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# Early-Life-History Profiles, Seasonal Abundance, and Distribution of Four Species of Carangid Larvae off Louisiana, 1982 and 1983

Richard F. Shaw
David L. Drullinger

U.S. Department of Commerce

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U.S. DEPARTMENT OF COMMERCE
Robert Mosbacher, Secretary
National Oceanic and Atmospheric Administration
John A. Knauss, Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
William W. Fox, Jr., Assistant Administrator for Fisheries

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RICHARD F. SHAW
DAVID L. DRULLINGER*
*Coastal Fisheries Institute*
*Center for Wetland Resources*
*Louisiana State University*
*Baton Rouge, Louisiana 70803-7503*

### ABSTRACT

**We present data on ichthyoplankton distribution, abundance, and seasonality and supporting environmental information for four species of coastal pelagics from the family Carangidae: blue runner *Caranx crysos*, Atlantic bumper *Chloroscombrus chrysurus*, round scad *Decapterus punctatus*, and rough scad *Trachurus lathami*. Data are from 1982 and 1983 cruises off Louisiana sponsored by the Southeastern Area Monitoring and Assessment Program (SEAMAP). Bioprofiles on reproductive biology, early life history, meristics, adult distribution, and fisheries characteristics are also presented for these species.**

**Maximum abundances of larval blue runner, Atlantic bumper, and round scad were found in July inside the 40-m isobath, although during the rest of the cruises these species were rarely found together. Larval Atlantic bumper were captured in June and July only; blue runner in May, June, and July; and round scad in all seasons. Atlantic bumper larvae, concentrated mostly off western Louisiana, were by far the most abundant carangid in 1982 and 1983. Larval blue runner were the second most abundant summer-spawned carangid in 1982 and 1983, but their abundance and depth distribution varied considerably between years. Relative abundance of larval round scad off Louisiana was low, and they were captured only west of the Mississippi River delta, although they are reported to dominate carangid populations in the eastern Gulf of Mexico. Rough scad were primarily winter/spring and outer-shelf (40–182 m) spawners. They ranked third in overall abundance, but were the most abundant target carangid on the outer shelf. Ecological parameters such as surface salinity, temperature, and station depth are presented from capture sites for recently hatched larvae (<2.5 mm notochord length, except round scad) as well as for all sizes of fish below 14 mm standard length.**

*Present address: Surface Water Quality Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, MI 48909.

## Introduction

Exploratory fishing surveys in the Gulf of Mexico have identified the carangids as being abundant (Juhl 1966, Bullis and Carpenter 1968, Bullis and Thompson 1970, Klima 1971) and have found evidence that commercial quantities of round scad *Decapterus punctatus*, rough scad *Trachurus lathami*, and blue runner *Caranx crysos* may exist (Klima 1971). In the United States these species may have commercial potential for export marketing and as baitfish. Also, in conjunction with the small and abundant Atlantic bumper *Chloroscombrus chrysurus*, these species constitute an important, if not primary, food source for many predatory game and commercial fishes and may therefore directly affect the biomass of these predators. Other available forage fish may not be as abundant throughout their geographical range, reach high enough schooling densities, nor have the same palatability as these species (Reintjes 1979a).

Despite the potential importance of such coastal pelagics as the carangids, we do not presently know enough about them to accurately assess the extent to which they can be feasibly exploited (Nakamura 1980, Vaughan et al. 1986). This inadequacy is especially apparent in our understanding of the early-life-history stages. Very little is known about larval abundance, seasonality, and distribution of these species off Louisiana, or about the oceanographic factors that may be important for their survival. Knowledge of spawning location and season, for example, could have immediate applications because some of the carangid fisheries exploit only spawning concentrations (Elwertowski and Boely 1971). Information on spawning aggregations could affect efficiency and development of the fisheries (Leak 1977).

This research was undertaken to augment information on the early life history of the four previously mentioned species of carangids. This is especially important in light of (1) the increasing awareness that some of our fisheries may be approaching, or may have already reached, their maximum sustainable yields; (2) today's political and economic climate with its justifiable emphasis on creating new job opportunities, utilizing untapped renewable resources, and balancing the international trade deficit; and (3) the appreciation of each Gulf state's need to develop, maximize, effectively manage, and partition fishery resources while minimizing conflicts between commercial and recreational users. Information provided in this report should help solidify the data foundation necessary for sound management of the Gulf's "fisheries of the future."

Our research approach for this 2-year project was to (1) thoroughly survey the pertinent literature and compile, consolidate, and synthesize appropriate data for incorporation into bioprofiles of the early life histories of the selected species; and (2) sort, identify, and analyze larval fish samples requested from the Southeast Area Monitoring and Assessment Program (SEAMAP), focusing on collections in Louisiana territorial and offshore waters during 1982 and 1983 cruises.

**Table 1**
**Summary of 1982 SEAMAP ichthyoplankton sampling in Louisiana proximal waters.**

| Vessel or state | Cruise | Dates | Station no. | Sample no. | Gear | Location |
|---|---|---|---|---|---|---|
| *Oregon II* | 125 | 02/24-03/17 | 36005-36580 | 869-963 | Bongo | Mississippi delta area |
| *Oregon II* | 126 | 04/20-05/24 | 36689-36777 | 91-360 | Bongo/Neuston | Louisiana offshelf |
| *Oregon II* | 127 | 06/02-06/27 | 36788-36937 | 497-634 | Bongo/Neutson | Louisiana shelf |
| Louisiana | 0 | 06/01-07/30 | 01-43 | 454-496 | Ring | Louisiana coastline |
| *Jeff and Tina* | 0003 | 06/16-07/06 | B200-B220 | 415-447 | Bongo/Neuston | East Texas/West Louisiana, shelf |
| *Oregon II* | 130 | 10/17-11/23 | 37389-38268 | 2052-2127 | Bongo/Neuston | East Louisiana/Mississippi, shelf |

**Table 2**
**Summary of 1983 SEAMAP ichthyoplankton sampling in Louisiana proximal waters.**

| Vessel or state | Cruise | Dates | Station no. | Sample no. | Gear | Location |
|---|---|---|---|---|---|---|
| | | | | 2133-2162 | | |
| *Oregon II* | 133 | 03/13-03/29 | 38604-38775 | 3339-3341 | Bongo/Neuston | East of Mississippi River delta |
| *Oregon II* | 134 | 04/25-05/23 | 39073-39198 | 1163-1471 | Bongo/Neuston | Louisiana offshelf |
| *Oregon II* | 135 | 06/08-07/05 | 39242-39390 | 1908-1994 | Bongo/Neuston | Louisiana shelf |
| *Tommy Munro* | 135 | 06/07-06/14 | A1-B182 | 1639-1673 | Bongo/Neuston | Mississippi shelf |
| Louisiana | 02 | 06/13-06/16 | 01001-07005 | 1703-1735 | Ring | Louisiana coastline |
| Louisiana | 03 | 06/21-06/23 | 01001-07005 | 1736-1765 | Ring | Louisiana coastline |
| *Suncoaster* | 01 | 07/01-07/04 | B179-B183 | 1685-1696 | Bongo/Neuston | Mississippi shelf |
| *Oregon II* | 138 | 10/12-10/31 | 39580-39849 | 3352-3452 | Bongo/Neuston | East of Mississippi River delta |
| *Tommy Munro* | RD83 | 10/18-10/19 | 1-3 | 1884-1889 | Bongo | Mississippi shelf |
| *Oregon II* | 140 | 12/14-12/21 | 40197-40231 | 1814-1838 | Bongo/Neuston | Louisiana offshelf |

## Methods and Materials

### Ichthyoplankton samples

Samples of larval and early juvenile carangids from the SEAMAP ichthyoplankton collections were examined for the presence of our target species: *Caranx crysos*, *Chloroscombrus chrysurus*, *Decapturus punctatus*, and *Trachurus lathami*. Samples analyzed in 1982 were from cruises conducted 24 February–17 March and 20 April–30 July (Richards et al. 1984), and an additional cruise 17 October–23 November. In 1983, samples were analyzed from cruises conducted 13 March–5 July, and during 12–31 October and 14–21 December (Kelley et al. 1985). For both years our targeted species were analyzed from station locations off Louisiana between long. 88°30′W and 94°30W and from the Louisiana coast to lat. 26°00′N, approximately 322 km offshore. Offshore stations were generally arranged in a systematic grid at minimum intervals of 55 km (30 nautical miles) or one-half degree, but coastal stations were usually irregularly spaced or clumped. SEAMAP vessels were provided by the National Marine Fisheries Service and by state agencies (Tables 1 and 2). Sampling consisted of oblique plankton tows taken with 60-cm bongo nets (0.333-mm mesh) within 5 m of the bottom (at station depths of <205 m) or from a depth of 200 m, and 10-min neuston tows with the 1×2-m net (0.947-mm mesh) half submerged (Thompson and Bane 1986). In addition, 0.5-m ring nets with 0.333-mm mesh were used aboard Louisiana and Alabama vessels to take 10-min surface hauls on north-south transects within the 5-m depth contour. Towing speed for all collections was 0.8m/s. A more detailed treatment of the sampling grid and procedures is presented elsewhere (Stuntz et al. 1982, Thompson and Bane 1986).

Carangid larvae were identified to the lowest taxonomic level possible and verified against available ichthyoplankton reference collections. Many carangids found in the SEAMAP samples were either nontarget species or unidentifiable. Larvae and juveniles of the *Caranx hippos/latus* complex were by far the most common nontarget carangids. Other carangids found were undescribed *Caranx* spp., *Elagatis bipinnulata*, *Oligoplites saurus*, *Selar crumenophthalmus*, *Selene* spp., *Seriola* spp., and *Trachinotus* spp.

Target species were enumerated and measured. Standard lengths (SL) were taken to the nearest tenth millimeter and are presented in 1-mm increments (i.e., 1.0–1.9 mm, 2.0–2.9 mm) in the length-frequency histograms. Standard length was considered synonymous with notochord length in preflexion larvae. Any fishes larger than 13.9 mm SL were considered juveniles and not included in this analysis. In each sample, all fish of a target species were measured unless there were more than 52 individuals. For collections of over 52 specimens, we measured the longest and shortest individuals and used a random-numbers table to select 50 others from a dish with a grid system. We adjusted the length-frequency histograms from net collections with greater than 52 larvae of a given species, using a multiplier to give equal weight to the length data subsampled from the larger collections.

**Table 3**
**Number of SEAMAP stations sampled for carangids off Louisiana, 1982 and 1983. No samples taken in January, August, or September. NS = no samples taken.**

| Year | Gear and depth | Feb | Mar | Apr | May | June | July | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bongo** | | | | | | | | | | |
| 1982 | <40 m | 5 | 27 | | | 17 | 3 | | 11 | |
| | 40–182 m | | 36 | | 8 | 14 | 1 | | 12 | |
| | >182 m | | | 23 | 26 | 8 | | 2 | 5 | |
| | Total | 5 | 63 | 23 | 34 | 39 | 4 | 2 | 28 | NS |
| 1983 | <40 m | | 2 | | | 13 | 1 | 6 | | |
| | 40–182 m | | 1 | 4 | 1 | 11 | 4 | 2 | | 3 |
| | >182 m | | 2 | 10 | 18 | | | 4 | | 6 |
| | Total | NS | 5 | 14 | 19 | 24 | 5 | 12 | NS | 9 |
| **Neuston or Ring** | | | | | | | | | | |
| 1982 | <40 m | | | | | 37 | 23 | | | |
| | 40–182 m | | | | 8 | 14 | | | 1 | |
| | >182 m | | | 23 | 29 | 8 | | 3 | 2 | |
| | Total | NS | NS | 23 | 37 | 59 | 23 | 3 | 3 | NS |
| 1983 | <40 m | | | | | 54 | 1 | | | |
| | 40–182 m | | | 4 | 1 | 11 | 4 | | | 3 |
| | >182 m | | 3 | 10 | 17 | | | 4 | | 5 |
| | Total | NS | 3 | 14 | 18 | 65 | 5 | 4 | NS | 8 |

Spawning season and location (depth or distance from shore), larval distribution and abundance, and larval ecology (i.e., temperature and salinity at time of capture) were determined for all target species. Yearly abundance of each larval species was determined at three depth zones: inner shelf (depths <40 m), outer shelf (40–182 m), and offshore (>182 m). Station abundances and length-frequency data for each species were plotted by gear type and month. Monthly groupings were considered optimal because they allowed variations in the sampling effort (cruise tracks) and spawning intensity or site location to be viewed over time without considerable loss of sample size or geographic coverage. Abundances of larvae caught in unmetered neuston or 0.5-m ring nets are listed as catch-per-unit-effort (CPUE), where a unit of effort is defined as one complete tow (∼10 min). Only bongo nets were metered, allowing calculations of the volume of water filtered. Abundances of fish captured in bongo nets are presented as the number of larvae under 10 $m^2$ of sea surface, written in the text as no. fish/10 $m^2$. Yearly mean abundances were calculated over those months when capture of a species was deemed likely, referred to as the larval season. Both positive and zero-catch stations were included in mean abundance estimates. The number of total stations sampled each month is given in Table 3.

## Bioprofiles

We found most of the literature reviewed in the bioprofiles (see Appendix) through computer-assisted literature searches utilizing on-line databases such as *Aquatic Science Abstracts* (1978–83), *BIOSIS* (1969–83), *Comprehensive Dissertation Abstracts* (1861–1983), *Oceanic Abstracts* (1964–83), and *Zoological Record* (1978–80).

The total number of literature citations on these species is somewhat deceptive; review of the literature reveals relatively few early-life-history studies from the Gulf of Mexico targeting these species. The available summary information often pieced together data from throughout the world's oceans or on similar species of the same genus. For these reasons, we have purposely avoided using summations of all the available information to make all-inclusive statements on spawning seasonalities, egg and larval distributions, meristics, etc., in our early-life-history bioprofiles. We have instead reported specific facts from specific authors and locales so that readers can locate information relevant to their particular problems or decide how much weight to give to each finding based on its timeliness or proximity to a given geographical area. In the absence of data from the Gulf or on the appropriate species, we have provided information from other areas, oceans, or species, and have so indicated in each instance.

# Results

### *Caranx crysos*

In general, young of *C. crysos* (1.5–13.0 mm SL), our second most abundance target species, were distributed across Louisiana's continental shelf waters, except east of the Mississippi River delta (Figs. 1-4). During May 1982 offshore sampling (depths >182 m), larvae were captured only along the edge of the continental shelf, suggesting that there

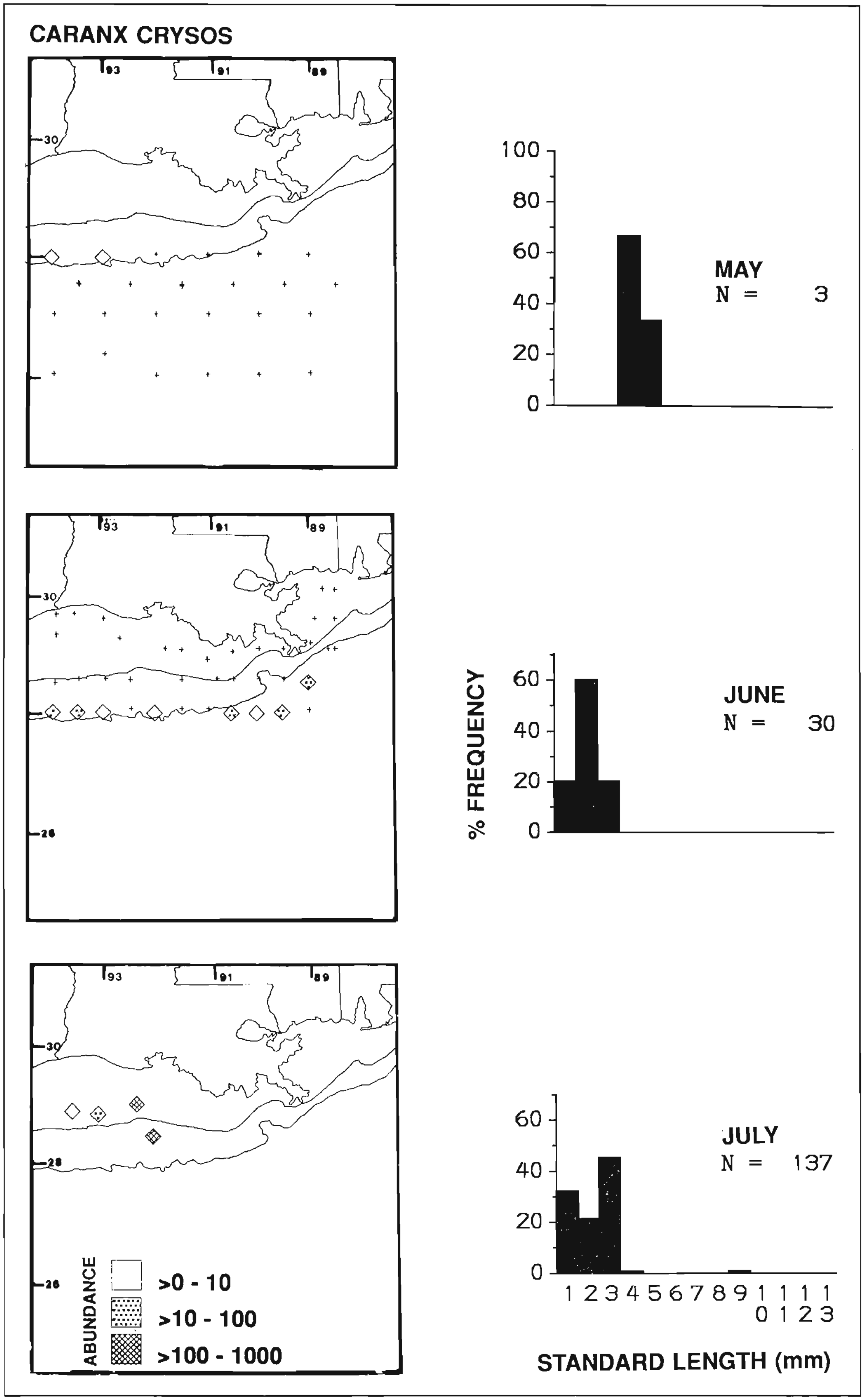


**Figure 1**
Size-frequency distribution and abundance ($N$/10 $m^2$) of *Caranx crysos* larvae for positive-catch months during 1982 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.

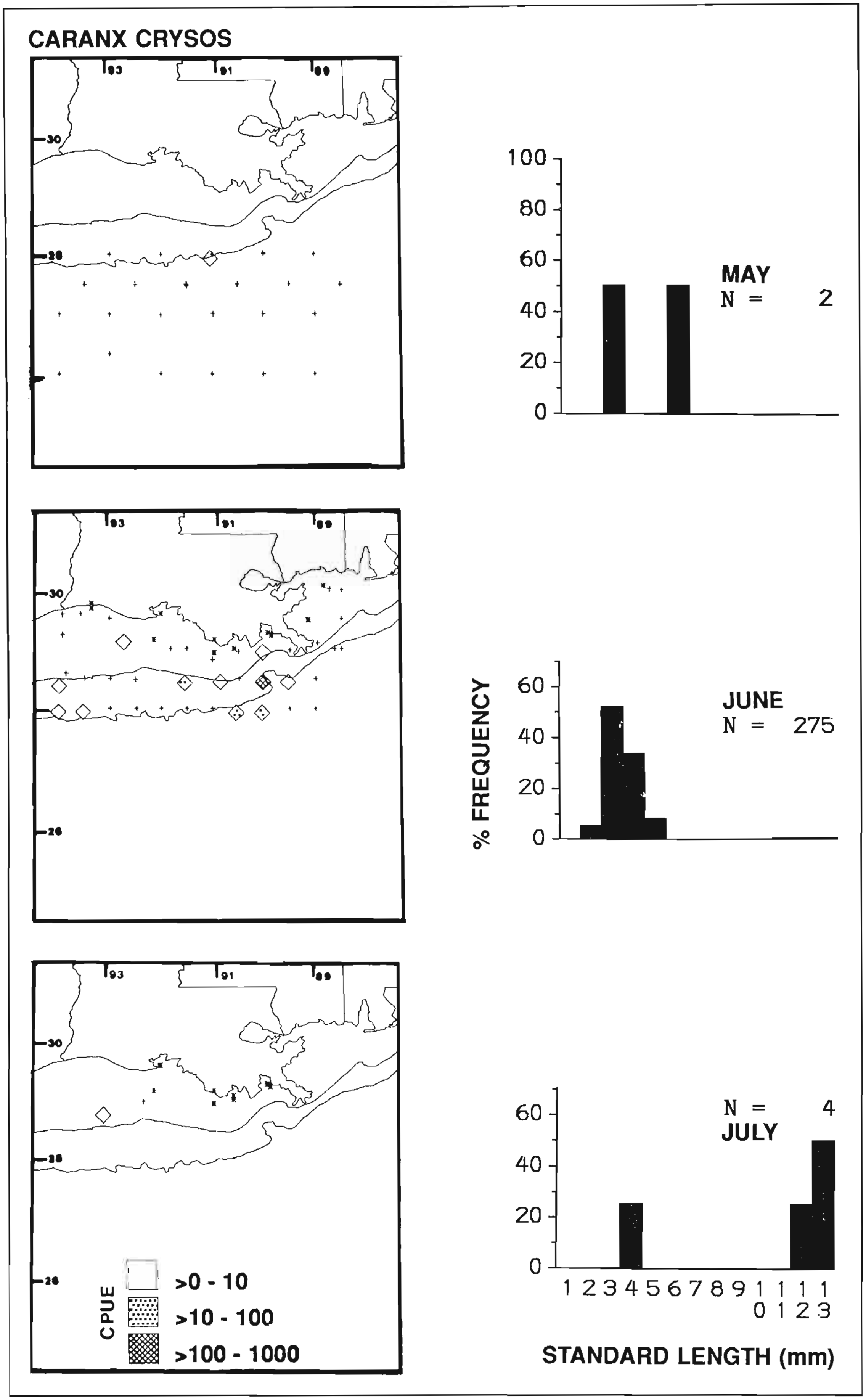


**Figure 2**
Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Caranx crysos* larvae for positive-catch months during 1982 SEAMAP neuston and half-meter ring net collections off Louisiana. Stations sampled: + neuston, * ring nets. *N* = total number caught; no larvae taken in ring nets.

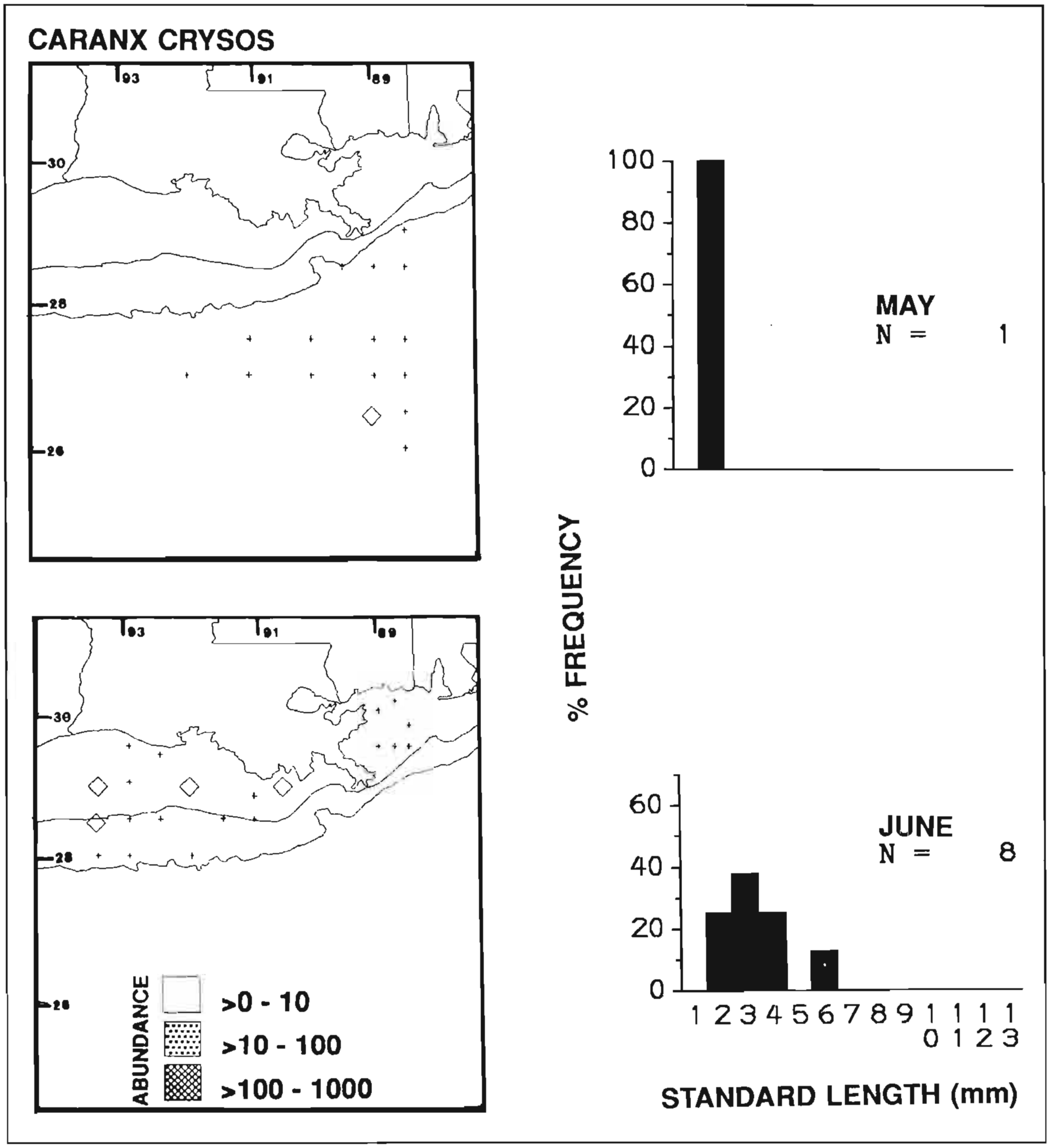


**Figure 3**

Size-frequency distribution and abundance ($N$/10 $m^2$) of *Caranx crysos* larvae for positive-catch months during 1983 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.

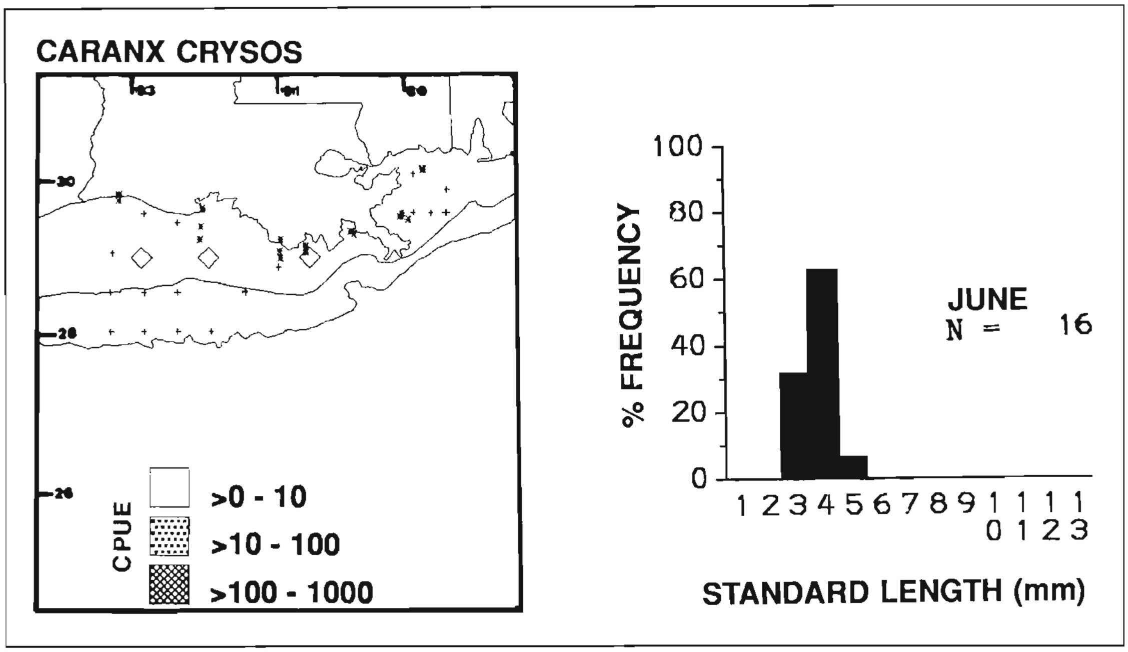


**Figure 4**
**Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Caranx crysos* larvae for June (the only positive-catch month) during 1983 SEAMAP neuston and half-meter ring net collections off Louisiana. Stations sampled: + neuston, * ring nets. *N* = total number caught; no larvae taken in ring nets.**

may have been high abundance on the shelf where no stations were sampled. This supposition was not supported by the June 1982 bongo net surveys, however, which indicated that the highest abundance was indeed at the shelf break, although the neuston net collections indicated the presence of larvae across the shelf. In July 1982, larvae were present in high abundance on the inner shelf (depth <40 m), but because coverage of the stations at all depths was poor, the across-shelf distribution of larvae could not be resolved.

During 1983, the association of high larval abundance with the shelfbreak was not evident. The only larva taken in May (21 May, 2.8 mm SL) was collected in the central Gulf. In June, larvae were found much nearer shore than during the same period in 1982. Many of those larvae were small (2–3 mm SL), indicating inshore spawning as opposed to inshore transport from offshore spawning sites. Abundance decreased slightly in the offshore direction (Table 4), primarily because the few positive stations on the inner shelf had relatively large numbers of larvae.

Most of the 478 *C. crysos* larvae collected were taken in June, when coverage of onshelf stations was good. Maximum abundance in 1982, however, occurred during July when larvae were captured at all bongo stations sampled (Table 5). Larvae in the 1–3 mm SL size range were caught in May, June, and July (Figs. 1–4) indicating spawning each of those months. Larvae longer than 6.0 mm SL were rarely captured. The earliest spawning was indicated by a 4.5-mm SL larva captured on 5 May, which points to a late-April hatch.

**Table 4**
**Abundance ($N$/10 m$^2$) and depth distribution of target carangid larvae by species and year. Numbers in parentheses are positive-catch stations per total stations sampled. Abundances and total stations are for months during larval season only.**

| Taxa | <40 m | 40–182 m | >182 m |
|---|---|---|---|
| *Caranx crysos* | | | |
| 1982 | 4.8 (3/58) | 2.8 (7/71) | 1.6 (4/64) |
| 1983 | 0.4 (3/22) | 0.3 (1/23) | 0.2 (1/34) |
| *Chloroscombrus chrysurus* | | | |
| 1982 | 150.7 (11/20) | 1.7 (4/23) | 0.0 (0/59) |
| 1983 | 81.3 (8/20) | 2.2 (2/22) | 0.0 (0/32) |
| *Decapterus punctatus* | | | |
| 1982 | 0.6 (4/58) | 0.4 (4/71) | 0.0 (0/64) |
| 1983 | 0.1 (1/22) | 0.1 (1/26) | 0.3 (2/40) |
| *Trachurus lathami* | | | |
| 1982 | 0.1 (1/43) | 4.7 (13/56) | 0.0 (0/54) |
| 1983 | 0.0 (0/2) | 11.2 (5/9) | 0.5 (2/56) |

At locations where recently hatched larvae (<2.5 mm SL) were captured, surface temperature was 28.8°–30.1°C and salinity 25.0–36.2 ppt (Table 6). At locations where all sizes of larvae were captured, surface salinity was 24.8–37.7 ppt, with most larvae captured at salinities below 33 ppt, despite the predominance of collections near the shelfbreak. Surface temperature at locations where all sizes of larvae were captured was 23.3°–32.0°C.

## Table 5

**_Caranx crysos_ mean larval abundance ($N/10\ m^2$) as determined from metered bongo tows, and mean catch-per-unit-effort (number captured/tow) as determined from neuston and unmetered 0.5-m ring net tows, for positive-catch stations only. Spawning season considered to be March–November (Ditty et al. 1988). For total SEAMAP yearly sampling effort by month, gear type, and depth, see Table 3.**

| Mean variable | May | | June | | July | |
|---|---|---|---|---|---|---|
| Bongo catch | | | | | | |
| 1982 | 0.5 | [1](2/34) | 3.0 | (8/39) | 97.4 | (4/4) |
| 1983 | 0.3 | (1/19) | 1.0 | (4/24) | 0.0 | (0/5) |
| Neuston or ring catch | | | | | | |
| 1982 | 2.0 | (1/37) | 25.1 | (11/59) | 4.0 | (1/23) |
| 1983 | 0.0 | (0/18) | 5.3 | (3/65) | 0.0 | (0/5) |
| Surface salinity (ppt) | | | | | | |
| 1982 | 37.0 | [2](36–38) | 31.6 | (25–36) | 30.2 | (28–32) |
| 1983 | 36.7 | | 30.9 | (25–35) | | |
| Surface temperature (°C) | | | | | | |
| 1982 | 23.5 | (23–24) | 29.8 | (28–32) | 29.4 | (29–30) |
| 1983 | 26.9 | | 27.2 | (27–28) | | |
| Station depth (m)[3] | | | | | | |
| 1982 | 106 | (71–150) | 259 | (19–954) | 30 | (20–52) |
| 1983 | 2926 | | 21 | (11–42) | | |

[1]Frequency of occurrence: number of positive-catch stations per number of stations sampled.
[2]Range of values.
[3]Sampling methodology for bongo nets limits tows to upper 200 m of water (see Methods section).

## Table 6

**Mean surface salinities, temperatures, and water depths at sites where larvae <2.5 mm SL were captured.**

| | Salinity (ppt) | | Temperature (°C) | | Station depth (m) | |
|---|---|---|---|---|---|---|
| | $\bar{x}$ | min–max | $\bar{x}$ | min–max | $\bar{x}$ | min–max |
| *Caranx crysos* | | | | | | |
| 1982 | 31.1 | 25.0–36.2 | 29.6 | 28.8–30.1 | 269 | 23–954 |
| 1983 | * | | | | | |
| *Chloroscombrus chrysurus* | | | | | | |
| 1982 | 27.0 | 16.5–33.7 | 30.1 | 27.0–32.1 | 18 | 2–49 |
| 1983 | 26.4 | 19.8–36.1 | 27.6 | 26.7–28.7 | 17 | 6–51 |
| *Decapterus punctatus* | | | | | | |
| 1982 | * | | | | | |
| 1983 | * | | | | | |
| *Trachurus lathami* | | | | | | |
| 1982 | ** | | 20.2 | 18.0–21.0 | 59 | 37–91 |
| 1983 | 36.0 | 35.8–36.3 | 22.3 | 21.8–23.0 | 111 | 102–121 |

*Larvae <2.5 mm SL were either not present or were too difficult to identify to species level.
**Salinity data not available.

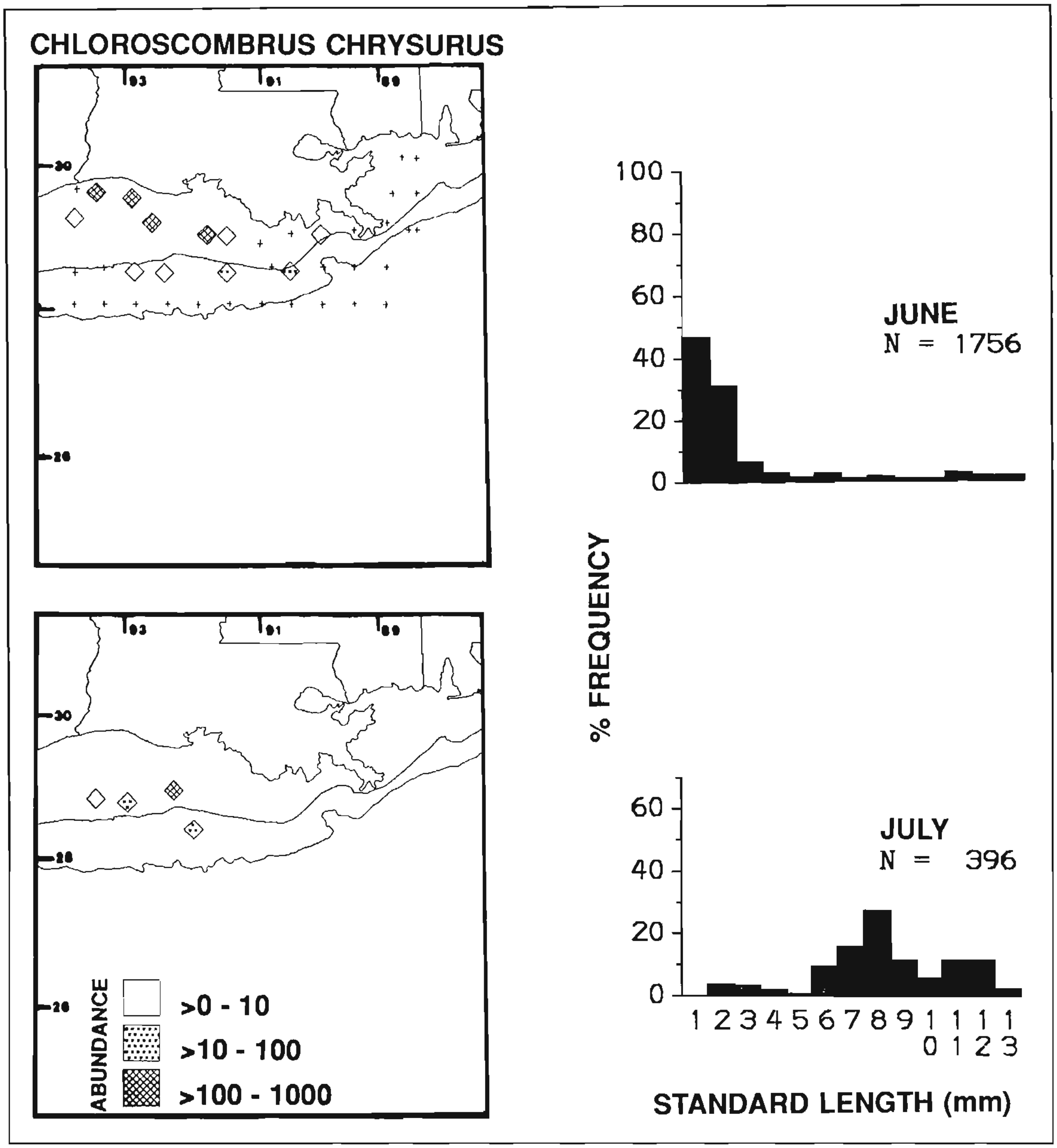


**Figure 5**

**Size-frequency distribution and abundance (*N*/10 m²) of *Chloroscombrus chrysurus* larvae for positive-catch months during 1982 SEAMAP bongo net collections off Louisiana. Stations sampled (+); *N* = total number caught.**

## Chloroscombrus chrysurus

Larval Atlantic bumper, our most abundant target species, were captured along the entire Louisiana coastline, both east and west of the Mississippi River delta, though highest concentrations were west of long. 91.5°W (Figs. 5–8). The largest single-station catches taken by neuston net (679 fish, 6.4–13.0 mm SL) and by bongo net (953 fish or 2118 fish/10 $m^2$, 1.2–3.8 mm SL) were from south of central Louisiana in 18–20 m of water during 1982 and 1983, respectively. Most larvae were taken inshore of the 27-m isobath. Only 40 of the 4675 larvae and early juveniles captured were taken between 27 and 60 m, and beyond that only a single 4.9-mm SL larva was taken at 100 m.

Inner-shelf abundance was one to two orders of magnitude above that of the other carangid larvae examined (Table 4). *Chloroscombrus chrysurus* were also captured at 48% of the inner-shelf stations sampled, the highest among the target carangids.

Atlantic bumper are primarily summertime spawners and their larvae were captured during June and July only (Table 7). Spawning by May or perhaps earlier was indicated by specimens as large as 13 mm SL taken as early as 17 June. No larvae were found in pre-June SEAMAP collections, but

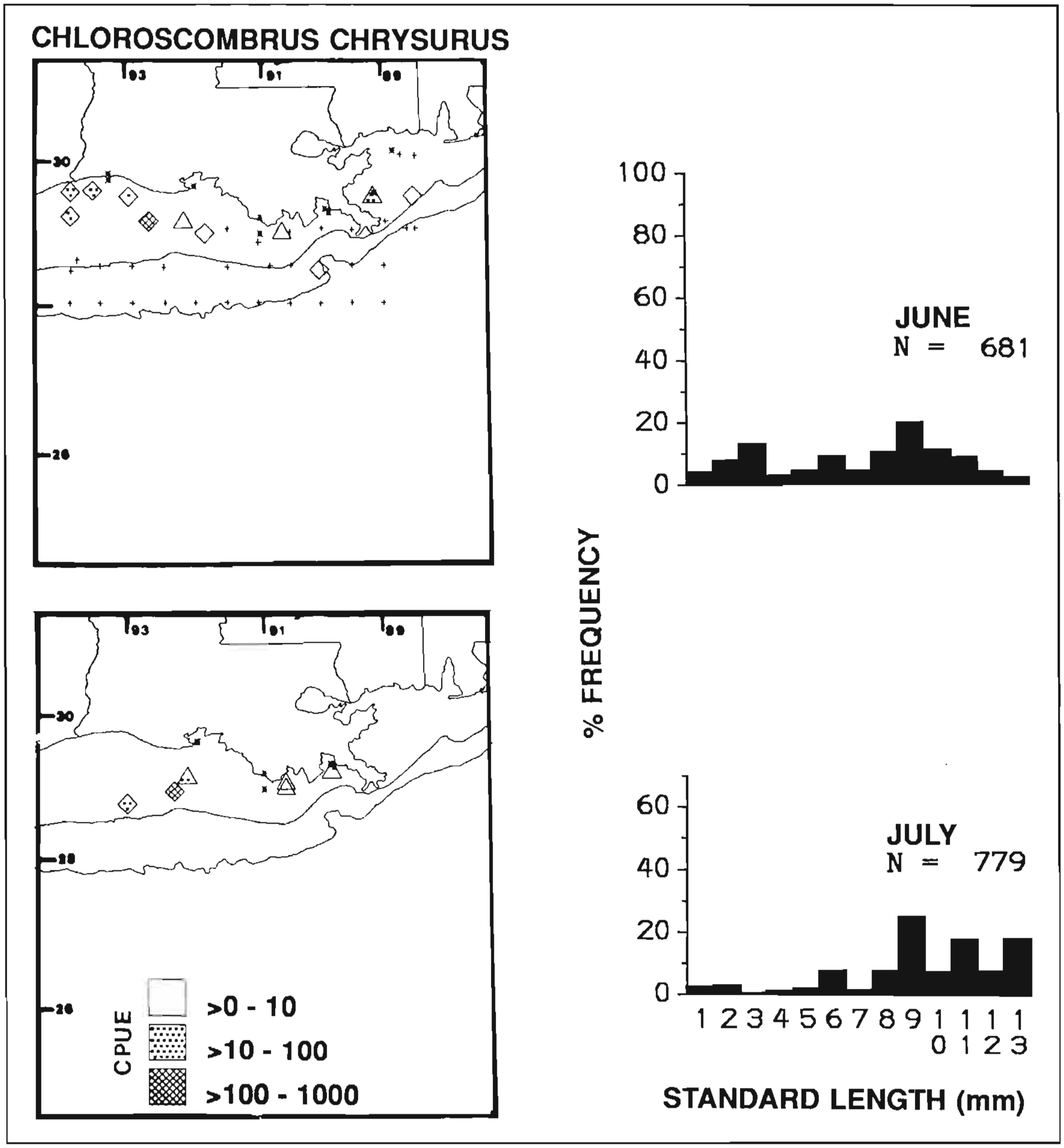


**Figure 6**

**Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Chloroscombrus chrysurus* larvae for positive-catch months during 1982 SEAMAP neuston and half-meter ring net collections off Louisiana. Stations sampled: + neuston, * ring nets. Catch: ◇ neuston, △ ring. *N* = total number caught.**

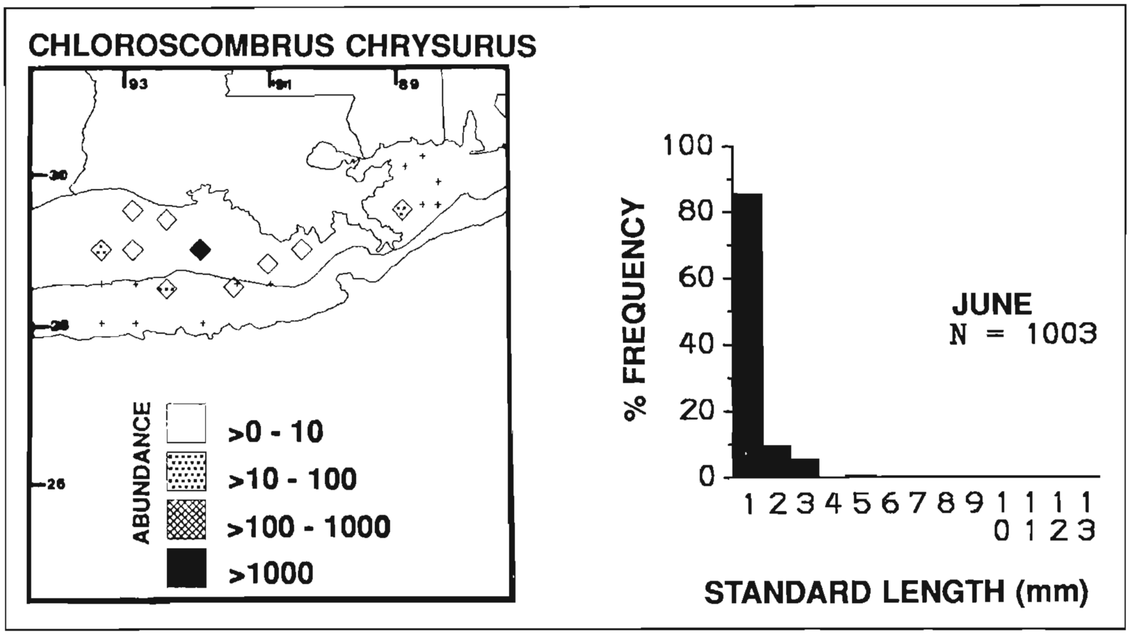


**Figure 7**

**Size-frequency distribution and abundance ($N$/10 m$^2$) of *Chloroscombrus chrysurus* larvae for June (the only positive-catch month) during 1983 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.**

station coverage during those months was restricted to offshore waters where there is apparently no spawning. No larvae were captured in October SEAMAP samples (no cruises in August or September), but adults are known to spawn off Louisiana in August and September (D. Leffler, R. Shaw, and D. Drullinger, unpubl. data). Length-frequency data indicated that larvae were generally longer in July than in June (Figs. 5–8).

Recently hatched *Ch. chrysurus* larvae (<2.5 mm SL) were captured where surface salinity was 16.5–36.1 ppt (Table 6). Larger larvae were captured at salinities as low as 10.4 ppt. Mean salinity at spawning sites was well below 30 ppt, which is typical for nearshore waters off Louisiana. Surface temperature where recently hatched larvae were captured was 26.7°–32.1°C, and larger larvae were found generally within the same temperature range.

**Table 7**

***Chloroscombrus chrysurus* mean larval abundance ($N$/10 m$^2$) as determined from metered bongo tows, and mean catch-per-unit-effort (number captured/tow) as determined from neuston and unmetered 0.5-m ring net tows, for positive-catch stations only. Spawning season considered to be April–November (Ditty et al. 1988; this work). For total SEAMAP yearly sampling effort by month, gear type, and depth, see Table 3.**

| Mean variable | June | | July | |
|---|---|---|---|---|
| Bongo catch | | | | |
| 1982 | 176.3 | [1](11/39) | 282.4 | (4/4) |
| 1983 | 22.5 | (10/24) | 0.0 | (0/5) |
| Neuston or ring catch | | | | |
| 1982 | 49.1 | (14/59) | 97.8 | (8/23) |
| 1983 | 5.3 | (7/65) | 1.0 | (1/5) |
| Surface salinity (ppt) | | | | |
| 1982 | 26.7 | [2](10–34) | 27.2 | (18–32) |
| 1983 | 25.8 | (12–36) | | |
| Surface temperature (°C) | | | | |
| 1982 | 29.7 | (27–32) | 30.1 | (29–32) |
| 1983 | 27.3 | (25–29) | 30.0 | |
| Station depth (m)[3] | | | | |
| 1982 | 23 | (9–100) | 19 | (2–52) |
| 1983 | 18 | (6–51) | 90 | |

[1]Frequency of occurrence: number of positive-catch stations per number of stations sampled.
[2]Range of values.
[3]Sampling methodology for bongo nets limits tows to upper 200 m of water (see Methods section).

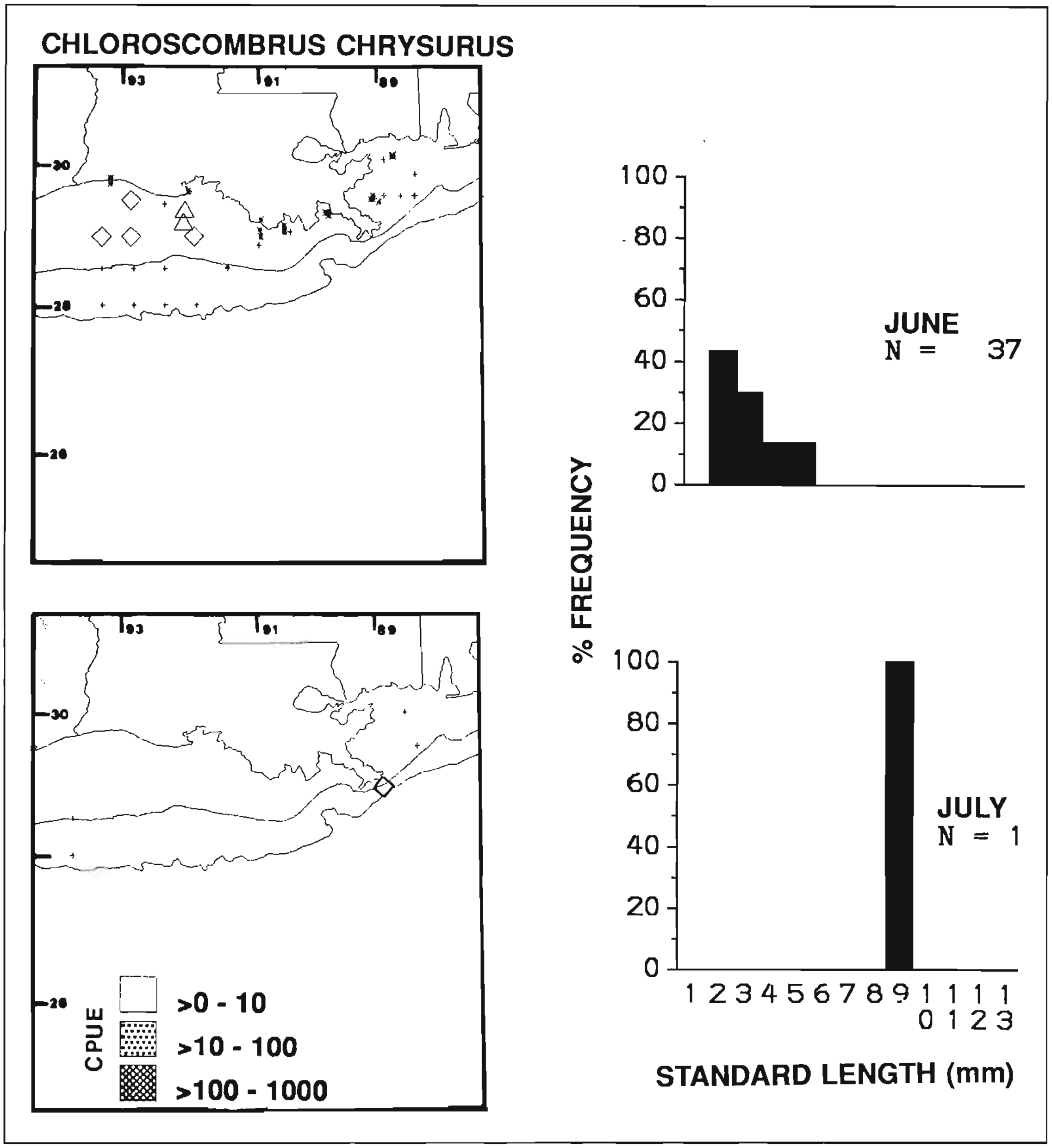


**Figure 8**

**Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Chloroscombrus chrysurus* larvae for positive-catch months during 1983 SEAMAP neuston and half-meter ring net collections off Louisiana. Stations sampled: + neuston, * ring nets. Catch: ◇ neuston, △ ring. *N* = total number caught.**

## *Decapterus punctatus*

Larval round scad were captured most commonly off western Louisiana, with no larvae collected east of the Mississippi River delta (Figs. 9–12). Preflexion larvae were collected between 13 and 115 m (usually <40 m) during June and July, indicating inner- to midshelf spawning during those months. The few larvae captured in March, May, October, and December were widely scattered, primarily beyond the 48-m isobath. Highest abundances were on the continental shelf during 1982 but beyond the shelf during 1983 (Table 4).

A total of 81 larvae and early juveniles (2.6–13.9 mm SL) were captured off Louisiana during 1982 and 1983. Of those, 70 were taken in 1982. Only 5 of 11 larvae captured in 1983 were taken in bongo nets, so abundance calculations are based on very small catches. Overall, *D. punctatus* were the least abundant of the four species examined.

Larvae were most abundant in June and July (Table 8); specifically in July of 1982, when they were captured in 3 of 4 bongo tows and 2 of 2 neuston tows off west Louisiana. Unfortunately, the low number of samples taken at that time prevented a determination of how widespread the larvae

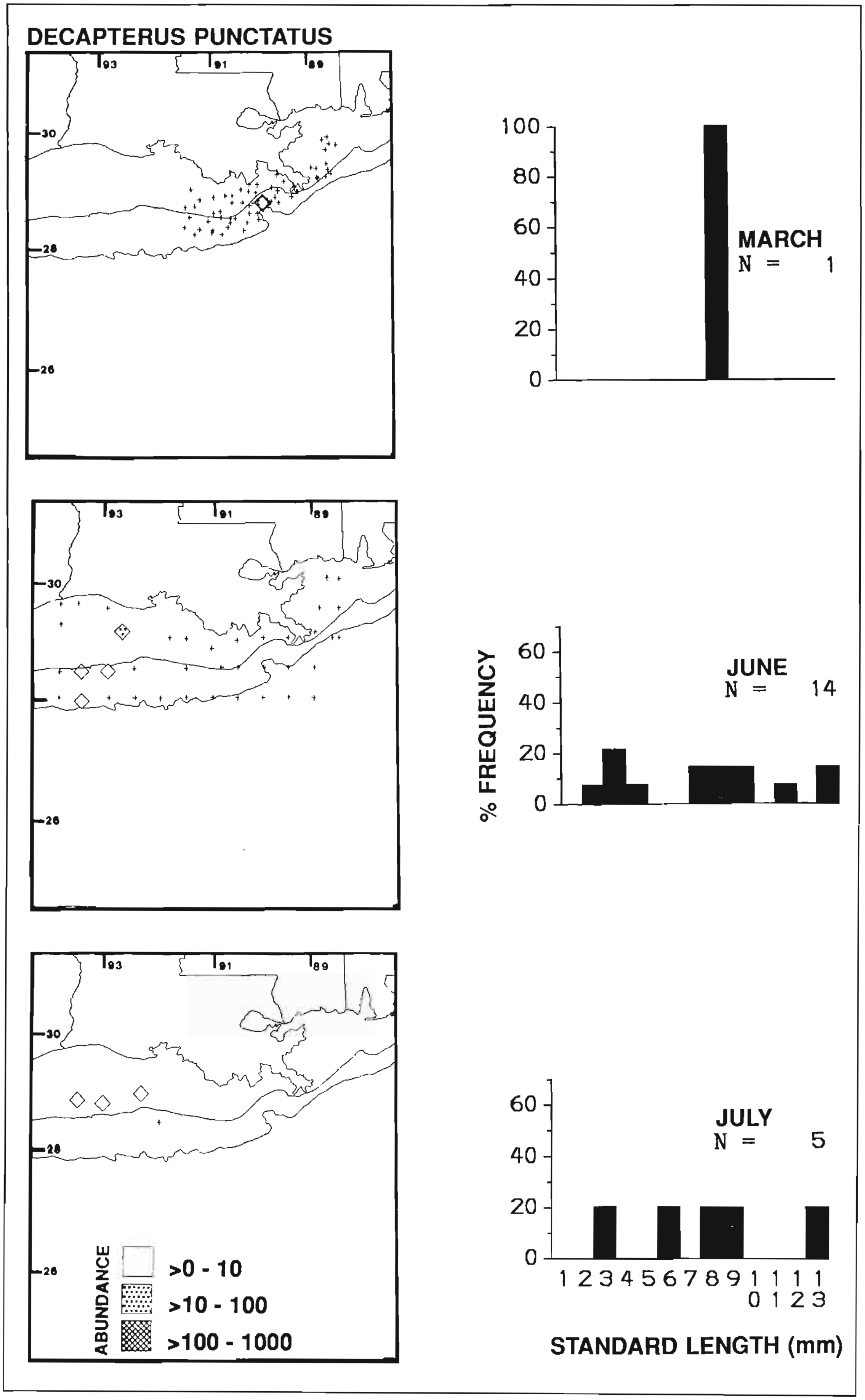


**Figure 9**
Size-frequency distribution and abundance ($N$/10 m$^2$) of *Decapterus punctatus* larvae for positive-catch months during 1982 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.

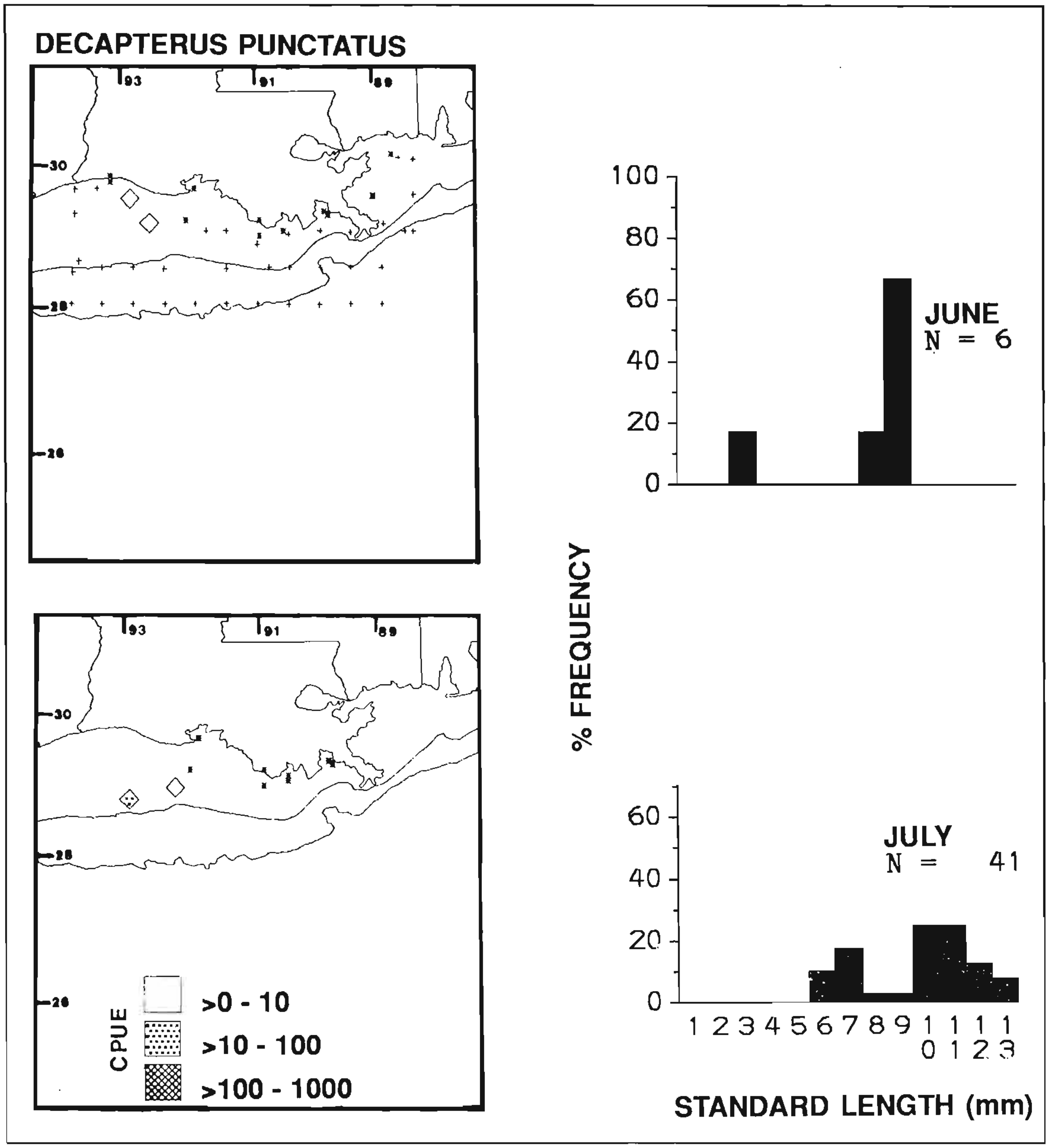


**Figure 10**

**Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Decapterus punctatus* larvae for months with positive neuston catches during 1982 SEAMAP neuston and half-meter ring net collections off Louisiana. Stations sampled: + neuston, * ring nets. *N* = total number caught; no larvae taken in ring nets.**

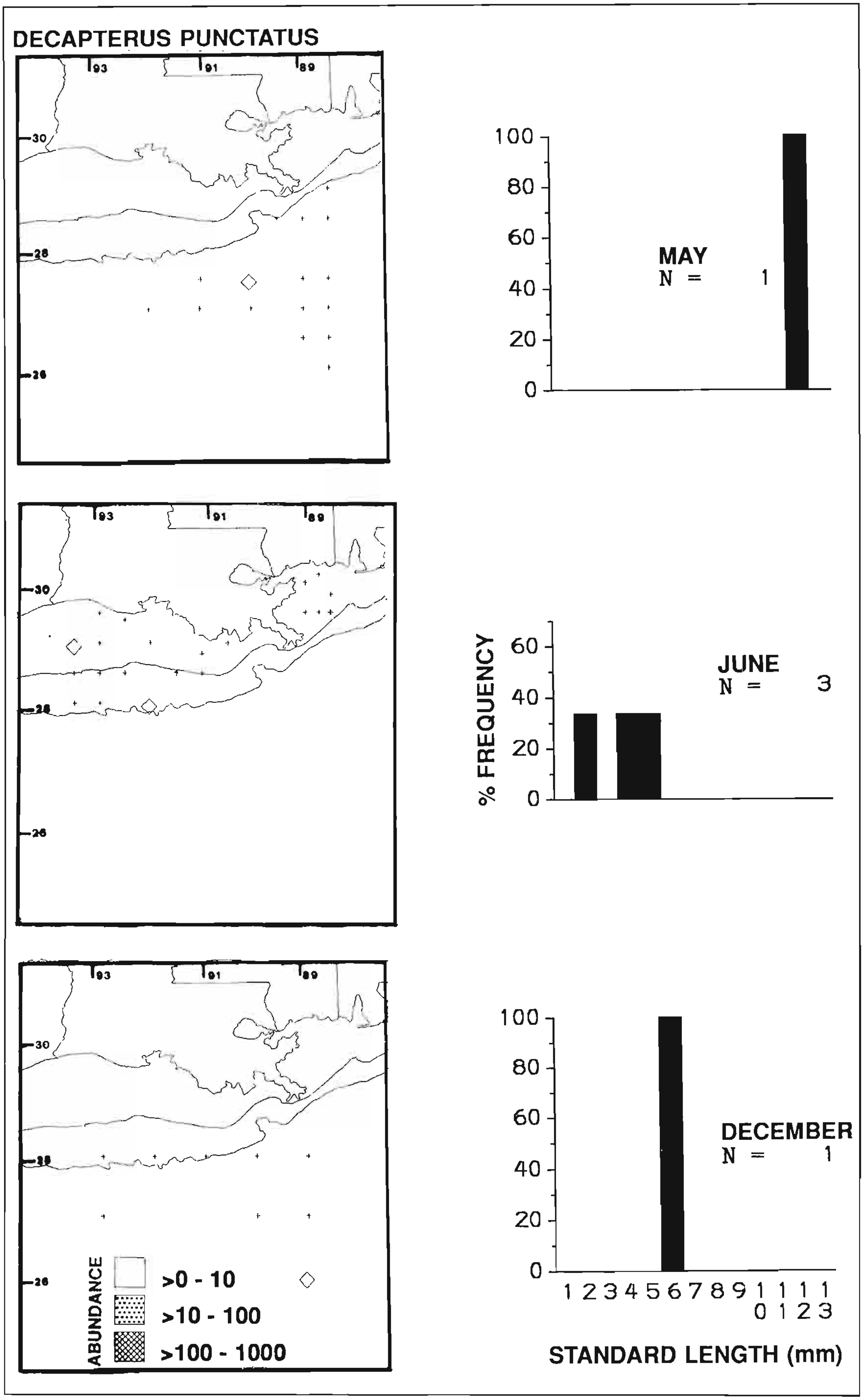


**Figure 11**
Size-frequency distribution and abundance ($N$/10 $m^2$) of *Decapterus punctatus* larvae for positive-catch months during 1983 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.

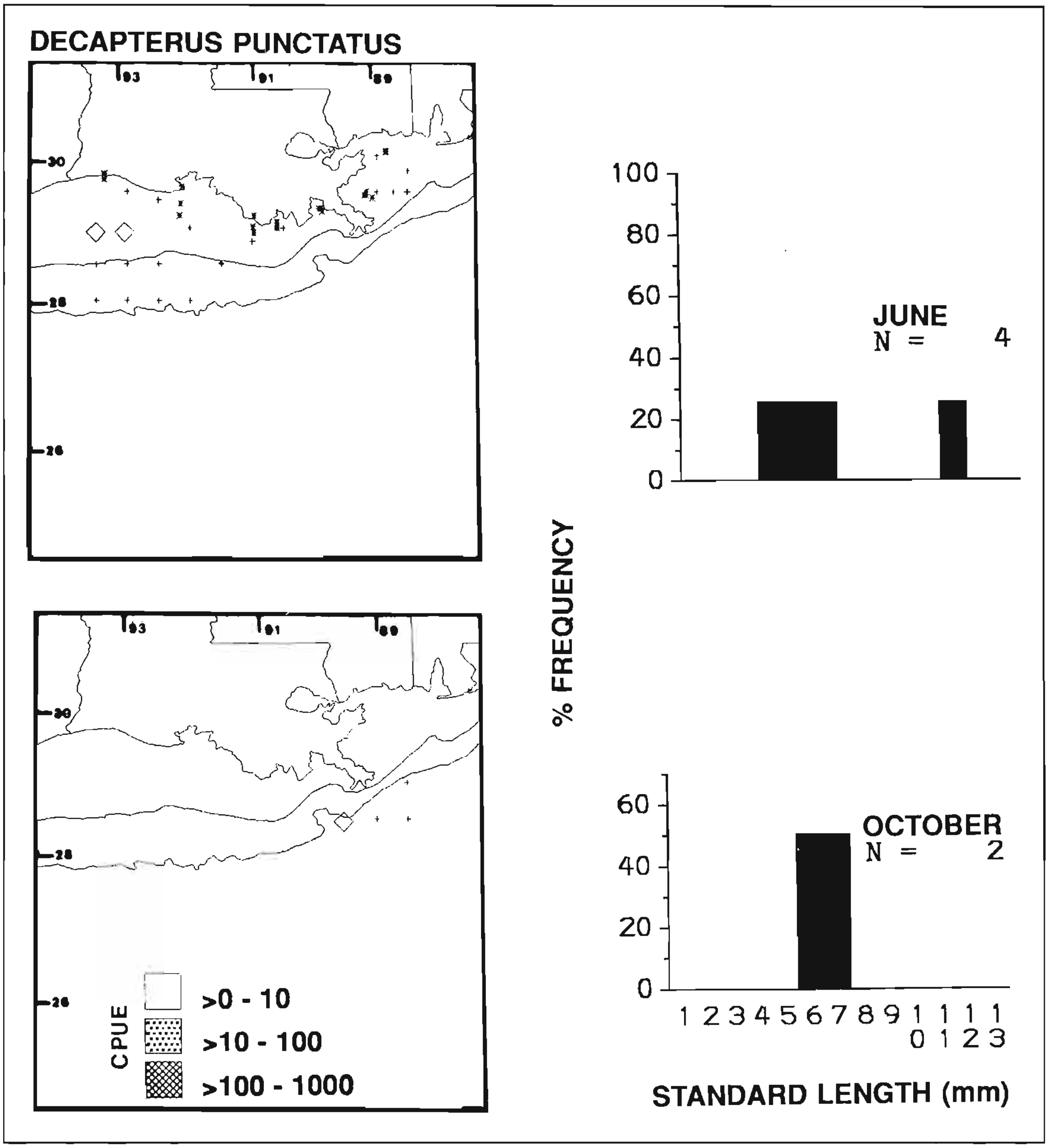


**Figure 12**

Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Decapterus punctatus* larvae for months with positive neuston catches during 1983 SEAMAP neuston and half-meter ring net collections off Louisiana. Stations sampled: + neuston, * ring nets. *N* = total number caught; no larvae taken in ring nets.

actually were. Surface-towed 0.5-m ring nets were used extensively in nearshore waters during June and July, but no larval *D. punctatus* were taken, possibly because the ring nets were used to depths of only 9 m. No specimens were captured inshore of 13 m, even in bongo or neuston nets towed in waters as shallow as 5 m.

June and July were the only months when larvae less than 6.0 mm SL were captured. In addition, year-round spawning was indicated by the presence of a 8.2-mm SL larva captured on 11 March, a 12.6-mm individual captured on 3 May, a 6.4-mm larva captured on 14 December; and two individuals, 6.8 and 7.8 mm, captured on 12 October (Figs. 9–12).

Surface temperatures and salinities at spawning sites could not be clearly determined because of the lack of recently hatched specimens (<2.5 mm SL). Not only were small fish lacking in our samples, but the problem may have been compounded by the difficulty in identifying early post-yolksac *D. punctatus*. Surface-temperature and salinity means (ranges) at locations where all sizes of larvae were captured were 28.5°C (19.0°–30.0°C) and 29.8 ppt (27.6–33.2 ppt), respectively, in 1982; and 26.2°C (23.1°–27.4°C) and 34.3 ppt (33.3–36.4 ppt), respectively, in 1983.

**Table 8**

***Decapterus punctatus*** **mean larval abundance ($N$/10 $m^2$) as determined from metered bongo tows, and mean catch-per-unit-effort (number captured/tow) as determined from neuston and unmetered 0.5-m ring net tows, for positive-catch stations only. Spawning season considered to be year-round (Ditty et al. 1988; this work). For total SEAMAP yearly sampling effort by month, gear type, and depth, see Table 3. NS = no samples taken; NA = data not available.**

| Mean variable | March | April | May | June | July |
|---|---|---|---|---|---|
| Bongo catch | | | | | |
| 1982 | 0.1 [1](1/63) | 0.0 (0/23) | 0.0 (0/34) | 1.4 (4/39) | 3.5 (3/4) |
| 1983 | 0.0 (0/5) | 0.0 (0/14) | 0.3 (1/19) | 0.4 (2/24) | 0.0 (0/5) |
| Neuston or ring catch | | | | | |
| 1982 | NS | 0.0 (0/23) | 0.0 (0/37) | 3.0 (2/59) | 22.0 (2/23) |
| 1983 | 0.0 (0/3) | 0.0 (0/14) | 0.0 (0/18) | 2.0 (2/65) | 0.0 (0/5) |
| Surface salinity (ppt) | | | | | |
| 1982 | NA | | | 29.6 [2](28–33) | 29.6 (28–32) |
| 1983 | | | 34.2 | 34.0 (33–36) | |
| Surface temperature (°C) | | | | | |
| 1982 | 19.0 | | | 29.1 (27–30) | 29.5 (29–30) |
| 1983 | | | 23.1 | 27.2 (27–28) | |
| Station depth (m)[3] | | | | | |
| 1982 | 48.0 | | | 38 (13–88) | 24 (20–27) |
| 1983 | | | 1181 | 47 (24–115) | |

| Mean variable | August | September | October | November | December |
|---|---|---|---|---|---|
| Bongo catch | | | | | |
| 1982 | NS | NS | 0.0 (0/2) | 0.0 (0/28) | NS |
| 1983 | NS | NS | 0.0 (0/12) | NS | 0.7 (1/9) |
| Neuston or ring catch | | | | | |
| 1982 | NS | NS | 0.0 (0/3) | 0.0 (0/3) | NS |
| 1983 | NS | NS | 2.0 (1/4) | NS | 0.0 (0/8) |
| Surface salinity (ppt) | | | | | |
| 1982 | | | | | |
| 1983 | | | 33.4 | | 36.4 |
| Surface temperature (°C) | | | | | |
| 1982 | | | | | |
| 1983 | | | 26.3 | | 25.0 |
| Station depth (m)[3] | | | | | |
| 1982 | | | | | |
| 1983 | | | 494 | | 3111 |

[1]Frequency of occurrence: number of positive-catch stations per number of stations sampled.
[2]Range of values.
[3]Sampling methodology for bongo nets limits tows to upper 200 m of water (see Methods section).

### *Trachurus lathami*

Sampling during December, April, and May (Figs. 13–15) in waters greater than 100 m deep revealed larval rough scad scattered between 102 and 3111 m (Table 9); however, they were generally found at the edge of the shelfbreak, possibly indicating concentrations on the sparsely sampled outer shelf. During March (1982 only), good onshelf station coverage in the Mississippi River delta area revealed that larvae were in fact relatively common on the outer shelf, but that they were virtually absent on the inner shelf.

A total of 102 larvae (1.8–7.7 mm SL) were captured off Louisiana during 1982 and 1983. Larvae were caught at 26 stations, but the numbers caught at each station were always low. Mean abundance on the outer shelf was clearly higher than that of the other three target carangids, but abundances on the inner shelf and offshore were very low (Table 4). In overall abundance they ranked third.

Relatively small larvae (1.8–7.7 mm SL) were present during all months of capture, December, March, April, and May (Figs. 13–15), indicating spawning throughout winter and spring. Length-frequency data were insufficient to provide information about spawning peaks or periods.

Recently hatched larvae (<2.5 mm SL) were found at surface temperatures of 18.0°–23.0°C and salinities of 35.8–36.3 ppt (Table 6). Many small larvae were captured near the mouth of the Mississippi River on a cruise in March 1982, a time when there was considerable freshwater input. Their proximity to that freshwater discharge would indicate that they are quite tolerant of low salinities. Unfortunately, no

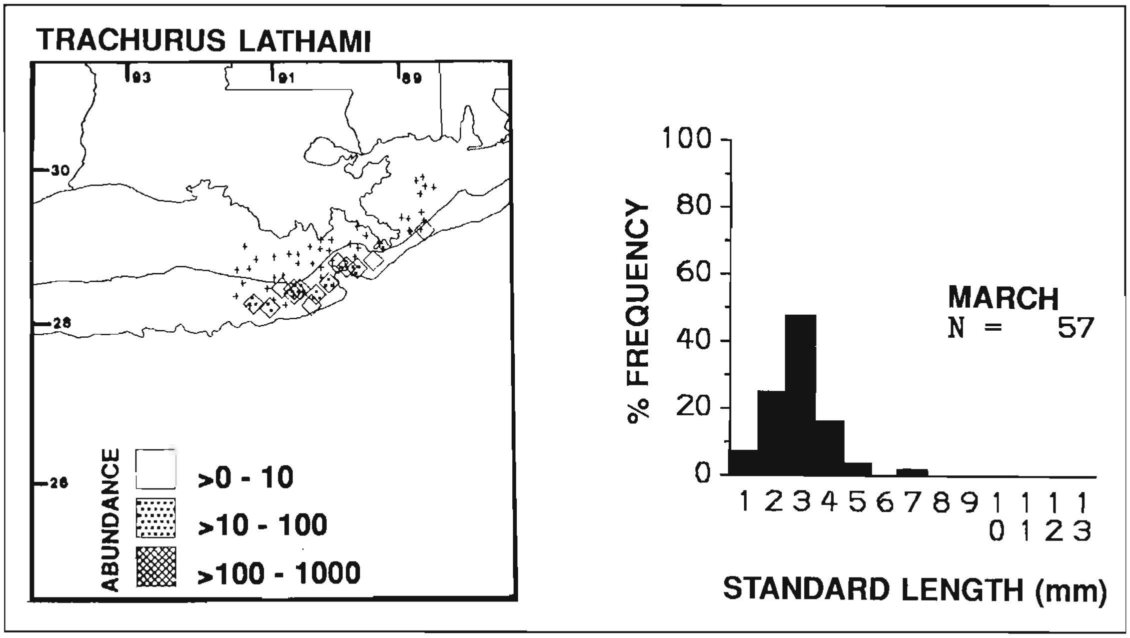


**Figure 13**
**Size-frequency distribution and abundance ($N$/10 m$^2$) of *Trachurus lathami* larvae for March (the only positive-catch month) during 1982 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.**

salinities were recorded on that particular cruise, so our reported minimum salinities at capture sites are probably high. At locations where all sizes of larvae were captured, surface temperatures were 18.0°–25.0°C, and salinities were 32.0–36.4 ppt.

## Discussion

Three of the species examined, *Caranx crysos*, *Chloroscombrus chrysurus*, and *Decapterus punctatus*, have summertime spawning periods, though *D. punctatus* was captured during all seasons. Maximum abundances for all three of the summer-spawning species occurred during July 1982. During that month only four stations were sampled (off western Louisiana near midshelf), but three of those stations yielded larvae of all three species, and only *D. punctatus* was absent from the fourth. Larvae of the summer-spawning species were otherwise rarely captured together (especially *C. crysos* and *Ch. chrysurus*). At those July stations, four other larval or early-juvenile carangid species were also captured: *Caranx hippos* or *latus*, *Oligoplites saurus*, *Selar crumenophthalmus*, and *Selene setapinnis* (Shaw and Drullinger, unpubl. data).

In a study off western Florida, *C. crysos* shorter than 5.5 mm SL were found only beyond the 67-m isobath, and were thought to have a completely separate depth distribution from the nearshore-dwelling *Ch. chrysurus* (Leak 1981). Montolio (1976), however, found *C. crysos* larvae primarily in depths of 10–20 m in Gulf waters off the United States and Mexico. Data presented herein are intermediate between those of Leak and Montolio. In 1982, larvae were usually concentrated beyond 40 m, but in 1983 they were frequently captured inside the 40-m isobath and as shallow as 11 m. There appears to be yearly or geographical variability in the depth distribution of *C. crysos* larvae.

In comparison with the other carangids examined, *C. crysos* had the highest offshore abundance. On the inner shelf, *C. crysos* abundance ranked a distant second to that of *Ch. chrysurus*, and on the outer shelf (40–182 m) it was below only that of *T. lathami*. Based on an ongoing survey around the Mississippi River delta in which *C. crysos* larvae dominated summertime collections (Shaw and Drullinger, unpubl. data), this species may be much more abundant than the SEAMAP coverage would indicate. SEAMAP summertime larval *C. crysos* abundance may have been underestimated if abundances were, in fact, highest on the shelf prior to or after June and July. In further support of this, spawning peaks for *C. crysos* in the north-central Gulf have been found to occur in April–May and in August–September (Montolio 1976), mostly on the shelf. This species requires further study of its geographical and yearly variability in spawning depth and season to elucidate actual larval distribution and abundance.

Similarly, little is known about *Ch. chrysurus* larvae from off Louisiana. In general, this and previous studies characterize *Ch. chrysurus* as a nearshore spawner and the most abundant carangid in the north-central Gulf. We found *Ch. chrysurus* larvae to be concentrated mostly off central and western Louisiana. Salinities reported from capture sites off Louisiana were often lower (as low as 10.0 ppt) than those reported from Florida (Leak 1977, 1981).

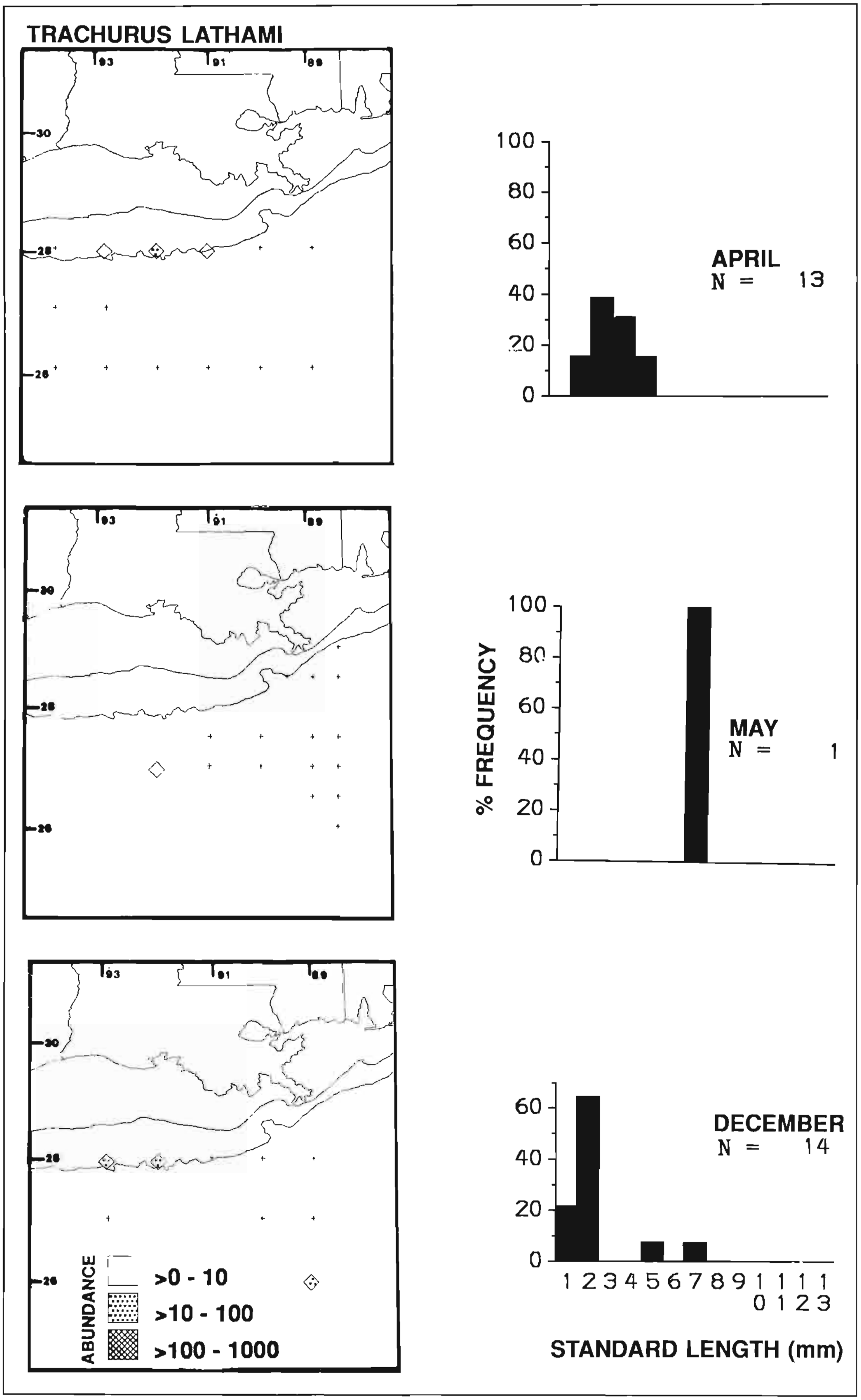


**Figure 14**
Size-frequency distribution and abundance ($N/10\ m^2$) of *Trachurus lathami* larvae for positive-catch months during 1983 SEAMAP bongo net collections off Louisiana. Stations sampled (+); $N$ = total number caught.

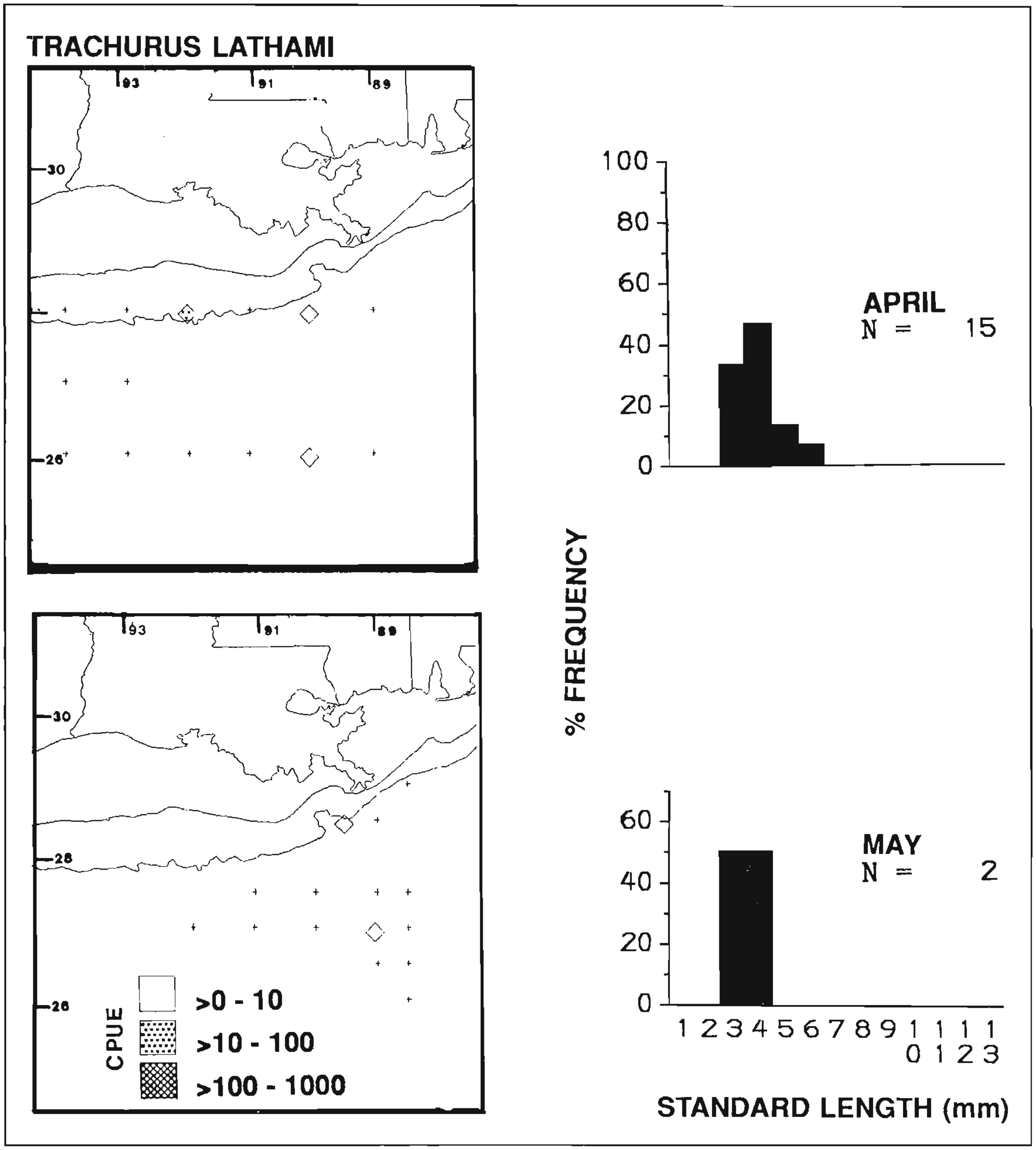


**Figure 15**

**Size-frequency distribution and catch-per-unit-effort (*N*/tow) of *Trachurus lathami* larvae for positive-catch months during 1983 SEAMAP neuston net collections off Louisiana. Stations sampled (+); *N* = total number caught.**

*Decapterus punctatus* are considered common east of the Mississippi River (Hoese and Moore 1977), but their larvae were absent adjacent to the delta and off the Mississippi coast. They were the least-common target carangid off Louisiana, except on the inner shelf where they were more abundant than *T. lathami*. Depth distribution for larval *D. punctatus* on the Louisiana shelf and off Florida's west coast were similar (Leak 1977, 1981). Their adults may migrate offshore for the winter and back onshore during spring (Leak 1977, 1981). Discovery of a 6-mm SL larva far offshore in the central Gulf during December may indicate spawning in that winter offshore population.

The principal winter-spawning species, *T. lathami*, has been found to school as adults with a winter-spawning clupeid *Etrumeus teres* (Reintjes 1979a, Leak 1981). We found the distribution of larvae of these two species to closely overlap on the outer shelf during March (Shaw and Drullinger 1990). Larvae were in close proximity to the mouth of the Mississippi River at a time of relatively high discharge. *Trachurus lathami* spawning is known to be associated with "high amplitude events" or gradients (Leak 1977, 1981), so it was not surprising to find their larvae associated with zones of turbulent mixing between the Mississippi River plume and the high-salinity oceanic waters of the open Gulf.

**Table 9**

***Trachurus lathami* mean larval abundance ($N$/10 $m^2$) as determined from metered bongo tows, and mean catch-per-unit-effort (number captured/tow) as determined from neuston and unmetered 0.5-m ring net tows, for positive-catch stations only. Spawning season considered to be November–May (Ditty et al. 1988). Note gap between December and March; for total SEAMAP yearly sampling effort by month, gear type, and depth, see Table 3. NS = no samples taken; NA = data not available.**

| Mean variable | December | March | April | May |
|---|---|---|---|---|
| Bongo catch | | | | |
| 1982 | NS | 4.7 (14/63) | 0.0 (0/23) | 0.0 (0/34) |
| 1983 | 9.2 [1](3/9) | 0.0 (0/5) | 4.9 (3/14) | 0.3 (1/19) |
| Neuston ring catch | | | | |
| 1982 | NS | NS | 0.0 (0/23) | 0.0 (0/37) |
| 1983 | 0.0 (0/8) | 0.0 (0/3) | 5.0 (3/14) | 1.0 (2/18) |
| Surface salinity (ppt) | | | | |
| 1982 | | NA | | |
| 1983 | 36.0 | | 35.5 [2](32–36) | 36.2 (36–36) |
| Surface temperature (°C) | | | | |
| 1982 | | 20.3 (18–22) | | |
| 1983 | 23.3 (22–25) | | 21.8 (20–23) | 22.9 (22–23) |
| Station depth (m)[3] | | | | |
| 1982 | | 63 (37–91) | | |
| 1983 | 1111 (102–3111) | | 658 (102–2926) | 1427 (459–2268) |

[1]Frequency of occurrence: number of positive-catch stations per number of stations sampled.
[2]Range of values.
[3]Sampling methodology for bongo nets limits tows to upper 200 m of water (see Methods section).

The vast majority of *T. lathami* larvae were captured between 40 and 182 m, which agrees with previous findings off Florida (Houde et al. 1984) and Louisiana (Ditty and Truesdale 1984). Reported adult distributions are similar (Mansueti 1960, Fischer 1978b).

Larvae of *T. lathami* superficially resemble those of *D. punctatus*, but behaviorally they may be quite different. Most *D. punctatus* captured were large; about half were near or above the maximum cutoff size for fish included in this analysis (13.9 mm), and only 10 were below 5.0 mm SL. Conversely, only small *T. lathami* were captured; none were above 7.7 mm SL, and only 10 were above 5.0 mm SL. It appears that *T. lathami* larvae longer than approximately 8.0 mm SL either dwell nearbottom, below maximum bongo sampling depth, or are much more capable of avoiding capture than are *D. punctatus* of equal size. Since adult and juvenile *T. lathami* reside near the bottom (Stuck and Perry 1982), the hypothesis that larvae avoid capture through a demersal lifestyle has some credence. Juveniles of *D. punctatus* are nearsurface pelagics (Fischer 1978a) especially during the daytime (Fahay 1975), which could account for our capture of larger fish in surface and oblique gear. The reason for low numbers of small *D. punctatus* remains a mystery, except that a few were possibly misidentified and therefore not included in this analysis.

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## Adult Distribution

### Geographic

**Western North Atlantic** Found from Halifax Harbor, Nova Scotia, throughout the Gulf of Mexico, Caribbean, Bermuda, and West Indies to Cananeia and Sáo Paulo, Brazil (Fischer 1978a). Has 28 species of Carangidae (Aprieto 1974); other *Caranx* spp. in the Gulf of Mexico are *C. bartholomaei*, *C. hippos*, *C. latus*, *C. lugubris*, *C. ruber* (Hoese and Moore 1977; Laroche et al., in prep.); *C. sexfasciatus* (circumtropical) and *C. vinctus*, whose juveniles resemble *C. crysos* (Nichols 1939, 1944); *C. dentex* (Berry 1959); and *C. guara* (Erdman 1956, Puerto Rico).

### Vertical (depth) or distance from shore

A pelagic schooling fish (Reintjes 1979a) almost always taken in upper 100 m (McKenney et al. 1958), apparently present over the continental shelf as juveniles and adults, but uncommon, if at all, in Gulf estuaries (Leak 1977).

## Stock Abundance

Presently unknown for the Gulf—clearly an area of needed research.

## Fisheries

### Gulf of Mexico

**Northern Gulf** Traditionally used for bait, but recently sold as fresh and frozen food fish; potential for export marketing (Reintjes 1979a).

**Florida** Over 278,379 kg sold ($26,880) as food fish from both coasts of Florida in 1956; highly prized live bait for amberjack *Seriola* spp., and sailfish *Istiophorus platypterus* (McKenney et al. 1958). Catch fluctuated between 270 and 99 metric tons (t) in the last decade; taken primarily by beach seine in northwestern Florida April–September and sold as bait for snapper (family Lutjanidae) or to Puerto Rico and the Virgin Islands as food (Leak 1977).

**Louisiana/Mississippi** Off the barrier islands, large incidental catches often taken by commercial red drum (*Sciaenops ocellatus*) purse-seiners, who often set on the surface-schooling *C. crysos*, which stack over red drum schools (Overstreet 1983).

### Other

**Gulf and Caribbean** Important food item in West Indies and Gulf, eaten in Puerto Rico and Trinidad (McKenney et al. 1958).

**Gulf** According to 1975 FAO statistics, catch in the Gulf (Area 31) of 6579 t—only 635 t landed in the U.S.—marketed fresh or salted (Fischer 1978a).

Small fisheries for *Caranx* spp. worldwide; fish imported from the United States sold as food in Puerto Rico and the Virgin Islands (Leak 1977).

### Problems

Recognized as a respectable game fish (Berry 1959) and baitfish (McKenny et al. 1958, Reintjes 1979a).

## Reproduction

### Sexual maturity

**Northwest Florida** Age-at-maturity size ≤267 mm fork length (FL), based on 185 fish taken May–August (Goodwin and Finucane 1985).

**South Pass, Louisiana** Four females (247–267 mm SL) with enlarged ovaries (but not running ripe) and one male (225 mm SL) with enlarged testes taken in July (Berry 1959).

**Pensacola Beach, Florida** Gonads of six specimens (three males and three females) taken in July were enlarged but not as well developed as those of the South Pass, Louisiana, specimens (Berry 1959).

### Sex ratio

**Northwest and south Florida** Male-to-female ratio significantly different from 1:1 (1.0M:1.66F and 1M:1.91F, respectively) whereas 1M:1.15F off the Mississippi River delta (Goodwin and Finucane 1985).

### Fecundity

**Off south and northwest Florida and Mississippi River delta** Based on 25 fish, fecundity ranged from 41,000 (243 mm FL, 288 g) to 1,546,000 ova (385 mm FL, 1076 g) (Goodwin and Finucane 1985).

### Spawning season

Spawning takes place at night for *Caranx* sp. from Madras, India (Subrahmanyam 1964).

**Off south and northwest Florida and Mississippi River delta** June–August spawning season, based on data collected using a gonadosomatic index (GSI), but a second and significant GSI peak observed off northwest Florida in October 1980 and 1981 with small females (200–250 mm FL) suggests the possibility of two spawning peaks in the Gulf, which might explain the presence of larvae year-round (Goodwin and Finucane 1985).

**Gulf** Larvae found throughout but greatest densities in the central region; most abundant April–May and August–September in 10–20 m depths (Montolio 1976).

**Eastern Gulf** Twelve larvae identified as *C. crysos*, 72 as *Caranx* spp.; virtually all taken beyond the 50-m contour during spring–summer (Houde et al. 1979).

**Florida and Caribbean** Spawning possibly year-round, but primarily January–August with a peak in summer (April–August), when 75% of the postlarvae were collected; larvae and juveniles taken over deep water in upper 100 m in temperatures of 20°–30.8°C and salinities of 33.2–36.2 ppt (McKenney et al. 1958).

**West Florida** *Caranx* spp. larvae beyond the 50-m isobath and >140 km offshore; *C. crysos* move offshore to spawn; larvae taken in August—no larvae <5.5 mm taken at stations shallower than 67 m (Leak 1977, 1981).

**Puerto Rico** Based on ripe or near-ripe gonads, spawns in May (Erdman 1956).

**Southeastern U.S. coast** Spawns offshore near or beyond 183-m contour early April–early September (based on a 12.4-mm SL individual taken in May and a 13.2-mm SL specimen taken in October); concentrations of larvae and juveniles found in the Gulf Stream May–November (peak June to mid-August), larvae taken in temperatures of 20.4°–29.4°C and salinities of 35.2–36.0 ppt (Berry 1959).

**U.S. South Atlantic Bight** Total of 59 larvae taken year-round, but most taken January–August with a peak in summer (Fahay 1975).

**North and South Atlantic** Larval specimens taken from Nova Scotia to Brazil in all months except September and November; most taken January–August, particularly after April (Leak 1977).

## Eggs

### General description

No information for *C. crysos*.

**Hawaii** *Caranx mate* eggs are pelagic, clear, and spherical, with a yolk diameter of 0.66±0.02 mm (Miller and Sumida 1974).

General characters for Carangidae eggs (Fahay 1983:240): "Pelagic, shell smooth, yolk homogeneous or segmented, 1 oil globule anterior in late eggs and hatchling (eggs described in only a few species)."

### Egg diameter

No information for *C. crysos*.

*Caranx mate* egg diameter (live) 0.72±0.02 mm (Miller and Sumida 1974).

### Perivitelline space

No information for *C. crysos*.

*Caranx mate* perivitelline space 0.026±0.004 mm (Miller and Sumida 1974).

### Oil globule

No information for *C. crysos*.

*Caranx mate* has one oil globule 0.19–0.20 mm (Miller and Sumida 1974).

### Incubation time

No information for *C. crysos*.

*Caranx mate* incubation time of 26 h at 24.5°C (Miller and Sumida 1974).

## Larvae

### Hatching length

No information for *C. crysos*.

*Caranx mate* larvae hatch at a mean length of 1.46 mm SL (range 1.32–1.70 mm SL; $N$=47), preserved mean length of 0.98 mm SL (0.87–1.03 mm SL; $N$=10) (Miller and Sumida 1974).

### Early-life-history information

**Gulf** During four research cruises in 1973–74, the greatest concentrations of fry taken in depths of 10–20 m; no significant ratio between day and night catch (Montolio 1976).

**Florida and Caribbean** No evidence of any diurnal migration in larvae collected (McKenney et al. 1958).

**Charleston, South Carolina** Significantly more larvae caught (total number 191; 7–37 mm TL) with a Boothbay neuston net during the day than at night in July (Eldridge et al. 1977).

**Southeastern U.S. coast** Larvae and juveniles have an affinity for the Gulf Stream and offshore waters; some move inshore after attaining lengths of 80–100 mm (Berry 1959).

Laroche et al. (in prep.) cite Chacko (1950) and Padoa (1956) as providing early-life-history information from the Indian Ocean and Gulf of Napoli, respectively.

### Meristics

**Dorsal** VIII+I, 22–25, well formed at 5.4 mm SL (Berry 1959, southeast U.S. coast); VIII+I, 23 (Boschung 1957, Mobile Bay, Alabama).

**Anal** II+I (full complement by 5.4 mm SL), 19–21 (developed by 7.5–8.5 mm SL, Berry 1959); II+I, 20 (Boschung 1957).

**Pectorals** I, 19–23 (by 8.5 mm SL, Berry 1959).

**Myomeres** 25 (Fahay 1983, northwestern Atlantic).

### Larval description

**Gulf** Illustrations of wild-caught larvae (Montolio 1976). *Caranx* sp. (Laroche et al., in prep.).

**Florida and Caribbean** Illustrations and comparative information for wild-caught larvae (McKenney et al. 1958).

**West Florida** Comparative descriptions and early-life-history information for wild-caught larvae (Leak 1977).

**Southeastern U.S. coast** Illustrations and comparative information for wild-caught larvae; also illustrations of *C. bartholomaei* and *C. hippos/latus* larvae (Berry 1959).

**U.S. Mid-Atlantic Bight** Atlas of larval stages compiled from the works of other authors listed above (Johnson 1978).

**West Africa** Illustrations and comparative information for wild-caught larvae; also illustrations of *C. rhonchus* and *C. senegallus* larvae (Aboussouan 1975). *C. rhonchus* (Conand and Franqueville 1973).

**Java Sea** *Caranx* sp., *C. armatus*, *C. crumenophthalmus*, *C. kurra*, *C. macrosoma* (Delsman 1926).

**India** *C. kalla* (Bapat and Prasad 1952).

## Juvenile

Undergoes metamorphosis at ~8.5 mm SL; virtually all adult characteristics present at 59.3 mm (Johnson 1978).

Juveniles associated with floating objects such as *Sargassum* (Dooley 1972, Bortone et al. 1977, Fischer 1978a).

**West Florida** One juvenile taken in May, and 19 taken in June–July over depths of 70–225 m (Leak 1977).

**Dauphin Island, Alabama** One juvenile (146 mm) taken in June (Swingle 1971).

**Mississippi** Juveniles (21–30.0 mm SL) taken off barrier islands in August surface tows (Stuck and Perry 1982).

**Central Gulf** Juveniles and larvae most abundant during April–May and August–September (Montolio 1976).

**Louisiana** One juvenile (45 mm) taken in June in waters 29.3°C and 21.8 ppt (Perret et al. 1971).

**Gulf Stream off southeastern U.S. coast** Juveniles collected April–May to October (Berry 1959, Dooley 1972) and year-round, with a peak in summer (Fahay 1975).

## Adult Distribution

### Geographic

**Western Atlantic and Gulf** Found from Cape Cod, Massachusetts, to Uruguay and throughout the Gulf of Mexico (Briggs 1958); off Bermuda and possibly throughout the West Indies (Fischer 1978a); uncommon north of South Carolina (Hildebrand and Schroeder 1928).

### Vertical (depth) or distance from shore

**Eastern Gulf** Adults and juveniles present nearshore along beaches and within estuaries spring–fall, but absent in winter (Leak 1977).

Adults school around pilings and range offshore to the 1800-m isobath, but are generally taken within 18-m contour (Klima 1971, Johnson 1978).

## Stock Abundance

### Gulf of Mexico

**Gulf** Common in shallow Gulf and high-salinity bays (Hoese and Moore 1977). Commonly taken by both seining and trawling in open waters (Ginsburg 1952).

**West Florida** Abundant nearshore and accessible to coastal fisheries (Leak 1981).

**Mississippi Sound** Sixteenth-most abundant species taken (Christmas and Waller 1973).

**Louisiana** Most abundant carangid collected (Perret et al. 1971).

**Off Caminada Pass, Louisiana** Fifth-most abundant taxa of larvae collected, representing 94% of all carangid larvae taken and 5% of the total number of larvae collected (Ditty 1986).

**Texas** Fourth-most abundant species taken in nearshore trawling during 1965 (Compton 1965).

### Other

No data found.

## Fisheries

### Gulf of Mexico

Little potential as a food fish, but possible potential for a reduction or pet-food fishery because of nearshore abundance; presently no directed fishery, probably would develop only as a bycatch—in 1979, 700 t were landed in the northeastern Gulf as bycatch of a baitfish and shrimp-trawl fishery (Leak 1977,1981).

### Other

**Venezuela** No specific fishery but abundant locally and marketed fresh, salted, and frozen (Fischer 1978a).

**West Africa** Landings of 1000–1200 t/yr (Conand and Franqueville 1973; Leak 1977, 1981).

### Problems

Very bony (Leak 1977).

## Reproduction

### Sexual maturity

**Texas** Males mature by 137 mm and females by 155 mm (Gunter 1945).

Both males and females mature by 135 mm (Reintjes 1979a)

### Sex ratio

No species-specific data found.

### Fecundity

No species-specific data found.

### Spawning season

**Eastern Gulf** All 774 larvae taken in spring and summer within the 50-m depth contour with 95% of occurrences in depths <35 m (Houde et al. 1979).

**West Florida** Spawns May–November (peak in August–September); taken in surface temperatures of 24°–31°C (peak 29°–32°C) and salinities of 27–37 ppt (peak 36–37 ppt) within the 50-m isobath (primarily within the 30-m contour and within 80 km of shore); larvae <3.5 mm look like *Caranx crysos*, but spawning areas separate enough to allow "cautious identification" (*C. crysos* spawns at depths >50 m and >140 km offshore) (Leak 1977, 1981).

**Everglades, southwest Florida** In coastal waters, 3751 specimens taken (depths 0.8–12 m) in temperatures of 20.8°–30.0°C and salinities of 31.9–38.4 ppt during quarterly sampling; most abundant in May (1.5–9.5 mm SL larvae collected) and August (1.2–5.3 mm SL); taken year-round in coastal waters, one specimen (14 mm SL) taken in estuarine waters in August (Collins and Finucane 1984).

**Lower Mobile Bay, Alabama** Total of 261 larvae ($\bar{x}$ length 2.5 mm) taken July–October, peak in August; fifth-most abundant larval species (2.8% of total catch) (Williams 1983).

**Back and Biloxi Bays, Mississippi** Total of 22 larvae taken in July and August (Shultz and Richardson 1985).

**Mississippi Sound** Specimens 5–21 mm TL taken in plankton tows June–July and specimens 35 mm TL or less June–October; spawning seems to peak in summer (Christmas and Waller 1973).

**Mississippi** Off the barrier islands, larvae (2.0–7.0 mm SL) taken June–October, with peak in August; 92% taken in waters 23°–31°C (Stuck and Perry 1982).

**Barataria and Timbalier Bays, Louisiana** Spawns in depths <20 m, <15 km offshore in July and August; 1061 larvae (2.0–18.6 mm) taken (Walker 1978).

**Caminada Bay, Louisiana** Total of 147 specimens (10–51 mm SL) collected June–August with a peak in July (Sabins 1973).

**Off Caminada Pass, Louisiana** During an ichthyoplankton survey November 1981–October 1982, larvae taken June–October with a peak abundance in July; 94% of larvae taken when surface water temperatures averaged 30°C, most (60%) near mid-depth, 31% near surface, and 9% near bottom (Ditty 1986).

**Central Gulf** Larvae collected between the Mississippi and Atchafalaya river deltas and the 10–100 m isobaths during July 1976; 95% taken inside 25-m contour (Ditty and Truesdale 1984).

**Aransas–Corpus Christi Bay Complex, Texas** Total of 129 larvae taken June–November, peak June–July (Allshouse 1983).

**Aransas Pass, Texas** Larvae (6–28 mm) collected June–September (Hoese 1965).

**Texas** Ripe males and females taken June and August (Gunter 1945).

**Southeastern U.S.** Probably spawns spring–summer (Fischer 1978a).

**U.S. South Atlantic Bight** Eight larvae taken May–October (Fahay 1975).

**Southern Brazil** Larvae taken over continental shelf August–November in waters 18°–22°C (Leak 1977).

## Eggs

### General description

No species-specific data found.

General characters for Carangidae eggs (Fahay 1983:240): "Pelagic, shell smooth, yolk homogeneous or segmented, 1 oil globule anterior in late eggs and hatchling (eggs described in only a few species)."

### Egg diameter

No species-specific data found.

### Perivitelline space

No species-specific data found.

### Oil globule

No species-specific data found.

### Incubation time

No species-specific data found.

## Larvae

### Hatching length

No species-specific data found.

### Early-life-history information

**Caminada Pass, Louisiana** Caught mostly during daytime ebb tides (Sabins 1973).

### Meristics

**Dorsal** VIII+I, 26–28 (modally 27) (Johnson 1978, Mid-Atlantic Bight); VIII+I, 25–28 for juveniles (Laroche et al., in prep., Gulf); VIII+I, 27–28 (Boschung 1957, Mobile Bay, Alabama); VII–VIII+I, 24–28 (Fahay 1983, northwest Atlantic).

**Anal** II+I, 25–27 (Johnson 1978); 26–28, usually 27 (Boschung 1957); II+I, 25–28 (Laroche et al., in prep.).

**Pectorals** 18–20, predominantly 19 (Johnson 1978); 19–20 (Boschung 1957); 20–21 formed by 9.5 mm SL (Laroche et al., in prep.).

**Vertebrae** 10+14 (Miller and Jorgenson 1973, Western Atlantic; Laroche et al., in prep.).

### Larval description

**West Florida** Comparative descriptions and early-life-history information for wild-caught larvae (Leak 1977).

**Northern Gulf** Illustrations and comparative information for wild-caught larvae (Laroche et al. 1984, In prep.).

**West Africa** Illustrations and comparative information for wild-caught larvae (Aboussouan 1975). *C. cosmopolita* (Aboussouan 1968).

## Juvenile

Young fish may occur far offshore (Fischer 1978a); frequently associated with jellyfish (Reid 1954, Franks 1970, Fischer 1978a).

**Buttonwood Canal, Everglades, Florida** Total of 24 specimens taken September–November in water temperatures of 23.3°–34.0°C and salinities of 15.5–41.1 ppt (Roessler 1970).

**Alligator Harbor, Florida** Young taken in early September (Joseph and Yerger 1956).

**West Florida** Juveniles taken along beaches and within estuaries spring–fall, but absent during winter (Leak 1977). Six specimens (42–46 mm) taken from marshes in October (25°C, 30.2 ppt) (Kilby 1955).

**Cedar Key, Florida** Total of 17 juveniles (30–47 mm) taken in October (23°–24°C, 21.8–22.0 ppt) (Reid 1954).

**Tampa Bay, Florida** Two specimens (23.2 and 39 mm) taken in July (Springer and Woodburn 1960).

**Alabama** Total of 113 specimens taken in estuaries July (one 21-mm fish) to December (one 39-mm fish), but almost all taken August–September; minimum sizes taken in August and September, 35 mm and 20 mm, respectively (Swingle 1971).

**Mobile Bay, Alabama** Large numbers of small fish (<38 mm) taken in October (Boschung 1957).

**Mississippi Sound** Specimens 19–114 mm TL collected; fish <35 mm taken June–October (peak in August) in waters 15°–35°C with salinities mostly over 25 ppt (Christmas and Waller 1973).

**Mississippi** Off the barrier islands, juveniles (8.0–74.0 mm SL) taken in plankton tows June–October, with a peak in September (Stuck and Perry 1982).

**Chandeleur Islands, Louisiana** Seven specimens (25–32 mm SL) collected in July and four (16–24 mm SL) taken in September (Laska 1973).

**Louisiana** Most abundant carangid; 699 collected (29–114 mm) in April and June–November with peak abundances June–September (Perret et al. 1971).

**Vermilion Bay, Louisiana** In July, 33 specimens collected (15°–35°C, 6–36 ppt) (Norden 1966).

**Marsh Island, Louisiana** Total of 139 juveniles collected late June–early October, with peak abundances in June and July; water temperatures at capture 26.2°–32°C (Tarbox 1974).

**Texas** Total of 144 fish including some adults (66–205 mm) taken June–October; in August fish 68–178 mm (25.4°–30.0°C, 16.5–37.2 ppt) (Gunter 1945).

**Galveston Island, Texas** Fish (50–110 mm) taken July–October (Arnold et al. 1960).

**Mustang Island, Texas** Juveniles taken March–August (McFarland 1963).

**Aransas Pass, Texas** Juveniles collected in a tidal trap October–February (Copeland 1965).

## Adult Distribution

### Geographic

Found throughout the Gulf of Mexico, Caribbean, West Indies, and Bermuda (Fischer 1978a).

**Western North Atlantic** Present from Nova Scotia to Rio de Janeiro, Brazil (Jordan and Evermann 1896, Berry 1968); 28 species of Carangidae (Aprieto 1974); three species of *Decapterus* distinguished by scale and scute counts: *D. macarellus*, *D. punctatus*, and *D. tabl* (Berry 1968).

### Vertical (depth) or distance from shore

**Gulf** Occurs uncommonly, if ever, in estuaries (Christmas and Waller 1973, Leak 1977). Evidently common over the continental shelf of the eastern Gulf, but less abundant westward (Montolio 1976, Reintjes 1979a); taken in the eastern Gulf to 366 m, peak abundance 57-92 m; greatest numbers in spring in depths ≤18 m, in summer in depths 18-37 m, in fall uniformly distributed over the shelf and in waters 37-93 m deep (Klima 1971); gulfwide, concentrated in 10-20 m depths, but also occurs past 50-m depths (Montolio 1976). Widespread and not uncommon on the outer shelf and inshore east of the Mississippi (Hoese and Moore 1977).

A schooling species, primarily in midwater or nearbottom in shallow water to about 90 m, but is also a nearsurface pelagic, especially as a juvenile (Fischer 1978a).

**Eastern Gulf** May migrate onshore (depths <18 m) in spring, and offshore and/or southward during winter; found 80-160 km from shore in depths 30-100 m most of the year (Leak 1977, 1981).

**Southeastern U.S. continental shelf** Adults taken in bottom trawls between 10 and 110 m; summer though winter, greatest catches in depths of 18-55 m; in spring, greatest catches 10-18 m; contributed greatest biomass of the pelagic species (Barans and Burrell 1976).

Juveniles up to 80 mm SL caught as far offshore as 473 km; larger fish caught nearer shore at mid-depth or the surface (Berry 1968).

Found schooling with chub mackerel, *Scomber japonicus* (Reintjes 1979b).

## Stock Abundance

### Gulf of Mexico

**Gulf** Subject of experimental electrified bottom-trawling by Russians (Maksimov 1977).

**Eastern Gulf** Has potential to provide large catches (Houde et al. 1984); most abundant carangid larvae—adult stock estimated at 100,000-200,000 t and annual potential yield at 70,000-80,000 t (Leak1977).

**Western Florida** Between Cape St. George and San Blas, 18-20 schools (7-9 t each) sighted at the surface during one survey (Juhl 1966).

### Other

**Venezuela** Abundant (Fischer 1978a).

## Fisheries

### Gulf of Mexico

Along with *Opisthonema oglinum* and *Sardinella aurita* (family Clupeidae), potential aggregate catches of 1 million-2 million t for use as bait and cat food (Houde 1975; Reintjes 1979a, 1980).

**Eastern Gulf** Potential for exploitation of *D. punctatus* to significantly increase world catch of round scads; 0.5 million t of *Decapterus* species landed in 1978 (179 t landed in the northeastern Gulf by beach seining and nearshore purse seining spring-early fall, when fish were nearshore); potential uses include human consumption, bait, reduction, and cat food (Leak 1977, 1981).

**Western Florida** Commercially exploited; 316 t ($104,512) landed in 1975 (Snell 1977).

**Florida** Small beach-seine fishery April-November for bait (Klima 1971); bait fishery takes fish 100-170 mm between 0+ and 2 years old (Reintjes 1979a).

### Other

Presently large fisheries on *Decapterus* species in the East China Sea, Sea of Japan, Philippine Archipelago, and off west Africa (Leak 1981).

### Problems

Beach-seine and nearshore purse-seine fisheries exploit only a fraction of the stock; full utilization of the resource would require greater fishing effort offshore, where the stock is abundant year-round (Leak 1977, 1981).

## Reproduction

### Sexual maturity

**West Florida** Young-of-the-year, mature *D. punctatus* females as small as 107 mm SL may spawn around September; these fish may be as young as 4–7 months if they grow as fast as *D. pinnulatus* and *Selar crumenophthalmus* off Hawaii, or *Trachurus trachurus* in the North Sea (Leak 1977, 1981).

**Northwest Florida** All males mature at 145–149 mm; all females mature at 130–134 mm (Naughton et al. 1986).

**Eastern Gulf** Fish of <135 mm FL (<1 yr old) rarely observed to have mature ovaries, but age 0+ fish may contribute substantially to spawning (Houde et al. 1984).

### Sex ratio

1M:1F (Reintjes 1979a).

1.12M:1F in 1981, 1.11M:1F in 1982 survey (Houde et al. 1984).

### Fecundity

Asynchronous oocyte development (Reintjes 1979a).

**Northwest Florida** Apparently a serial spawner—batch fecundity of 20 fish (146–188 mm) was 21,000–146,000 ova (Naughton et al. 1986).

### Spawning season

Dense plankton concentrations possibly stimulate spawning and enhance larval survival; plankton volumes weakly but significantly correlated with abundance of larvae; spawning possibly associated with upwellings or frontal zones (Leak 1977).

**Gulf** Larvae taken throughout the Gulf, but appear most abundant on west Florida shelf (Aprieto 1974, Montolio 1976); larvae found mostly in 10–20 m depths, but also past 50 m; two major spawning periods, April–May and October–November (Montolio 1976).

**Eastern Gulf** Most frequently occurring carangid larvae and among the 20 most frequently observed species; 4431 larvae collected year-round (throughout the eastern Gulf, spring–fall; winter larval distribution restricted to south Florida), most larvae (68% of occurrences) taken at depths <50 m (Houde et al. 1984).

**West Florida** Most abundant carangid larvae in eastern Gulf; spawns year-round in surface temperatures of 20°–30°C (significantly greater catches in waters 23°–30°C) and salinities of 27–37 ppt (peak catches in waters 36–37 ppt) over entire west Florida shelf, but larvae most abundant in spring and summer (primarily spawning in depths of 2–100 m), decreasing steadily in fall and winter (spawning in depths of 30–100 m, 80–160 km offshore); small larvae taken from a total depth range of 2–225 m, 55% of larval catch taken in depths of 30–100 m, 37% in depths <30 m, and 9% in depths >100 m; some evidence of bimodal spawning off both west Florida and south Texas (Leak 1977, 1981).

**Florida and Yucatan Straits** Larvae taken year-round at surface temperatures of 21°–31°C, lowest larval abundances in late fall–winter (Lyons 1978).

**Mississippi** Off barrier islands, larvae (3.0–15.0 mm SL) taken in bottom tows June–August with a peak in July (Stuck and Perry 1982).

**Off Caminada Pass, Louisiana** An ichthyoplankton survey November 1981–October 1982 took larvae in May (Ditty 1986).

**Texas** Based on larval abundance, spawns April–September in depths of 42–182 m, 45–95 km offshore (Finucane et al. 1979).

**South Texas, west Florida, and eastern Atlantic** Spawns in water temperatures >20°C (Aboussouan 1975).

**Beaufort, North Carolina** Spawns May–November (peak in July–September) inshore and offshore (Hildebrand and Cable 1930).

**U.S. South Atlantic Bight** 826 specimens taken year-round, peak larval abundance in spring (Fahay 1975).

**West Africa** Begins spawning in water temperatures >20°C (Conand and Franqueville 1973).

## Eggs

### General description

No specific information on *D. punctatus*.

General characteristics for Carangidae eggs (Fahay 1983: 240): "Pelagic, shell smooth, yolk homogeneous or segmented, 1 oil globule anterior in late eggs and hatchling (eggs described in only a few species)."

### Egg diameter

No species-specific information found.

### Perivitelline space

No species-specific information found.

### Oil globule

No species-specific information found.

### Incubation time

No species-specific information found.

## Larvae

### Hatching length

No species-specific information found.

### Early-life-history information

Larvae may be associated with dense plankton concentrations, upwellings, or frontal zones (Leak 1977, Lyons 1978).

**Gulf** No apparent day/night catch differences (Montolio 1976, Leak 1981).

**Charleston, South Carolina** During mid-July, 118 juveniles (24–27 mm TL) taken using a Boothbay neuston net; statistically more fish captured during the day (Eldridge et al. 1977).

### Meristics

**Dorsal** VIII+I, 29–37 (dorsal fins continuous to ~30–50 mm SL [Berry 1968, western Atlantic]); VIII+I, 27–34 (completion of fin rays by 10 mm [Fahay 1983, northwest Atlantic]); VIII+I, 30–33 attained by 11 mm SL (Laroche et al., in prep., Gulf).

**Anal** II+I, 24–31 (anal fins continuous to ~30–40 mm SL, Berry 1968); II+I, 24–30 attained by 9–11 mm, (Fahay 1983); II+I, 26–28 attained by 11 mm SL (Laroche et al., in prep.).

**Pectorals** 18–20 (Berry 1968); 19–21 attained by 11 mm SL (Laroche et al., in prep.).

**Myomeres/Vertebrae** 25 myomeres, 10+15 vertebrae (Berry 1968, Fahay 1983).

### Larval description

**Gulf** Illustrations and comparative information for wild-caught larvae (Aprieto 1974). Illustrations of wild-caught larvae (Montolio 1976, Laroche et al. 1984).

**North Carolina** Illustrations of wild-caught larvae (Hildebrand and Cable 1930).

**U.S. Mid-Atlantic Bight** Atlas of larval stages compiled from works of other authors listed above (Johnson 1978).

**West Africa** Illustrations and comparative information for wild-caught larvae (Aboussouan 1975).

**Mediterranean** Schnakenbeck (1931).

**Black Sea** *D. russelli* (≅*Caranx kurra*) (Delsman 1926).

**Arabian Sea** *D. kilione* (Tsokur 1977).

**Madras Coast, India** *D. russelli* (Vijayaraghavan 1958).

*D. maruadsi* (Shojima 1962).

## Juvenile

**Gulf** Transforms to juvenile stage at ~10 mm (Aprieto 1973). Transforms to juvenile stage at 10.9–19.0 mm SL (Laroche et al., in prep.).

**Florida** 282 specimens (35–78 mm) taken from the *Sargassum* complex of the Florida Current, all but four juveniles (53–60 mm) collected November–June (Dooley 1972).

**Mississippi** Off barrier islands, juveniles (16–22.0 mm SL) taken in plankton tows between July and September (Stuck and Perry 1982).

**U.S. South Atlantic Bight** Juveniles apparently rise to the surface during predawn period, occupy the surface during the day, and descend at night (Fahay 1975).

## Adult Distribution

### Geographic

**Western North Atlantic** Found from Nova Scotia to northern Argentina, including the Gulf of Mexico (Berry and Cohen 1972, Reintjes 1979a); apparently rare in the West Indies (Fischer 1978b).

**Western Atlantic** Usually recognized as the only species of *Trachurus* in the western Atlantic (Nichols 1940, Ginsburg 1952, Berry and Cohen 1972), although *T. picturatus binghami* has been reported from the Caribbean south to Panama (Nichols 1940); genus has a total of 13 species (Berry and Cohen 1972).

### Vertical (depth) or distance from shore

A pelagic species usually not taken in shore-seining but apparently found near bottom (Ginsburg 1952) in depths of 50–90 m (Mansueti 1960; Fischer 1978b).

**Gulf** Present from Florida to Texas; adults form large schools over the outer continental shelf in depths >183 m January–March; found schooling with chub mackerel (Reintjes 1979a,b). Fairly common in the northern Gulf, east of the Mississippi River, generally found slightly farther offshore than other coastal pelagics (Klima 1971, Christmas and Waller 1973, Hoese and Moore 1977); occurs uncommonly if at all in Gulf estuaries; larvae and probably adults as well are much more common off south Texas than over the west Florida shelf, based on larval collections (Leak 1977, Finucane et al. 1979).

**Tampa Bay, Florida** More abundant offshore and over rocky reefs (Springer and Woodburn 1960).

## Stock Abundance

### Gulf of Mexico

**Eastern Gulf** Stock estimated at 20,000–50,000 t and annual potential yield at 12,000–14,000 t for a seasonal midwater trawl fishery near the edge of the continental shelf winter–early spring; *Trachurus* is characterized by large abundances in high-amplitude cycles such as upwellings, countercurrents, and rips (Leak 1977).

**Cameron, Louisiana** Massive school of *Etrumeus teres* (family Clupeidae) and rough scad, 56 km long (18 km of which was without interruption) sighted during a January 1969 *Oregon II* cruise (Reintjes 1979a).

**Texas** Second-most abundant carangid after *Selene setapinnis* in trawls on the brown shrimp grounds; one of the most abundant fish on the Labos Island ground in 1954 (Hildebrand 1954).

### Other

**West Indies** Apparently rare (Fischer 1978b).

## Fisheries

### Gulf of Mexico

**Eastern Gulf** Commercial catches small, but possibility of a significant catch from the Gulf as a whole if western stocks are larger, especially if the rough scad bycatch from an *Etrumeus teres* fishery is developed, since massive combined schools have been reported (Leak 1981).

### Other

Major fisheries for *Trachurus* species in the northeast Atlantic, off Chile and Peru, in the East China Sea, and off west and southwest Africa, which landed 2.7 million t in 1978, a major contribution to the world fish catch; Atlantic fisheries are primarily for reduction (meal and oil) while Pacific fisheries are primarily for food (Leak 1977, 1981).

Small developing fisheries off Venezuela and California, on the Mediterranean and Black Seas, and off New Zealand that use midwater trawls, purse seines, lampara, and lift nets (Leak 1977, 1981).

### Problems

Most efficient means of exploitation involves midwater trawling targeted at spawning concentrations, as is presently employed in west Africa (Leak 1977).

## Reproduction

### Sexual maturity

Age at maturity probably <2 years; off Argentina, size at this age 130–150 mm TL (Reintjes 1979a).

### Sex ratio

**Argentina** 1M:1F (Reintjes 1979a).

### Fecundity

No specific information on *T. lathami* (Reintjes 1979a).

**California** *T. symmetricus*, mean number of eggs/g from 30 fish was 109 (based on 15 fish, 217–258 mm FL, 66 eggs/g, and 15 fish, 438–554 mm FL, 152 eggs/g) (MacGregor 1976).

**North Sea and English Channel** *T. trachurus*, fecundity range of 168,000–860,000 oocytes for fish 250–380 mm TL (Macer 1974).

### Spawning season

**West Florida** Spawns primarily offshore November–May (peak January–February in 50–200 m depths) beyond the 30-m isobath (total depth range 20–219 m); proportion of larvae collected from depths of 30–50 m smaller than that from depths >50 m (140 km offshore); larvae collected from waters with surface temperatures of 18°–26°C and salinities of 35–36 ppt. Spawning associated with upwellings, countercurrents, rips, high zooplankton production, and temperatures of 10°–25°C (Leak 1977, 1981).

**Eastern Gulf** Total of 185 larvae taken fall–spring (apparently does not spawn in summer), generally over depths >50 m (70% of occurrences in 50–200 m), widely distributed (Houde et al. 1984).

**Lower Mobile Bay, Alabama** Larvae taken in June and August (Williams 1983).

**Off Caminada Pass, Louisiana** An ichthyoplankton survey November 1981–October 1982 took larvae in February (Ditty 1986).

**Louisiana** Larvae collected January–February 1976 between the Mississippi and Atchafalaya deltas in 10–100 m; 99% of the rough scad larvae taken outside of the 30-m contour (Ditty and Truesdale 1984).

**South Texas** Larvae collected January–May, surface temperatures 13°–21°C; larvae most abundant at depths >45 m and >50 km offshore (Finucane et al. 1979).

**Gulf and Caribbean** Probably spawns offshore from April to June; epipelagic when very young (Fischer 1978b).

**Charleston, South Carolina** Young collected with a Boothbay neuston net during mid-July (Eldridge et al. 1977).

**Indian River, Delaware** Three larvae (3–5 mm) taken in June (de Sylva et al. 1962).

**California** *T. symmetricus* (jack mackerel) appears to prefer spawning around midnight (Farris 1963).

## Eggs

### General description

No specific information on *T. lathami*.

General characteristics for Carangidae eggs (Fahay 1983: 240): "Pelagic, shell smooth, yolk homogeneous or segmented, 1 oil globule anterior in late eggs and hatchling (eggs described in only a few species)."

**California** *T. symmetricus*, yolk diameter of 0.68–0.88 mm (Ahlstrom and Ball 1954).

**Africa** *T. trachurus*, egg spherical, with a thin transparent membrane and a segmented yolk (Kiliachenkova 1970, Haigh 1972).

### Egg diameter

No specific information on *T. lathami*.

**California** *T. symmetricus*, egg diameter of 0.90–1.08 mm (Ahlstrom and Ball 1954).

**Africa** *T. trachurus*, egg diameter of 0.9–1.1 mm (Kiliachenkova 1970) or 0.7–1.09 mm (Haigh 1972).

### Perivitelline space

No specific information on *T. lathami*.

**California** *T. symmetricus*, perivitelline space 0.09 mm (Ahlstrom and Ball 1954).

### Oil globule

No specific information on *T. lathami*.

**Africa** Diameter of *T. trachurus* oil globule 0.19–0.28 mm, yellowish-brownish pigment around anterior part (Haigh 1972); single oil droplet 0.15–0.20 mm wide (Kiliachenkova 1970).

### Incubation time

No specific information on *T. lathami*.

## Larvae

### Hatching length

No specific information on *T. lathami*.

**Northwest Africa** *T. trachurus* hatches at 1.8–1.9 mm with no functional mouth and unpigmented eyes (Kiliachenkova 1970).

### Early-life-history information

No major early life history studies found.

### Meristics

**Dorsal** VIII+I, 28–33 (Boschung 1957, Mobile Bay, Alabama); ($\bar{x}$ 30.3 rays [Nichols 1940, Gulf]); VIII+I, 30–33 attained by 10 mm SL (Laroche et al., in prep., Gulf); 28–34 rays, $\bar{x}$ 30.8 (Berry and Cohen 1972, western Atlantic and Gulf).

**Anal** II+I, 26–30 (Boschung 1957); II+I, 27–30 attained by 10 mm SL (Laroche et al., in prep.); 24–30 rays, $\bar{x}$ 27.6 (Berry and Cohen 1972).

**Pectorals** 21–22 (Boschung 1957).

**Vertebrae** 10+14 (Boschung 1957, Berry and Cohen 1972); 24 (Fahay 1983, northwest Atlantic; Laroche et al., in prep.).

**Scutes** 67–75, $\bar{x}$ 70.1 (Nichols 1940).

### Larval descriptions

Larval development of *T. lathami* most closely resembles that of *T. mediterraneus* and is sometimes confused with that of *Decapterus punctatus*; *T. lathami* larvae <4.0 mm more densely pigmented, especially along ventral and dorsal surfaces, than *D. punctatus* of the same length, but larger larvae of both species may be similarly pigmented (Leak 1977); also see (Laroche et al., in prep.).

**Gulf** Illustrations and comparative information for wild-caught larvae (Laroche et al. 1984).

**U.S. Mid-Atlantic Bight** Excellent atlas of larval stages (Johnson 1978).

**California** *T. symmetricus* (Ahlstrom and Ball 1954).

**British waters** *T. trachurus* (Russell 1976).

**West Africa** *T. picturatus*, *T. trecae* (Aboussouan 1975).

**South Africa** *T. trachurus* (Haigh 1972).

**Northwest Africa** *T. trachurus* (Kiliachenkova 1970).

**USSR seas** *T. mediterraneus* (Aleev 1957).

**Mediterranean Sea** *T. mediterraneus* (Dechnik and Seniokova 1964).

**Sea of Marmara/Black Sea** *T. mediterraneus*, *T. trachurus* (Demir 1961).

**Peru** *T. symmetricus murphyi* (Santander and de Castillo 1971).

**Gulf of Guinea** *T. trachurus* (Zhudova 1969).

**Japan** *T. japonicus* (Uchida et al. 1958).

**Argentina** *T. picturatus australis* (Ciechomski and Weiss 1973).

**Arabian Sea** *T. mediterraneus* (Tsokur 1977).

## Juvenile

**Florida Current, Miami** Description of juveniles (Schekter 1972).

**Tampa Bay, Florida** Juveniles collected (Springer and Woodburn 1960).

**Mississippi** Off barrier islands, juveniles (32 mm SL) taken in bottom tows during July and October (Stuck and Perry 1982).

**Texas** In July, 29 specimens (99–120 mm) collected in waters of 28.3°C and 35.8 ppt (Gunter 1945). Juveniles collected by trawling in depths >37 m (Hildebrand 1954).

**Chesapeake Bay** One specimen (102 mm SL) collected in July at a depth of 18 m and salinity of 14 ppt in a shrimp trawl (Mansueti 1960).

**New Jersey** Juveniles taken in temperatures of 14°–18.5°C and salinities of 29–30.5 ppt (Milstein and Thomas 1976).

**Newburyport, Massachusetts** One specimen (103 mm) taken on rod and reel; juveniles reach ~75–80 mm, 1-year-olds reach 80–140 mm (one annulus) (Merriman 1943).