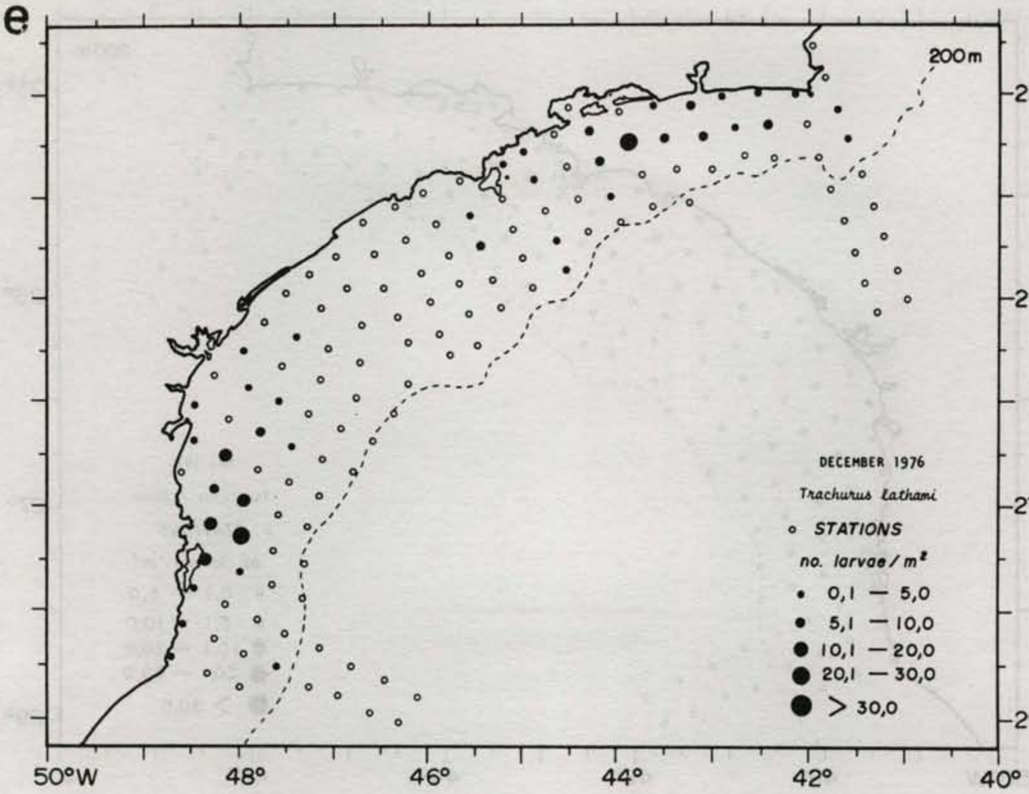


Fig. 2. Distribution and abundance (no. of larvae/m²) of *Trachurus lathami* larvae. c) May 1976; d) September and October 1976.



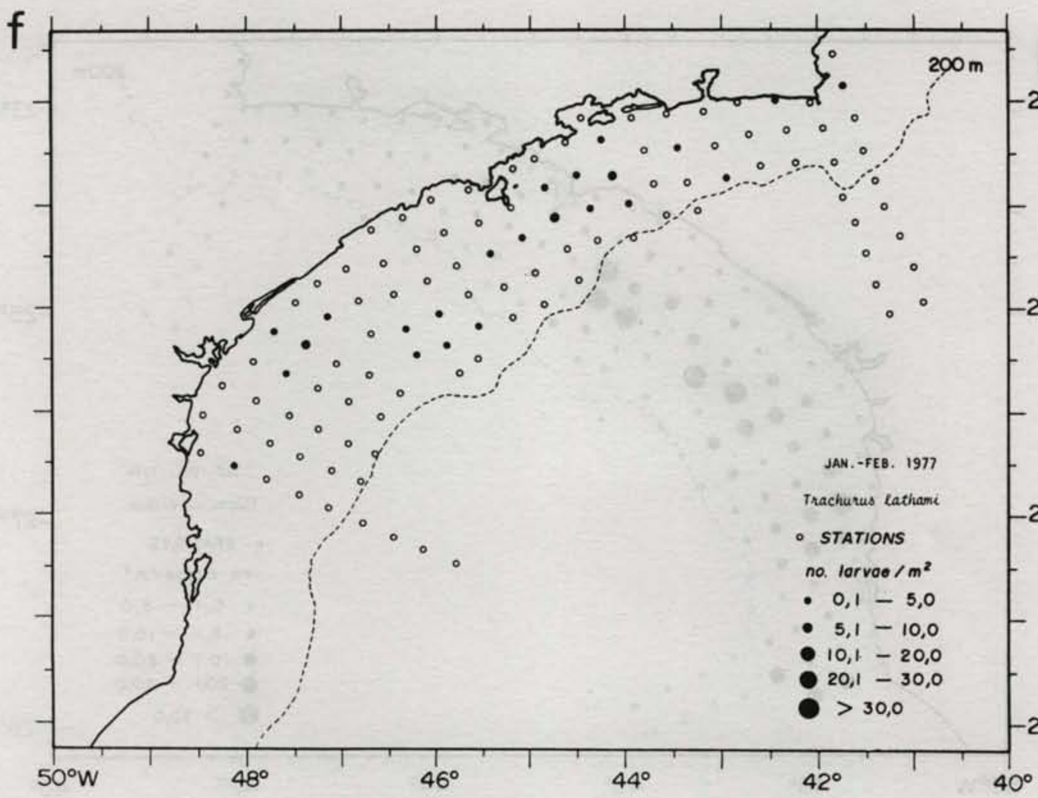
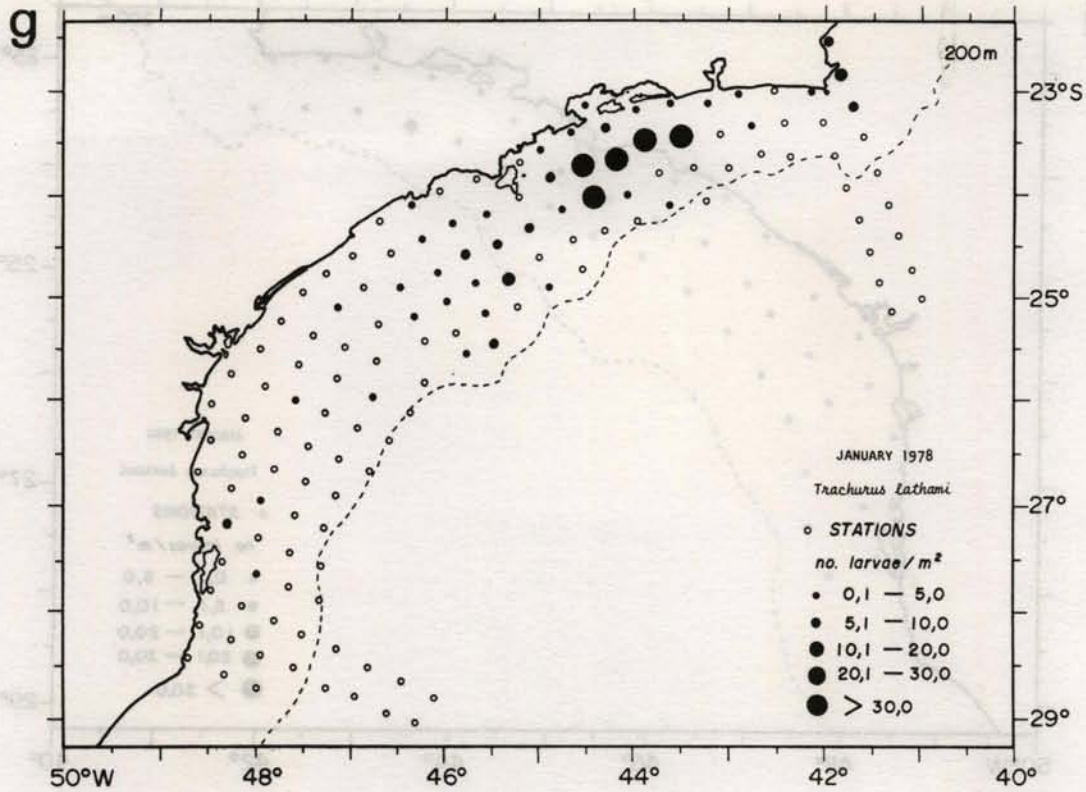


Fig. 2. Distribution and abundance (no. of larvae/m^2) of *Trachurus lathami* larvae. e) December 1976; f) January and February 1977.



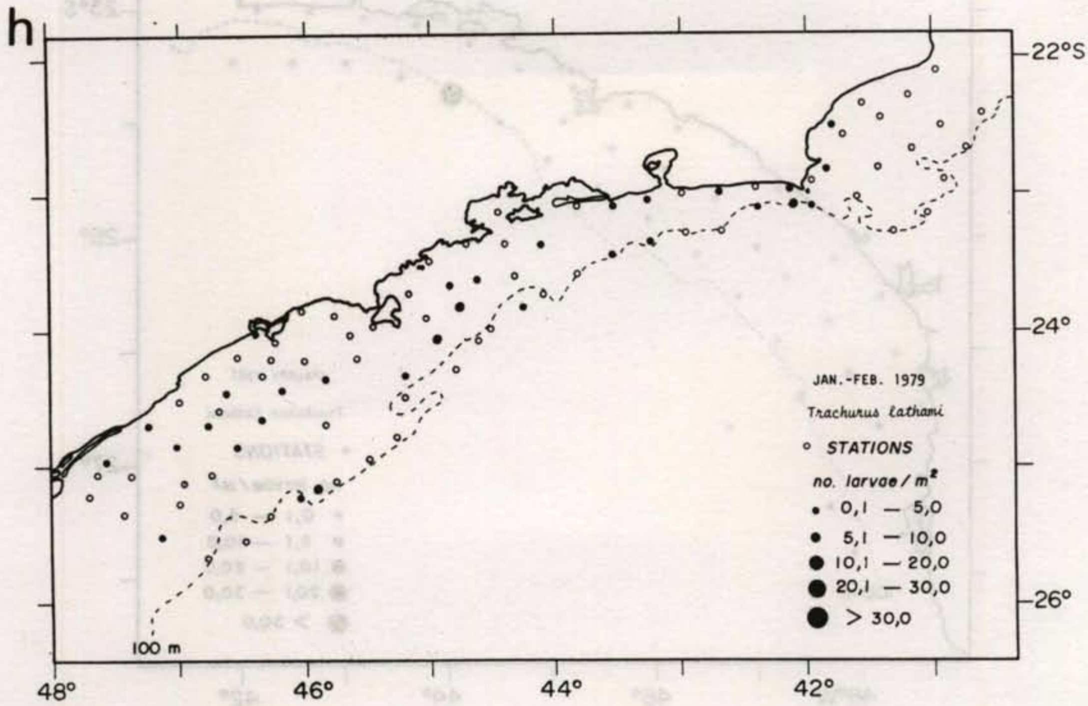


Fig. 2. Distribution and abundance (no. of larvae/m^2) of *Trachurus lathami* larvae. g) January 1978; h) January and February 1979.

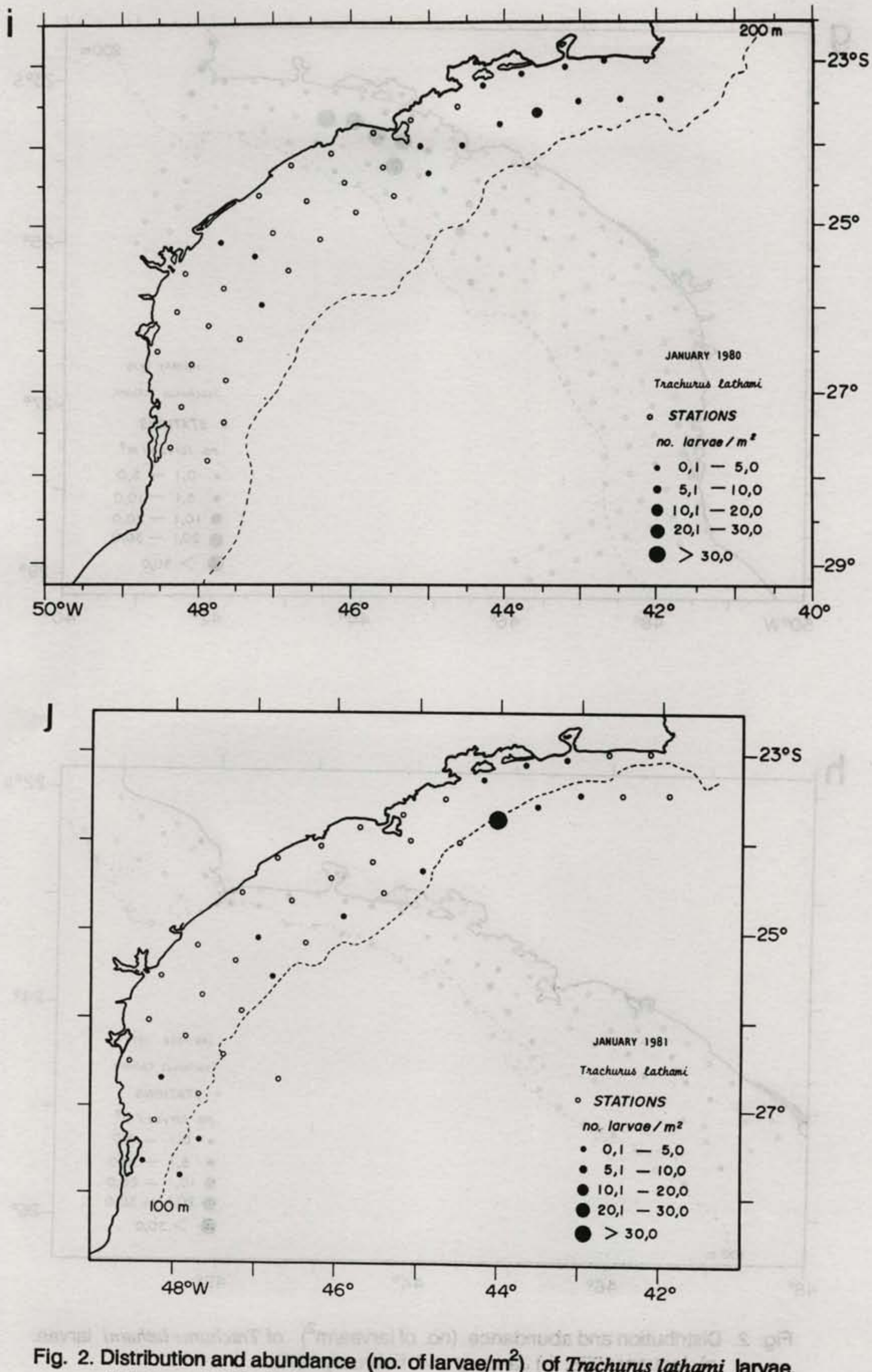


Fig. 2. Distribution and abundance (no. of larvae/m^2) of *Trachurus lathami* larvae. i) January 1980; j) January 1981.

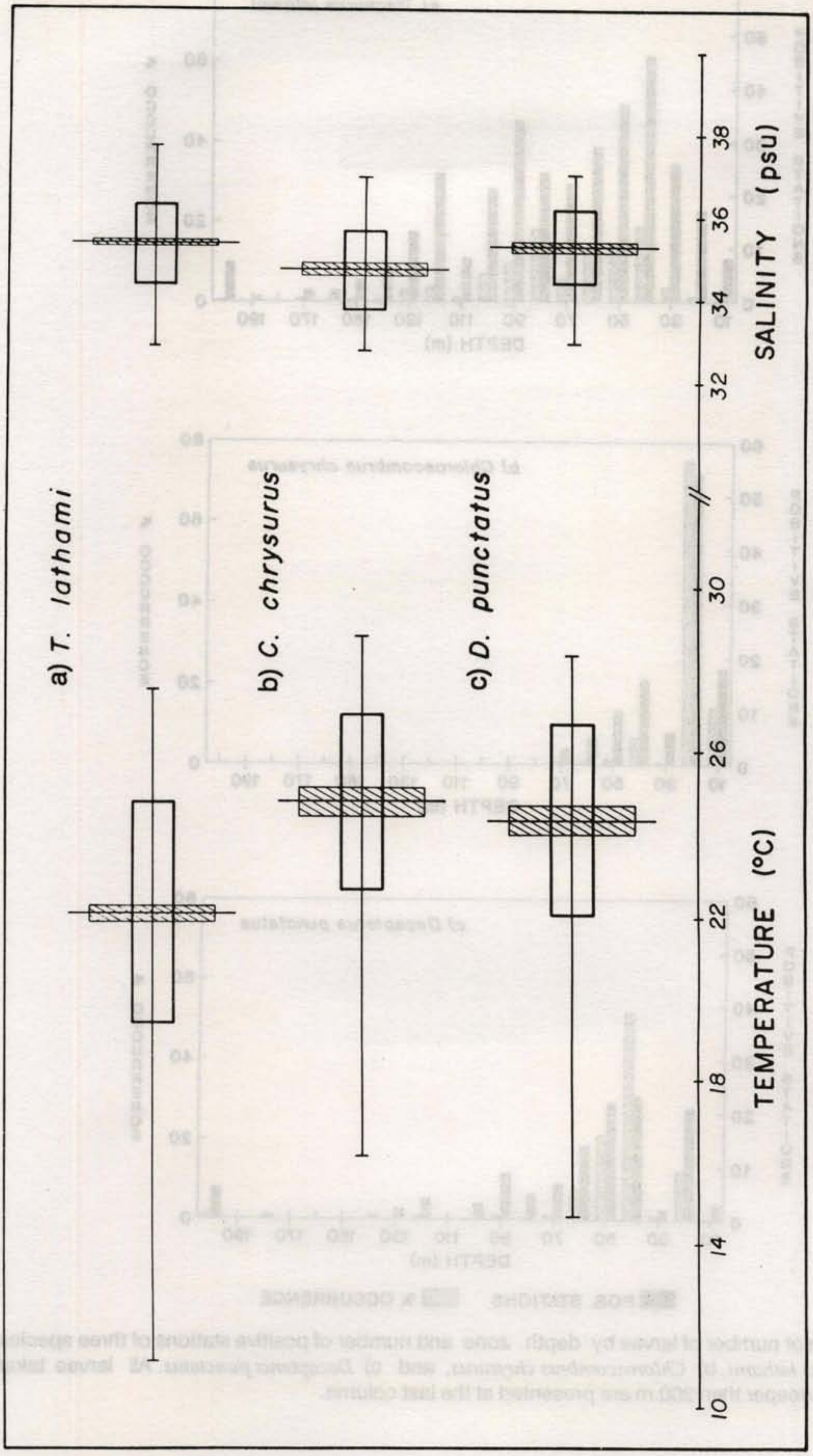


Fig. 3. Temperature and salinity ranges obtained from all positive stations for three species: a) *Trachurus lathami,* b) *Chloroscombrus chrysurus,* and c) *Decapterus punctatus.*

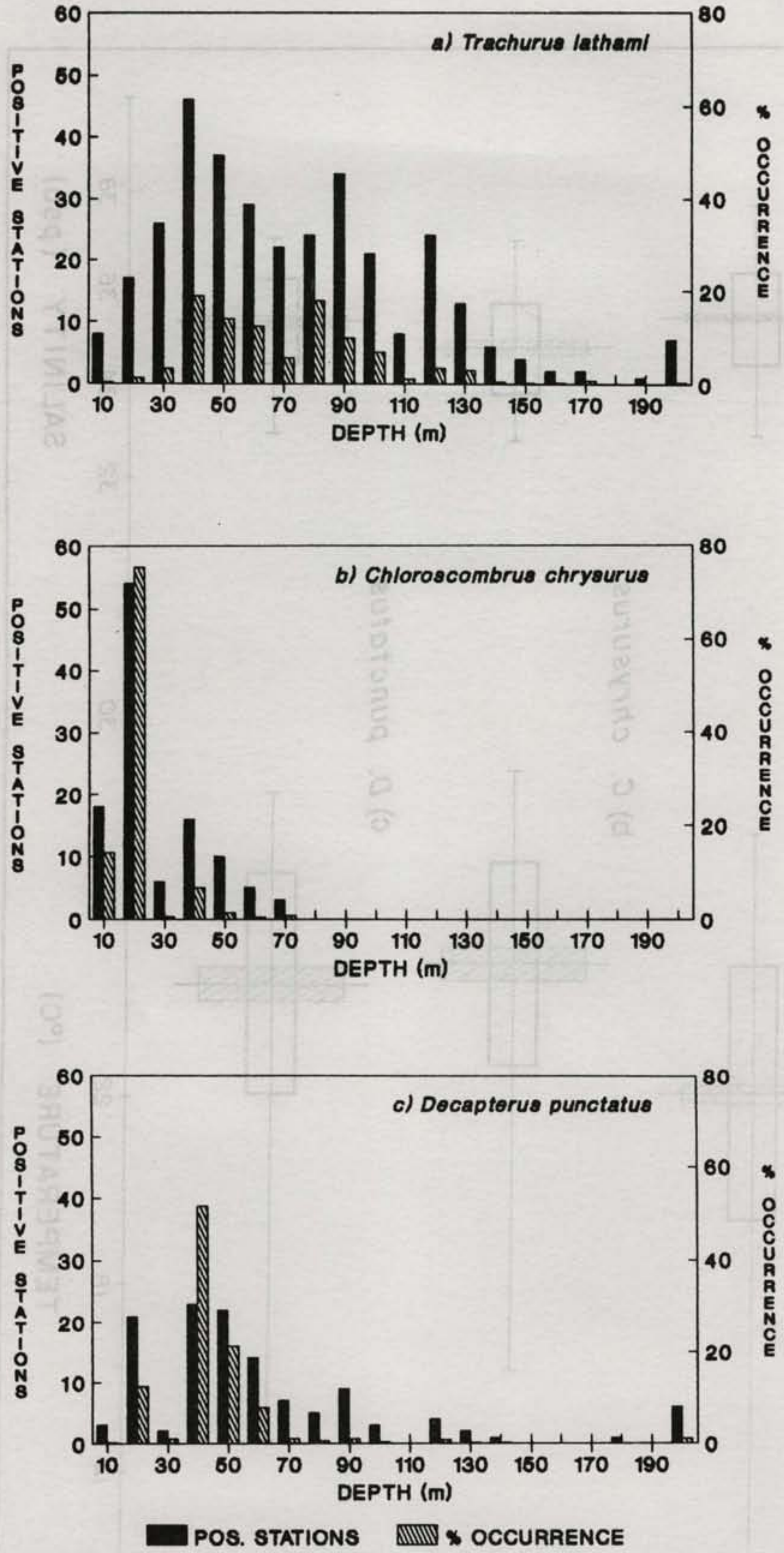
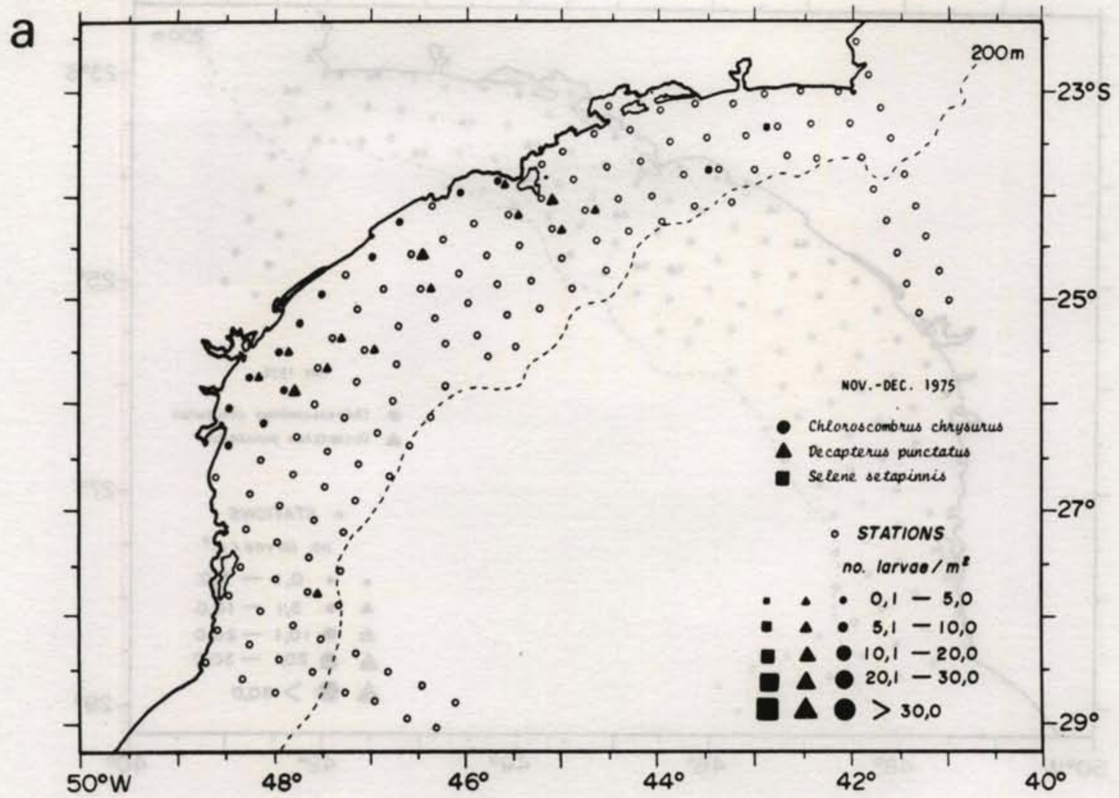


Fig. 4. Proportion of number of larvae by depth zone and number of positive stations of three species: a) *Trachurus lathami*, b) *Chloroscombrus chrysurus*, and c) *Decapterus punctatus*. All larvae taken at stations deeper than 200 m are presented at the last column.



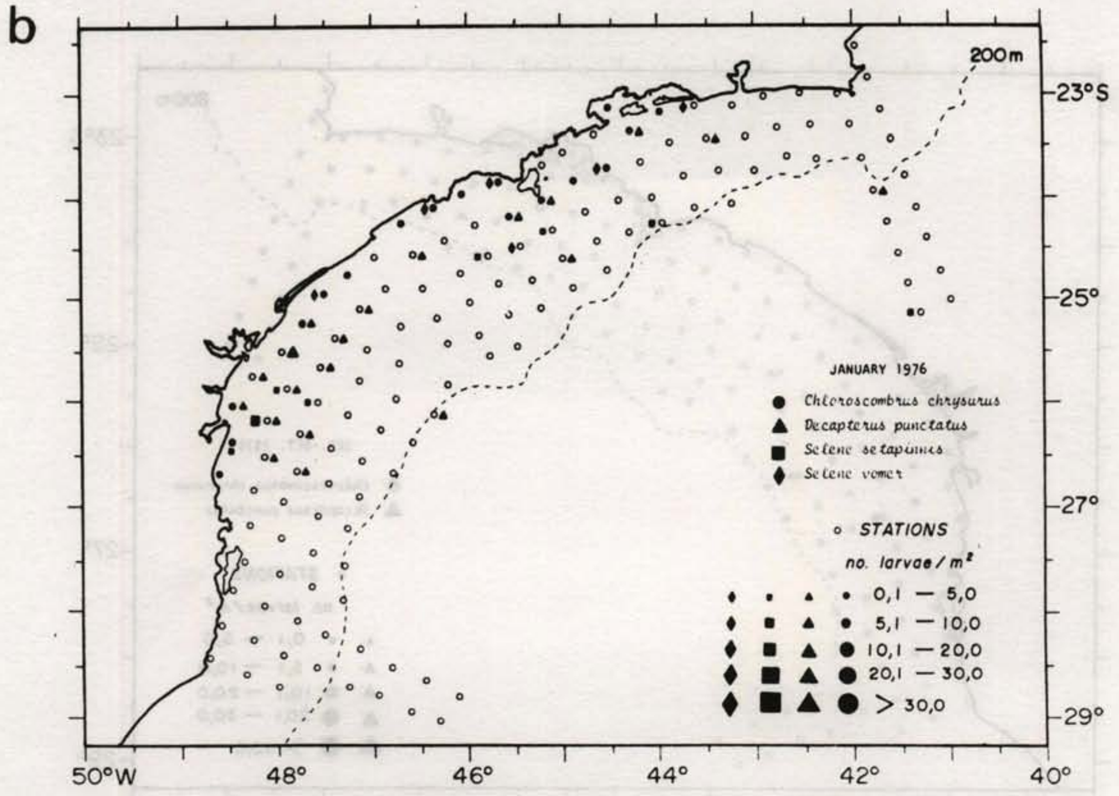
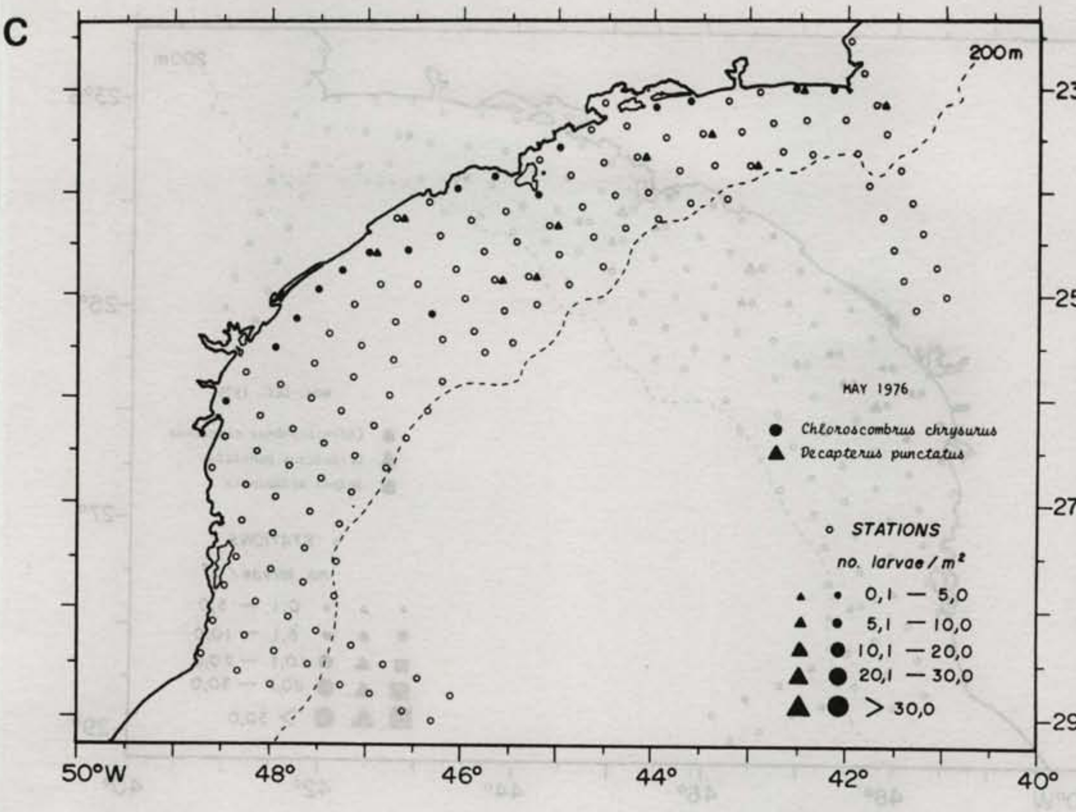


Fig. 5. Distribution and abundance (no. of larvae/m^2) of *Chloroscombrus chrysurus, Decapterus punctatus, Selene setapinnis* and *Selene vomer* larvae. a) November and December 1975; b) January 1976.



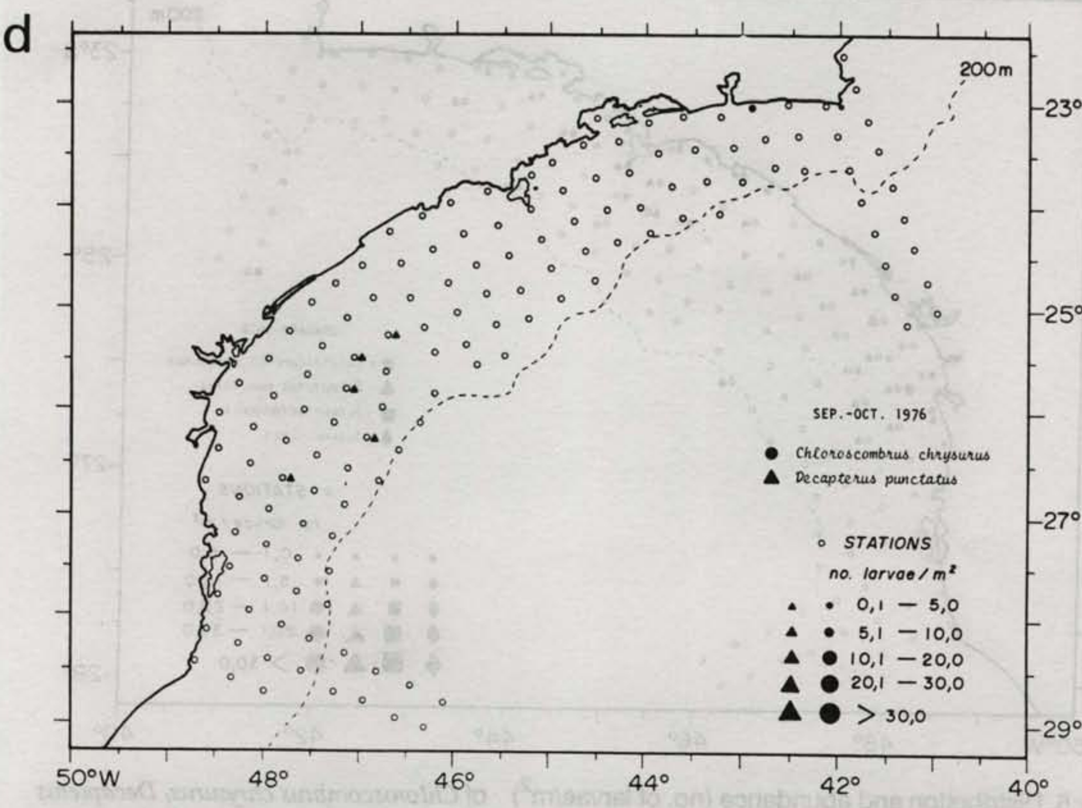


Fig. 5. Distribution and abundance (no. of larvae/m^2) of *Chloroscombrus chrysurus* and *Decapterus punctatus* larvae. c) May 1976; d) September and October 1976.

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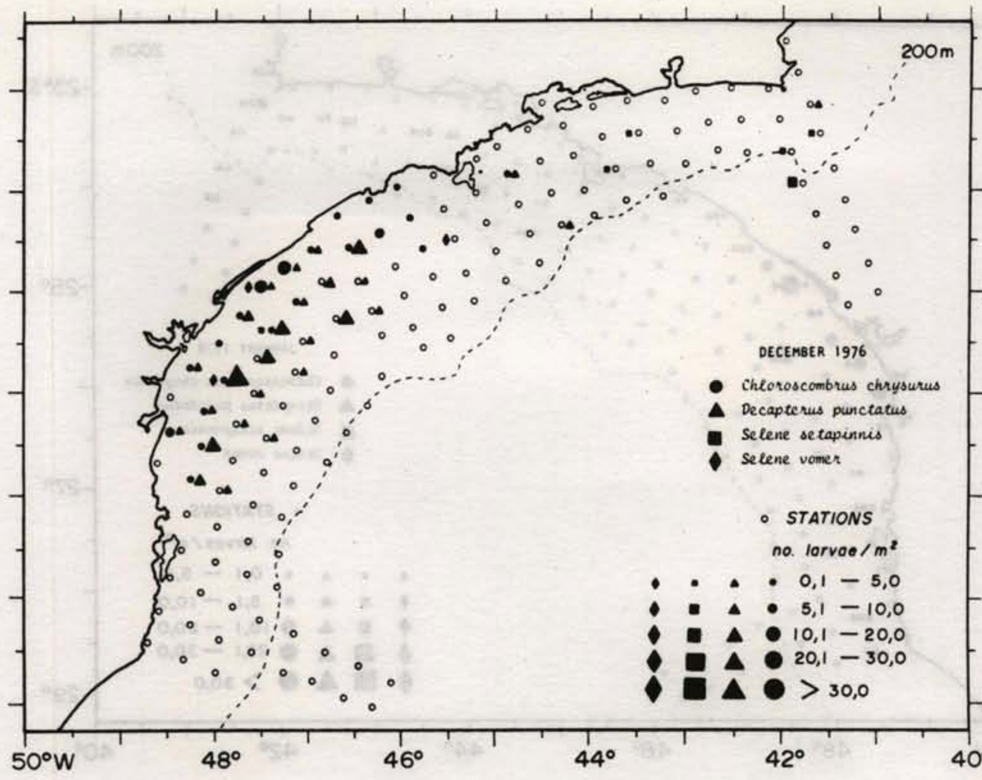

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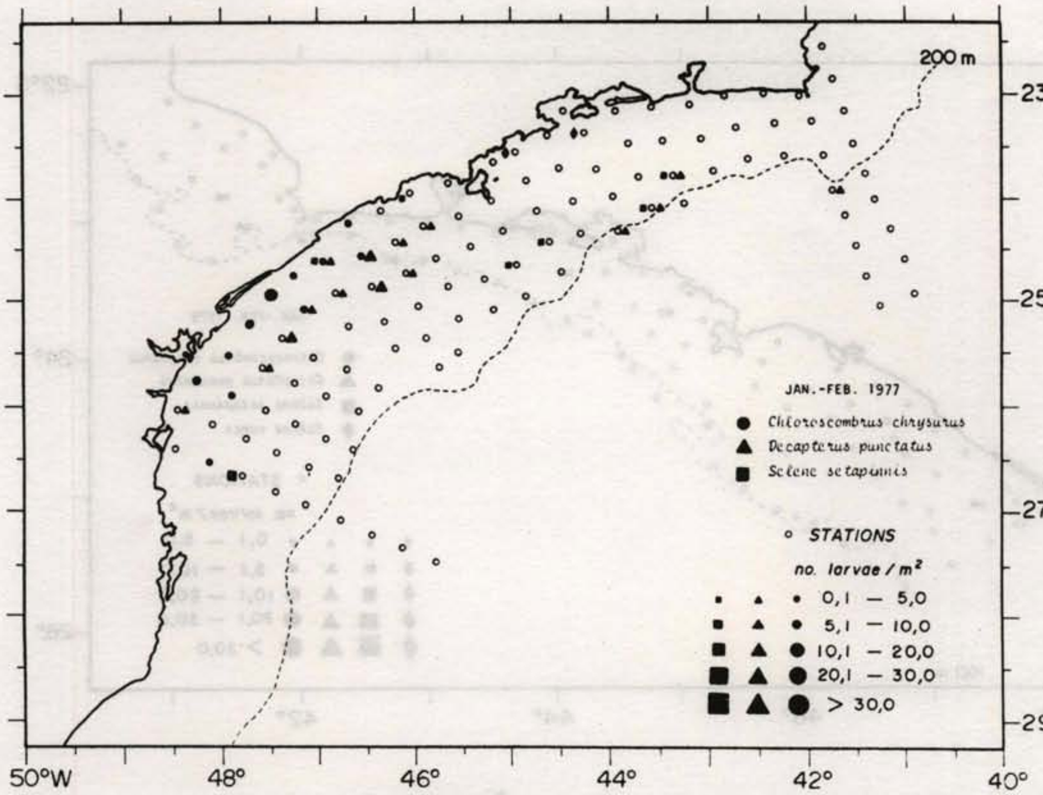
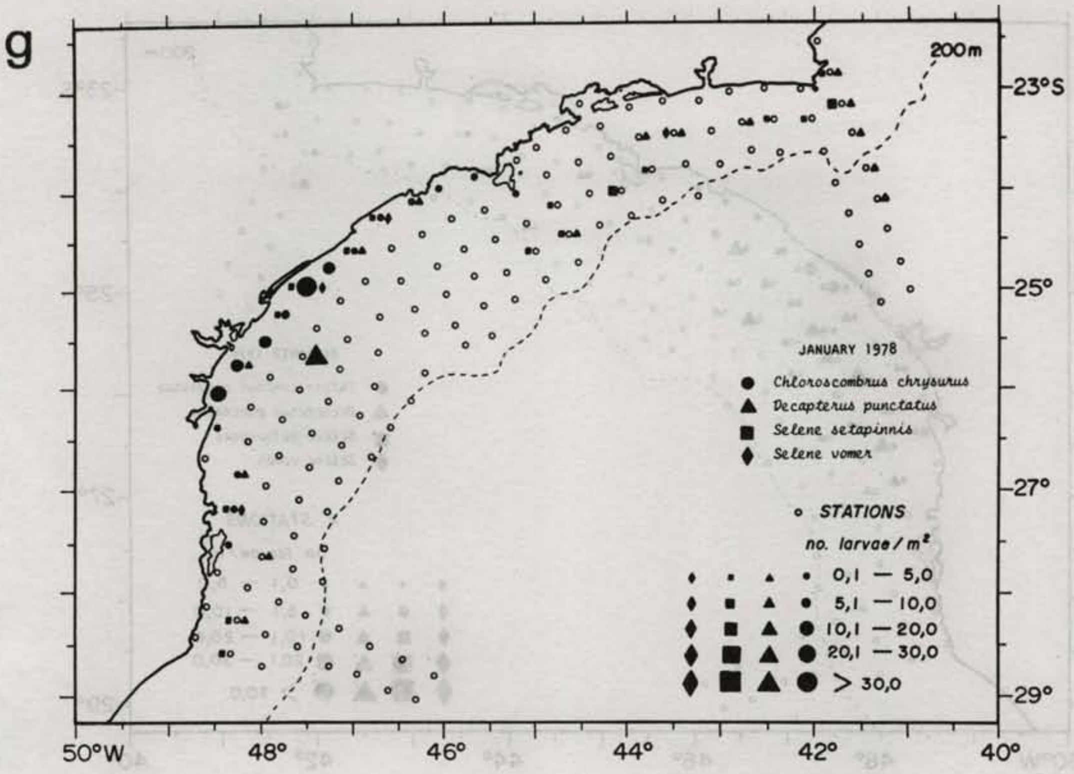


Fig. 5. Distribution and abundance (no. of larvae/m²) of *Chloroscombrus chrysurus*, *Decapterus punctatus*, *Selene setapinnis* and *Selene vomer* larvae. e) December 1976; f) January and February 1977.



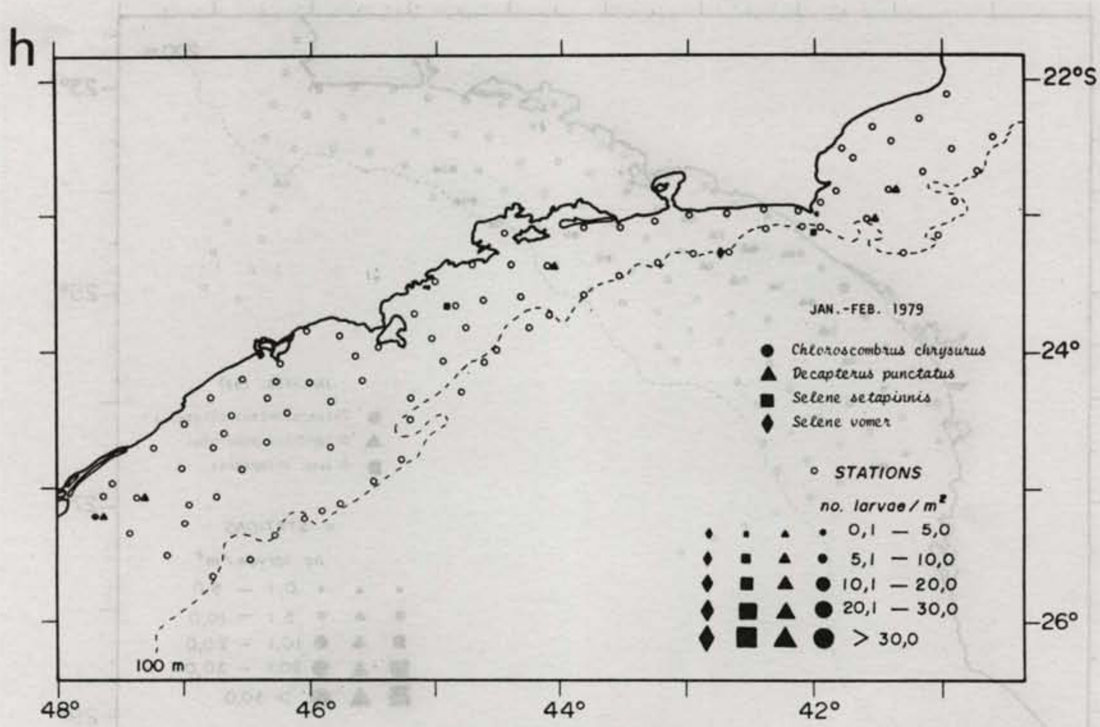


Fig. 5. Distribution and abundance (no. of larvae/m^2) of *Chloroscombrus chrysurus, Decapterus punctatus, Selene setapinnis* and *Selene vomer* larvae. g) January 1978; h) January and February 1979.

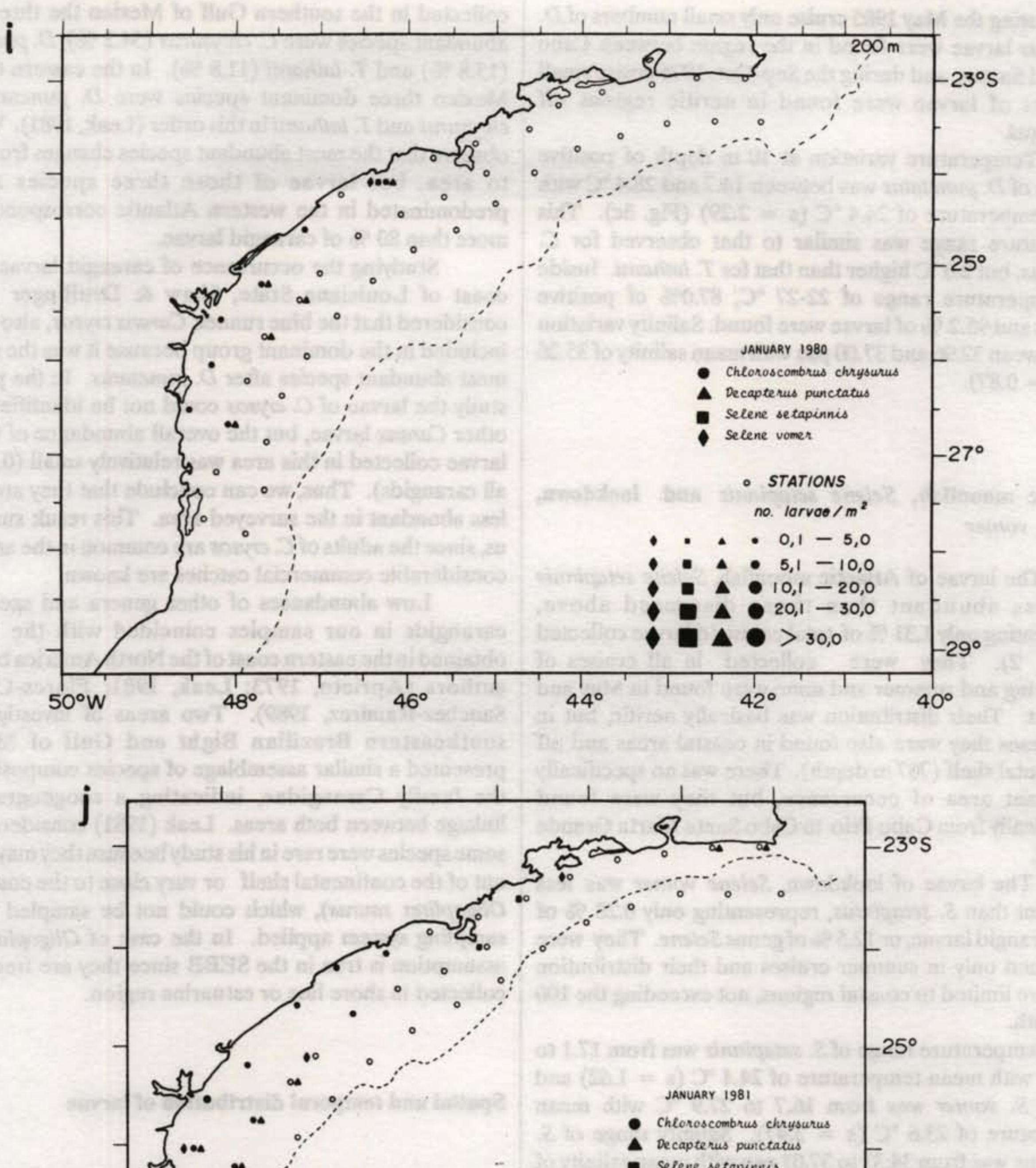


Fig. 5. Distribution and abundance (no. of larvae/m^2) of *Chloroscombrus chrysurus, Decapterus punctatus, Selene setapinnis* and *Selene vomer* larvae. i) January 1980; j) January 1981.

During the May 1985 cruise only small numbers of *D. punctatus* larvae were found in the region between Cabo Frio and Santos, and during the Sep-Oct. 1976 cruise small numbers of larvae were found in neritic regions off Paranaguá.

Temperature variation at 10 m depth of positive stations of *D. punctatus* was between 14.7 and 28.4 °C with mean temperature of 24.4 °C (s = 2.29) (Fig. 3c). This temperature range was similar to that observed for *C. chrysurus*, but 2.0 °C higher than that for *T. lathami*. Inside the temperature range of 22-27 °C, 87.0% of positive stations and 95.2 % of larvae were found. Salinity variation was between 32.96 and 37.00 psu with mean salinity of 35.26 psu (s = 0.87).

Atlantic moonfish, *Selene setapinnis* and lookdown, *Selene vomer*

The larvae of Atlantic moonfish, *Selene setapinnis* was less abundant than those discussed above, representing only 1.31 % of total carangid larvae collected (Table 2). They were collected in all cruises of late-spring and summer and none were found in May and Sep-Oct. Their distribution was basically neritic, but in some cases they were also found in coastal areas and off continental shelf (707 m depth). There was no specifically important area of occurrence, but they were found sporadically from Cabo Frio to Cabo Santa Marta Grande (Fig. 5).

The larvae of lookdown, *Selene vomer* was less abundant than *S. setapinnis*, representing only 0.28 % of total carangid larvae, or 12.5 % of genus *Selene*. They were also found only in summer cruises and their distribution was more limited to coastal regions, not exceeding the 100 m isobath.

Temperature range of *S. setapinnis* was from 17.1 to 26.6 °C with mean temperature of 24.4 °C (s = 1.62) and that of *S. vomer* was from 16.7 to 27.9 °C with mean temperature of 23.6 °C (s = 3.47). Salinity range of *S. setapinnis* was from 34.31 to 37.01 psu with mean salinity of 36.01 psu (s = 0.66) and that of *S. vomer* was from 33.03 to 36.50 psu with mean of 35.07 psu (s = 0.87).

Discussion

Relative abundance

Three carangid species predominated in the surveyed area: *Trachurus lathami* (58.5 %), *Chloroscombrus chrysurus* (15.2 %) and *Decapterus punctatus* (12.1 %). They are also abundant in other areas of the western Atlantic. Flores-Coto & Sanchez-Ramirez (1989) verified that among eight species of carangid larvae collected in the southern Gulf of Mexico the three most abundant species were *C. chrysurus* (54.2 %), *D. punctatus* (15.8 %) and *T. lathami* (11.8 %). In the eastern Gulf of Mexico three dominant species were *D. punctatus*, *C. chrysurus* and *T. lathami* in this order (Leak, 1981). We can observe that the most abundant species changes from area to area, but larvae of those three species always predominated in the western Atlantic corresponding to more than 80 % of carangid larvae.

Studying the occurrence of carangid larvae in the coast of Louisiana State, Shaw & Drullinger (1990) considered that the blue runner, *Caranx crysos*, also can be included in the dominant group because it was the second most abundant species after *D. punctatus*. In the present study the larvae of *C. crysos* could not be identified from other *Caranx* larvae, but the overall abundance of *Caranx* larvae collected in this area was relatively small (0.4 % of all carangids). Thus, we can conclude that they are really less abundant in the surveyed area. This result surprised us, since the adults of *C. crysos* are common in the area and considerable commercial catches are known.

Low abundances of other genera and species of carangids in our samples coincided with the results obtained in the eastern coast of the North America by other authors (Aprieto, 1973; Leak, 1981; Flores-Coto & Sanchez-Ramirez, 1989). Two areas of investigations, southeastern Brazilian Bight and Gulf of Mexico, presented a similar assemblage of species composition of the family Carangidae, indicating a zoogeographical linkage between both areas. Leak (1981) considered that some species were rare in his study because they may spawn out of the continental shelf or very close to the coast (e.g. *Oligoplites saurus*), which could not be sampled by the sampling system applied. In the case of *Oligoplites* this assumption is true in the SEBB since they are frequently collected in shore line or estuarine region.

Spatial and temporal distribution of larvae

Among 13 known species of the genus *Trachurus* in the world, *T. lathami* is the only one occurring in the western Atlantic from the Gulf of Maine to the northern Argentine (Berry & Cohen, 1974). In the southeastern Brazilian Bight they are typical neritic species, occurring from depth zone between 50-100 m (Saccardo, 1987). Menezes & Figueiredo (1980) observed that this species did not approach to coastal regions less than 40 m depth. On the other hand the distributions of larvae and juveniles demonstrated that they could occur from the coast (16 m depth) to as far as off continental shelf. However, the main areas of occurrence (85.5 % of positive stations) were found in the same depth zone of adult (40-100 m). Similar results were obtained in the eastern Gulf of Mexico where larvae were found in depth zone 20-219 m, but major occurrences were in neritic region (more than 50 m depth) (Leak, 1981). On the Louisiana shelf *T. lathami* larvae were collected in depth zone 10-100 m, but 99 % of larvae were found in waters more than 30 m depth (Ditty & Truesdale, 1984).

Presence of larvae can be considered as an index of recent spawning in the area (Farris, 1961; Aprieto, 1973), specially for the preflexion larvae. Thus, we can estimate the spawning areas and its intensity based on the distribution pattern of larvae and their size frequency distribution. From the results obtained in this study we can conclude that the spawning of *T. lathami* in the SEBB takes place in all surveyed area, but with two areas of preference, one between Rio de Janeiro and Ubatuba and another between Paranaguá and Florianópolis.

Spawning season of *T. lathami* extends all year-round in the area since the preflexion larvae were collected from all survey cruises. However, it was more intensive in early spring and summer cruises. Peak abundance was observed in the Sep-Oct. cruise and the lowest abundance was observed in May cruise (autumn). Based on macroscopical observation of adult gonads, Saccardo (1980) observed more limited spawning season from spring to summer with peak spawning in November in the same area. On the Uruguayan shelf and northern Argentine a short spawning season was observed from November to March with intensive spawning in December and January (Cousseau, 1967; Ciechomski & Weiss, 1973; Ciechomski & Cassia, 1980; Pacheco Tack, 1988). In the Gulf of Mexico *T. lathami* spawns all year-round with peak spawning in late autumn and early spring (Leak, 1981; Flores-Coto & Sanchez- Ramirez, 1989).

Geographical distribution of *Chloroscombrus chrysurus* extends from Massachusetts to Uruguay in the western Atlantic (Berry & Smith-Vaniz, 1978) and from Morroco to Senegal in the eastern Atlantic (Aboussouan, 1968; Conand & Franqueville, 1973). Habitat of adult extends from coastal waters to open ocean (1800 m depth) (Johnson, 1978). Juveniles of this species are frequently observed in symbiotic association with moon jellyfish *Aurelia aurita* (Tolley, 1987). In the SEBB *C. chrysurus* is a common species in littoral zone, bay and estuary (Menezes & Figueiredo, 1980).

Typical coastal distribution was the characteristics of *C. chrysurus* larvae, most of them occurring in coastal water less than 30 m depth. This coincides with the results observed in the Gulf of Mexico (Leak, 1981; Flores-Coto & Sanchez-Ramirez, 1989; Shaw & Drullinger, 1990). Along the northwestern coast of Africa a similar distribution was observed by Conand & Franqueville (1973), having a main distribution in depth zone of 20-50 m. In southern Brazil Weiss *et al.*, (1976) observed a different distribution pattern, i.e. they occurred from coast to 200 m isobath over the continental shelf along the Rio Grande do Sul State.

Larvae of *C. chrysurus* were found all year-round with major occurrences in December and January in the SEBB, meanwhile, the peak of larval occurrences was in August-November in the Rio Grande do Sul State, southern Brazil (Weiss *et al.*, 1976). In the eastern central Atlantic they were found mainly in August-November period (Conand & Franqueville, 1973) and in the Gulf of Mexico they were found in June-August period (Shaw & Drullinger, 1990).

Species of genus *Decapterus* occur in neritic and oceanic waters in tropical, subtropical and temperate regions (Stanton Hales, Jr., 1987). In the western Atlantic three species are known: *D. macarellus* (Cuvier), *D. punctatus* (Cuvier) and *D. tabl* Berry (Berry & Smith-Vaniz, 1978), from which *D. punctatus* is the most common in the southwest Atlantic. *D. tabl* may also occur in the southeastern Brazil (Menezes & Figueiredo, 1980), but we found only larvae of *D. punctatus*. Larval distribution pattern of this species was similar to that observed with *T. lathami* from the coast to off continental shelf area. This pattern is also observed in other areas (Hildebrand & Cable, 1930; Aprieto, 1973; Leak, 1981; Naughton *et al.*, 1986).

In the Gulf of Mexico and the South Atlantic Bight *D. punctatus* larvae occurred all year-round with seasonal variation in different geographical areas (Aprieto, 1973; Naughton *et al.*, 1986). For example, the peak spawning occurs during spring in the South Atlantic Bight (Fahay, 1975; Johnson, 1978) and during spring-summer in the Gulf of Mexico (Leak, 1981). In the surveyed area they were found all year- round peaking in austral summer.

Distribution of *S. setapinnis* extends from Nova Scotia, Canada, to Mar del Plata, Argentine. Adults of this species form schools and live close to the bottom in coastal region (Berry & Smith-Vaniz, 1978). In the SEBB occurrences of *S. setapinnis* larvae were scattered over the continental shelf which was similar to the results obtained in the southern Gulf of Mexico (Flores-Coto & Sanchez-Ramirez, 1989). They were mainly found during austral summer in the SEBB, but in low density. Aprieto (1973) found small number of *S. setapinnis* larvae during summer in the Gulf of Mexico, suggesting summer spawning. Johnson (1978) found hydrated females in July in the western Gulf of Mexico. On the other hand, Flores-Coto & Sanchez-Ramirez (1989) found the *S. setapinnis* larvae all year-round with higher density during spring-summer in the southern Gulf of Mexico.

Distribution of *S. vomer* is limited in the western Atlantic and extends from Maine, USA, to Uruguay, living in shallow coastal waters. In the SEBB, *S. vomer* larvae were rare and their distribution was more restricted than that of *S. setapinnis*. Most of the larvae were found in shallow waters (less than 40 m) from December to February, suggesting short and limited spawning during summer.

Hydrographic conditions and larval distribution

Oceanographic structure of this area has been extensively studied since the pioneering work of Emílsson (1961). There are at least three important water masses in the southeastern Brazil, namely, 1) Tropical water (TW)

(Brazil Current), 2) South Atlantic Central Water (SACW), and 3) Coastal water (CW). Mixture of three water masses through the heating process by solar radiation results in the formation of shelf water (Emílsson, *op. cit.*).

Hydrographic configuration over the continental shelf depends mainly on the intensity of penetration of the SACW in the bottom layer over the continental shelf and coastal water which are influenced by many factors, such as dominant wind system and intensity and meander of the Brazil Current. Remarkable seasonal variation was observed in the intensity of penetration of the SACW which reached the coastal region during late-spring and summer and retreated to offshore during winter (Matsuura, 1986). Ascending process of the SACW in the coastal region by the Ekman transport of surface CW offshore induces a coastal upwelling (Miranda, 1982; Castro Filho *et al.*, 1987) which has been frequently observed at Cabo Frio and less frequently at Cabo Santa Marta Grande. This seasonal variation on hydrographic structure seems to have an important influence on spawning season and area as well as on the distribution pattern and abundance of fish larvae.

Since the original work on the critical period concept proposed by Hjort (1914), many authors have investigated influence of environmental processes on reproductive success of fishes (e.g. May, 1974; Cushing, 1977; Loeb, 1980; Lasker, 1975; 1978; Sinclair & Trembley, 1984). Meteorological and oceanographic conditions will influence the availability of food organisms and the eggs and larvae transport by residual current and thus will affect on reproductive success, resulting in recruitment variation (Norcross & Show, 1984).

It is well known that most of the species have characteristic reproductive strategies, adjusting their reproductive patterns with environmental factors, such as surface current. For example, in the northeast Pacific many coastal species which have pelagic stages of larvae tend to spawn during winter, when wind-induced surface transport directs onshore and not during the intensive upwelling season when there is a strong offshore transport. In the strong upwelling region in the northern California which is characterized by strong surface Ekman transport in the offshore direction, spawning of only small number of surface spawning species takes place, avoiding quick transport of their offspring into less productive offshore region (Parrish *et al.*, 1981).

In the southeastern Brazil it is not yet known the details of the periodicity and amplitudes of these physical processes over the biological process of the region and reproductive success of fishes, but some interpretation can be made based on the results obtained in other areas. Bakun & Parrish (1990) conducted a comparative study on reproductive habitats of two species of sardines in the SEBB and California Current regions using the results obtained from the maritime meteorological data. They observed a considerable similarity in relation to environment/life cycle between the two populations : Brazilian sardine (*Sardinella brasiliensis*) and California sardine (*Sardinops sagax*). The reproductive strategy of the former during summer was attributed to the following factors: 1) enrichment of coastal waters by injection of nutrient rich SACW by upwelling process, 2) vertical stability of the water column, resulting in a high density of food organisms in midwater, and 3) retention process by large gyral circulation within the Bight. Similar physical/biological processes are well known in the Southern California Bight where many small pelagic fishes spawn (Parrish *et al.*, 1983). Different seasonal and spatial distribution patterns of larvae can be also observed for carangid species. Some of them have restricted occurrences to late- spring and summer, such as *Oligoplites* spp., *Caranx* spp., *S. setapinnis* and *S. vomer* larvae. On the other hand, those showing year-around larvae occurrence have a preferential season, e.g. spring and summer for *T. lathami* and summer for *C. chrysurus* and *D. punctatus*. This fact seems to demonstrates that most carangids studied here preferred to spawn in austral summer using the same strategy adapted by *S. brasiliensis* as observed by Bakun & Parrish (1990).

When we compare the larval distributions of *T. lathami* and *S. brasiliensis* (Matsuura, 1983) we can observe some similarity in distribution patterns during summer season when both species occupy the entire continental shelf in the SEBB. Temperature and salinity variation in the positive stations for both species was similar, e.g. mean temperature and salinity of the former was 23.74 °C (s = 3.55) and 34.95 psu (s = 0.81) respectively, and those of the latter were 22.09 °C (s = 2.67) and 35.31 psu (s = 0.94). Larvae of both species occur mainly in neritic regions, but major concentrations of them on the same cruise didn't overlap.

However, we must consider differences in geographical habitats of the two species. *S. brasiliensis* in the southwestern Atlantic is a typical tropical species which occupies only the southeastern Brazilian coast (22 °S-30 °S) with relatively large population biomass. On the other hand, *T. lathami* inhabits a larger geographical area from Cabo São Tomé (22°S) to Mar del Plata (40°S) in the southwestern Atlantic and its spawning takes place in both temperate waters (10-11°C) (Cousseau, 1967) and tropical waters with surface temperature 27.5°C, as shown in this report.

The largest occurrences of *T. lathami* larvae were found on the cruise of Sep-Oct. 1976, meanwhile, only three *S. brasiliensis* larvae were found on the same cruise. This suggests that spawning of *T. lathami* takes place in early spring, coinciding with the beginning of intrusion of the SACW over the continental shelf, and extends into the summer. In contrast, the spawning of *S. brasiliensis* takes place intensively in late-spring and summer. As can be seen in the commercial catches of the two species in the southeastern Brazil, the population biomass of the *S. brasiliensis* seems to be much larger than that of *T. lathami*. The largest larval densities of the two species confirm this observation, i.e. more than 1000 lârvae m^{-2} of *S. brasiliensis* (Matsuura, 1983) versus 108.4 larva m^{-2} of *T. lathami*.

D. punctatus is another species which occupies neritic regions and seems to apply the same reproductive strategy of the two species mentioned above, but the larval abundance was much lower than that of *T. lathami*.

C. chrysurus shows peak spawning in austral summer, but its distribution is basically related with the Coastal Water mass. Spawning strategy of this species is similar to that observed in with *Harengula jaguana* (another species of Clupeidae). *H. jaguana* eggs were collected exclusively in coastal region (less than 37 km from the coast), but the larvae showed a wider distribution (Matsuura, 1983). In both cases, after spawning part of larvae should be dispersed offshore with the Coastal Waters by Ekman transport.

Resumo

No presente trabalho estudaram-se a distribuição e a abundância de larvas de peixes da família Carangidae da costa sudeste do Brasil, entre Cabo Frio (23°S) e Cabo de Santa Marta Grande (29°S). As amostras foram coletadas com rede Bongô (malhagens de 0,505 mm e 0,333mm) em arrastos oblíquos, durante dez cruzeiros oceanográficos com o N/Oc. "Prof.W.Besnard", do Instituto Oceanográfico da USP e com N/Oc. "Cruz del Sur", da PDP-SUDEPE.

Foram identificados cinco táxons ao nível de espécie (*Trachurus lathami*, *Chloroscombrus chrysurus*, *Decapterus punctatus*, *Selene setapinnis* e *Selene vomer*), além de quatro ao nível de gênero (*Oligoplites*, *Caranx*, *Seriola* e *Trachinotus*). A espécie mais abundante foi *T. lathami* (58,44% do total de larvas da familia Carangidae), seguida por *C. chrysurus* (15,22%) e *D. punctatus* (12,17%). *T. lathami* e *D. punctatus* apresentaram distribuição ampla por toda a região nerítica, enquanto que *C. chrysurus* restringiu-se apenas às regiões mais próximas da costa. As larvas de carangídeos foram encontradas durante todas as épocas do ano, mas na primavera e no verão observou-se a maior abundância, o que caracteriza maior intensidade de desova durante estas estações. Esse período de pico de desova relaciona-se, aparentemente, à variação da estrutura hidrográfica da região.

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