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# SEAMAP-SA Nearshore Trawl Survey: 1987 & 1988 Results

**December 1997**

# Results of the Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA) Nearshore, Day/Night Trawl Sampling in the Coastal Habitat of the South Atlantic Bight during 1987 and 1988

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prepared by

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## Preface

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## Abstract

Fishes and crustaceans of coastal waters off the southeast U.S.A. were collected in trawl samples on 5 cruises (August-November) in 1987, and 8 cruises (May-November) in 1988. The Carolinian sampling area was divided into four regions and a station established in each. At each station day and night samples were taken at three sites: an Inlet (near an inlet), Beach (in waters ~4.6 m deep near the beach), and Offbeach (off the beach in water ~ 9.2 m deep). There were no significant differences in water temperature or salinity between years or among sites, but there were among stations and cruises. Significant differences in biomass occurred among cruises and stations, due to fluctuations in finfish (primarily sciaenids) biomass. The catch of cownose ray, *Rhinoptera bonasus*, added significantly to the biomass in Fall 1988 and was almost equal to the biomass of finfish. The teleost community was dominated by two members of the sciaenid family, Atlantic croaker (*Micropogonias undulatus*) and spot (*Leiostomus xanthurus*). The third and fourth-ranked finfish were also sciaenids, *Menticirrhus americanus* and *Cynoscion regalis*. *L. xanthurus* and *M. americanus* occurred in over 90% of the SEAMAP-SA samples. The brown shrimp (*Penaeus aztecus*) was the numerically dominant crustacean. Overall abundance of 10 priority finfish species was greatest in collections from Cape Fear; among the 4 top-ranked sciaenids, only *M. americanus* was more abundant at another station (Georgia).

## INTRODUCTION

The coastal habitat of the South Atlantic Bight (SAB, defined herein as ocean waters inshore of the Gulf Stream between Cape Hatteras, North Carolina, at 35° 15'N latitude and Cape Canaveral, Florida, at 28° 30'N latitude) ranges from the beaches seaward 15 to 25 km where the depths are approximately 9 to 18 m. The sea bottom in this area is mostly homogeneous consisting of sand and sandy mud with varying amounts of mixed shell (Struhsaker, 1969). Interspersed are rock out-croppings, often referred to as "live bottom" due to the extensive, benthic invertebrates and algal growth covering the rocks. Fishes and crustaceans inhabiting this area consist of year-round residents and migrant species in transit to or from their spawning grounds or those which utilize the coastal habitat as a spawning ground (Chao, 1978; Johnson,1978; Williams,1984; Wenner and Sedberry,1989).

Several investigations have examined the shelf waters of the SAB to document species composition, abundance, and biomass of species in the area. The species receiving the most attention are those with commercial or recreational value, including (but not limited to) several members of the sciaenid family, the mackerels, bluefish, and penaeid shrimp. Anderson et al. (1977) found several economically important finfish species in the surf zone off South Carolina. Four of these were members of the sciaenid family, the most abundant of which was the Gulf kingfish (*Menticirrhus littoralis).* Bluefish (*Pomatomus saltatrix)* and Spanish mackerel (*Scomberomorus maculatus*) were also present. Dahlberg (1972) collected 12 species of sciaenids in seine samples taken from a front beach in Georgia, including all of those for which there are fisheries in the SAB. He also collected bluefish and king and Spanish mackerels. Wenner and Sedberry (1989) found that members of the Sciaenid family made up 56% of the abundance and 66% of the biomass in their collections, resulting in the conclusion that coastal waters of the SAB is mostly a sciaenid habitat. Spot, croaker, southern kingfish, and weakfish contributed 60% of the total finfish biomass in their collections. Wenner (1983) conducted a trawl survey in the SAB and found that samples collected during daylight were more variable in numerical abundance, but generally contained more biomass than collections taken at night. He attributed this to dense schools formed by some species during the day. Night collections had a greater number of species than those taken in daylight.

The fish and decapod crustacean species in the coastal waters of the SAB support several major fisheries with harvests approaching 150 million pounds (123,361,775 lbs. of finfish and 20,062,912 lbs. of shrimp landed in the SAB in 1993) and revenues in excess of $84 million (J.E. Moran, SCMRD Statistic Section, Pers. Comm.). This is indicative of the high demand for seafood products. The current trend of increased dietary awareness with respect to health will most likely drive the demand for seafood products even higher. It is also indicative of a high level of fishing pressure in this region and the potential for increases in fishing pressure as supply keeps pace with increasing demand. In addition to commercial fishing pressures, recreational harvests are rising due to increasing popularity and increasing population in coastal areas. Recreational fishing is equaling and, for some fisheries, surpassing commercial fishing in economic impact (U.S. Dept. of Interior, Fish and Wildlife Service and U.S. Dept. of Commerce, Bureau of Census, 1993) and approaches the commercial level of harvest (over 44 million pounds of finfish in the South Atlantic Bight in 1993) (U.S. Dept. of Commerce, NOAA/NMFS, 1995). Fishing pressures act directly to deplete fishery stocks, but coastal ground fish are also diminished by habitat destruction, pollution, and through mortality caused by fishing gears that target other species (by-catch).

Economical dependence of coastal communities on commercial and recreational fisheries coupled with the pressures these combined fisheries exert towards depleting stocks create a crucial need for management. Shrimp and blue crab have been managed for many years and most coastal pelagic fish species (most notably bluefish and the mackerels) also have management plans in place. Presently, ASMFC, SAFMC, and state agencies are focused on the sciaenids (red drum and spotted seatrout, which are rare in trawl collections, spot, croaker, weakfish, and southern kingfish) most of which have management plans in place, and on small coastal sharks. The assessment phase of a management plan generally considers age and maturity components of commercial, recreational, and bycatch for which length-at-age keys and age at maturity information are essential. Coastal monitoring surveys like the SEAMAP Program provide the data necessary to create the age-at-length keys, determine age at maturity, test models, and identify natural population fluctuations in abundance, biomass, and distributions.

The objective of this survey was to examine the distribution, abundance, and biomass of fish and decapod crustacean species in the coastal habitat of the SAB. Patterns of species composition, abundance, and biomass, as well as length-frequency distributions of 14 commercially and numerically important species, are examined latitudinally, temporally, and by light-phase. Reported herein are the results of two years of day and night trawl sampling throughout the SAB.

## METHODS AND MATERIALS

### Description of the Study Area and Sampling Design

Four stations were established in the coastal habitat of the South Atlantic Bight between Cape Hatteras, North Carolina, and Cumberland Island, Georgia (Figure 1). Each station was subdivided into three trawling sites, designated as Beach (~4.6 m of water as near the beach as possible), Offbeach (~9.2 m of water as close to the Beach site as possible), and Inlet (just seaward of the inlet nearest to the Beach sites). Sampling stations were located off Bogue Banks and Bogue Inlet, near Cape Lookout,

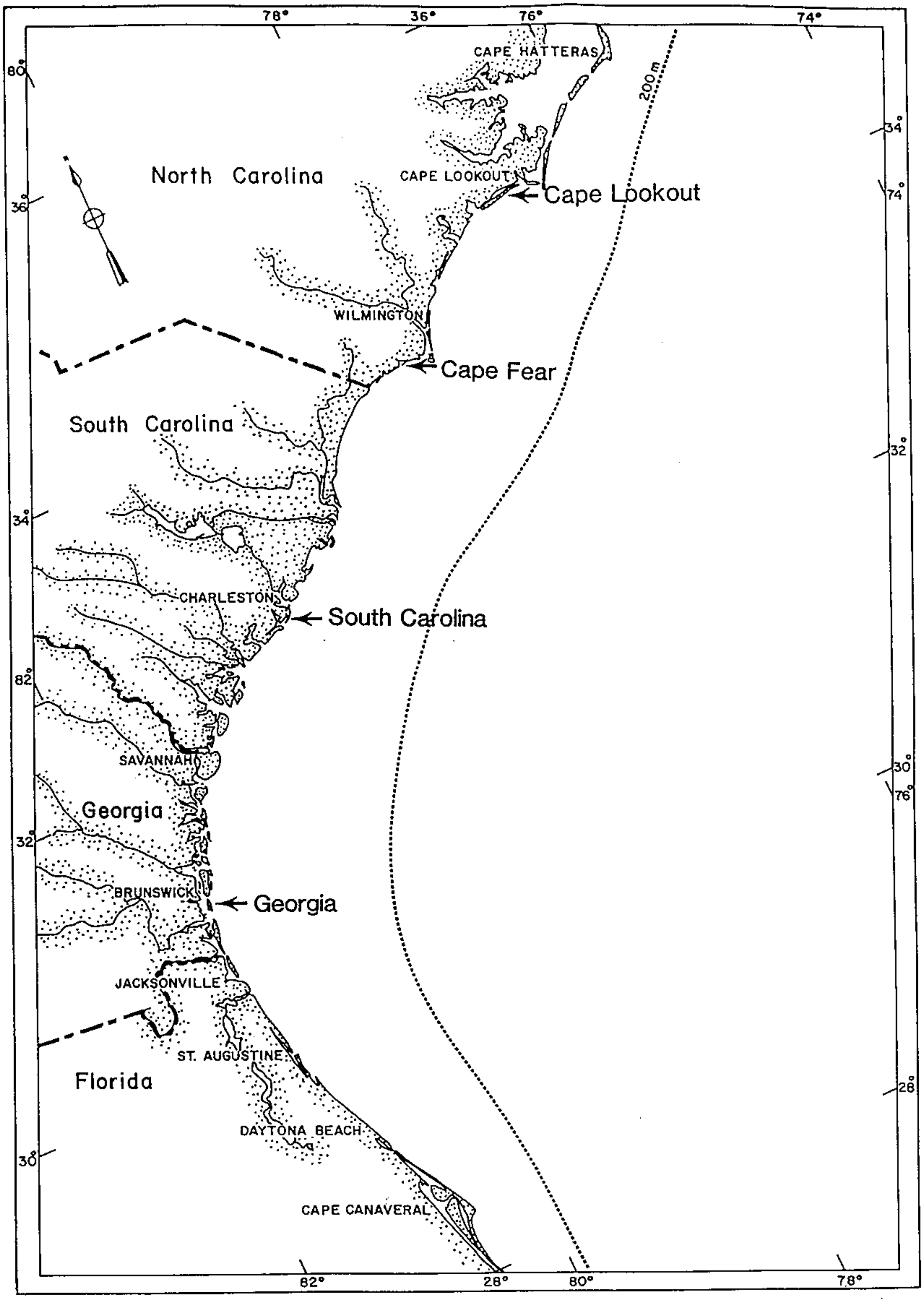


Figure 1. SEAMAP-SA sampling stations 1987 and 1988

North Carolina; Long Beach and Lockwood Folly Inlet, near Cape Fear, North Carolina; Kiawah Island and Stono Inlet, near Charleston, South Carolina; and Cumberland Island and Saint Andrews Sound Inlet, near Brunswick, Georgia. Each site was sampled once during daylight (1-hour after sunrise to 1-hour before sunset) and once at night (1-hour after sunset to 1-hour before sunrise) during each cruise. The order in which the trawling sites were sampled at each station was determined randomly.

Five cruises were conducted from summer through the fall in 1987, and 8 cruises from spring through fall in 1988 (Table 1). Each cruise consisted of a northern leg during which the two stations off North Carolina were sampled and a southern leg during which the South Carolina and Georgia stations were sampled. Total cruise lengths ranged from 10 to 18 days.

Table 1. Cruise dates for 5 SEAMAP Cruises in 1987 and 8 SEAMAP Cruises in 1988.

**1987**

| Cruise 1 | Cruise 2 | Cruise 3 | Cruise 4 | Cruise 5 |
|---|---|---|---|---|
| August 10-19 | August 24-September 2 | September 14-23 | October 5-21 | November 7-24 |

**1988**

| Cruise 1 | Cruise 2 | Cruise 3 | Cruise 4 | Cruise 5 | Cruise 6 | Cruise 7 | Cruise 8 |
|---|---|---|---|---|---|---|---|
| May 23-June 8 | June 13-22 | July 11-22 | August 1-10 | August 29-September 13 | September 19-29 | October 3-12 | October 25-November 4 |

Sampling efforts were carried out aboard the ***R/V Lady Lisa***, a 22.9 m wooden hull, double-rigged St. Augustine shrimp trawler owned and operated by the South Carolina Marine Resources Division (SCMRD). Nets used in sampling were 22.9 m mongoose-type high-rise trawls. A 91.4 m three-lead bridle was attached to a pair of wood and chain doors measuring 3.0 m x 1.0 m and to a tongue centered on the head-rope of the trawl. The head-rope, excluding the tongue, was 22.0 m and the foot-rope was 22.9 m. The body of the trawl was constructed of #15 twine with a 45 mm stretch mesh, and the cod-end tail bag was constructed of #30 twine with a 35 mm stretch mesh. A tickler chain attached to each door was positioned to drag over the bottom 0.9 m ahead of the foot-rope. A 60" inflatable red float was attached to the tongue at the bridle connection and 8" trawl floats were attached mid-way along each wing. Paired trawls were towed for twenty minutes, excluding wire-out and haul-back time. The contents of port and starboard nets were processed separately with catch sorted into 3 taxonomic groups: finfish, elasmobranchs, and crustaceans. Each group was weighed collectively and the species within each group recorded. Eighteen species, 14 finfish and 4 decapod crustacean species, were selected as priority or target species based on their importance to commercial and recreational fisheries of the region (Table 2). However, four of the finfish species, *Sciaenops ocellatus, Cynoscion nebulosus, Archosargus probatocephalus,* and *Pogonias cromis* were removed from the list once their rarity in the samples was determined. Target species were separated, enumerated, weighed collectively, and measured to the nearest centimeter. For large catches of a particular species, total number was estimated from total weight and weight of a random subsample consisting of thirty to sixty individuals, all of which were measured.

Table 2. Priority species for the 1987 and 1988 sampling efforts, ranked by mean number of individuals/tow.

| | Total n=312 | 1987 n=120 | 1988 n=192 |
|---|---|---|---|
| FINFISH | | | |
| ***Micropogonias undulatus*** | 570.5 | 259.6 | 764.8 |
| ***Leiostomus xanthurus*** | 315.2 | 221.9 | 373.5 |
| ***Menticirrhus americanus*** | 101.1 | 109.8 | 95.6 |
| ***Cynoscion regalis*** | 29.0 | 11.0 | 40.3 |
| ***Scomberomorus maculatus*** | 12.1 | 8.3 | 14.5 |
| ***Chaetodipterus faber*** | 10.3 | 12.8 | 8.7 |
| ***Pomatomus saltatrix*** | 6.3 | 2.1 | 9.0 |
| ***Paralichthys dentatus*** | 4.5 | 5.5 | 3.8 |
| ***Scomberomorus cavalla*** | 3.1 | 1.8 | 3.9 |
| ***Paralichthys lethostigma*** | 1.0 | 1.5 | 0.7 |
| **DECAPODS** | | | |
| ***Penaeus aztecus*** | 81.8 | 27.1 | 116.0 |
| ***Penaeus setiferus*** | 48.3 | 54.6 | 44.4 |
| ***Penaeus duorarum*** | 25.8 | 8.5 | 36.6 |
| ***Callinectes sapidus*** | 10.1 | 16.5 | 6.0 |

A bottom water sample was collected at each site immediately following the trawl tow with a bottom tripping Van Dohrn Bottle. Temperature was measured on site with a stem thermometer and water samples were returned to the laboratory and analyzed with a Beckman RS7A or RS7B Induction Salinometer to determine salinity levels.

Location was determined using a combination of Loran "C", radar and known landmarks and U.S. National Ocean Service navigational charts. Depth of water was recorded from a SITEX Strip Depth Recorder.

**Data Analysis**

Data from the two individual nets were combined as a standard unit of effort (tow) for analytical purposes. Bonyfishes, elasmobranchs, decapod crustaceans, and stomatopod crustaceans were examined as groups with weights of the species contained in each group pooled for analysis of trends in biomass. Statistically significant differences in mean biomass among stations, cruises, sites, and between light-phases were determined by analysis of variance when the distribution was homogeneous (Sokal and Rohlf, 1981). Biomass data were transformed ($\log_{10}$) after an F-max test revealed that some groupings were not homogeneous. A Kruskal-Wallis analysis was performed on biomass data that remained heteroscedastic after transformation. Two-way analysis of variance was used to determine day-night differences with respect to cruise or station for collective biomass. A row by column contingency table test of independence, using the G-statistic, was used to determine differences in number of species collected among stations, cruises, light-phases, sites, and years. Kruskal-Wallis analysis was also preformed to determine statistical differences in median length of individuals of a species among treatments when $\log_{10}$ transformation failed to homogenize variances. Significance level for all analyses was $\alpha = 0.05$ (or less when stated).

Correction for net size was necessary before catch comparisons to the 1986 SEAMAP-SA collections (Wenner et al., 1987) could be made. The 9.1 m trawls were identical to the 22.9 m trawls except in size. Abundance estimates from the 1986 survey were multiplied by the difference in footrope length (a factor of 2.517) for comparison to 1987 and 1988 data.

Direct annual comparison of various data parameters was not valid due to the absence of spring and early summer samples in 1987. However, in order to get a general idea of annual differences in abundance of priority species among cruises, data in 1987 were compared to that from the last 5 cruises of 1988, which roughly correspond chronologically. A T-test was used to test for differences in mean temperature and salinity from these cruises to establish a statistical basis for making comparisons between years. Kruskal-Wallis analysis (Zar, 1984) was performed on temperature and salinity data to determine statistical differences among means for stations, sites, and cruises. Seasonal changes in water temperature were not analyzed.

# RESULTS AND DISCUSSION

## Hydrographic Factors

Driving forces behind the hydrography of shallow coastal waters of the SAB include interactions of temperature, wind speed and direction, river run-off, the southerly flowing coastal current and proximity of the Gulf Stream (Bumpus, 1973; Blanton, 1981; Blanton and Atkinson, 1983; Atkinson, 1985; Mathews and Pashuk, 1986). Approximately 80% of the mean annual river discharge into the SAB occurs between Cape Fear and Jacksonville, Florida (Windom and Smith, 1985; McClain et al., 1988), the volume of which is estimated to be about 66 $km^3$ (Windom and Smith, 1985). Only 53% of the coastline in the SAB falls between these two points. This freshwater influx causes a drop in salinity in coastal waters as the river run-off mixes with highly saline marine waters (Bumpus, 1973). The lower salinity thus created is pushed southward by the southerly flowing coastal current until it is impeded by the northerly flowing Gulf Stream off central Florida (Blanton, 1981; Blanton and Atkinson, 1983; Atkinson, 1985). The result of this process is a general area of lower salinity water off lower South Carolina and Georgia. Annual and seasonal variations in river run-off, atmospheric temperatures, wind speed and direction, and migrations of the Gulf Stream dictate parameter fluctuations of this hydrographic pattern.

The Cape Lookout station in Onslow Bay is somewhat isolated from northern influences by Cape Lookout and Lookout Shoals, which extends out across 43% of the shelf, and from southern influences (and the other stations) by Cape Fear and Frying Pan Shoals, which extends across 63% of the shelf. Onslow Bay receives very little fresh water through inlets; therefore, salinity is generally higher than waters to the south of Cape Fear (Pietrafesa et al., 1985).

Bottom salinities recorded during this study are consistent with published hydrographic descriptions (Wenner et al., 1979a; Wenner et al., 1979b; Wenner et al., 1979c; Wenner et al., 1980; Wenner and Sedberry, 1989). There was no significant difference in mean salinities between the two years when comparable cruises were compared ($T = 0.5$, $df = 8$, $p = 0.6$). A significant difference did occur in salinities among cruises both years (1987: $\chi^2 = 32.2$, $p < 0.001$; 1988: $\chi^2 = 25.8$, $p < 0.001$), with higher salinities occurring in the summer months of July and August (Table 3). Salinity did not differ significantly among sites either year (1987: $\chi^2 = 1.1$, $p = 0.6$; 1988: $\chi^2 = 1.1$, $p = 0.6$) (Table 4), but did differ among stations both years (1987: $\chi^2 = 30.5$, $p < 0.001$; 1988: $\chi^2 = 84.2$, $p < 0.001$) (Table 5). Cape Lookout had the highest salinity both years and South Carolina had the lowest. This was expected considering the absence of river outflow in Onslow Bay and the abundance of freshwater influx into the area south of Cape Fear.

Water temperature followed expected seasonal patterns, being highest in the summer and lower in spring and fall. No significant difference in bottom water temperature occurred among stations in 1987 ($\chi^2 = 3.8$, $p = 0.3$), but did in 1988 ($\chi^2 = 12.8$, $p < 0.005$), increasing progressively from the Cape Lookout station south to the Georgia station (Table 5). The difference in 1988 was not simply a reflection of more pronounced latitudinal differences during spring months when water temperatures were cooler, but a significant difference among stations still occurred when the first three cruises of 1988 were eliminated ($\chi^2 = 19.0$, $p < 0.001$). Mean temperatures from the five cruises in 1987 were not significantly different from the mean temperatures of the five comparable 1988 cruises ($T = 0.2$, $df = 8$, $p = 0.9$). No significant difference in temperature occurred among sites in 1987 ($\chi^2 = 1.1$, $p = 0.6$) or in 1988 ($\chi^2 = 112.0$, $p = 0.6$) (Table 4).

Table 3. Mean temperature and salinity of bottom water by cruise for 1987 and 1988.

**1987**

| Cruise | Date | Temperature (°C) | Salinity ($^o/_{oo}$) |
|---|---|---|---|
| Cruise 1 | Aug 10-19 | 29.1 | 35.5 |
| Cruise 2 | Aug 24-Sept 2 | 29.2 | 35.3 |
| Cruise 3 | Sept 14-23 | 28.0 | 34.3 |
| Cruise 4 | Oct 5-21 | 21.4 | 34.3 |
| Cruise 5 | Nov 7-24 | 17.4 | 34.7 |

**1988**

| Cruise | Date | Temperature (°C) | Salinity ($^o/_{oo}$) |
|---|---|---|---|
| Cruise 1 | May 23-June 8 | 23.9 | 34.3 |
| Cruise 2 | June 13-22 | 24.6 | 34.3 |
| Cruise 3 | July 11-22 | 27.6 | 35.0 |
| Cruise 4 | Aug 1-10 | 28.8 | 35.4 |
| Cruise 5 | Aug 29- Sept 13 | 26.7 | 34.8 |
| Cruise 6 | Sept 19-29 | 25.9 | 34.2 |
| Cruise 7 | Oct 3-12 | 22.7 | 34.3 |
| Cruise 8 | Oct 25- Nov 4 | 18.4 | 34.6 |

Table 4. Mean temperature and salinity of bottom water by site for 1987 and 1988.

**1987**

| Site | Temperature (°C) | Salinity ($^{o}/_{oo}$) |
|---|---|---|
| Inlet | 24.8 | 35.5 |
| Beach | 25.2 | 34.6 |
| Offbeach | 24.5 | 34.4 |

**1988**

| Site | Temperature (°C) | Salinity ($^{o}/_{oo}$) |
|---|---|---|
| Inlet | 23.5 | 35.6 |
| Beach | 24.3 | 34.9 |
| Offbeach | 25.3 | 34.1 |

Table 5. Mean temperature and salinity by station for 1987 and 1988.

**1987**

| Station | Temperature (°C) | Salinity ($^{o}/_{oo}$) |
|---|---|---|
| Cape Lookout | 24.8 | 35.5 |
| Cape Fear | 25.2 | 34.6 |
| South Carolina | 24.5 | 34.4 |
| Georgia | 24.8 | 34.6 |

**1988**

| Station | Temperature (°C) | Salinity ($^{o}/_{oo}$) |
|---|---|---|
| Cape Lookout | 23.5 | 35.6 |
| Cape Fear | 24.3 | 34.9 |
| South Carolina | 25.3 | 34.1 |
| Georgia | 26.1 | 34.2 |

**Species Composition**

A total of 177 species, consisting of 40 decapod and stomatopod crustacean species (Appendix 1), 119 finfish (Appendix 2), and 18 elasmobranch species (Appendix 3) were collected on the 13 cruises in 1987 and 1988. The number of species collected on cruises was independent of year (Table 6) and ranged from 96 on Cruise 3 in 1988 to 118 on Cruise 4 in 1987 (Appendix 4). The number of species taken among stations was also independent of year (Table 6) and ranged from 94 off Georgia both years to 126 off Cape Lookout in 1988 (Appendix 4). The greatest number of finfish species occurred at Cape Lookout both years where the fewest crustacean species occurred. The number of species taken among stations and cruises was independent of light-phase both years (Table 6), even though more species were collected at night both years.

Number of species occurring at sites was independent of station both years (Table 6). Overall, Inlet sites produced the greatest number of species and Beach sites produced the fewest.

Table 6. Results of row by column contingency table analysis of number species using the G-statistic.

| | | | |
|---|---|---|---|
| | **1987** | | |
| Station*light-phase | G=2.00 | df=3 | NS |
| Cruise*light-phase | G=1.42 | df=4 | NS |
| Station*location | G=0.90 | df=6 | NS |
| | **1988** | | |
| Station*light-phase | G=5.47 | df=3 | NS |
| Cruise*light-phase | G=1.79 | df=7 | NS |
| Station*location | G=1.02 | df=6 | NS |
| | **1987/1988** | | |
| Station*year | G=0.49 | df=3 | NS |
| Cruise*year | G=1.18 | df=7 | NS |

Of the 177 species collected during this survey, 40 were collected in more than 50% of the trawl tows. The Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, was the only elasmobranch species present in more than half the tows (Appendix 3). Fifteen crustacean species, including all of the target decapod crustacean species and 2 species of stomatopod crustaceans, were present in over half the tows (Appendix 1). *Portunus gibbesii* and *Callinectes similis* were the most frequently encountered crustaceans, each occurring in over 85% of the collections. Twenty-four finfish species, including 7 of the 10 target species, occurred in more than half of the collections (Appendix 2). Three finfish species, *Leiostomus xanthurus, Menticirrhus americanus*, and *Etropus crossotus* were present in over 85% of the collections.

## Biomass

Mean biomass/tow for finfishes, elasmobranchs, and crustaceans was 71.7 kg/tow in 1987 and 97.2 kg/tow for all tows in 1988. No difference in biomass was found between 1987 and the comparable cruises in 1988 ($F = 0.6$, $df = 1$, $p = 0.8$). Mean biomass of the samples collected during this comparable period in 1988 (August-November) was 89.1 kg/tow. Finfish were the most important contributors to biomass, making up 73% of the biomass. Mean biomass/tow of all groups reflected dominance of finfish except when elasmobranch biomass increased substantially during the last cruise of 1988 (Table 7).

In 1987, there was a significant difference in biomass among cruises ($F = 9.1$, $df = 4$, $p < 0.05$). Mean biomass/tow for finfish was fairly consistent (Table 7), except during Cruise 4 when catches were down to about half that of the other cruises. Greatest biomass of elasmobranchs and crustaceans was collected on Cruise 5. A significant difference in biomass among cruises occurred in 1988 as well ($F = 2.9$, $df = 7$, $p < 0.001$). Finfish biomass on the first cruise was over twice that of any other cruise in 1988. After the first cruise, biomass levels fluctuated throughout the summer, rising to the second highest level in fall. Elasmobranch biomass was an order of magnitude less than that of finfish throughout 1987 and most of 1988 (Table 7). In 1987, the highest elasmobranch biomass (13.0 kg/tow) occurred in fall. In 1988, biomass of sharks and rays on the first cruise was almost twice that of any cruise in 1987. Like finfish, biomass of elasmobranchs decreased during the summer and increased in fall when half of the total elasmobranch biomass was collected on Cruise 8. Crustacean biomass fluctuated with no discernable pattern, with the highest level for all cruises occurring on the last cruise of 1987.

Table 7. Mean biomass/tow of three major taxonomic groups for day and night collections by cruise (n = 24 trawl tows/cruise).

| Cruise | 87-1 | 87-2 | 87-3 | 87-4 | 87-5 | 88-1 | 88-2 | 88-3 | 88-4 | 88-5 | 88-6 | 88-7 | 88-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Finfish | | | | | | | | | | | | | |
| Day | 59.0 | 53.7 | 47.1 | 25.6 | 64.4 | 273.9 | 84.7 | 68.8 | 39.0 | 49.1 | 40.6 | 57.2 | 103.3 |
| Night | 63.9 | 73.1 | 60.2 | 37.6 | 58.6 | 61.5 | 99.8 | 56.4 | 57.5 | 74.5 | 53.0 | 61.4 | 52.1 |
| Total | 61.5 | 63.4 | 53.6 | 31.6 | 61.5 | 167.7 | 92.3 | 62.6 | 48.2 | 61.8 | 46.8 | 59.3 | 77.7 |
| Elasmobranchs | | | | | | | | | | | | | |
| Day | 2.5 | 2.9 | 4.7 | 3.6 | 7.9 | 15.9 | 6.4 | 2.8 | 5.4 | 4.2 | 4.2 | 7.8 | 137.2 |
| Night | 4.7 | 6.0 | 8.3 | 8.1 | 18.1 | 28.5 | 6.2 | 2.6 | 3.3 | 4.6 | 5.8 | 7.4 | 15.7 |
| Total | 3.6 | 4.4 | 6.5 | 5.9 | 13.0 | 22.2 | 6.3 | 2.7 | 4.4 | 4.4 | 5.0 | 7.6 | 76.5 |
| Crustaceans | | | | | | | | | | | | | |
| Day | 7.9 | 7.7 | 4.0 | 10.9 | 16.2 | 3.2 | 6.0 | 8.1 | 4.8 | 12.1 | 7.9 | 4.8 | 6.9 |
| Night | 14.2 | 15.8 | 15.2 | 16.4 | 30.9 | 10.0 | 10.6 | 15.2 | 7.5 | 14.6 | 17.4 | 14.0 | 16.5 |
| Total | 11.1 | 11.7 | 9.6 | 13.6 | 23.5 | 6.6 | 8.3 | 11.7 | 6.2 | 13.3 | 12.6 | 9.4 | 11.7 |
| Grand Total | 76.2 | 79.5 | 69.7 | 51.1 | 98.0 | 196.5 | 106.9 | 77.0 | 58.8 | 79.5 | 64.4 | 76.3 | 165.9 |

The difference in mean biomass/tow among stations (Table 8) was significant in 1987 and 1988 (1987: $F = 10.4$, $df = 3$, $p < 0.05$; 1988: $F = 12.0$, $df = 3$, $p < 0.001$). Cape Fear had greatest mean biomass/tow both years. Cape Lookout had lowest mean biomass/tow in 1987 and Georgia had lowest mean biomass/tow in 1988 and overall. All stations except for Georgia had an increase in biomass from 1987 to 1988 (29% at Cape Lookout, 73% at Cape Fear, and 41% at South Carolina), whereas in Georgia, biomass decreased by 26%. Finfish were not solely responsible for changes in mean biomass/tow at all stations. The increase in South Carolina was due to an order of magnitude increase in elasmobranch biomass (Table 8).

Differences in mean biomass/tow among sites (Table 9), theoretically due to proximity to the inlet, depth, or distance from shore, were not significant either year (1987: $F = 1.6$, $df = 2$, $p = 0.3$; 1988: $F = 1.5$, $df = 2$, $p = 0.2$). In 1987 mean biomass/tow was greatest at Inlet sites due to large catches of sciaenids at Inlet sites off North Carolina. In 1988, greatest biomass/tow was collected at Beach sites where large samples of croaker and elasmobranchs were taken.

Biomass of night collections was significantly greater than that of day collections among cruises both years (1987: $F = 61.5$, $df = 1$, $p < 0.01$; 1988: $F = 18.7$, $df = 1$, $p < 0.005$). In 1987, mean biomass/tow for finfish was greater at night on all cruises except Cruise 5 (Table 7), when an enormous croaker catch occurred at Cape Fear during the day. In 1988, mean biomass/tow of finfish was substantially greater during the day on the first and last cruises, and to a lesser degree on Cruise 3. Biomass of elasmobranchs was greater at night in 1987, but was not consistently greater during either light phase in 1988. The large elasmobranch catches on the last cruise of 1988 consisted primarily of the Cownose ray, *Rhinoptera bonasus*, taken during the day. Crustacean biomass was greater at night on every cruise both years.

In 1987, night catches contained significantly more biomass than day catches among stations ($F = 17.5$, $df = 1$, $p < 0.05$), and were greater at all stations except Cape Fear where catches of finfish and elasmobranchs were higher in daylight samples (Table 8). Crustacean biomass at Cape Fear was greater at night. At the other stations, finfish, elasmobranchs, and crustaceans all occurred in greater quantities at night. A significant difference occurred between mean biomass of day and night catches among stations in 1988 as well ($F = 21.1$, $df = 1$, $p < 0.001$). Biomass was greater in daylight catches overall, but no obvious pattern was observed. At Cape Lookout, catches of finfish and elasmobranchs were fairly even between day and night, but greater crustacean biomass was collected at night. At Cape Fear, only finfish biomass was greater during the day, but the amount was considerable. Finfish biomass was greater in night collections in South Carolina and Georgia. Wenner (1983) also observed greater biomass of fishes in day trawls than in night trawls.

Table 8. Mean biomass/tow for finfish, elasmobranchs and crustaceans by station for day and night collections. (n =30 trawl tows/station in 1987 and n = 48 trawl tows/station in 1988)

| Station | 1987 | | | | 1988 | | | |
|---|---|---|---|---|---|---|---|---|
| | Cape Lookout | Cape Fear | South Carolina | Georgia | Cape Lookout | Cape Fear | South Carolina | Georgia |
| Finfish | | | | | | | | |
| Day | 36.0 | 87.4 | 27.1 | 39.4 | 53.1 | 219.5 | 26.2 | 17.8 |
| Night | 40.9 | 71.3 | 47.3 | 67.7 | 51.1 | 104.9 | 42.4 | 57.0 |
| Total | 38.5 | 79.3 | 37.2 | 46.9 | 52.1 | 162.2 | 34.3 | 37.4 |
| Elasmobranchs | | | | | | | | |
| Day | 3.9 | 8.2 | 3.6 | 1.6 | 7.2 | 5.5 | 77.9 | 1.4 |
| Night | 9.0 | 7.5 | 7.6 | 5.3 | 7.1 | 17.4 | 11.4 | 1.2 |
| Total | 6.4 | 7.9 | 5.6 | 8.4 | 7.1 | 11.4 | 44.7 | 1.3 |
| Crustaceans | | | | | | | | |
| Day | 3.0 | 15.2 | 15.0 | 3.1 | 7.8 | 5.4 | 9.0 | 3.3 |
| Night | 18.0 | 23.5 | 27.4 | 5.1 | 17.0 | 15.5 | 13.5 | 6.8 |
| Total | 10.5 | 19.4 | 21.2 | 3.4 | 12.3 | 10.5 | 11.3 | 5.0 |
| Grand Total | 55.4 | 106.6 | 64.0 | 58.7 | 71.5 | 184.1 | 90.3 | 43.7 |

Table 9. Mean biomass/tow in kg for finfish, elasmobranchs and crustaceans by site for 1987 and 1988 (n = 40 trawl tows/site in 1987; n = 64 trawl tows/site in 1988).

| | 1987 | | | 1988 | | |
|---|---|---|---|---|---|---|
| Station | Inlet | Beach | Offbeach | Inlet | Beach | Offbeach |
| Finfish | 108.4 | 64.4 | 77.9 | 177.2 | 246.1 | 145.6 |
| Elasmobranchs | 11.0 | 9.4 | 10.5 | 17.4 | 75.3 | 26.5 |
| Crustaceans | 24.8 | 24.1 | 15.3 | 28.1 | 23.2 | 22.3 |
| Total | 144.2 | 97.9 | 103.7 | 222.7 | 344.6 | 194.4 |

**Abundance and Biomass of Priority Species**

Total catch of the 14 priority species for all collections in 1987 and 1988 was 389,768 individuals with a total biomass of 17,288 kg (Appendix 5). Mean number of individuals/tow (abundance) was 186.8 in 1987 and 282.4 in 1988. Patterns of combined abundance of priority SEAMAP-SA species in the SAB generally reflected the distributions of two members of the sciaenid family, the Atlantic croaker *Micropogonias undulatus* and the spot *Leiostomus xanthurus*, which were consistent in their numerical dominance. These two sciaenids contributed 72% of the total number of individuals, 72% of the total biomass of priority species, and 62% of the total finfish biomass. Although the Atlantic croaker was the most abundant finfish species both years, it did not occur in as many samples as did spot (Appendix 5). The southern kingfish, *Menticirrhus americanus*, was third in abundance and also occurred more frequently in collections than did Atlantic croaker. These three sciaenids, along with *Cynoscion regalis*, constituted 96.5% of total target finfish abundance and 83.3% of the total abundance of priority species. Four of the finfish and 2 of the 4 decapod species decreased in abundance from 1987 to 1988 (Appendix 5); only one of the numerically dominant sciaenids (*M. americanus*) fell into this group.

Greatest abundance of priority species occurred at the Cape Fear station in 1987 and 1988, where 49% of the total abundance occurred. The Cape Lookout station was lowest in abundance in 1987, whereas the Georgia station was the lowest in 1988, the lowest abundance of any station both years. Abundance of priority species was highest at the Inlet stations in 1987 and at the Beach stations in 1988.

The most abundant priority decapod species was the brown shrimp, *Penaeus aztecus* (Appendix 5), even though the white shrimp, *Penaeus setiferus,* was most abundant in 1987. Brown shrimp abundance was over 4 times greater in 1988 than it was in 1987.

## Individual Species Accounts For Priority Species

### *Micropogonias undulatus*

The Atlantic croaker, *Micropogonias undulatus*, is one of the most abundant finfish species in trawl catches in the SAB (Beatty et al., 1989; Wenner and Sedberry, 1989; Webster et al., 1990; Boylan et al., 1991; Beatty et al., 1992; Boylan et al., 1993). This species ranges from Argentina to the Gulf of Maine (Chao, 1976, 1978) and inhabits a wide range of habitats and salinities (Bearden, 1964; Dahlberg, 1972). Atlantic croaker are generally found over mud and sandy bottoms in coastal waters where they feed on bottom-dwelling organisms such as worms and small crustaceans (Chao, 1978). They reportedly prefer deeper channels when residing in the estuaries, and are notably absent from very low salinity areas, high salinity tide pools, the surf zone and ocean jetties (Cain and Dean, 1976; Anderson et al., 1977; Weinstein, 1979; Crabtree and Dean, 1982; Sedberry and Beatty, 1989).

Combined catch of Atlantic croaker from the 13 SEAMAP-SA cruises in 1987 and 1988 was 177,999 specimens (Appendix 5) that occurred in 82% of the collections (78% of the trawl tows in 1987 and 84% of the tows in 1988). It was the most abundant priority species and contributed the most biomass. Wenner and Sedberry (1989) found that *M. undulatus* ranked second to *Leiostomus xanthurus* in both number and weight in a seasonal survey of the coastal habitat of the SAB. In contrast, Wenner et al. (1987) found that Atlantic croaker ranked fifth numerically and third by weight during the 1986 SEAMAP-SA survey when samples were collected in November and December, exclusively.

Mean number of Atlantic croaker/tow differed significantly among stations during both years of this survey (1987: $F = 26.4$, $df = 3$, $p < 0.001$; 1988: $F = 15.1$, $df = 3$, $p < 0.001$) and was most abundant at the Cape Fear station (Figure 2). In 1987, 40% of the Atlantic croaker collected came from the Cape Fear station. Catch rates were fairly even among the remaining three stations, ranging from 18% to 23% of the total catch with lowest abundance at Cape Lookout. A large catch of 74,665 Atlantic croaker specimens (51% of the total number) was taken on the first cruise at the Cape Fear Beach site during the day in 1988. When this catch was included in data analyses, 88% of the annual catch for 1988 came from Cape Fear and, when excluded, Cape Fear still produced over 76% of the Atlantic croaker collected that year. Levels of

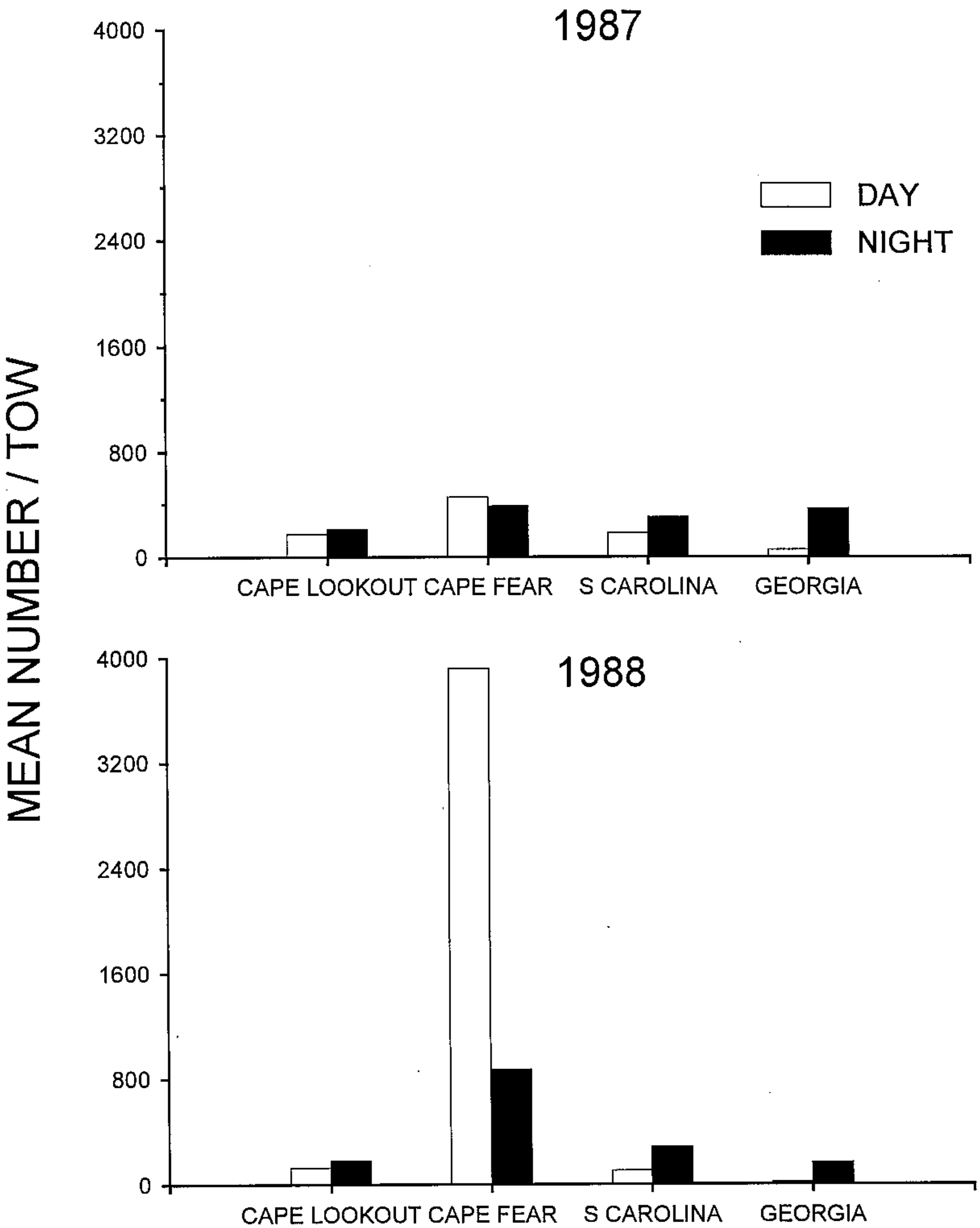


Figure 2. Diel abundance of *Micropogonias undulatus* by station.

Atlantic croaker abundance at the remaining three stations were very low compared to Cape Fear, even though abundances at Cape Lookout and off South Carolina were comparable to the 1987 collections. Abundance of this species off Georgia dropped considerably from 1987 to 1988.

Densities of Atlantic croaker fluctuate seasonally with greatest densities reported during late summer and early fall (Anderson, 1968; Knowlton, 1972; Keiser, 1976; Wenner and Sedberry, 1989). A significant difference in number of individuals/tow (1987: $F = 8.2$, $df = 4$, $p < 0.05$; 1988: $F = 6.9$, $df = 7$, $p < 0.001$) occurred among cruises both years (Figure 3), but did not fit the suggested pattern. Catch rates in 1987 were fairly even among cruises except during Cruise 4 in October when abundance was extremely low. Catches in spring of 1988 were heavy but declined through the year, becoming very light on Cruises 7 and 8, the time of year corresponding seasonally to Cruise 4 in 1987. Spring and early summer catches inflated the annual mean/tow to approximately 3 times the annual mean catch per tow for 1987 (Appendix 5). However, the mean catch/tow for the last 5 cruises of 1988, the cruises comparable to the sampling period in 1987, was only half the mean catch/tow values from 1987. The increase found on the fifth cruise of 1987 may have been due to fall emigration from the estuaries, but no such event occurred in fall of 1988.

Spawning of Atlantic croaker takes place offshore, probably over the outer shelf or slope areas, over a 5 month period from mid-September to late February (Bearden, 1964; Dahlberg, 1972; Warlen, 1982; Ross, 1988). The migration of adults from the estuary to offshore areas may have caused the increase in abundance seen in 1987 on Cruise 5. An increase in abundance at Inlet sites would be expected when emigration begins; however, no significant difference in abundance among sites occurred either year (1987: $F = 0.8$, $df = 2$, $p = 0.4$; 1988: $\chi^2 = 3.6$, $p = 0.2$). In North Carolina, two spawning peaks, one in October and the other in November, were evidenced by two peaks in larval abundance, in early-December and mid-January (Warlen, 1982; Ross, 1988). Growth data indicated that larval immigrants in the first peak may have been spawned by a different spawning group than those in the second peak (Warlen, 1982). Atlantic croaker enter the estuaries of the SAB as larvae from October through April (Bearden, 1964; Dahlberg, 1972; Warlen, 1982; Ross, 1988; McGovern and Wenner, 1990; Warlen and Burke, 1990). Juvenile croaker seem to inhabit deeper channels when they reside in the estuary. Wenner et al. (1982) reported Atlantic croaker as the most abundant species in trawl samples from deeper tidal rivers of South Carolina and Dahlberg (1972) reported that young croaker were not abundant in shallow areas in Georgia and did not occur in the upper, freshwater reaches of the estuary. Weinstein (1979) sampled shallow creeks and marsh edges throughout the extensive Cape Fear River Estuary and found densities of Atlantic croaker to be so low they were practically absent; however, he did not sample the deeper channels and most likely missed the habitat utilized by Atlantic croaker. Dahlberg (1972) reported that larger specimens are common in the middle to lower reaches of the estuaries from May to August even though abundance from that area was not very high offshore in SEAMAP-SA samples.

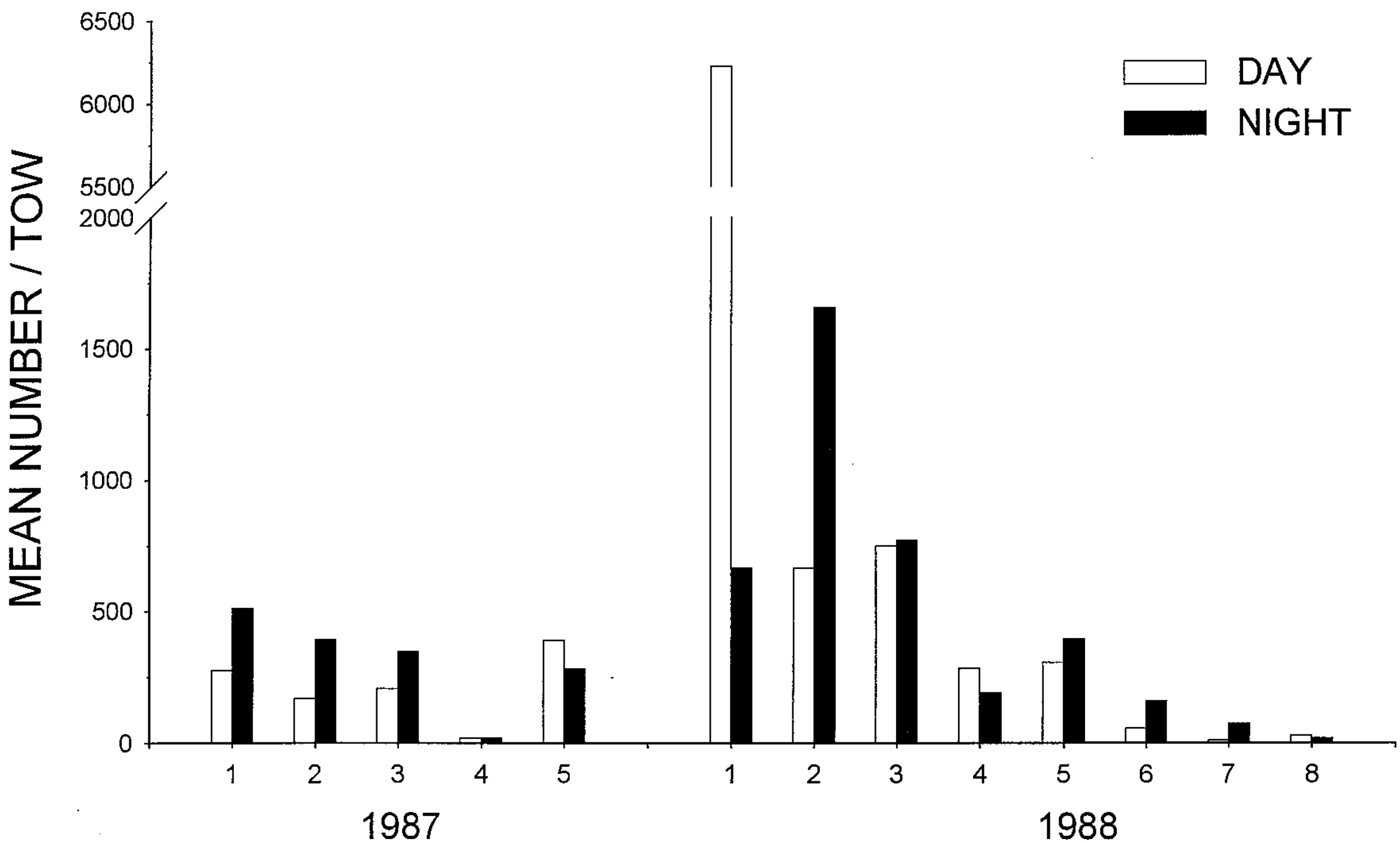


Figure 3. Diel abundance of *Micropogonias undulatus* by cruise.

Diel difference ($\chi^2$ = 11.1, p < 0.001) in abundance of Atlantic croaker from all 1987 and 1988 collections was significant, with greater catches occurring during the day. However, when the extremely large catch taken at Cape Fear in May was eliminated, the diel difference was still significant ($\chi^2$ = 11.9, p < 0.001), but abundance was greater at night. Two-way ANOVA found diel difference in catches were not significant among stations (F = 9.0, df = 1, p > 0.05) or cruises (F = 3.0, df = 1, p > 0.05) in 1987, although night catches were slightly larger than day catches (Figures 2 and 3). Diel difference in catch rates were significant with respect to station (F = 12.0, df = 1, p < 0.001) and cruise (F = 11.7, df = 1, p < 0.001) in 1988.

There are a few reports of diel variations in catch rates of Atlantic croaker. Dugas (1975) found more croaker at night than during the day in Vermilion Bay, Louisiana. This was primarily due to two unique events (large catches) and not a general trend. Jackson (1990) reported significantly greater numbers of Atlantic croaker in samples taken at night in a South Carolina estuary than were taken in comparable samples during the day. The specimens collected at night were also significantly smaller than individuals collected during the day.

Atlantic croaker in SEAMAP-SA collections ranged in length from 6-29 cm TL. A significant difference in length occurred among cruises in 1987 ($\chi^2$ = 420.9, p < 0.001) and in 1988 ($\chi^2$ = 109.7, p < 0.001), and mean length increased from first to last cruise (Figures 4 and 5). Ross (1988) found that age 0 fish were predominant in estuaries and ranged in length from 10-80 mm TL. Due to the extended spawning period of Atlantic croaker, he assigned Age I in October and found that Age I fish collected off the beaches of North Carolina ranged from 128-210 mm TL ($\bar{x}$ = 176 mm TL). Specimens collected inshore included smaller fish, ranging from 80-210 mm TL. Atlantic croaker from the Chesapeake - mid-Atlantic region are reportedly larger than those in the SAB (Barbieri et al., 1994) It appears that the Atlantic croaker from the 1987 and 1988 surveys were primarily age I fish. May, June, and July samples of 1988 contained primarily Age I fish with a few young of the year (YOY) mixed in. From August through October both years, it appears as though the Age 0 cohort increases its dominance in the catches. Age-class determination for fish Age II and older is complicated by size range overlap, according to Ross (1988). Age II fish from his study differed in size by month and were 210-280 mm TL in April, 220-280 mm TL in May-July, and 240-300 mm TL in August. If this holds true for the region, then only a few Age II fish were collected in SEAMAP-SA tows both years, and these were collected in October and November. In the Ross (1988) study, Age III fish followed a similar pattern of sizes increasing by month with ranges of 270-330 mm TL in April, 280-330 mm TL in May, and 300-360 mm TL in August. Barbieri et al. (1994) reported mean lengths of 263, 274, 285, 290, 307, 309, and 313 mm TL for Atlantic croaker of Ages II through VIII, respectively, indicating that his Age II and III fish are in the same range or smaller than those reported by Ross (1988), but his Age I fish were larger. Length-frequency distributions of Atlantic croaker collected by SEAMAP-SA trawls, when compared to

# *Micropogonias undulatus*

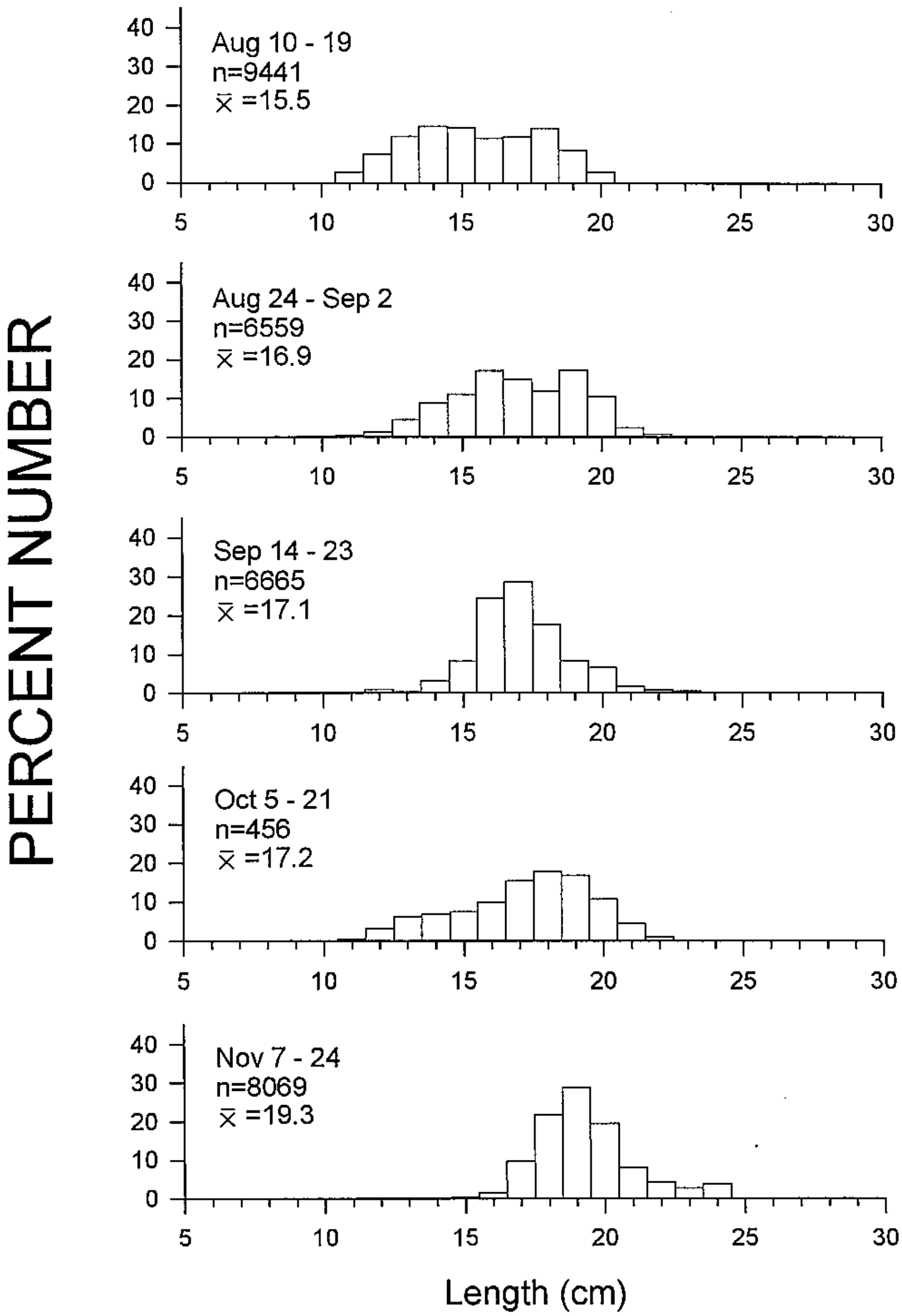


Figure 4. Length-frequency of Atlantic croaker from 5 SEAMAP cruises in 1987.

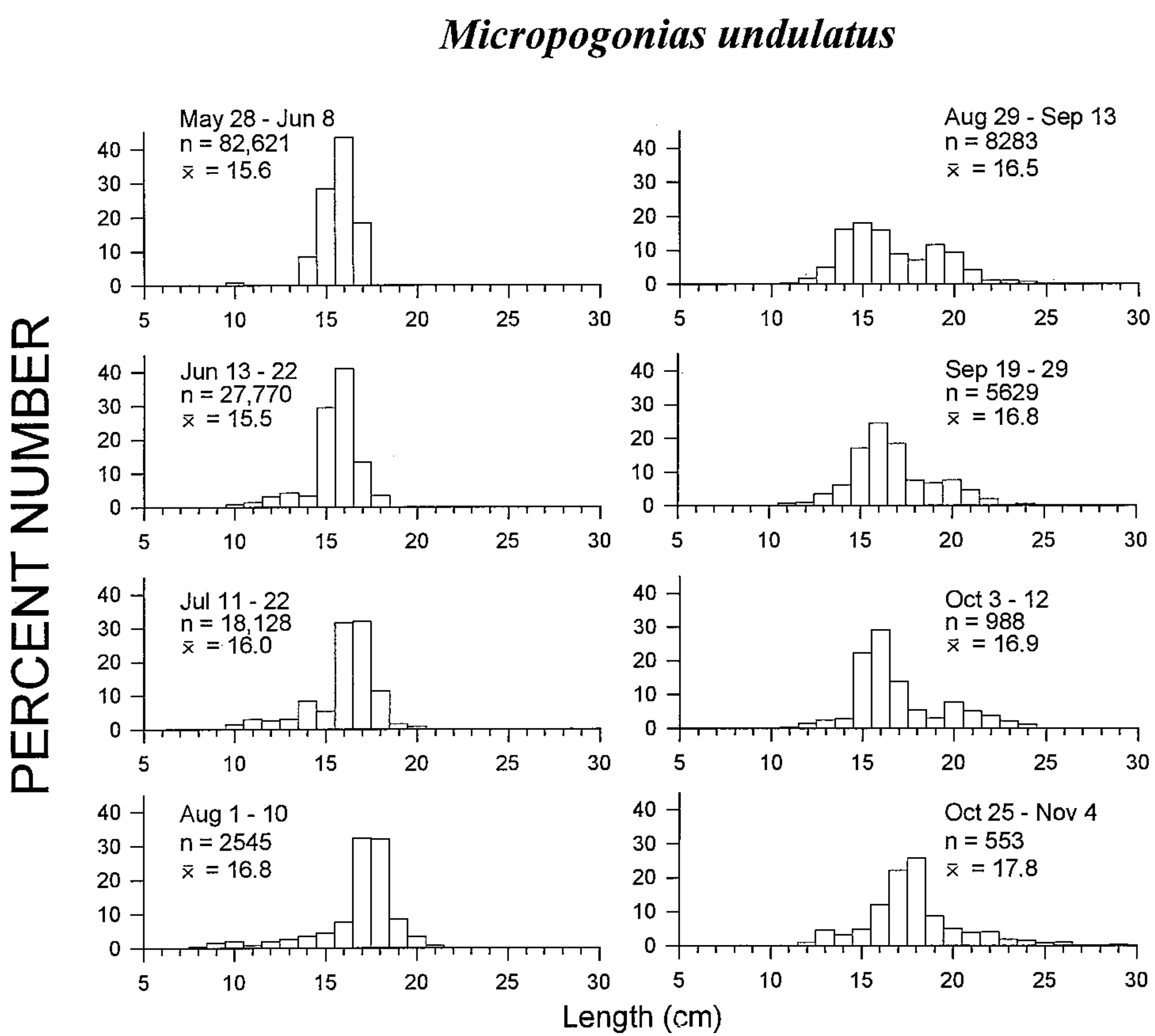


Figure 5. Length-frequency of Atlantic croaker from 8 SEAMAP cruises in 1988.

Ross' data, indicate that no Age III size fish were present. The same length-frequency distribution compared to data from Barbieri et al. (1994) indicates that Atlantic croaker collected by the SEAMAP-SA Survey could be as old as Age IV or V. White and Chittenden (1977) found that mean total lengths of Atlantic croaker were 155-165 mm at age I and 270-280 mm at age II for specimens from the Gulf of Mexico.

Pearson (1928) reported that Atlantic croaker reach maturity at the end of their second year. Wallace (1940) found that out of 1000 fish examined, 45% of the males and none of the females were mature at the end of their second year. The remainder of the male and all of the female fish he examined matured in their third year. This agrees with Welsh and Breder (1923) who reported that these fish reach maturity at 3 or 4 years. This suggests that very few of the specimens collected on the SEAMAP-SA cruises had reached maturity. However, age-growth and maturity work presently being conducted on SEAMAP-SA specimens have discovered females with developing ovaries as small as 140 to 150 mm TL and females approaching maturity under 250 mm TL (C. Walton, pers. comm.). This suggests that specimens collected on the SEAMAP-SA survey that were approaching Age II may be moving off shore to spawn.

No significant difference in total length occurred between day and night collections of Atlantic croaker either year, but lengths did differ significantly among stations both years (1987: $\chi^2 = 379.1$, $p < 0.001$; 1988: $\chi^2 = 116.0$, $p < 0.001$). Smallest fish were collected in Georgia in 1987 and in South Carolina in 1988, whereas largest fish were collected at Cape Fear in 1987 and at Cape Lookout in 1988.

### *Leiostomus xanthurus*

Spot range from Massachusetts throughout the Gulf of Mexico to the mouth of the Rio Grande (Chao, 1978) and is one of the most widely occurring and abundant fishes in the coastal waters of the South Atlantic Bight (Anderson, 1968; Keiser, 1976; Wenner and Sedberry, 1989). Commercial landings indicate that the center of abundance of adult spot along the Atlantic coast occurs from the Chesapeake to South Carolina. They are subjected to heavy commercial and recreational fishing pressure, the largest of which is the commercial gill-net fishery, which has contributed to the great fluctuations in commercial landings over the last 60 years (Mercer, 1989). Recreational landings have been estimated to exceed commercial landings for the past several years (South Carolina Marine Resources Department Office of Finfish Management).

The spot is an important member of estuarine communities from the upper, oligohaline reaches to the lower, polyhaline areas (Dahlberg, 1972; Weinstein, 1979; Wenner et al., 1982). It is common in coastal waters (Struhsaker, 1969; Keiser, 1976) and has been reported from the surf-zone (Anderson et al., 1977) and slope waters as deep as 110 m (Wenner et al., 1979a; Wenner et al., 1979b; Wenner et al., 1979c).

Spot in the SAB are thought to spawn over the outer continental shelf in water depths as great as 400 m (Powles and Stender, 1978; Warlen and Chester, 1985; Flores-Coto and Warlen, 1993). Larvae move inshore and enter the estuaries from early December to May, with the peak from late February to early April, where they grow rapidly throughout their first year (Warlen and Chester, 1985; McGovern and Wenner, 1990; Flores-Coto and Warlen, 1993). Although spot remain in the estuaries of the South Atlantic Bight year-round (Dawson, 1958; Bearden, 1961; Dahlberg, 1972; Weinstein, 1979), they probably leave shallow areas in winter when water temperatures drop and return to the shallow estuarine areas in spring as they do in the mid-Atlantic (Dawson, 1958; Pacheco, 1962; Hester, 1975). Spot mature late in their second or early in their third year (Gunter, 1950; Dawson, 1958) and migrate offshore to spawn in fall and early winter. It has been suggested that they die after spawning (Pearson, 1928); however, the maximum age for spot has been reported to be 4 or 5 years (Welsh and Breder, 1923; Pacheco, 1962; DeVries, 1982), an indication that some fish may spawn more than once or mature late in their third year or fourth years.

A total of 98,342 spot (315.2 individuals/tow) were collected in the two years sampled and occurred in 91% of the SEAMAP-SA collections in 1987 and 94% in 1988 (Appendix 5). Spot ranked second in both number and biomass among all priority species collected. Mean catch/tow was 222 individuals (11.8 kg) in 1987, similar to the estimate of 246 individuals/tow from the last 5 cruises of 1988, but much lower than the 374 individuals and 18.0 kg/tow from all collections in 1988. Abundance differed significantly among stations both years (1987: $\chi^2 = 36.4$, $p < 0.001$; 1988: $\chi^2 = 49.6$, $p < 0.001$) with Cape Fear producing greatest numbers (60% of the total) each year (Figure 6).

Mean catch/tow declined significantly ($\chi^2 = 12.4$, $p < 0.05$) from the first through the last cruise in 1987. In 1988, however, catch rates were very high on Cruises 1 and 2 in May and June and then dropped to the lowest level of abundance on Cruise 6 in September, but these differences were not found to be significant ($\chi^2 = 13.1$, $p = 0.07$) (Figure 7). A slight increase occurred in October and November of 1988, perhaps an indication of the expected fall emigration of spot from the estuaries. Peak emigration of spot mostly occurs in late November and December. Wenner et al. (1987) recorded spot abundance of 509 individuals/tow (after correction for net size) during the 1986 SEAMAP-SA coastal survey in late November and December. This exceeds abundance levels recorded by the 1987-88 SEAMAP-SA surveys in October and November of either year (Figure 7).

No significant difference occurred between day and night catches of spot in 1987 ($\chi^2 = 0.03$, $p = 0.9$), but did in 1988 ($\chi^2 = 5.4$, $p < 0.05$) with greater numbers collected during the day. No significant difference occurred among sites either year (1987: $\chi^2 = 1.2$, $p = 0.5$; 1988: $\chi^2 = 1.6$, $p = 0.5$).

Aging studies have shown that the vast majority of spot are two years old or younger, with some individuals at age III and very few reaching age IV or V. In the

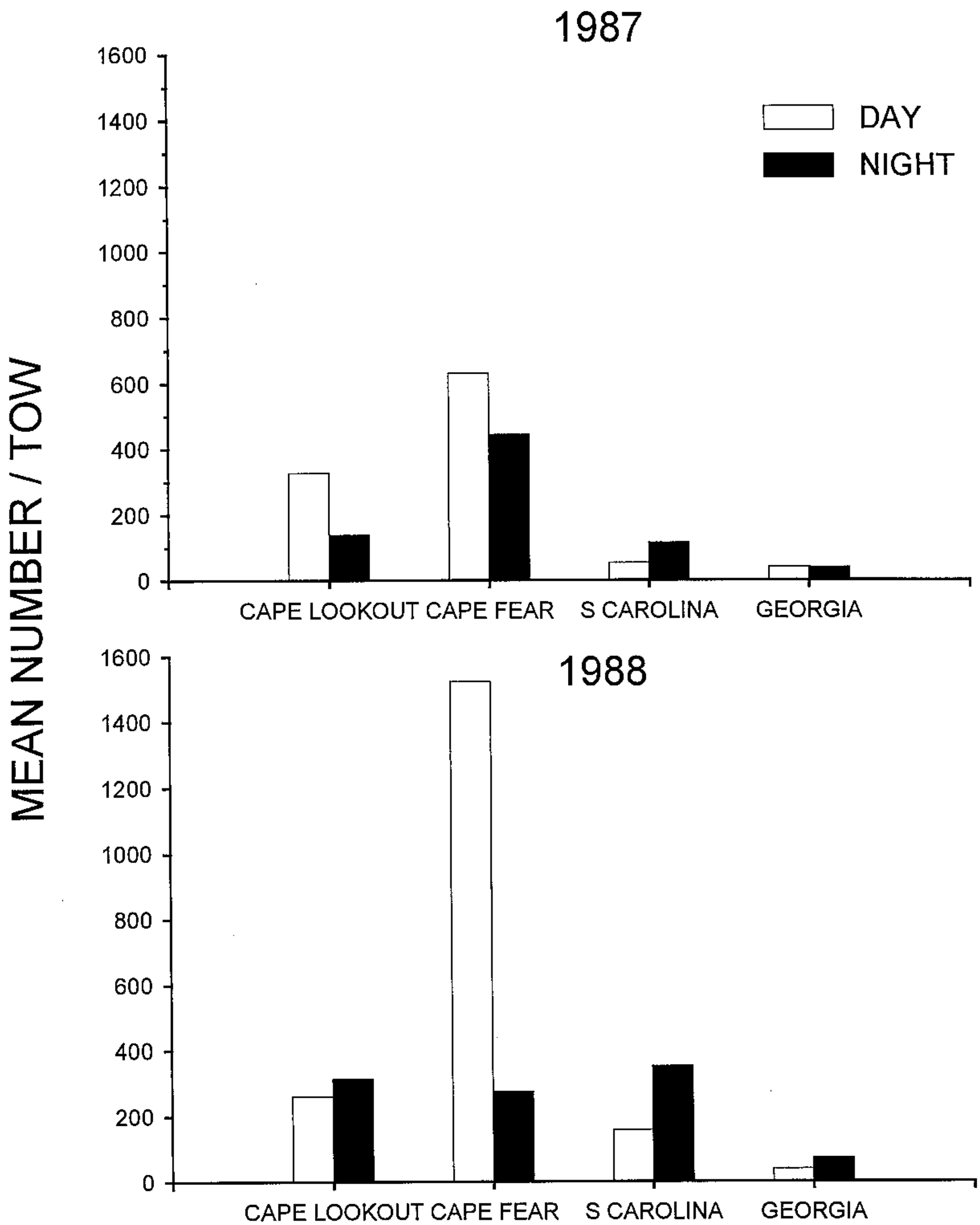


Figure 6. Diel abundance of *Leiostomus xanthurus* by station.

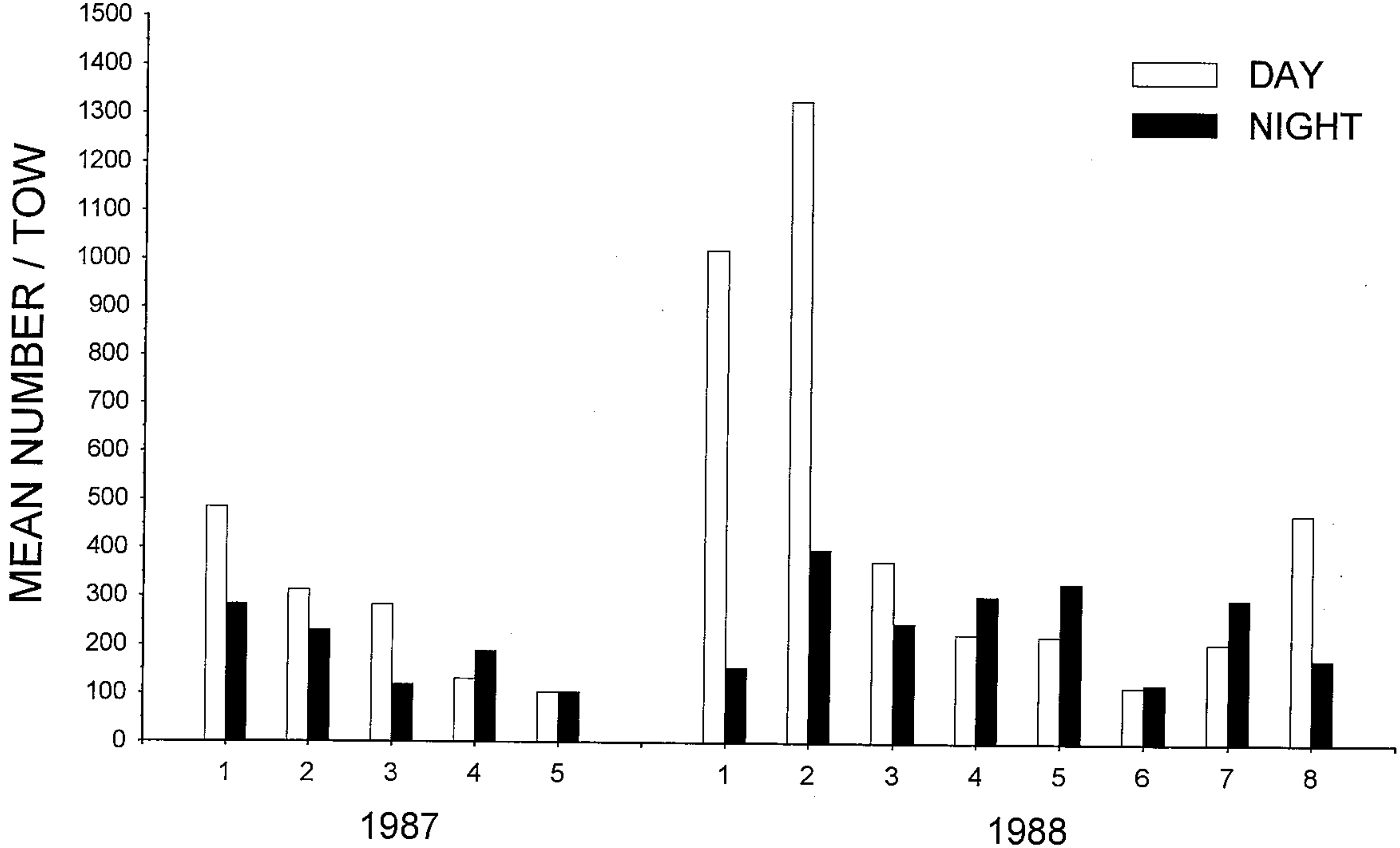


Figure 7. Diel abundance of *Leiostomus xanthurus* by cruise.

SAB, measurements of first-year spot range from 128-162 mm TL, from 201-222 mm TL at age II, and 219-252 mm TL at age III (Welsh and Breder, 1923; Hildebrand and Cable, 1930; Dawson, 1958; Pacheco, 1962; DeVries, 1982; Music and Pafford, 1984). Only a few age IV (30 cm FL) (Welsh and Breder, 1923) and age V (333 and 346 mm FL) (DeVries, 1982) spot have been reported from the SAB. Median lengths of spot were significantly different among stations (1987: $\chi^2 = 43.7$, $p < 0.001$; 1988: $\chi^2 = 197.1$, $p < 0.001$) and cruises (1987: $\chi^2 = 96.7$, $p < 0.001$; 1988: $\chi^2 = 109.8$, $p < 0.001$) both years. Cape Fear produced the largest spot both years while Cape Lookout in 1987 and South Carolina in 1988 produced the smallest specimens. An increase in mean length occurred over the sampling period in 1987 (Figure 8) with modal peaks between 15-18 cm, representing primarily Age I fish. Individuals measuring 10 cm and less on the first three cruises were YOY and those greater than 20 cm were probably Age II. In 1988, recruitment of the YOY cohort can be seen in May (Figure 9) and followed through the year until the cohort approaches Age I in October-November. The modal peak at 15-18 cm represents the Age I cohort that was approaching Age II in October-November. All spot collected by the SEAMAP-SA survey were less than 29 cm TL and were most likely Age III fish and younger.

### *Menticirrhus americanus*

The southern kingfish is a nearshore bottom-dwelling fish that ranges from New York to Texas and southward to Argentina, but is more common from North Carolina southward (Hildebrand and Cable, 1934; Bearden, 1963; Dahlberg, 1972; Chao, 1978; Johnson, 1978). This species is found on a variety of substrates including mud, sand, sand-mud, and mud-shell mixtures (Bearden, 1963; Chao, 1978; Smith and Wenner, 1985), but the adults prefer clean sandy bottoms along beaches and coastal sounds (Bearden, 1963). *M. americanus* is found over a wide range of salinities in the coastal habitat (Bearden, 1963; Fritsche and Crowe 1981). Bearden (1963) obtained maximum numbers of this species from August through November and assumed that they moved offshore during the winter. Smith and Wenner (1985) captured few individuals north of Savannah, Georgia, during winter in their survey from Cape Fear, North Carolina, to Cape Canaveral, Florida, and concluded that they move to the southern portion of the South Atlantic Bight during the colder months. *M. americanus* is the most abundant of the three species in the genus that occur in the South Atlantic Bight (Hildebrand and Cable, 1934; Bearden, 1963), and attains the largest maximum body size of the three species (Chao, 1978). The southern kingfish is an important recreational and commercial species (Bearden, 1963; Fritzche and Crowe, 1981; Smith and Wenner, 1985); however, it is commonly reported as *Menticirrhus* spp. along with the other two species of *Menticirrhus* by commercial fishermen. Commercial landings in the SAB come primarily from shrimp trawl by-catch (Keiser, 1977).

## *Leiostomus xanthurus*

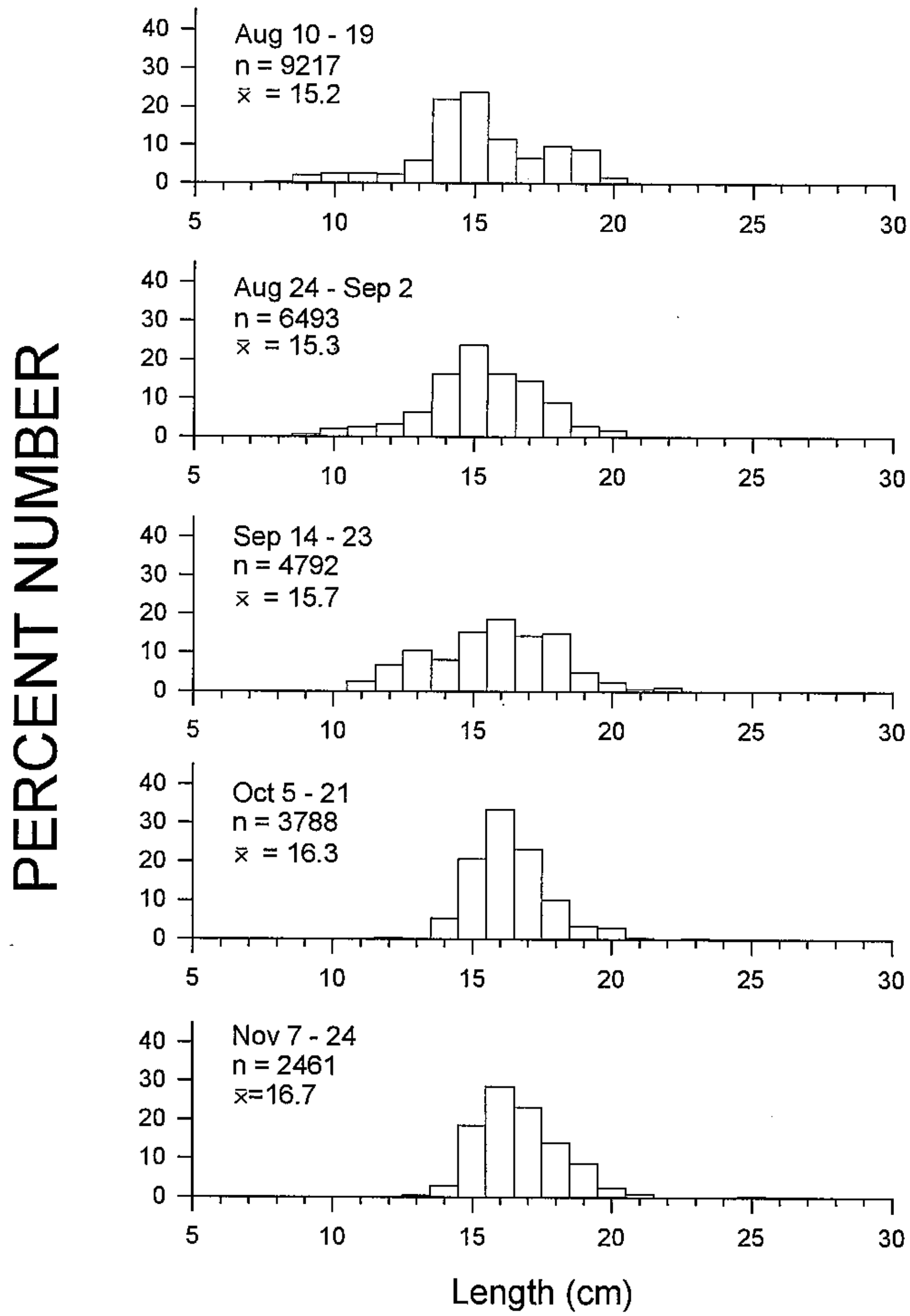


Figure 8. Length-frequency of spot from 5 SEAMAP cruises in 1987.

*Leiostomus xanthurus*

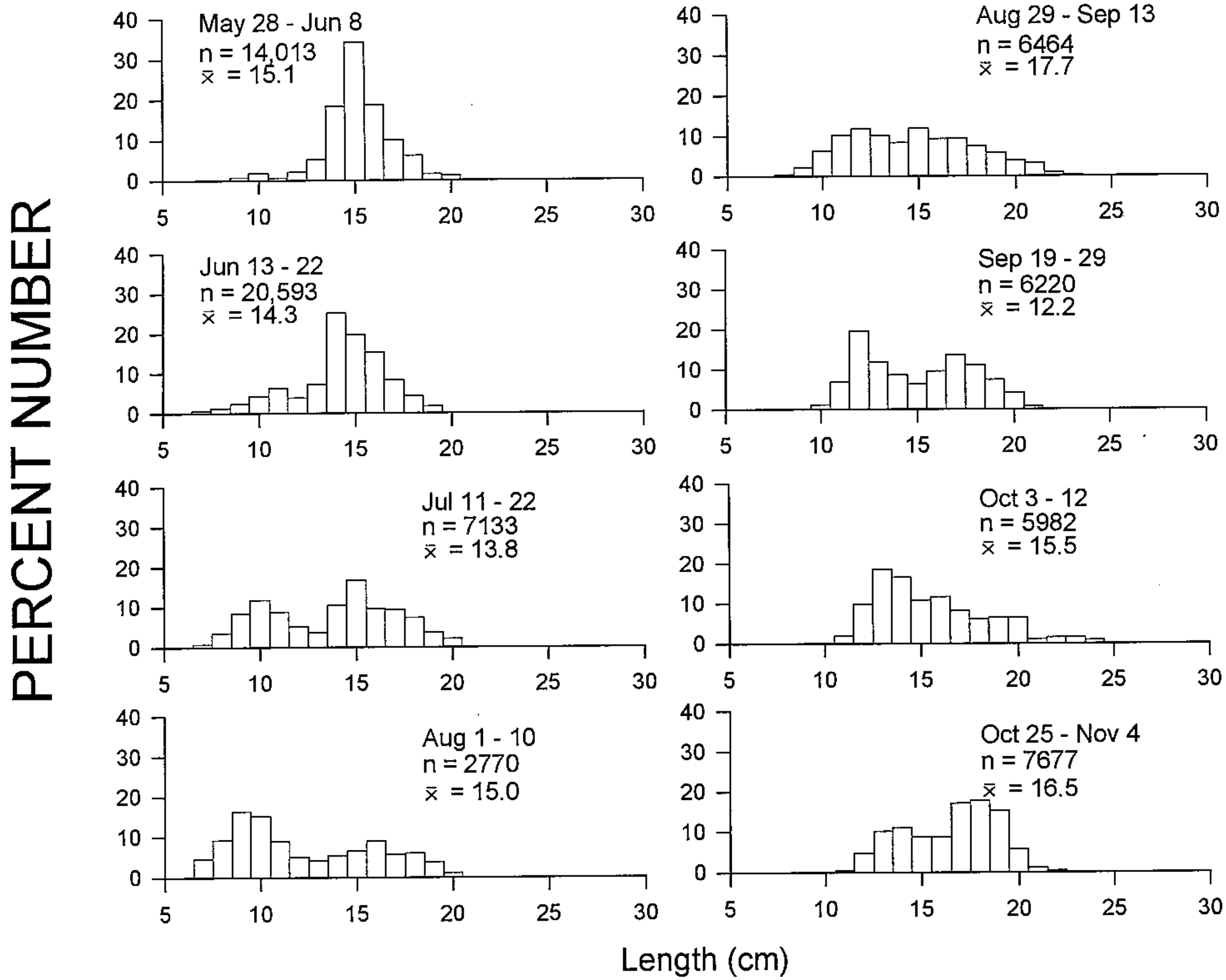


Figure 9. Length-frequencies of spot from 8 cruises in 1988.

A total of 31,428 specimens of southern kingfish were collected in 1987 and 1988 and occurred in 93% of the collections (Appendix 5). In 1987, *M. americanus* ranked third in both abundance and biomass (109.8 individuals/tow, 6.0 kg/tow) among target species and were present in 92% of the collections. In 1988, mean catch/tow was 95 individuals and 5.0 kg/tow. Southern kingfish were present in 99% of the collections from August through November or the time roughly corresponding with the 1987 collections. Differences in catch among stations were significant both years (1987: $F = 24.6$, $df = 3$, $p < 0.001$; 1988: $F = 14.7$, $df = 3$, $p < 0.001$) with Georgia contributing 52% of the total number of individuals in 1987 and 37% in 1988 (Figure 10). Cape Lookout produced the fewest both years.

Although the second cruise produced the greatest number of *M. americanus* individuals in 1987 (Figure 11), the difference was not found to be significant ($F = 1.2$, $df = 4$, $p > 0.05$). The difference in abundance among cruises was significant in 1988 ($F = 11.0$, $df = 7$, $p < 0.001$), with collections from late August to November having twice the number of specimens collected during the spring and early summer cruises. There was a significant diel difference in abundance both years (1987: $\chi^2 = 11.0$, $p < 0.001$; 1988: $\chi^2 = 28.0$, $p < 0.001$), with night collections having greater abundance than day collections. Even though Georgia produced greatest numbers of *M. americanus* in 1987, catch rate did not increase on the later cruises at that station, suggesting that winter migration to southern waters had not begun. Increased catch rate occurred at all stations after August 1988, suggesting movement of *M. americanus* out of the estuaries and into coastal waters, possibly as a prelude to southward migration.

Southern kingfish abundance differed significantly among sites in 1987 ($\chi^2 = 11.0$, $p < 0.05$) with greatest numbers occurring near the Beach and least abundance occurring at the deeper Offbeach sites. There was no significant difference among sites in 1988 ($F = 1.5$, $df=2$, $p = 0.2$).

Smith and Wenner (1985) reported on the biology of the southern kingfish and stated that after Age I, males and females have different growth rates. Both sexes matured at Age I in that study; males at 13.5 cm and females at 19.2 cm median length. Spawning occurred from April into August with the peak in June. This protracted spawning period caused age classes to overlap and created poorly defined length-at-age determinations. Mean length at capture from their study for males that were Age I was 187 mm TL, 230 mm TL at Age II, 260 mm TL at Age III, and 277 mm TL at Age IV. Females were 207 mm TL at Age I, 259 mm TL at Age II, 292 mm TL at Age III, and 326 mm TL at Age IV. The largest specimen collected by Smith and Wenner (1985) was 404 mm TL and was a 6 year-old female. Of the 9,000 fish collected in that study, 99% were 30 cm TL or less and were 3 years old or less.

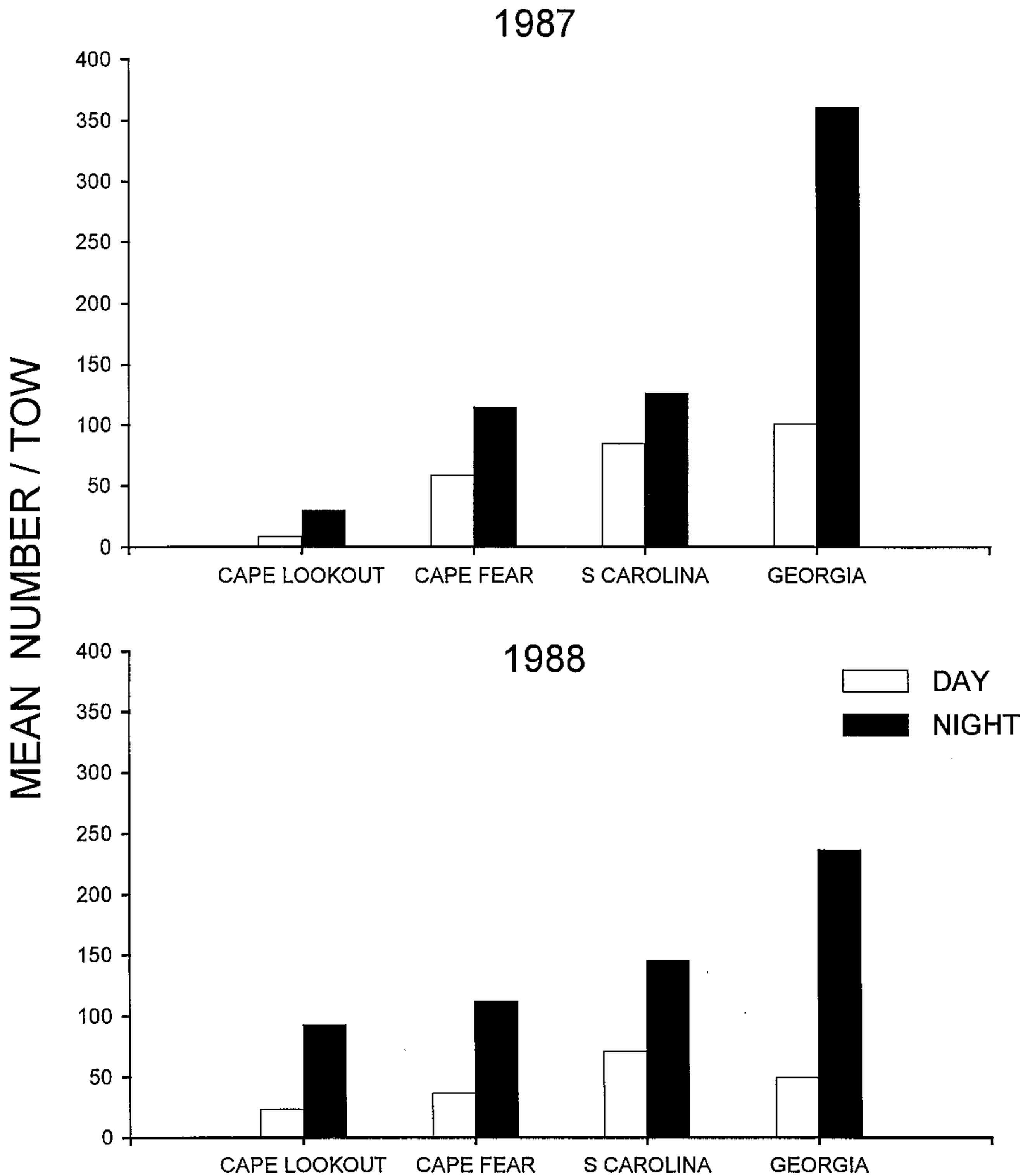


Figure 10. Diel abundance of *Menticirrhus americanus* by station.

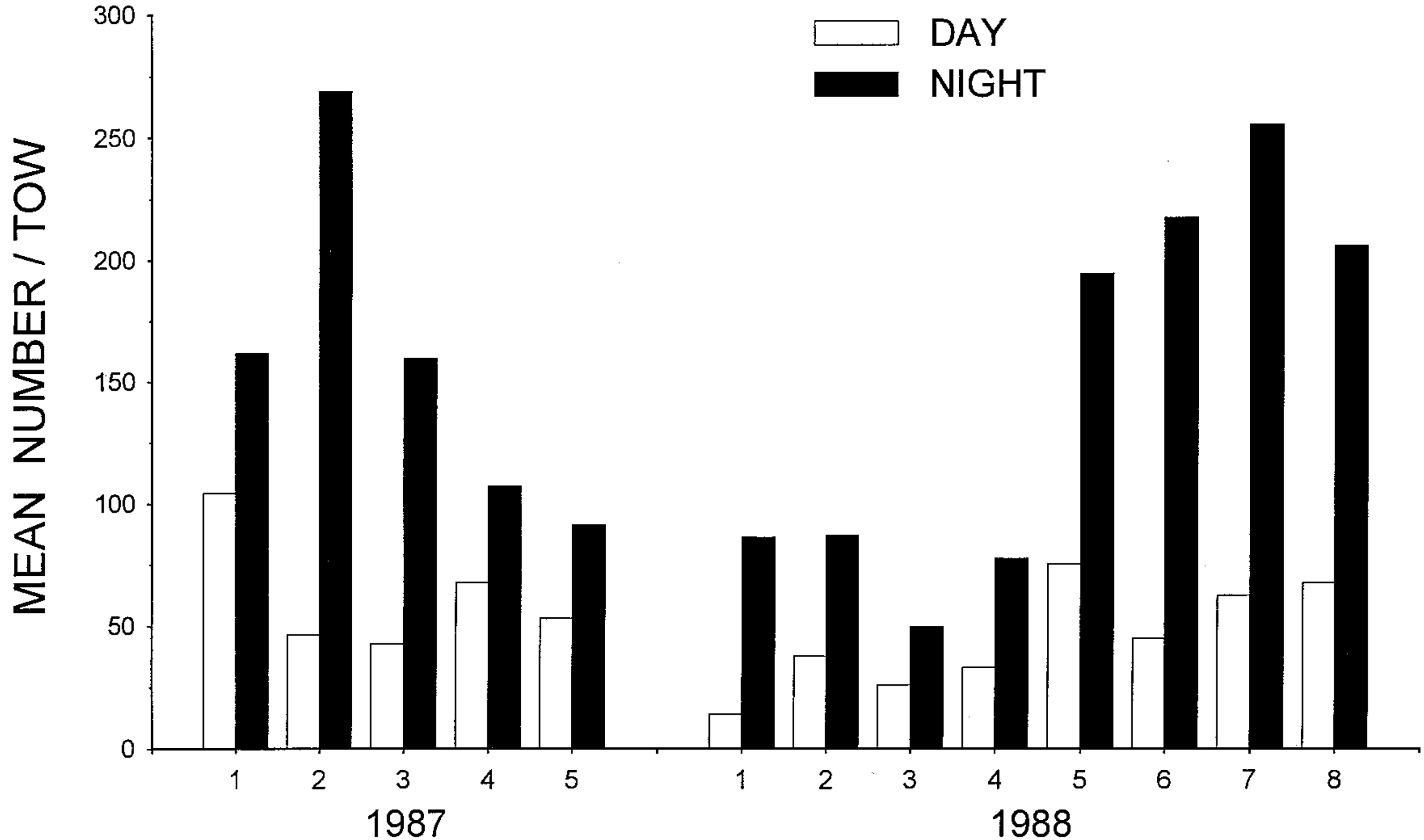


Figure 11. Diel abundance of *Menticirrhus americanus* by cruise.

Median lengths from SEAMAP-SA samples were significantly different among stations (1987: $\chi^2$ = 244.2, p < 0.001; 1988: $\chi^2$ = 125.2, p < 0.001) and among cruises ($\chi^2$ = 80.9, p < 0.001; 1988: $\chi^2$ = 121.0, p < 0.001) both years (Figures 12 and 13). Longest mean lengths occurred at Cape Lookout in 1987 and Georgia in 1988, and the shortest occurred at Cape Fear both years. Growth over time was noted in 1987, with the exception of Cruise 4 in October when shortest mean length was observed (Figure 12). Southern kingfish from the first two cruises of 1988 were primarily Age I fish (Figure 13), with recruitment of YOY specimens evident on Cruise 2 in June. After Cruise 2, the YOY cohort began to displace the Age I cohort until it became numerically dominant in late summer and fall. At that time, the YOY cohort became the Age I cohort and the Age I became Age II. Summer-spawned YOY measuring <10 cm were most abundant at the Cape Fear and South Carolina stations.

### ***Cynoscion regalis***

Weakfish occur along the Atlantic coast of the United States from Nova Scotia to southern Florida and occasionally to the Gulf coast of Florida (Bigelow and Schroeder, 1953; Chao, 1978). Some adult weakfish utilize estuaries in spring and summer as spawning and feeding grounds, although most spend their summers in oceanic waters (Hill, 1984; Mercer, 1985). Juveniles commonly inhabit shallow estuaries and near-shore coastal waters out to depths of 26 m (Thomas, 1971; Hill, 1984; Mercer, 1985). Weakfish in the SAB reportedly move south between North Carolina and Florida during fall migrations (Mercer, 1985). This is an important commercial and recreational species (Bigelow and Schroeder, 1953; Thomas, 1971; Chao, 1978; Mercer, 1985), with peak landings since the 1940's shifting from the Chesapeake and Middle Atlantic regions to the South Atlantic region, particularly in the North Carolina area (Mercer, 1985). This shift in landings is probably due to increased fishing pressure and not to a shift in weakfish distribution.

A total of 9,057 weakfish were found in 76% of the collections in 1987 and 1988 (Appendix 5). Differences in abundance among stations (Figure 14) were significant both years (1987: F = 92.5, df = 3, p < 0.01; 1988: F = 4.0, df = 3, p < 0.05). South Carolina produced 43% of the individuals taken in 1987 and Cape Fear produced 53% of the individuals produced in 1988. Mean catch/tow values were greater in 1988 than in 1987 (Figure 15).

Weakfish abundance among cruises also differed significantly for both years (1987: F = 7.3, df = 4, p < 0.005; 1988: F = 2.3, df = 7, p < 0.001). Catch rate in 1987 was highest on Cruise 1 in mid-August and steadily declined until an increase occurred on Cruise 5 in late October-early November (Figure 15). Although 56.4% of the weakfish collected in 1988 came from the first three cruises (May, June, and July),

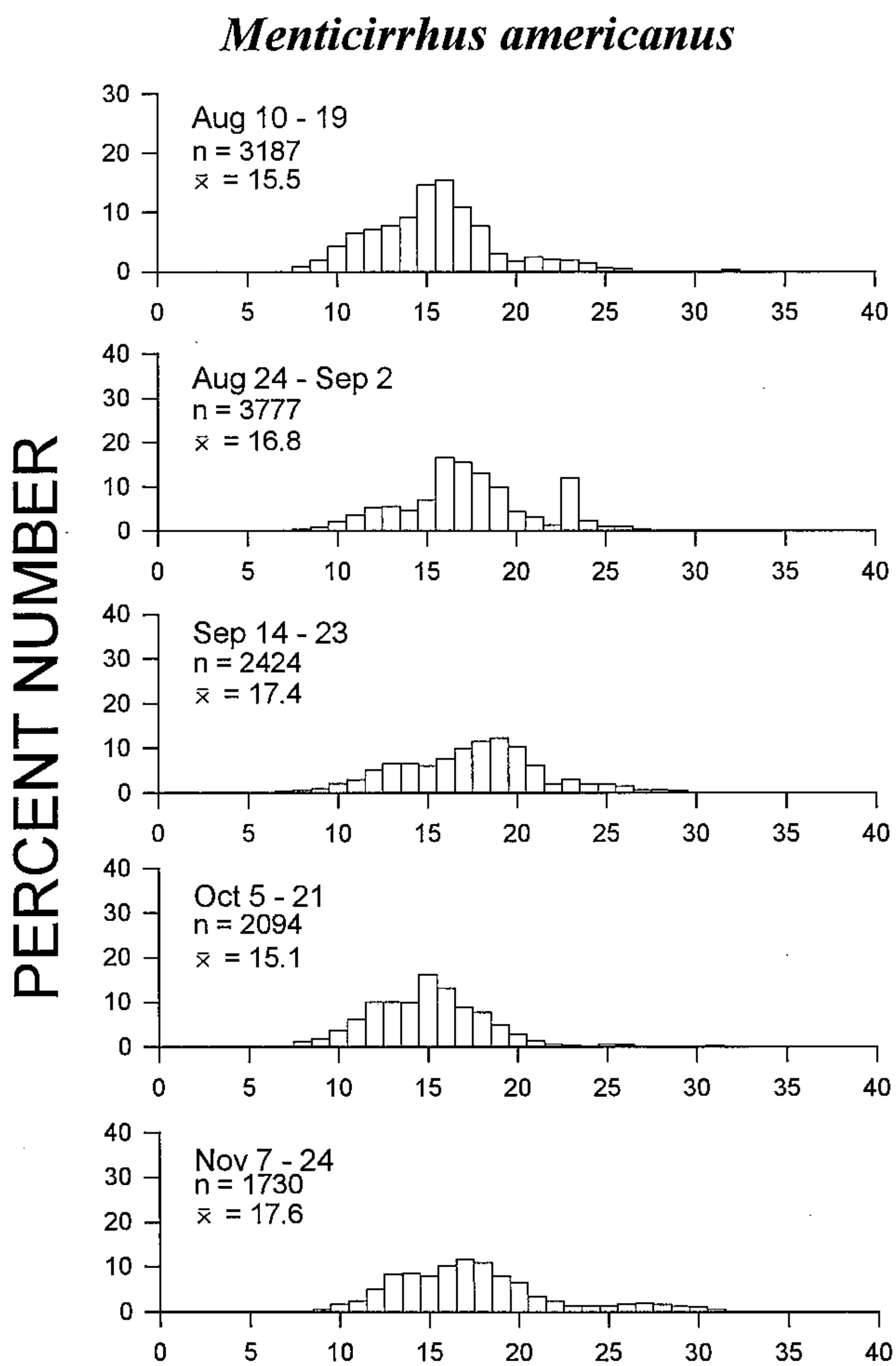


Figure 12. Length-frequency of southern kingfish from 5 SEAMAP cruises in 1987.

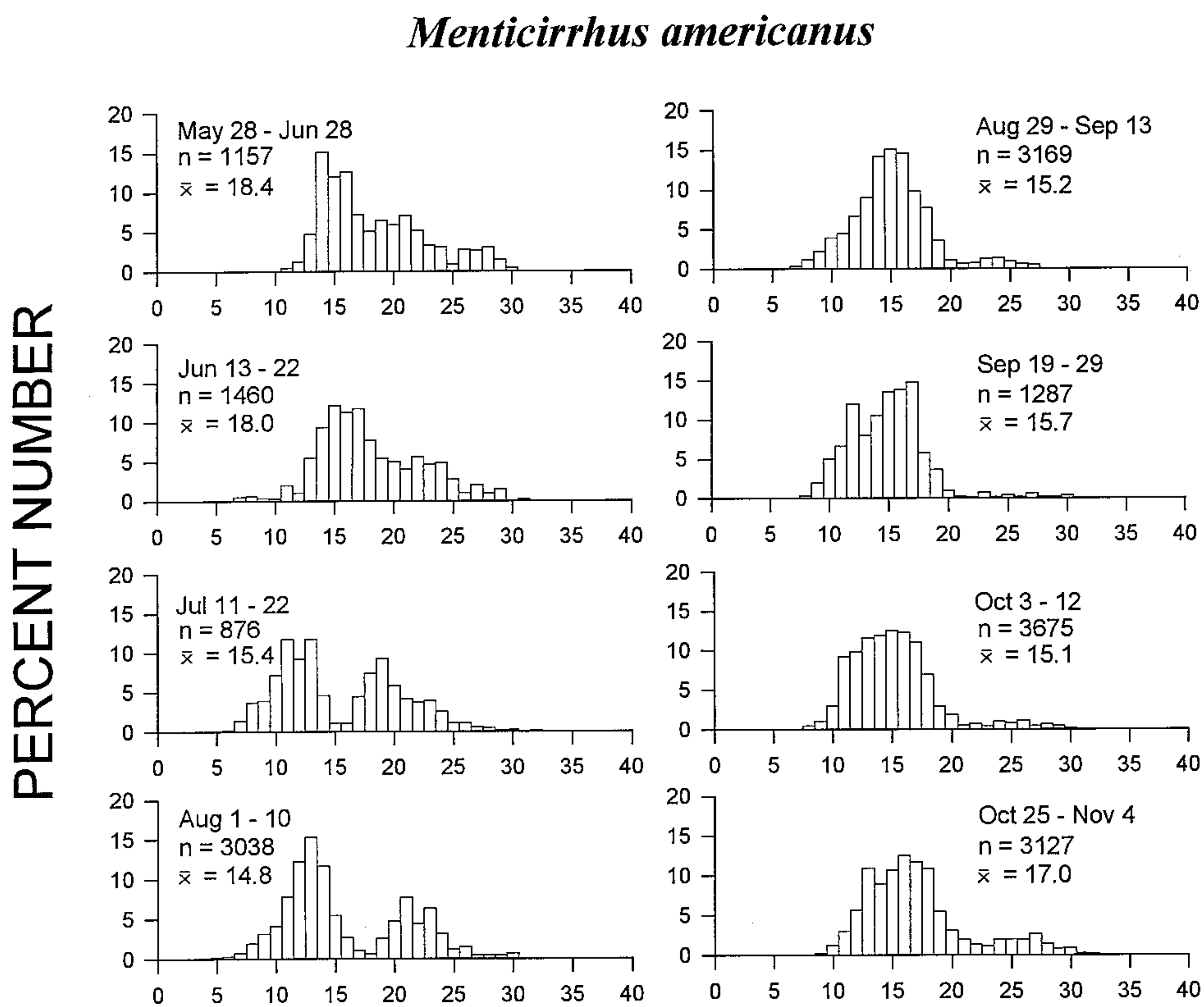


Figure 13. Length-frequency of southern kingfish from 8 SEAMAP cruises in 1988.

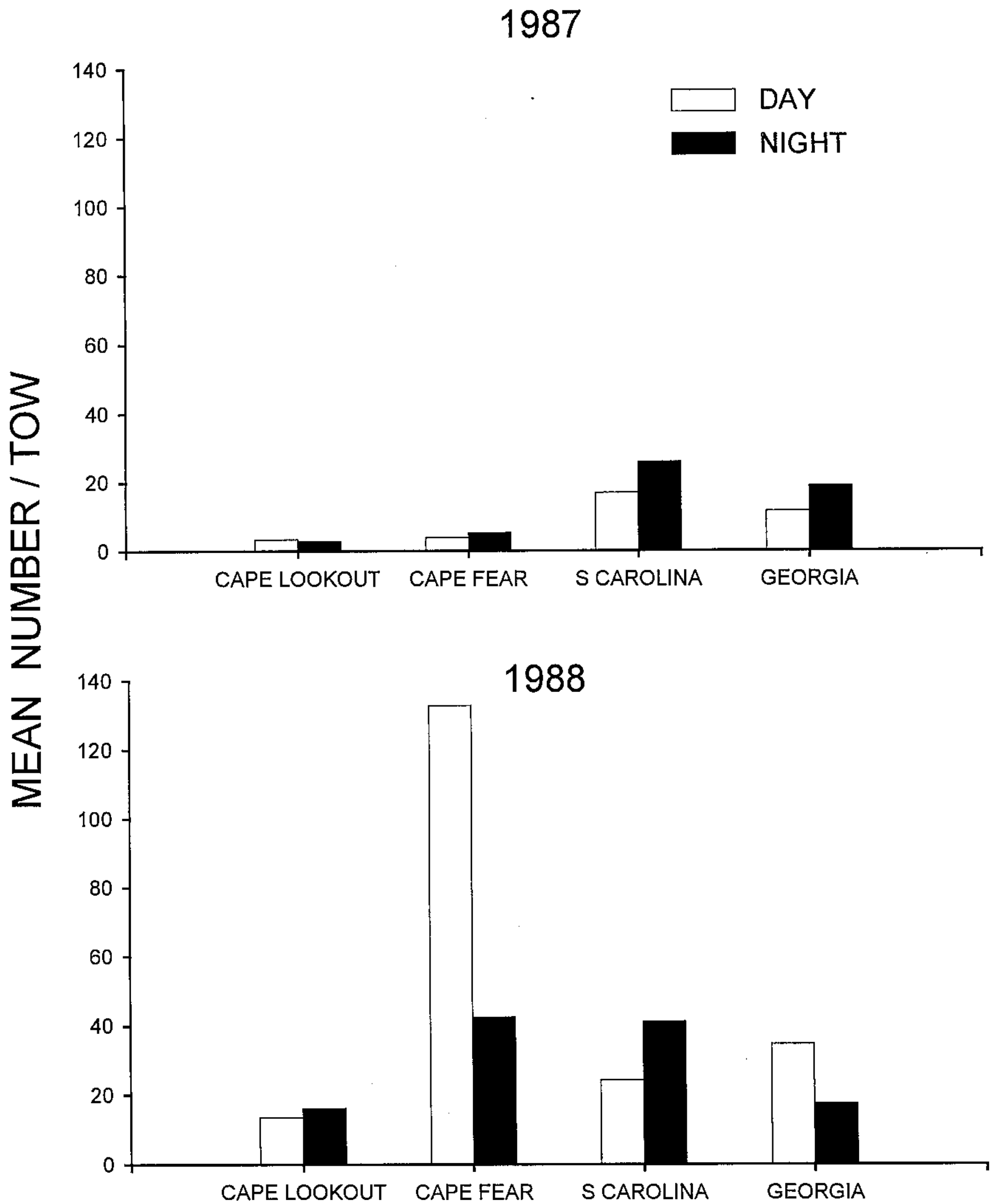


Figure 14. Diel abundance of *Cynoscion regalis* by station.

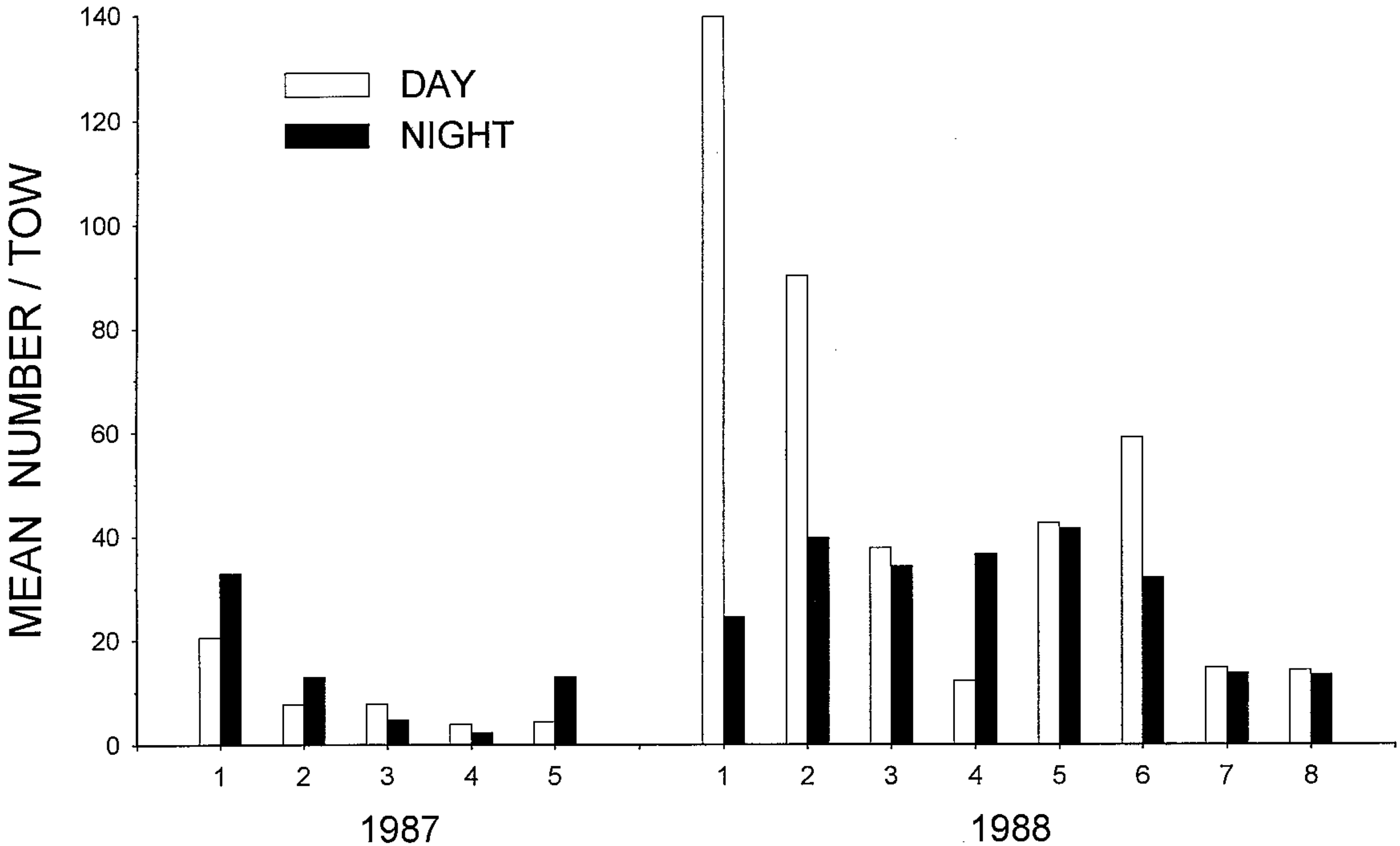


Figure 15. Diel abundance of *Cynoscion regalis* by cruise.

mean catch/tow from the last five cruises was over twice that of comparable cruises in 1987 (Appendix 5).

No significant diel differences were found in 1987 ($\chi^2 = 0.05$, $p = 0.8$), whereas in 1988 significant differences were found ($\chi^2 = 4.9$, $p < 0.05$). Highest abundance occurred during the day overall and in 1988 (Figures 14 and 15). Differences in abundance among sites were not significant in 1987 or 1988 (1987: $\chi^2 = 2.9$, $p = 0.2$; 1988: $\chi^2 = 1.3$, $p = 0.5$). Nevertheless, large daylight catches were taken at the Offbeach site at Cape Fear on the first two cruises of 1988.

Male and female weakfish attain sexual maturity at different lengths in North Carolina: males at a smaller size, 130-150 mm SL, and females at 145-190 mm SL (Merriner, 1976). Spawning takes place in estuarine and near shore waters from March to October with the peak from late April through June (Welsh and Breeder, 1923; Pearson, 1928; Pearson 1941; Hildebrand and Cable, 1934; Dahlberg, 1972; Merriner, 1976; Powles and Stender, 1976). Mean back-calculated standard lengths at age for weakfish from North Carolina for males and females, respectively, were Age I: 153 and 159 mm SL, Age II: 218 and 225 mm SL, Age III: 267 and 287 mm SL, Age IV: 317 and 357 mm SL, and Age V: 410 and 421mm SL (Merriner, 1973). Weakfish in the coastal waters of the SAB begin spawning as early as April and probably spawn throughout the summer (C. Walton, 1995, unpublished data, South Carolina Marine Resources Division). Almost all of her Age I specimens were sexually mature, including females as small as 170 mm TL and males as small as 164 mm TL.

Total lengths of weakfish in SEAMAP-SA collections ranged from 3-36 cm (Figures 16 and 17). Merriner's (1973) mean back-calculated standard length of 357 mm for age IV females in the South Atlantic region indicates that weakfish in our samples would all be age IV or younger with the majority being YOY and Age I fish. Lengths were significantly different among stations (1987: $\chi^2 = 165.2$, $p < 0.001$; 1988: $\chi^2 = 381.4$, $p < 0.001$), with specimens from Cape Lookout in 1987 and Cape Fear in 1988 having the largest mean lengths. Lengths were also significantly different among cruises both years (1987: $\chi^2 = 407.4$, $p < 0.001$; 1988: $\chi^2 = 465.5$, $p < 0.001$). Cruise 4 contributed the largest specimens and Cruise 3 the largest mean length in 1987, whereas Cruises 1 and 2 contributed the largest mean length and Cruises 6 and 7 produced the largest specimens in 1988. Smallest mean length in 1987 occurred on Cruise 5, reflecting recruitment of smaller fish and an absence of larger fish collected on earlier cruises. In 1988, a similar trend was noted on Cruise 5 when the YOY cohort was dominant and the Age I year class was almost absent.

*Cynoscion regalis*

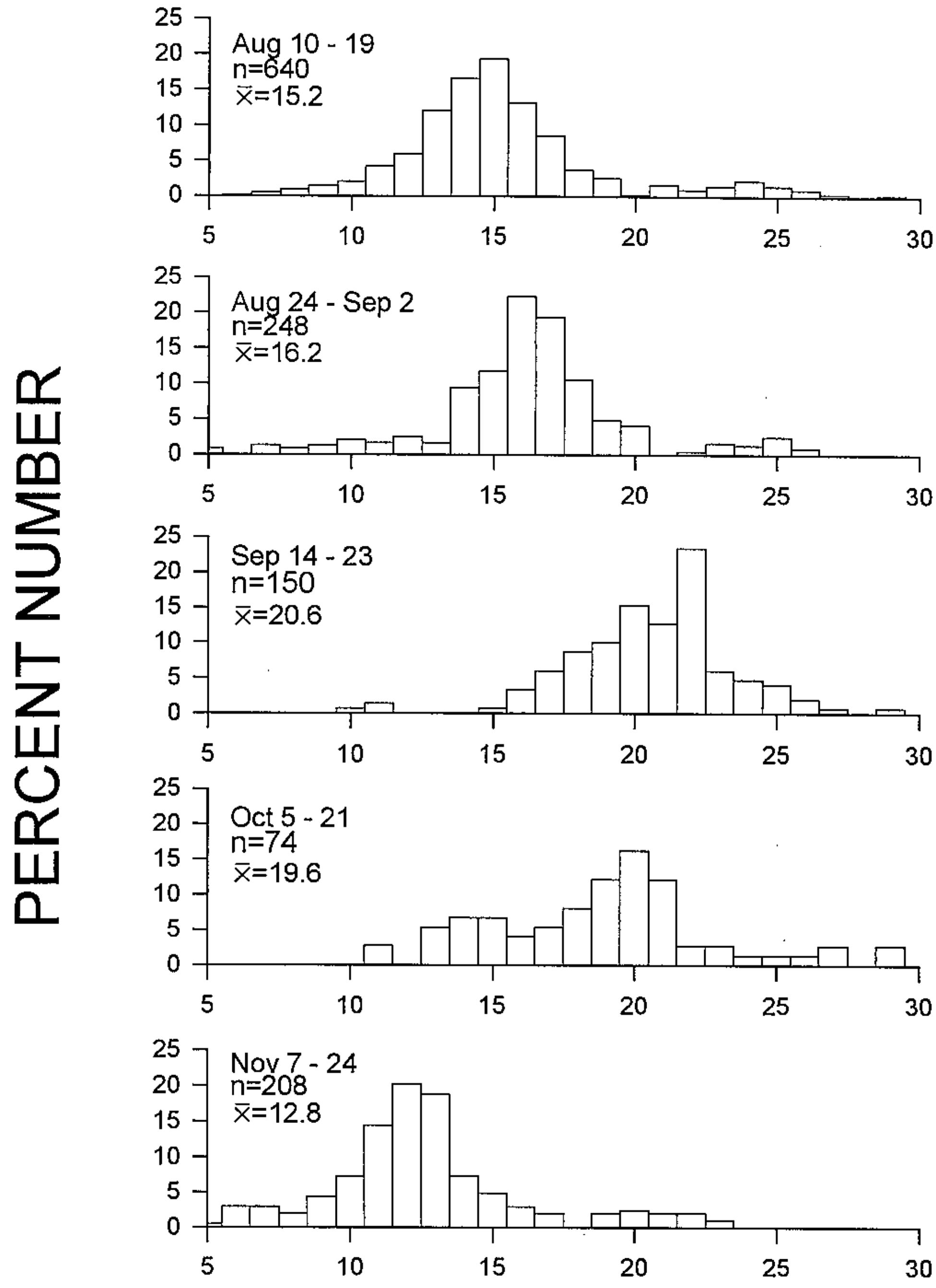


Figure 16. Length-frequency of weakfish from 5 SEAMAP cruises in 1987.

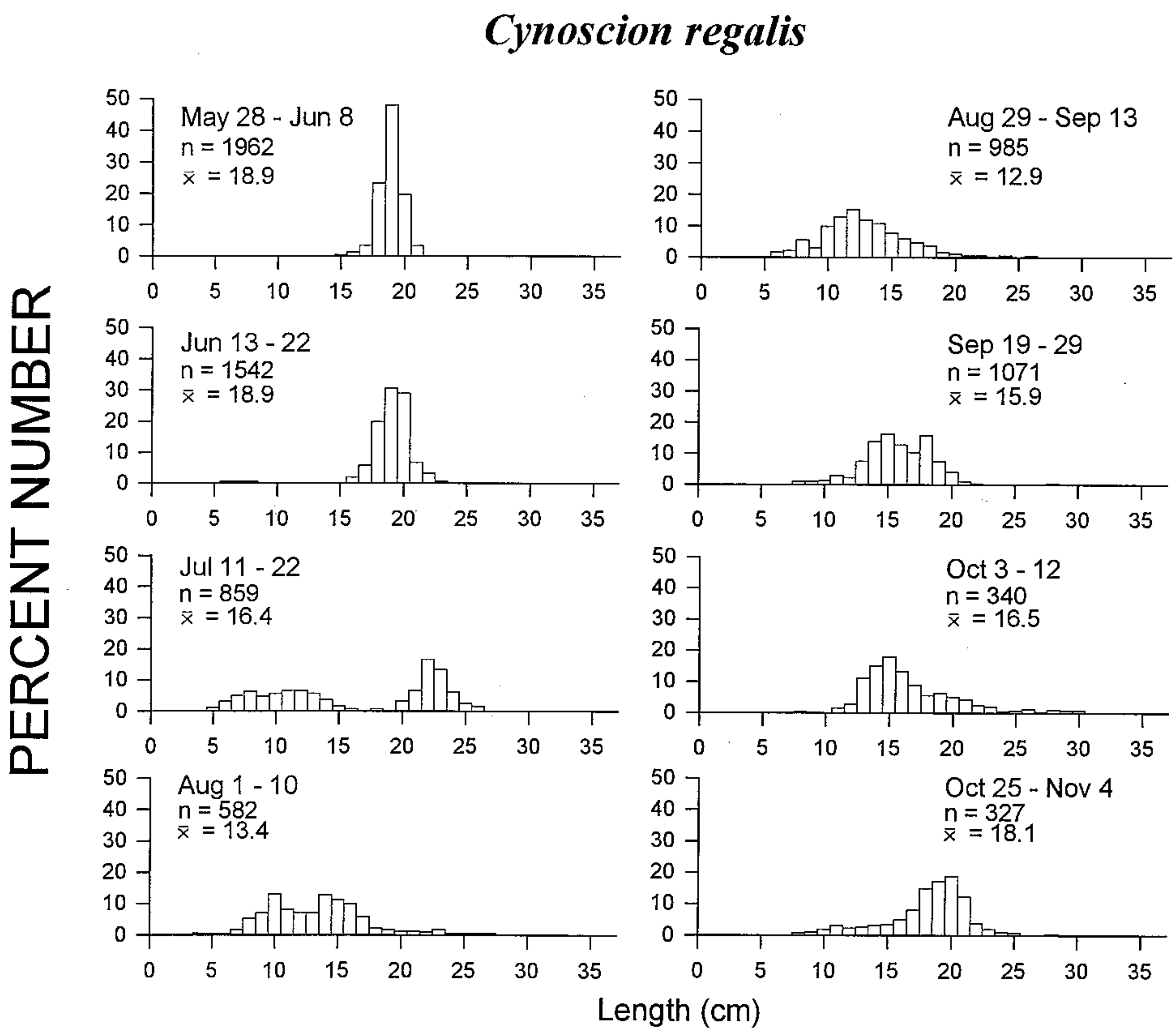


Figure 17. Length-frequency of weakfish from 8 SEAMAP cruises in 1988.

***Scomberomorus maculatus***

The Spanish mackerel ranges from Atlantic waters off Maine throughout the Gulf of Mexico to Yucatan and into the waters around Bermuda and Cuba (Berrien and Finan, 1977; Collette, 1978b), but is replaced by *S. brasiliensis* from Belize to Brazil (Collette and Russo, 1984). Generally occurring in coastal waters less than 72 m deep, *S. maculatus* is known to enter estuaries occasionally (Fritzsche, 1978; Collette, 1978b). Spanish mackerel are mainly piscivorous and prey heavily on schooling fishes (Collette, 1978b; Saloman and Naughton, 1983). It is known as an excellent food fish, making it the target of recreational anglers as well as supporting a large commercial purse seine and gill net fishery. Landings from the South Atlantic Bight totaled 247,555 lbs in 1986, 505,251 lbs. in 1987, and 439,315 lbs. in 1988, most of which came from North Carolina (Statistics Section, SCMRD).

A total of 3,786 specimens (12.1 individuals/tow) of Spanish mackerel were collected during this survey. Mean catch was 8.3 individuals/tow (0.4 kg/tow) in 1987 and 14.5 individuals/tow (1.1 kg/tow) in 1988 (Appendix 5). Differences in abundance among stations were significant in 1987 ($F = 16.8$, $df = 3$, $p < 0.05$), with 42% of the total number of individuals from Cape Fear (Figure 18). Cape Fear also produced the greatest number of Spanish mackerel in 1988, but the difference was not significant ($F = 0.8$, $df = 3$, $p > 0.05$). Difference among sites was significant in 1987 ($\chi^2 = 7.7$, $p < 0.05$), but not in 1988 ($\chi^2 = 5.5$, $p = 0.06$), with Beach sites producing the most specimens both years.

A significant difference in mean catch/tow occurred among cruises in both years (1987: $F = 11.2$, $df = 3$, $p < 0.01$; 1988: $F = 7.1$, $df = 7$, $p < 0.001$). Cruise 5 in November 1987 contributed only 2% to the total number of individuals (Figure 19). Abundance was low on the first two cruises of 1988, (May and June), but the subsequent two cruises produced over 50% of the total specimens for that year. Mean catch/tow from the last 5 cruises of 1988 was approximately twice that of the comparable cruises in 1987 (Appendix 5). Diel differences in abundance were not significant in 1987 ($\chi^2 = 0.1$, $p = 0.71$), but was in 1988 ($\chi^2 = 12.4$, $p < 0.001$). Diel differences in size, however, were significant both years (1987: $\chi^2 = 80.0$, $p < 0.001$, 1988: $\chi^2 = 242.4$, $p < 0.001$) with larger fish being collected during the day (Figure 20). On Cruise 4 in 1987, over twice as many Spanish mackerel were caught at night (Figure 20), corresponding with the smallest individuals (Figure 21). Peak abundance in 1988 occurred on Cruise 3 in July, the only cruise during which night catches exceeded those from day (Figure 19). The smallest specimens from 1988 were also collected during Cruise 3 (Figure 22). Abundance in night catches decreased steadily after Cruise 3 and corresponded with a steady increase in the mean size of individuals. Mean catch/tow on the last four cruises of 1988 was fairly even, but the day/night ratio increased considerably, as did the mean size of individuals.

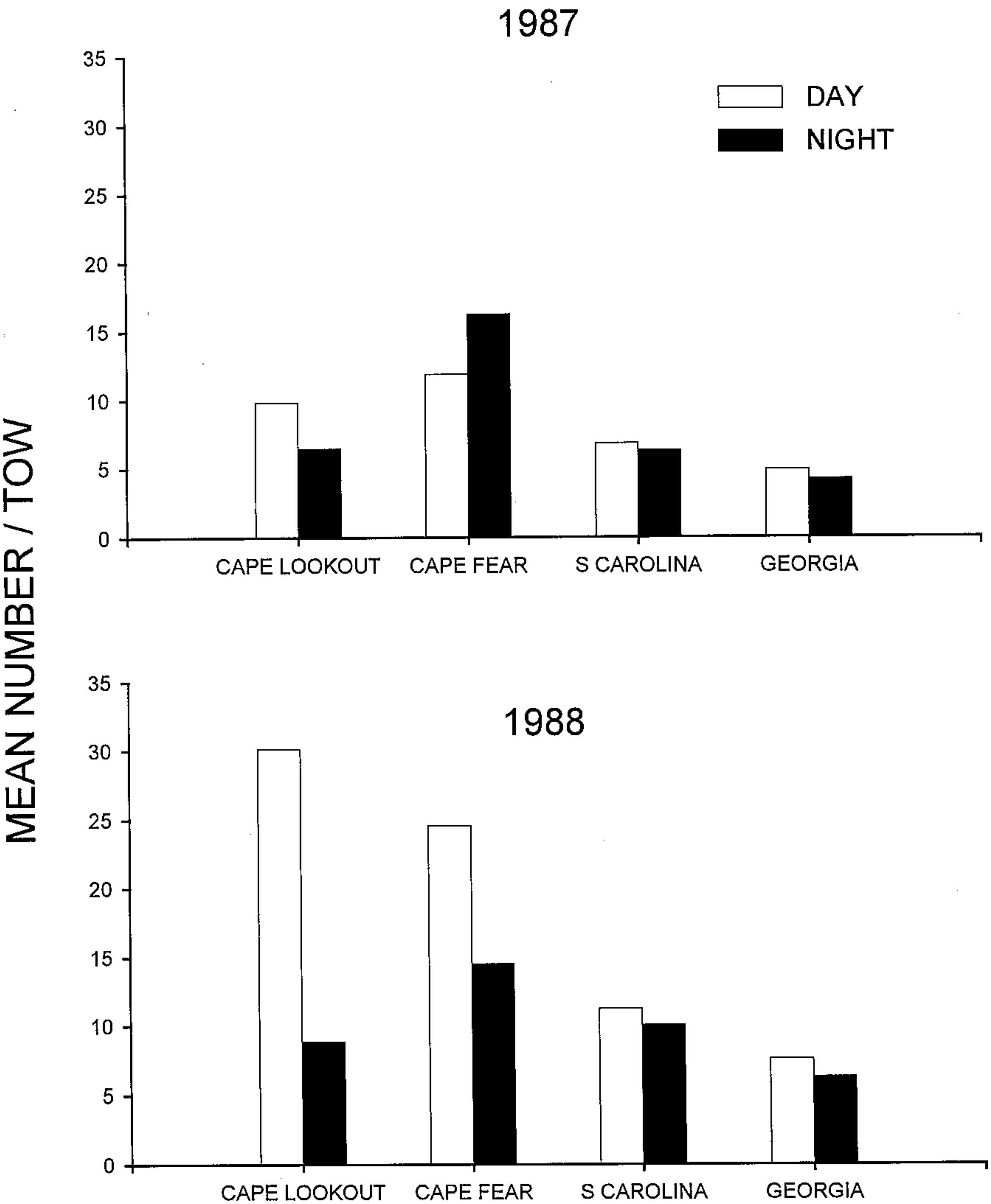


Figure 18. Diel abundance of *Scomberomorus maculatus* by station.

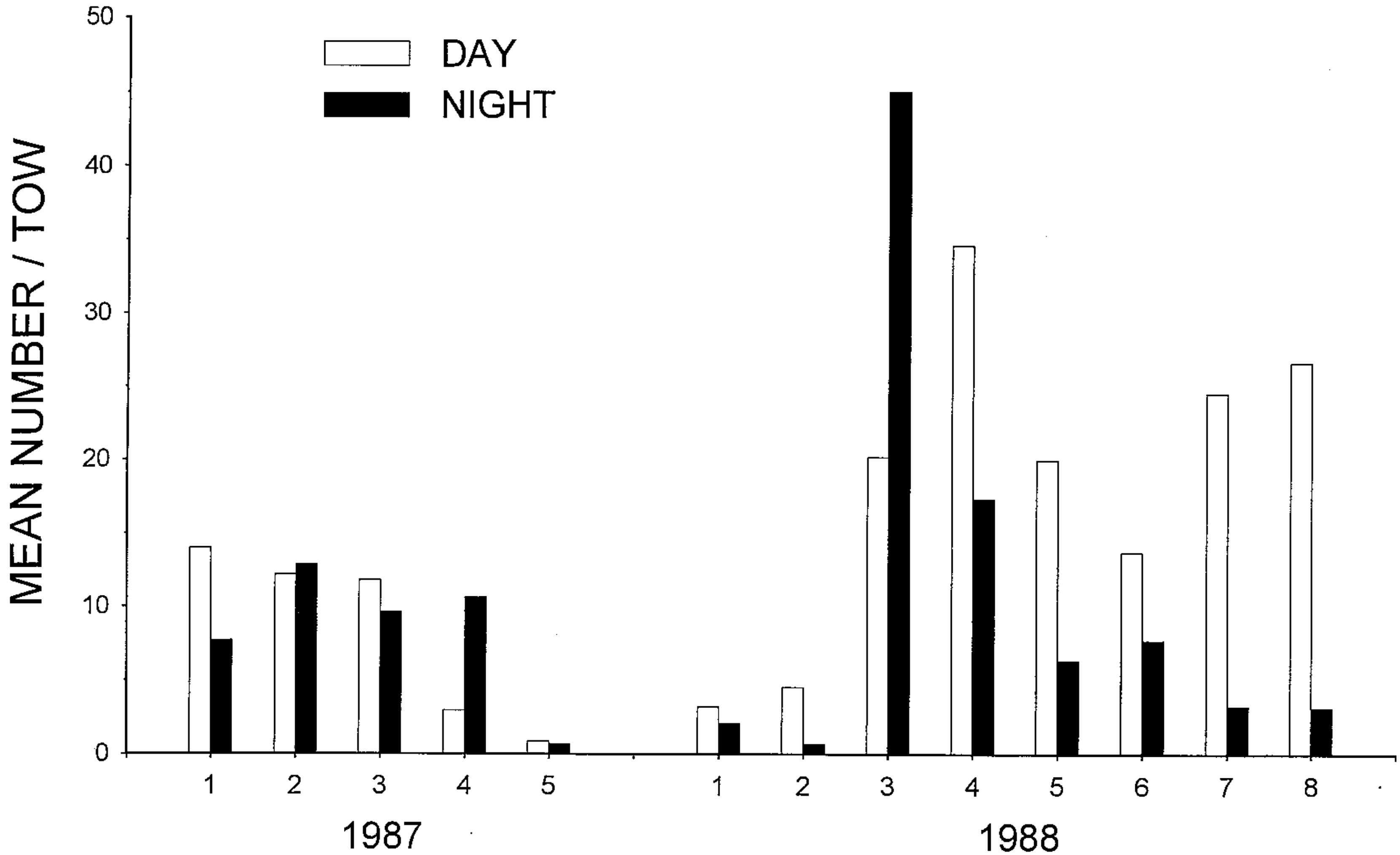


Figure 19. Diel abundance of *Scomberomorus maculatus* by cruise.

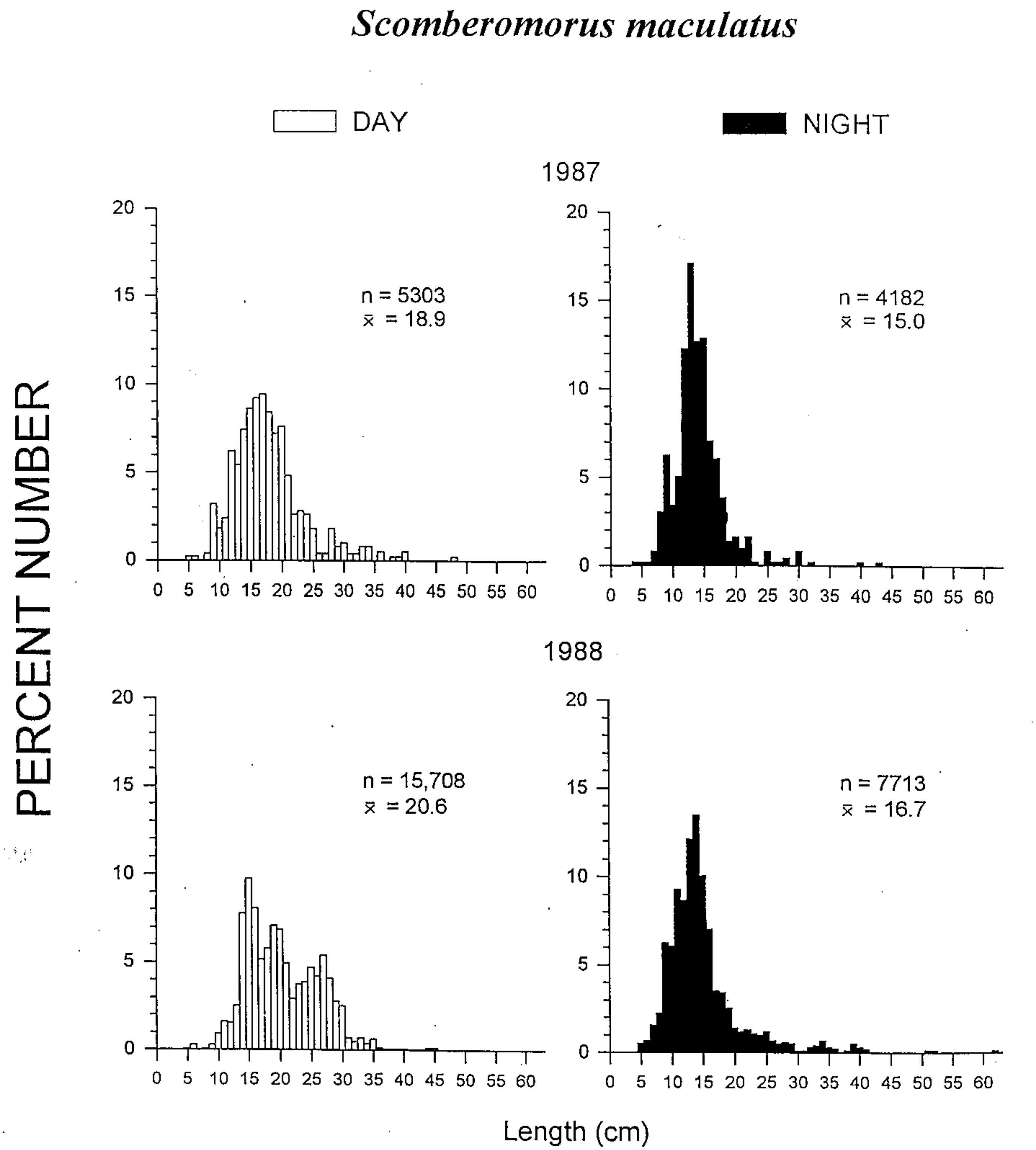


Figure 20. Length-frequencies of Spanish mackerel for day and night collections.

# *Scomberomorus maculatus*

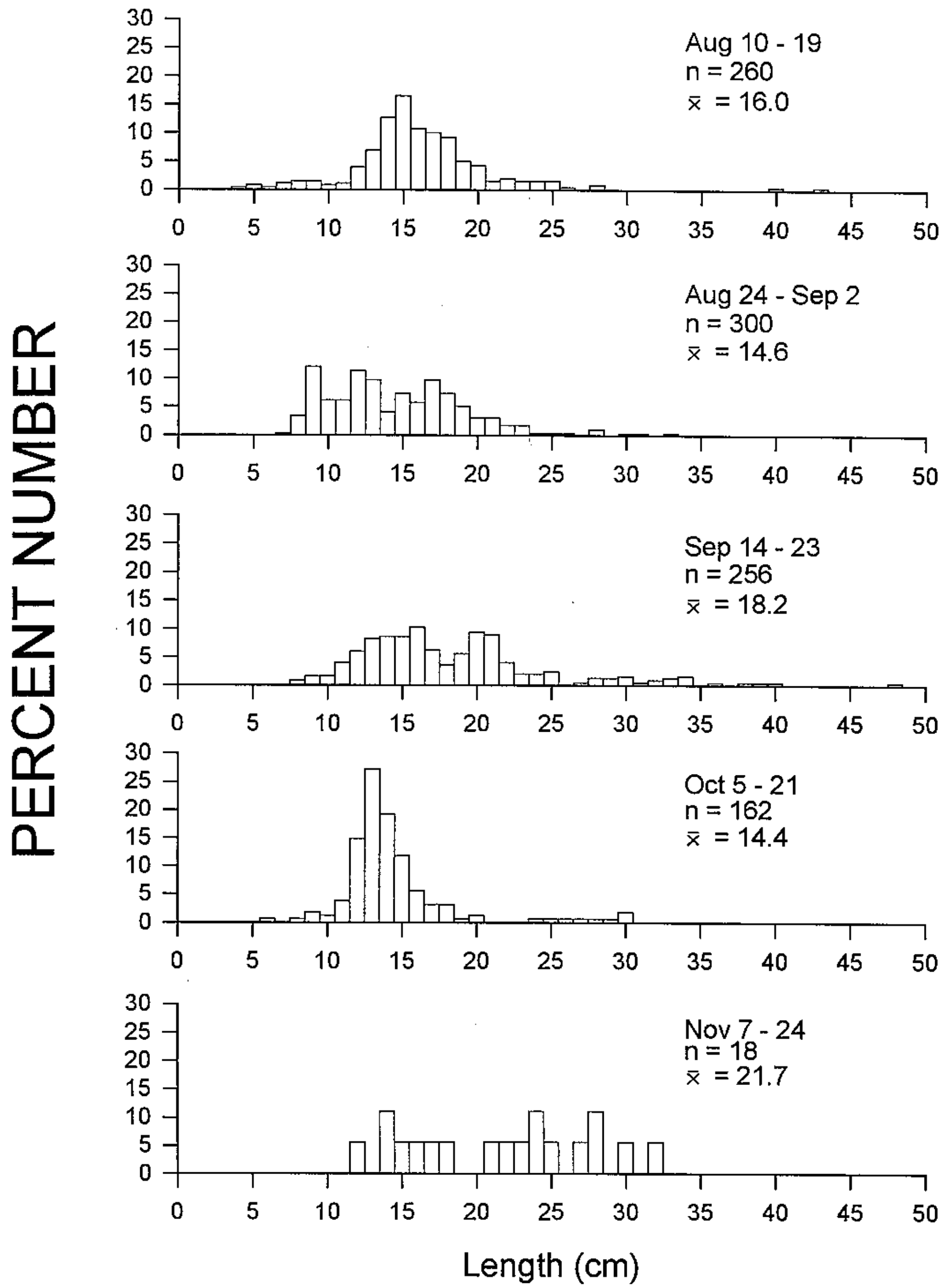


Figure 21. Length-frequency of Spanish mackerel from 5 SEAMAP cruises in 1987.

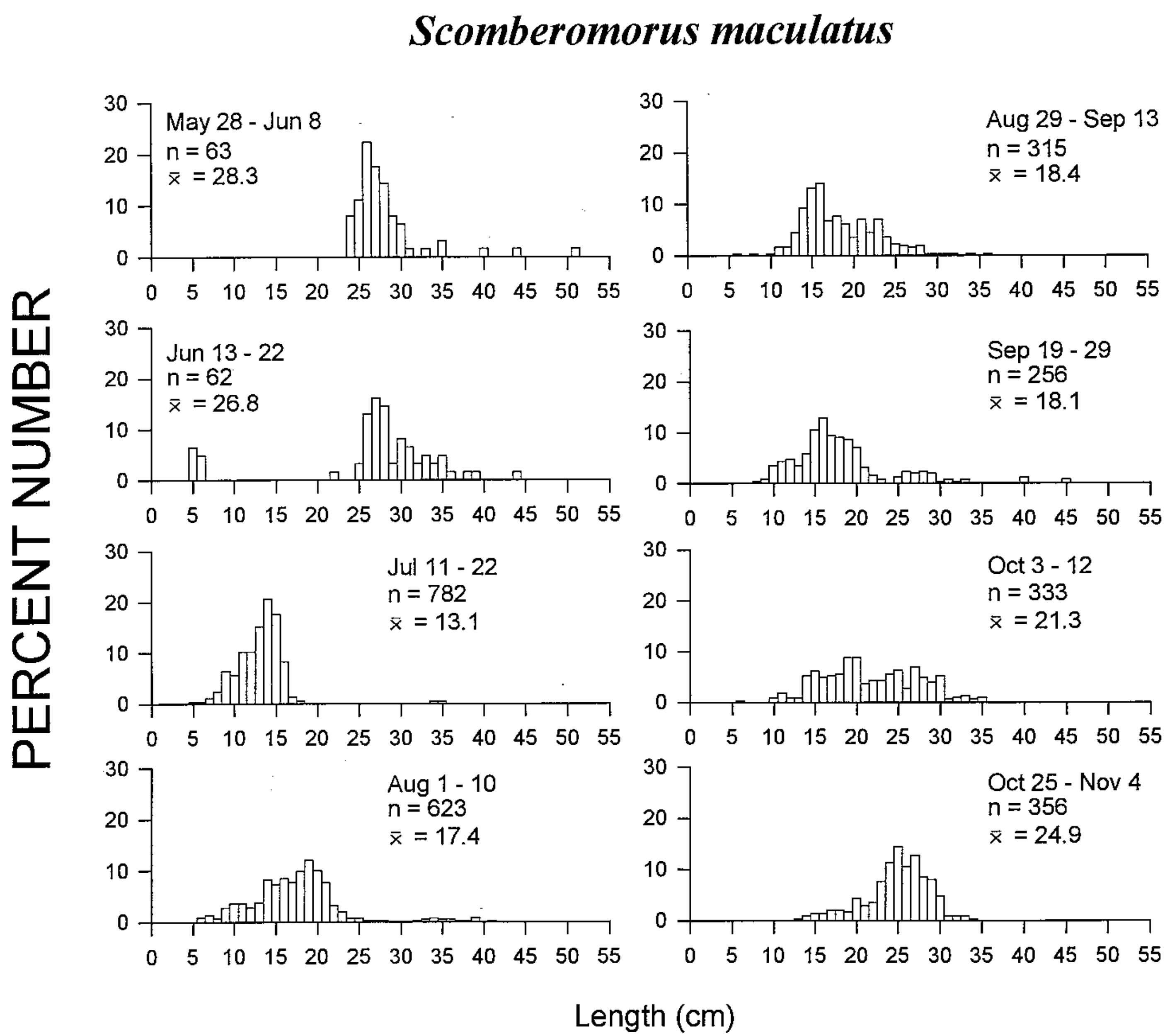


Figure 22. Length-frequency of Spanish mackerel from 8 SEAMAP cruises in 1988.

Schmidt et al. (1993) reported that spawning in the Atlantic group of Spanish mackerel occurs from spring through summer and that running ripe males are present from spring through early fall. Klima (1959) reported that males and females mature in their second or third year with size at maturation for females at 25-32 cm FL and males slightly larger at 28-34 cm FL. Powell (1975) suggested that the ages reported by Klima be reduced by 1 for both sexes. In waters off Georgia, South Carolina, and North Carolina, males and females first mature at approximately 275 mm FL and all females over 425 mm FL are considered to be mature (Finucane and Collins, 1986). Schmidt et al. (1993) found that females matured at 288-450 mm FL with the majority Age I, while males matured at 209-336 mm FL with the majority approaching the end of their first year. Spanish mackerel reached lengths greater than 30 cm FL by the end of their first year (Powell, 1975). They approached a meter at their longest and may have reached 5 (Klima, 1959) to 11 (Schmidt et al., 1993) years of age, with maximum ages of 8 (Powell, 1975) and 9 (Fable et al., 1987) also reported.

Lengths from the SEAMAP-SA survey ranged from 4-48 cm FL in 1987 (Figure 21), with significant differences in length among stations ($\chi^2 = 94.8$, $p<0.001$) and cruises ($\chi^2 = 103.1$, $p<0.001$). The largest specimens were taken in waters off Georgia and during Cruise 3 in September and Cruise 5 in November. In 1988 lengths ranged from 5-62 cm FL (Figure 22). Largest mean lengths occurred on Cruises 1 and 2 in May and June, after which a decrease in size signaled the beginning of recruitment on Cruise 3 in July. Mean length of individuals increased steadily throughout the sample period after Cruise 2, reflecting the growth of the YOY year-class. Length-frequency distributions in 1988 (Figure 22) clearly illustrates the recruitment pattern of Spanish mackerel. In spring (Cruise 1) only the previous year's cohort was present. On Cruise 2, YOY recruitment had begun, but the dominant cohort was the new Age I cohort. By Cruise 3 almost all of the Age I cohort was absent from the samples and the YOY cohort dominated the remainder of the cruises. Growth of the YOY individuals was indicated by a modal shift to the right and an increase in mean length. It is difficult to tell if the specimens collected on Cruise 3, resulted from a spawning peak or were recruited through migration. Recently recruited (6 cm FL) individuals were still present on Cruise 7 in early October, but were absent from collections from Cruise 8 in late October and early November. The widened range of lengths in the distribution may reflect a protracted spawning period, or may be an indication of different growth rates for the sexes which, reportedly, becomes apparent late in the first year, with females growing faster than males (Schmidt et al., 1993).

### ***Scomberomorus cavalla***

King mackerel are abundant along both coasts of Florida and throughout the SAB, ranging seasonally as far south as Brazil and as far north as Maine (Collette, 1978b; Berrien and Finan, 1977). They are known to occur individually and in schools

(Collette, 1978b; Beaumariage, 1973), and are generally limited to coastal waters where, historically, they were thought to migrate northward as the water warmed in spring and southward as waters cooled in the fall (Wollam, 1970; Berrien and Finan, 1977). More recent tagging (Sutter et al., 1991) and larval (Collins and Stender, 1987) studies indicate a spawning aggregation off the South Carolina shelf that would necessitate a spring and summer migration to that area. Prized as both food and sport fish, king mackerel are caught with gill nets, purse seines, and on hook-and-line (Collette, 1978b; Berrien and Finan, 1977), with 1.8 million pounds in 1986 and 1.6 million pounds in 1987 harvested commercially from the South Atlantic Bight. Most of these fish (87% in 1987) were landed off North Carolina (SCMRD Statistics Section). There are approximately 30 king mackerel tournaments each year in the South Atlantic Bight, evidence of the popularity of the species with recreational fishermen.

Finucane et al. (1986) reported that king mackerel spawn from May through September, with the peak occurring in July. Collins and Stender (1987) found king mackerel larvae present from May through September, with peak abundance in September, and felt that their data indicated a peak summer spawning that occurred beyond the shelf break with a subsequent inshore movement of larvae. This would necessitate spring and summer migrations of mature fish to this area. Collins and Wenner (1988) suggested that high-rise or tongue trawls catch more king mackerel than semi-balloon shrimp trawls. Using gear identical to the SEAMAP-SA trawls and fishing in waters out to 18 m, they discovered that 79% of the 865 YOY king mackerel collected over the two-year study came from water depths less than 9 m. They collected only three specimens that measured over 40 cm FL. Johnson et al. (1983) collected over 7,700 specimens of king mackerel from the Gulf of Mexico and the SAB by hook-and-line to study age, growth, and mortality and reported only one fish (a female) that measured less than 40 cm FL. This specimen was found to be YOY.

The 1987 and 1988 SEAMAP-SA surveys collected 976 specimens of *S. cavalla* that were present in 35% of the trawl tows (Appendix 5). Difference in mean number of individuals/tow among stations was not significant either year (1987: $F = 1.0$, $df = 3$, $p > 0.05$; 1988: $F = 2.3$, $df = 3$, $p > 0.05$); however, abundance was greatest at Cape Lookout in 1987 when over half of the specimens (53% or 3.9 individuals/tow) came from that station and at Cape Fear in 1988 which produced 43% (6.8 individuals/tow) of the total number of specimens (Figure 23). Lowest annual catch rates of 0.5 (1987) and 0.9 (1988) individuals/tow occurred at the Georgia station. The difference in mean number of individuals/tow among sites was not significant either year (1987: $\chi^2 = 1.1$, $p = 0.6$; 1988: $\chi^2 = 5.5$, $p = 0.06$), although greatest numbers of king mackerel were collected at Inlet sites in 1987 and at Beach sites in 1988.

Peak abundance of king mackerel from the SEAMAP-SA surveys occurred in September 1987, but the differences in abundance among cruises were not significant that year ($\chi^2 = 7.1$, $p = 0.13$). Abundance was also greatest in September of 1988 and

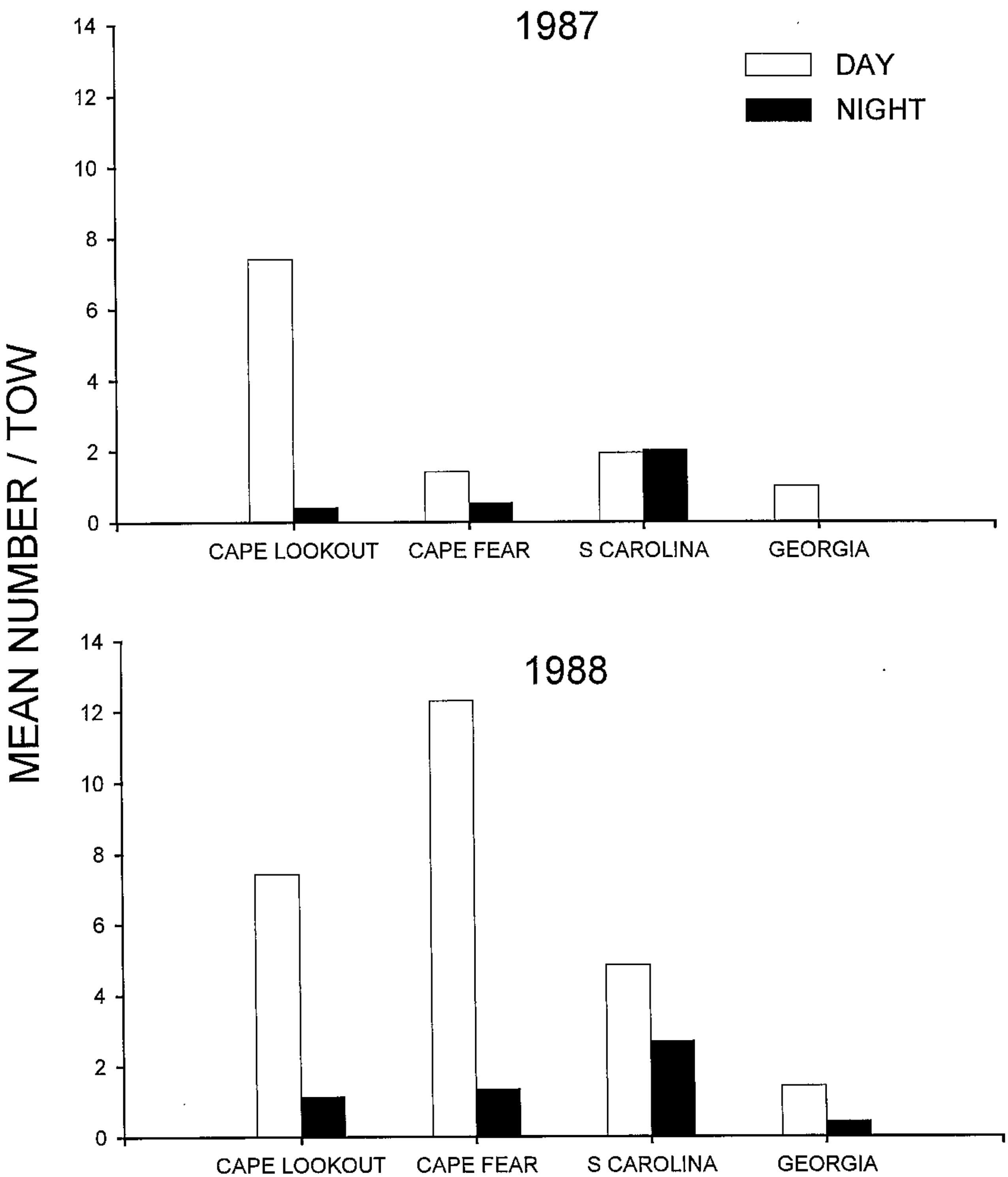


Figure 23. Diel abundance of *Scomberomorus cavalla* by station.

the differences in abundance among cruises were found to be significant ($\chi^2 = 19.0$, $p < 0.01$) (Figure 24). Cruise 3 in September 1987 had a mean catch of 4.4 individuals/tow and Cruise 6 in September of 1988 had a mean catch of 17.0 individuals/tow. Mean catch/tow estimates from 1988 were over twice the mean number of individuals/tow taken in 1987 (Appendix 5). Mean number of individuals/tow was greater in day collections in both 1987 (day: 2.9; night: 0.7) and in 1988 (day: 6.5; night: 1.4). Diel differences in abundance were significant in 1987 ( $\chi^2 = 5.3$, $p < 0.05$) and 1988. Significant diel differences in abundance among stations ($F = 9.8$, df = 3, $p < 0.005$) and cruises ($F = 15.7$, df = 1, $p < 0.001$) were found in 1988. No king mackerel specimens at night were collected during Cruise 5 in 1987, during any cruises off Georgia in 1987 (Figure 23), and during Cruises 2 and 8 in 1988 (Figure 24).

Male and female king mackerel have different growth rates, and mean-length for both sexes at the end of their first year is over 40 cm FL (Collins et al., 1989). Collins et al. (1989) reported that some males mature in their second year (Age I), whereas females mature in their third year (Age II). While conducting the study, Collins et al. (1989) aged 69 juvenile king mackerel that ranged in length from 79 to 330 mm FL and found them all to be less than a year old. Finucane et al. (1986) reported that female king mackerel mature at 3 years or older at lengths greater than 45 cm. However, Berrien and Finan (1977) reported that female king mackerel are not involved in their first major spawning until their fourth year at a length of around 82 cm, whereas males mature at 72 cm in their third year.

All specimens of king mackerel collected by the 1987 and 1988 SEAMAP-SA surveys measured less than 38 cm FL and were YOY based on Collins et al. (1989). Specimens ranged in length from 5-37 cm FL (Figures 25 and 26), and the largest specimens were collected in spring and early summer and in late fall of 1988. King mackerel display sexual dimorphism in size and maturity; however, this dimorphic feature is not exceptionally important in the size range of the *S. cavalla* taken in our trawls. As males are reported to mature in their third year at around 72 cm and females in their fourth year at 82 cm (Berrien and Finan, 1977); these specimens were all immature. Differences in lengths among stations were not significant in 1987 ($\chi^2 = 7.6$, $p > 0.05$), but were highly significant in 1988 ($\chi^2 = 113.3$, $p < 0.001$). In 1988 king mackerel were most abundant and mean length of specimens was largest ($\bar{x} = 16.5$ cm FL) in Cape Fear. Differences in lengths among cruises were significant both years (1987: $\chi^2 = 88.6$, $p < 0.001$; 1988: $\chi^2 = 88.6$, $p < 0.001$).

Magnitude of abundance is dependant on recruitment of YOY individuals. YOY were present on Cruise 1 in 1987 (Figure 25) when sampling began in August. In 1988, when sampling began in spring (Figure 26), although Cruises 1 - 4 produced few specimens, they clearly show the shift in the dominant cohort. All 18 specimens collected on the first two cruises of 1988 were from the 1987 cohort approaching Age I. By the third cruise this cohort was absent from the collections and the recruitment of the YOY cohort had begun. Recruitment was well underway by mid-August and peaked in mid-September (Cruise 6). Abundance dropped off again by the last cruise,

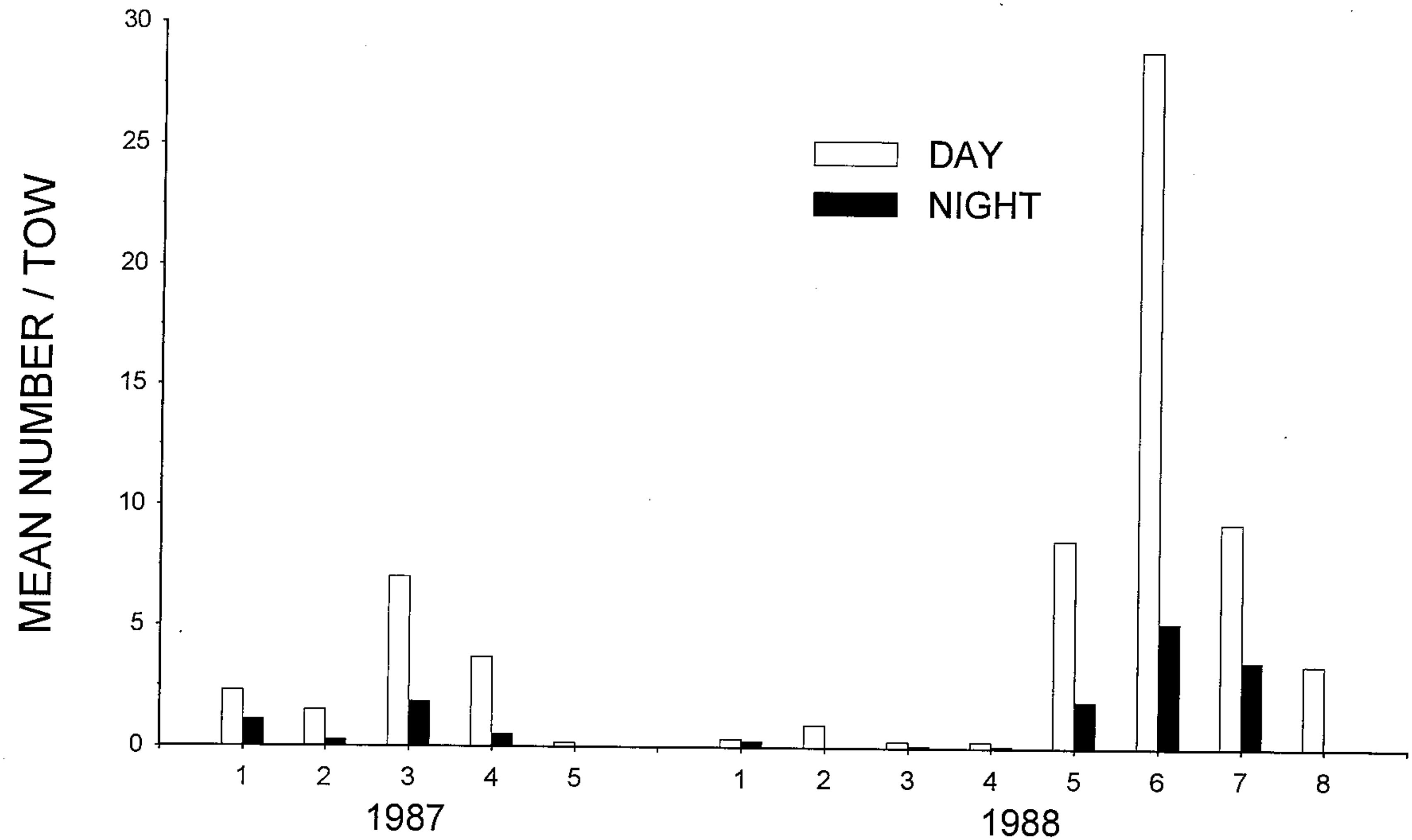


Figure 24. Diel abundance of *Scomberomorus cavalla* by cruise.

*Scomberomorus cavalla*

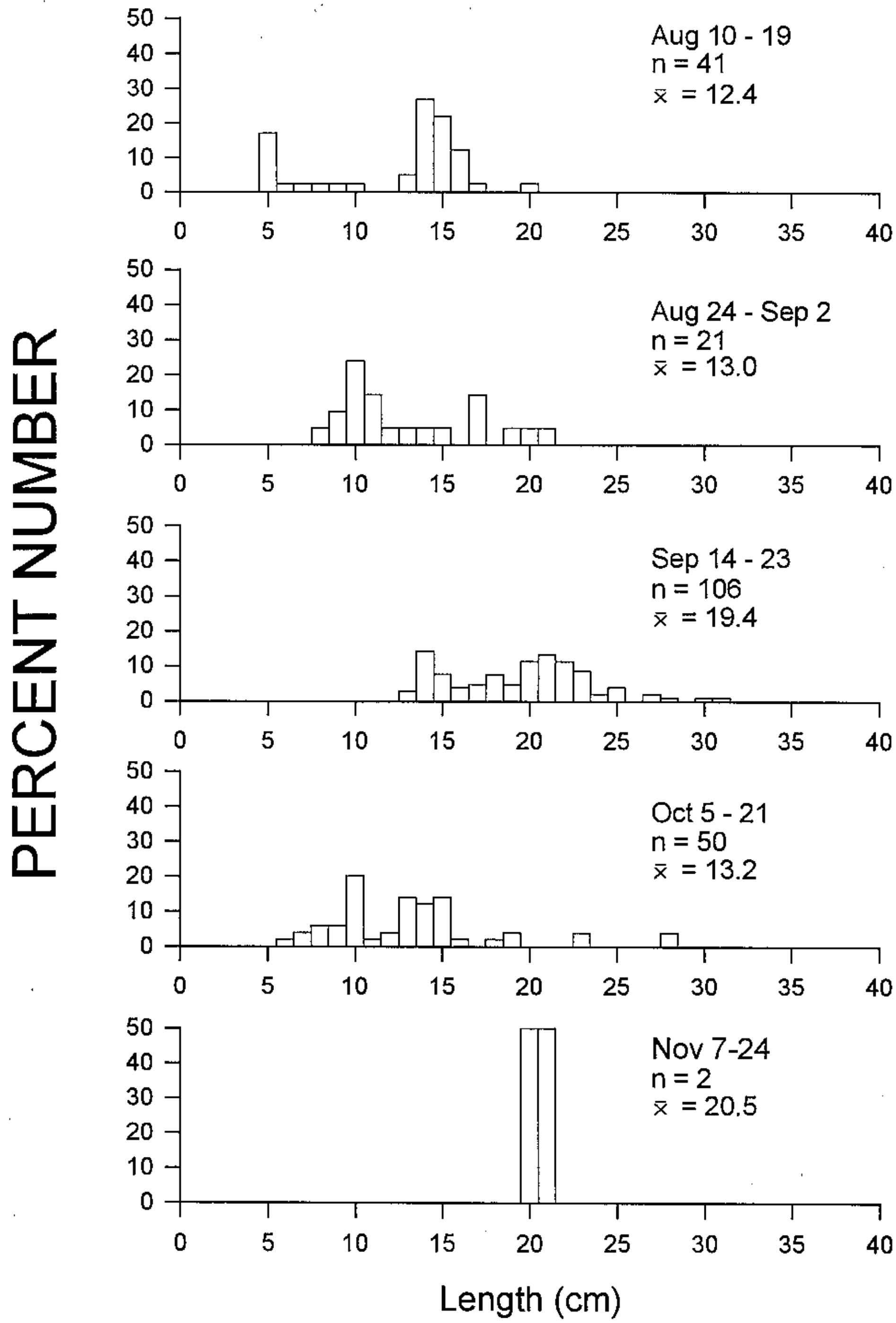


Figure 25. Length-frequencies of king mackerel from 5 SEAMAP cruises in 1987.

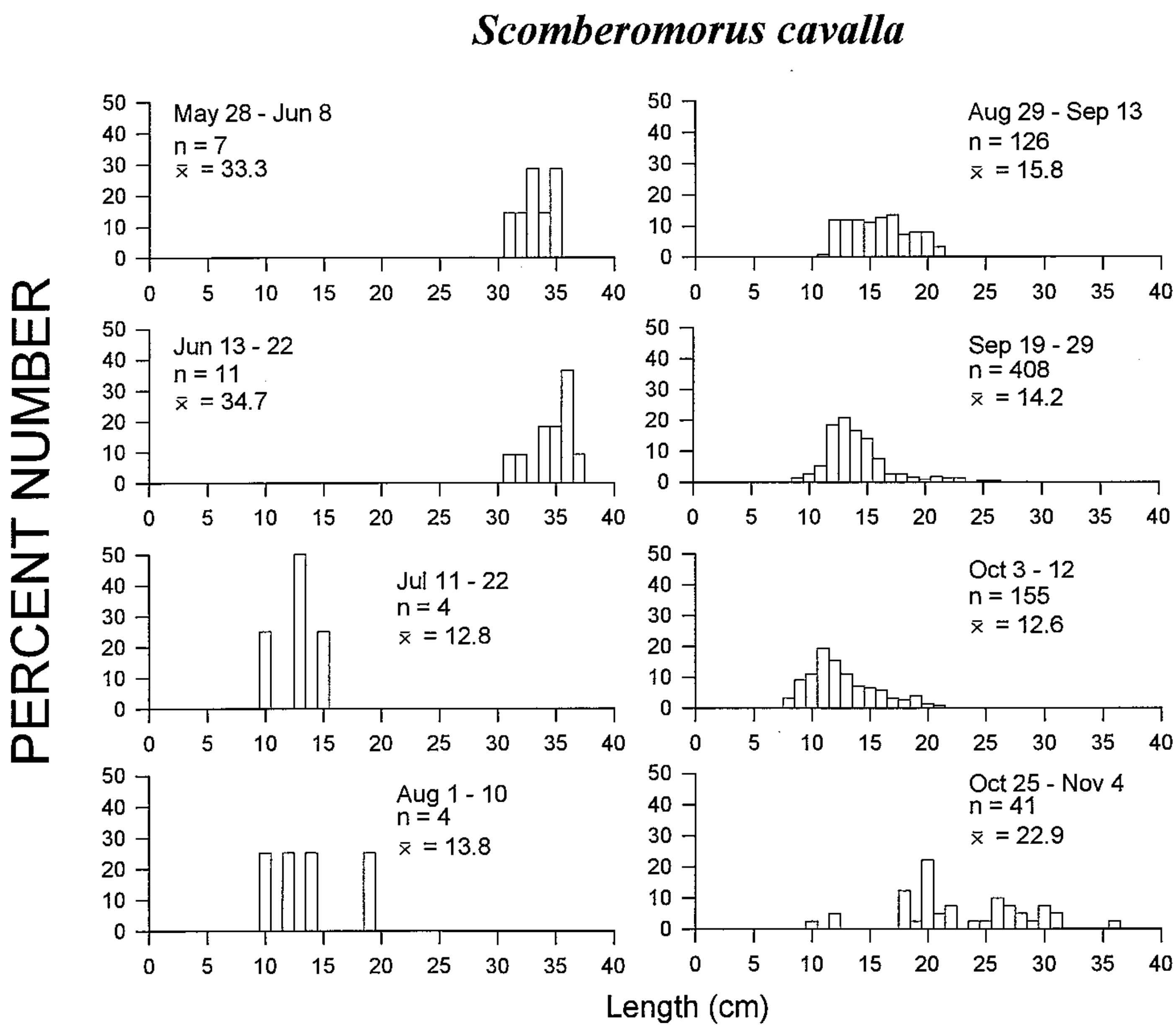


Figure 26. Length-frequencies of king mackerel from 8 SEAMAP cruises in 1988.

but the presence of small individuals is evidence of protracted spawning in king mackerel.

Size differences between specimens collected during the day and those collected at night were significant (1987: $\chi^2 = 7.9$, $p < 0.01$; 1988: $\chi^2 = 25.5$, $p < 0.001$), with larger individuals being collected during the day (Figure 27).

### *Chaetodipterus faber*

The Atlantic spadefish inhabits coastal waters from Chesapeake Bay to Brazil, throughout the Gulf of Mexico, and has been introduced into Bermuda (Burgess, 1978; Johnson, 1978). Adults tend to congregate in schools around wrecks, pilings, and rocky or reef areas (Burgess, 1978; Johnson, 1978; Moore et al., 1984). Spadefish are common in South Carolina, particularly from early spring to late fall. Hayse (1987) reported that spawning in South Carolina waters occurred offshore from May to October with juveniles being recruited into estuarine areas. He discovered that the YOY move into shallow offshore waters during the fall at the end of their first year. Mean length of Age 0 fish was 84 mm TL, and Age I fish had a mean length of 163 mm TL (Hayse, 1987). With more fisherman harvesting spadefish, they have become an increasingly important recreational species (Moore et al., 1984; Hayse, 1987).

Atlantic spadefish were present in 64% of the 1987 and 1988 SEAMAP-SA trawl collections (Appendix 5). Greatest abundance of Atlantic spadefish was taken at Cape Lookout and off Georgia in 1987 and off South Carolina in 1988 (Figure 28), although there was no significant difference among stations either year (1987: $F = 5.4$, $df = 3$, $p > 0.05$; 1988: $F = 2.4$, $df = 3$, $p > 0.05$). A significant difference in number of individuals/tow did occur among cruises (1987: $F = 152.0$, $df = 4$, $p < 0.001$; 1988: $F = 22.2$, $df = 7$, $p < 0.001$), with Cruise 4 contributing the greatest numbers in October of 1987 and Cruise 6 in September of 1988 (Figure 29). Peak abundance of Atlantic spadefish occurred in September and October (both years), with mean catch rates between 31 and 35 individuals/tow, whereas abundance was very low from November of 1987 through July of 1988. Diel differences in catch rates were found not to be significant either year (1987: $\chi^2 = 0.9$, $p = 0.35$; 1988: $\chi^2 = 0.8$, $p = 0.4$), nor were significant differences in abundance found among sites (1987: $\chi^2 = 5.8$, $p = 0.06$; 1988: $\chi^2 = 1.7$, $p = 0.4$).

Sizes of individuals ranging from 3-18 cm (Figures 30 and 31), excluding two large specimens (45 and 48 cm TL) that were collected on Cruise 4 in August 1988. Size-frequency distributions show that all of the individuals taken were YOY, except the two large specimens which were Age 5 or older (Hayse, 1987). Although lengths did differ significantly among stations (1987: $\chi^2 = 516.7$, $p < 0.001$; 1988: $\chi^2 = 287.7$, $p < 0.001$) and cruises (1987: $\chi^2 = 210.1$, $p < 0.001$; 1988: $\chi^2 = 439.5$, $p < 0.001$), no obvious patterns are discernable.

# *Scomberomorus cavalla*

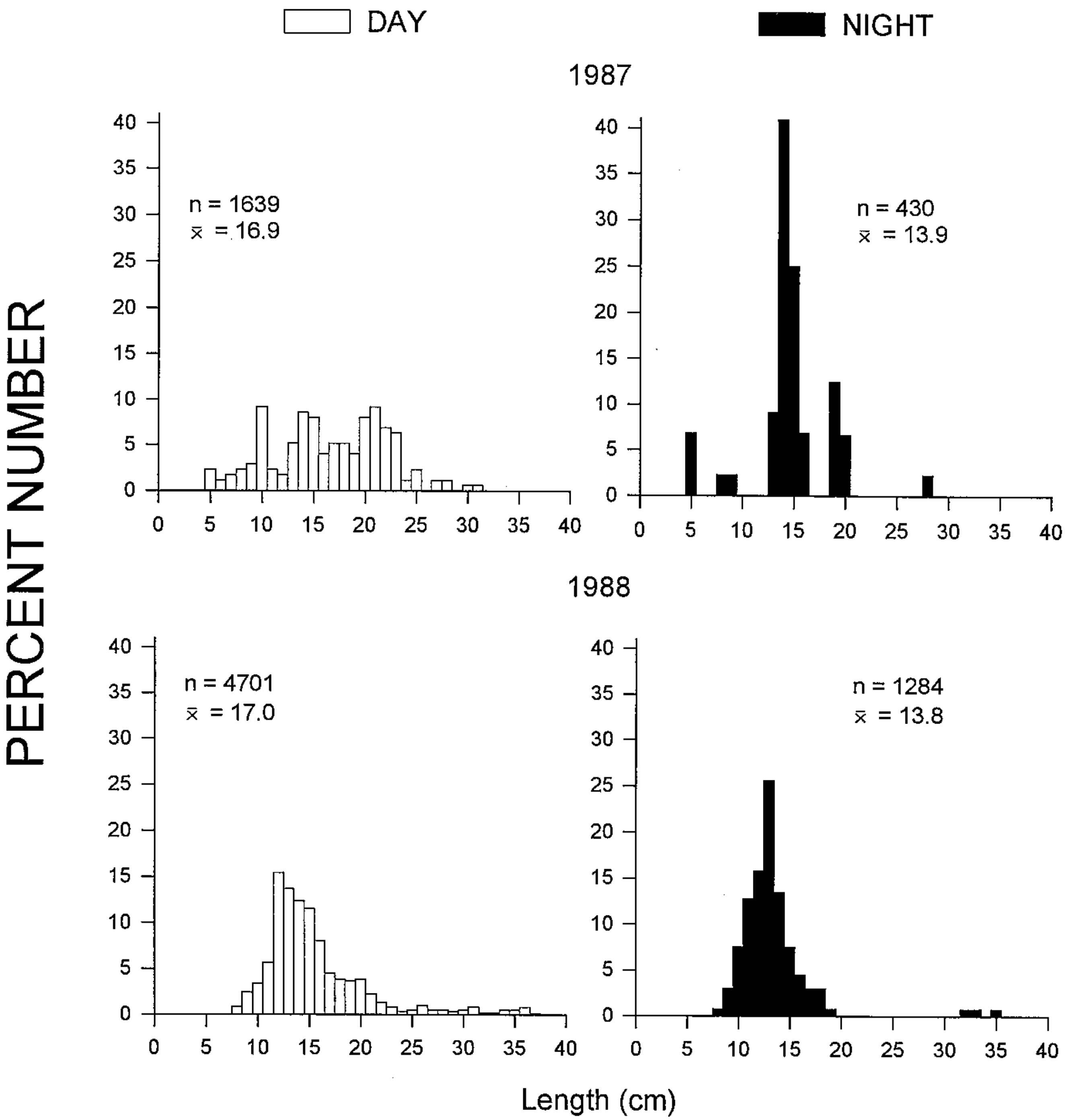


Figure 27. Length-frequencies of king mackerel for day and night collections.

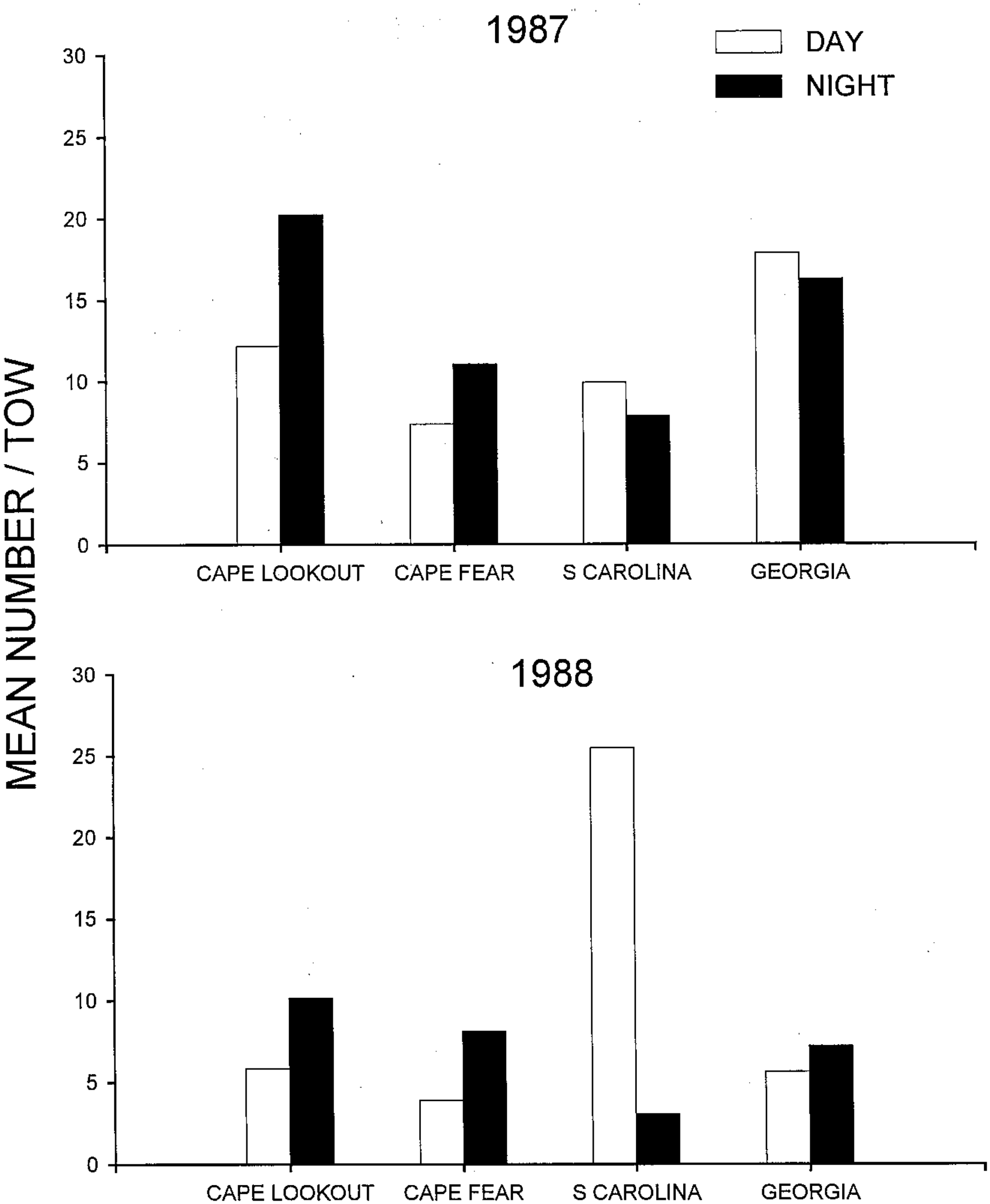


Figure 28. Diel abundance of *Chaetodipterus faber* by station.

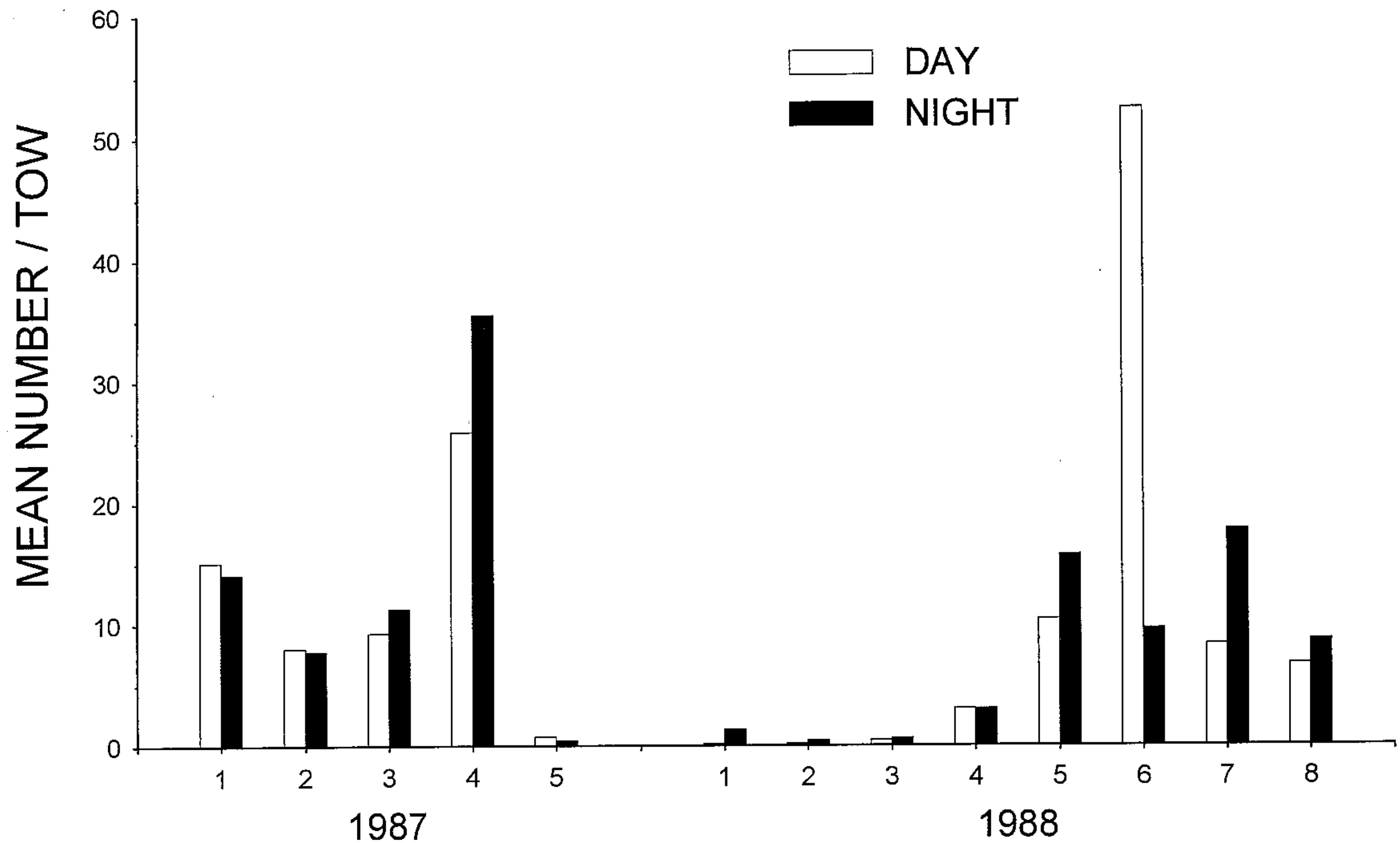


Figure 29. Diel abundance of *Chaetodipterus faber* by cruise.

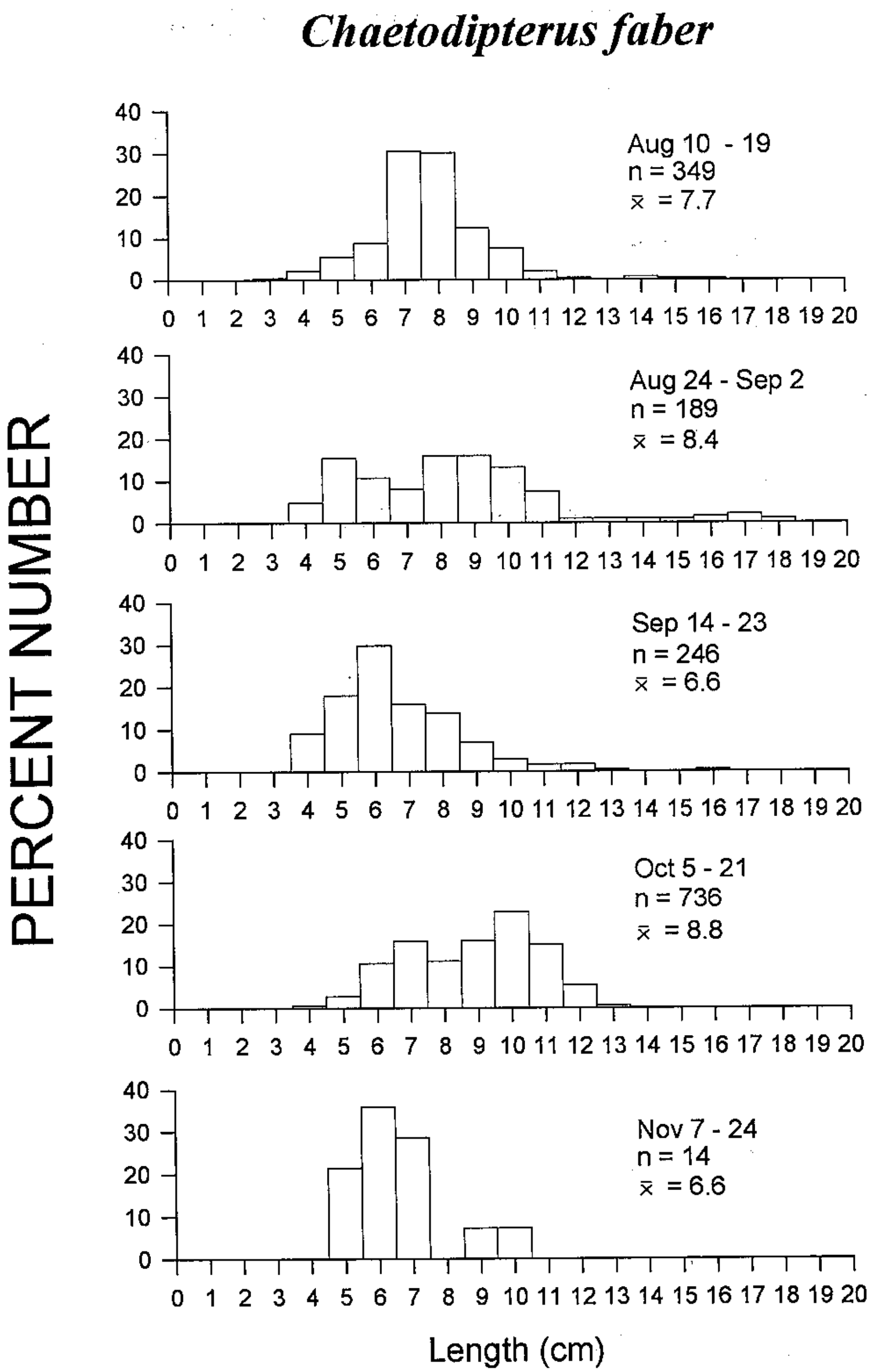


Figure 30. Length-frequency of Atlantic spadefish from 5 SEAMAP cruises in 1987.

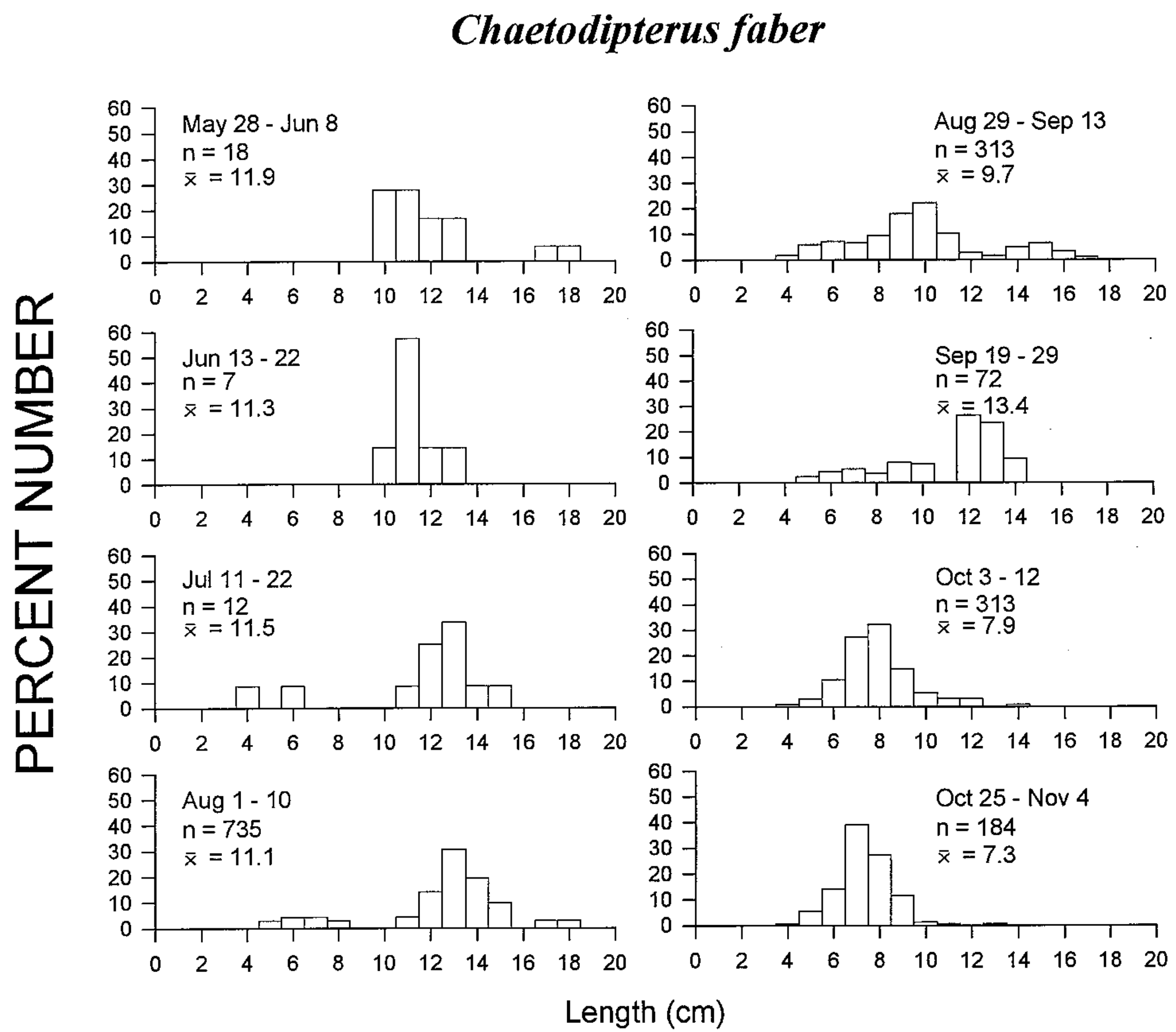


Figure 31. Length-frequency of Atlantic spadefish from 8 SEAMAP cruises in 1988.

### *Pomatomus saltatrix*

The bluefish is a wide-ranging species found in most temperate coastal regions throughout the world, occurring in estuaries, coastal waters, and pelagic habitats. In the western Atlantic, it is found from Nova Scotia to Argentina and throughout the Gulf of Mexico, including northern Cuba (Wilk, 1977; Collette, 1978a; Anderson, 1980). It also occurs in the eastern Atlantic, the Mediterranean, and the Indo-west Pacific (Collette, 1978a). Bluefish form in loose groups of similar-sized fish, generally traveling northward in spring and summer and southward in fall and winter (Wilk, 1977). Spawning in the South Atlantic Bight is reported to occur over the outer shelf in spring (April and May) and over the mid-Atlantic shelf in summer (Wilk, 1977). This concurs with Smith et al. (1994), who reported that egg distribution was limited to the Cape Hatteras area in May, and Kendall and Walford (1979), who theorized that eggs and larvae spawned in the SAB in spring are carried into the mid-Atlantic Bight by the Gulf Stream before moving shoreward. Larval distributions indicate a protracted spawning in the SAB, beginning in spring and continuing through summer into fall (Collins and Stender, 1987).

Juvenile bluefish occur in the estuaries of North Carolina (Schwartz et al., 1982), South Carolina (Wenner et al., 1982), and Georgia (Mahood et al., 1974a; Mahood et al. 1974b; Mahood et al. 1974c), and have been reported from the surf zone (Anderson et al., 1977). Adults may venture as deep as 100 m (Hardy, 1978). The species can tolerate salinities as low as 7 $^{o}/_{oo}$ and temperatures as low as 4.5° C (Hardy, 1978). Bluefish are extremely important as recreational and food fish and are the target of large commercial and recreational fisheries.

Only 251 bluefish were collected in 1987 occurring in 32% of the trawl tows, whereas 1721 specimens were collected in 50% of the trawl tows in 1988 (Appendix 5). Catches were significantly different among stations in 1987 ($F = 3.6$; $df = 3$, $p < 0.05$) and 1988 ($F = 9.7$, $df = 3$, $p < 0.001$). Highest catches of bluefish were found at Cape Lookout and decreased from north to south both years (Figure 32). Cape Lookout produced 58% of the specimens in 1987 and 65% of the specimens collected in 1988. Mean catch/tow values of 2.1 individuals and 0.2 kg were recorded in 1987 and 9.0 individuals and 0.8 kg in 1988 (Appendix 5). Differences in catch rates among cruises in 1987 were not significant ($F = 1.5$, $df = 4$, $p > 0.05$), although Cruise 5 in November produced the most specimens (Figure 33). The differences in abundance among cruises in 1988 were significant ($F = 3.0$, $df = 7$, $p < 0.01$), with 74% of the specimens collected on Cruise 8 in late October and early November. The increases in abundance on the last cruise of each year may be indicative of fall migrations.

Diel difference in abundance was not significant (1987: $\chi^2 = 1.5$, $p = 0.2$; 1988: $\chi^2 = 1.2$, $p = 0.3$), nor was there significant differences in abundance among sites (1987: $\chi^2 = 0.6$, $p = 0.7$; 1988: $\chi^2 = 0.5$, $p = 0.8$) either year.

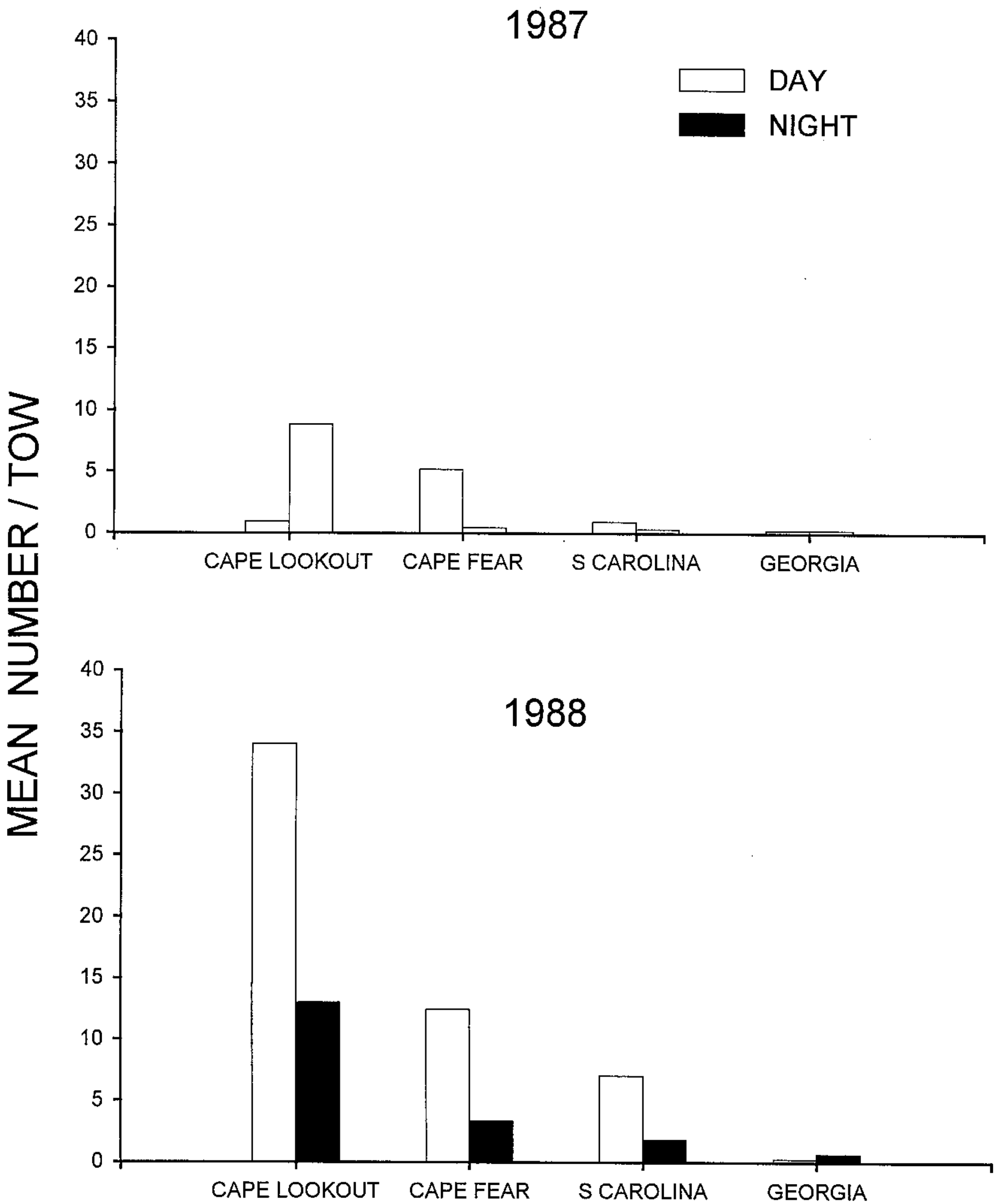


Figure 32. Diel abundance of *Pomatomus saltatrix* by station.

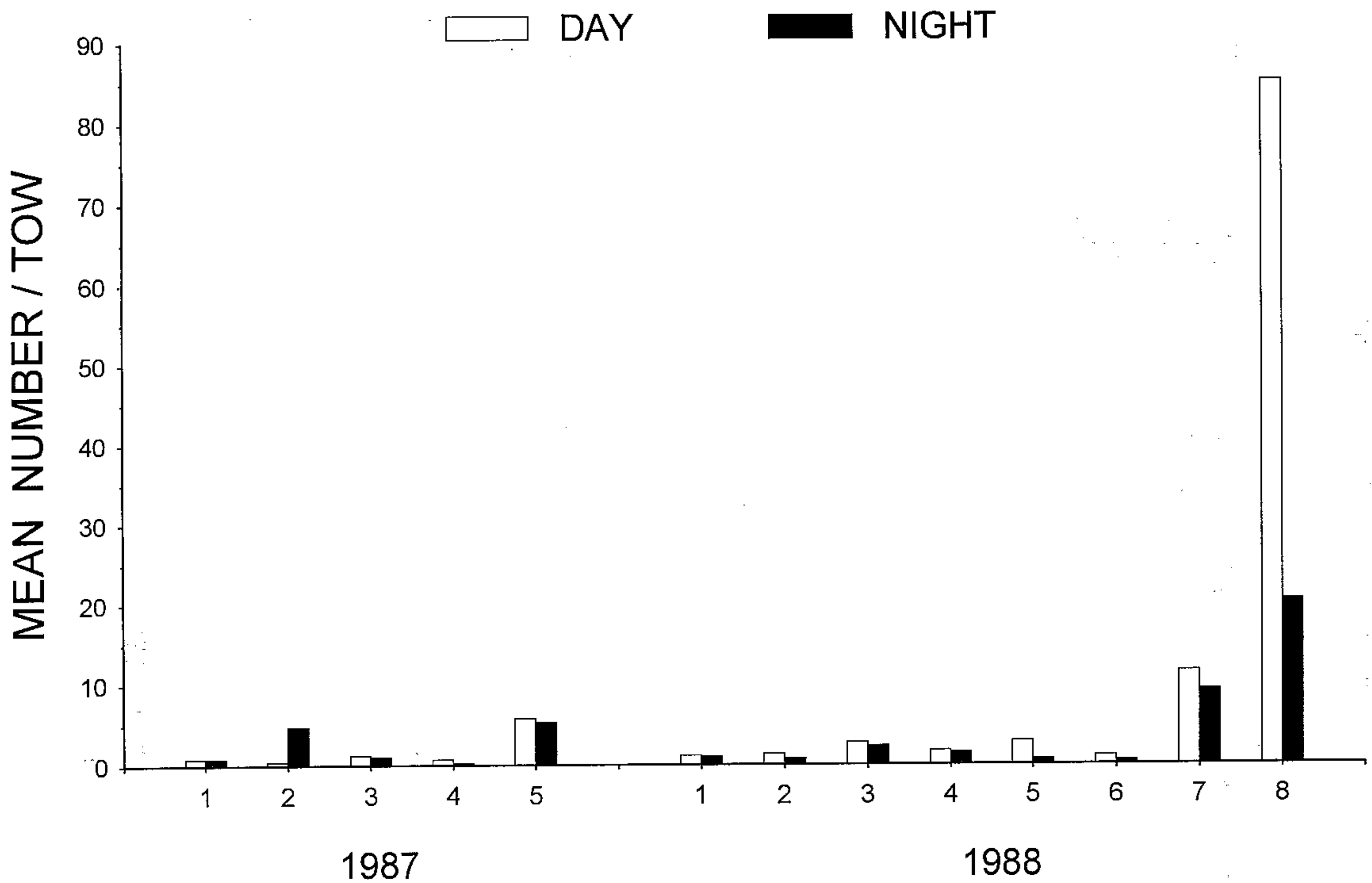


Figure 33. Diel abundance of *Pomatomus saltatrix* by cruise.

Bluefish reach a maximum total length of 110 cm and are common to 60 cm (Collette, 1978a). They are relatively long-lived fish reaching 14-15 years of age. Wilk (1977) reported the mean length of Age I fish as 21 cm FL and Age II fish as 35 cm FL. They mature at around 14-20 cm in the SAB (Hardy, 1978) at the end of their first year.

Bluefish in 1987 and 1988 SEAMAP-SA samples ranged from 8-45 cm FL (Figures 34 and 35), with all but 5 specimens less than 30 cm FL. The largest and smallest of these fish were collected in 1988, whereas in 1987 the size extremes were 12-33 cm FL. Barger (1990) reported that size distribution does not differ among male and female bluefish, which suggests that multiple modes in length-frequency distributions from SEAMAP-SA collections represent cohorts and not sex differences.

The differences in lengths that occurred among stations were significant ($\chi^2$ = 13.3, $p < 0.005$), with the Georgia station producing the largest fish both years and Cape Lookout in 1987 and South Carolina in 1988. Differences in length of fish among cruises were significant ($\chi^2$ = 58.3, $p < 0.001$), with smallest mean length occurring on Cruise 5 in November 1987 (Figure 34) and on Cruise 3 in July 1988 (Figure 35). The 60 specimens collected on Cruise 3 in 1988 were largely spring-spawned YOY recruits. YOY and Age I cohorts were present on all subsequent cruises, although the number of specimens was low through Cruise 6 in September. Abundance increased on Cruise 7 in October and length-frequencies indicate that both cohorts were present. Cruise 8 produced an order of magnitude increase in abundance (1249 individuals), which resulted in a decrease in mean-length from the previous cruise. Modes at 13 and 18 cm may indicate the presence of spring and summer spawned YOY; the Age I cohort may be absent from these collections. Increased abundance on the last cruise of both years may have resulted from the fall emigration of YOY fish from the estuaries.

### *Paralichthys dentatus*

The summer flounder ranges from Maine to Florida and are most abundant from Cape Cod to North Carolina (Smith, 1973; Smith and Daiber, 1977), although rare occurrences have been noted in Canada and the Gulf of Mexico (Norman, 1934; Bigelow and Schroeder, 1953; Martin and Drewry, 1978). They inhabit coastal and estuarine waters during the warmer months and during the fall and winter move onto the continental shelf and slope (Bigelow and Schroeder, 1953; Smith, 1973; Smith and Daiber, 1977). Young juveniles appear to utilize estuaries as nursery grounds (Smith, 1973; Powell and Schwartz, 1977). Unlike *P. lethostigma*, which is commonly found on muddy substrates in low salinity areas, summer flounder prefer sandy substrate in highly saline estuarine areas (Powell and Schwartz, 1977; Powell and Schwartz, 1979). Summer flounder are sought after by recreational anglers and are the target of a commercial fishery. Commercial trawlers take summer flounder both as a directed fishery (Poole, 1966) and as incidental to other fisheries. Keiser (1976) reported them as incidental catch in the shrimp fishery year round in South Carolina. He estimated

## *Pomatomus saltatrix*

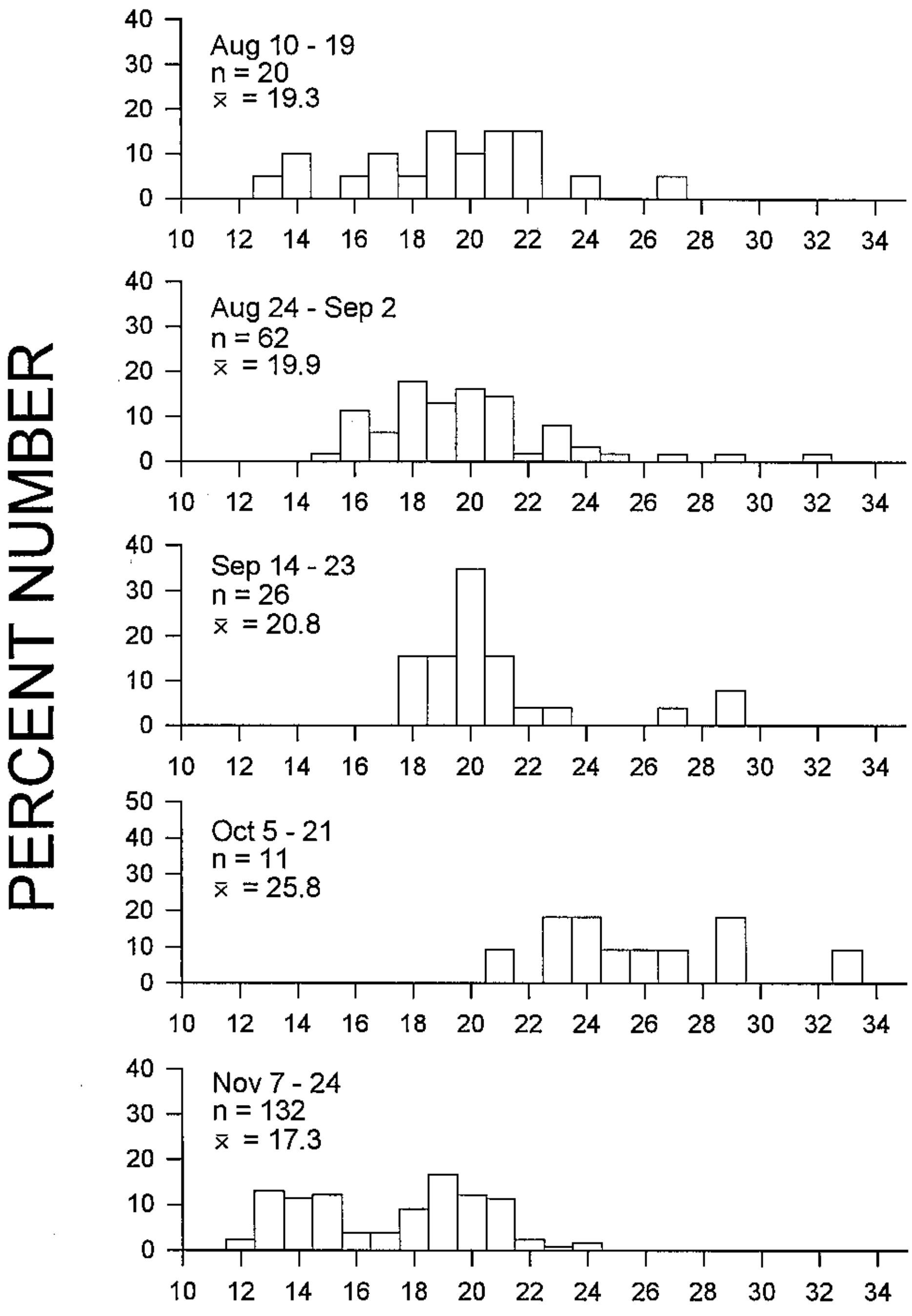


Figure 34. Length-frequency of bluefish from 5 SEAMAP cruises in 1987.

## *Pomatomus saltatrix*

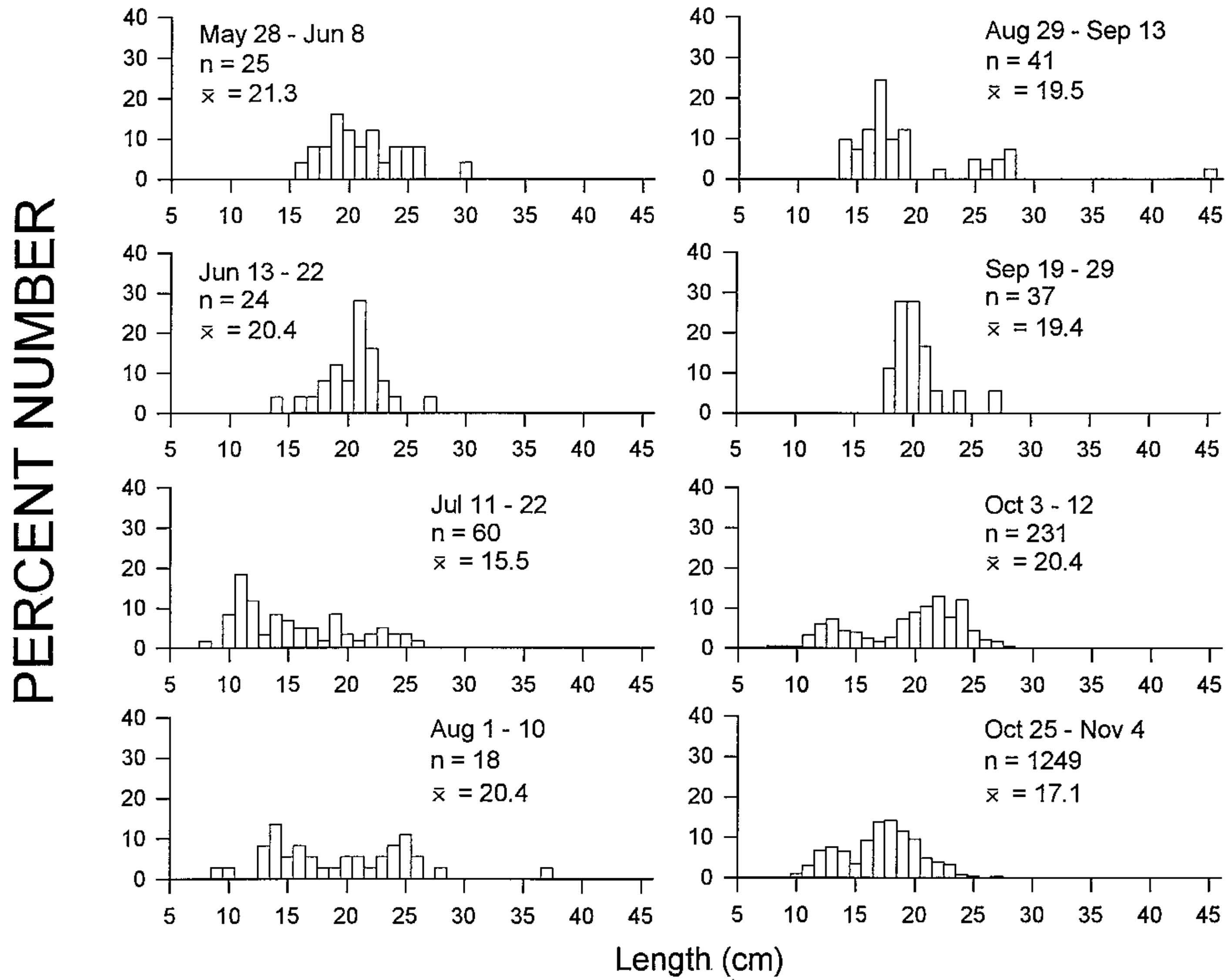


Fig. 35. Length-frequency of bluefish from 8 SEAMAP cruises in 1988.

that at that time 74% of the summer flounder taken in shrimp trawls made it into the markets; however, the initiation of the 30.5 cm size limit has probably reduced this significantly.

The 1987 and 1988 SEAMAP-SA trawl surveys collected 1395 individuals of *P. dentatus* (Appendix 5). Mean catch/tow in 1987 was 5.5 individuals and 0.8 kg/tow compared to 3.8 individuals and 0.7 kg/tow in 1988. This 30% drop in catch/tow also occurred when the first three cruises of 1988 (which produced 34% of the total catch for that year) were eliminated. Most individuals (43%) were collected off Cape Lookout in 1987 (Figure 36), although no significant differences were found among stations that year ($F = 3.1$, $df = 3$, $p > 0.05$). Highly significant differences in summer flounder abundance occurred among stations in 1988 ($F = 35.0$, $df = 3$, $p < 0.001$), when 56% were collected at Cape Lookout. A significant diel difference in abundance occurred between day and night catches of summer flounder both years (1987: $\chi^2 = 12.5$, $p < 0.001$; 1988: $\chi^2 = 11.8$, $p < 0.001$), with the majority collected during the night. Catch/tow among cruises differed significantly in 1987, but not in 1988 (1987: $F = 2.5$, $df = 4$, $p < 0.05$; 1988: $F = 1.6$, $df = 7$, $p > 0.05$) (Figure 37). The low abundance recorded on Cruise 4 in October 1987 was also observed in September 1988 (Cruise 5), followed by an increase in abundance both years. Although Inlet sites produced most summer flounder both years, the difference was not found to be significant (1987: $\chi^2 = 1.2$, $p = 0.5$; 1988: $\chi^2 = 4.7$, $p = 0.1$).

Different growth rates have been reported for male and female *P. dentatus,* although the age and degree of divergence differs somewhat (Eldridge, 1962; Poole, 1966; Smith and Daiber, 1977; Wenner et al., 1990). Males reach a maximum size of ~60 cm TL, whereas females reach ~80 cm TL (Poole, 1966). YOY enter the estuaries from January through April in South Carolina and reach a modal size of 22-23 cm by October-November (Wenner et al., 1990). Wenner et al. (1990) reported that yearlings (Age I) have a modal range from 23-25 cm TL from January through June and reach 28 cm TL by October. Fish mature as they approach Age II (Wenner et al., 1990). Spawning begins in October and probably runs through February into early March. *P. dentatus* from the mid-Atlantic region were reported to reach 15-18 cm TL at one year and 20-26 cm TL at the end of year two (Eldridge, 1962; Poole, 1966; Smith and Daiber, 1977), with some question as to when the first annulus was formed. In the SAB January was designated as the birth-month by Wenner et al. (1990). It has been suggested that summer flounder from above Cape Hatteras come from a separate spawning stock than those from the SAB (Wilk et al., 1980). Data from Wenner et al. (1990) support the theory that older individuals of the SAB stock that move offshore and are no longer collected in the SAB may be supplementing the mid-Atlantic breeding stock.

Individuals of *P. dentatus* ranged in size from 11- 43 cm TL (Figures 38 and 39). Significant size differences were found among stations (1987: $\chi^2 = 227.7$, $p < 0.001$, 1988: $\chi^2 = 169.5$, $p < 0.001$ ) and among cruises (1987: $\chi^2 = 135.2$, $p < 0.001$, 1988: $\chi^2 = 227.3$, $p < 0.001$ ) both years. Longest mean length was collected at the Cape

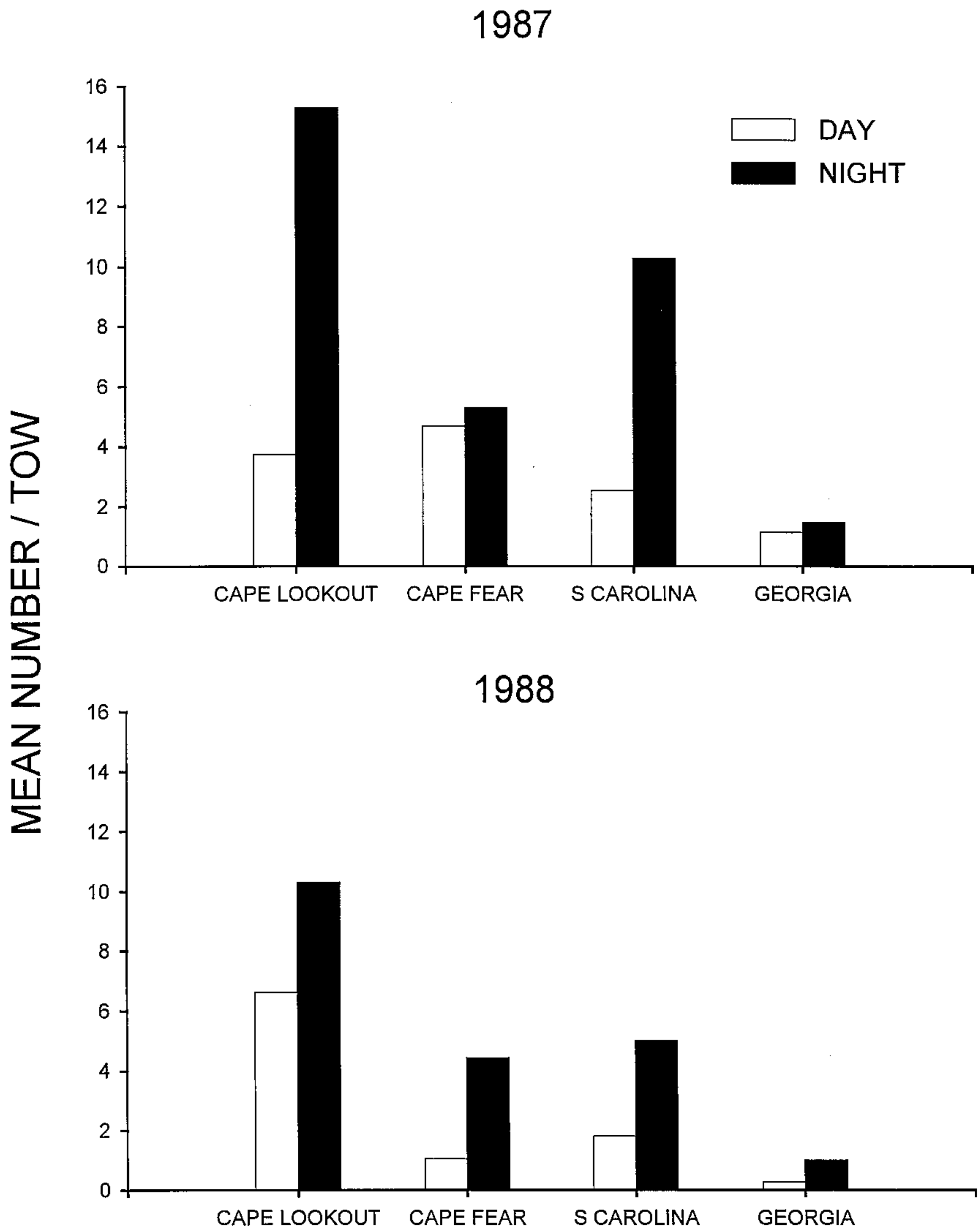


Figure 36. Diel abundance of *Paralichthys dentatus* by station.

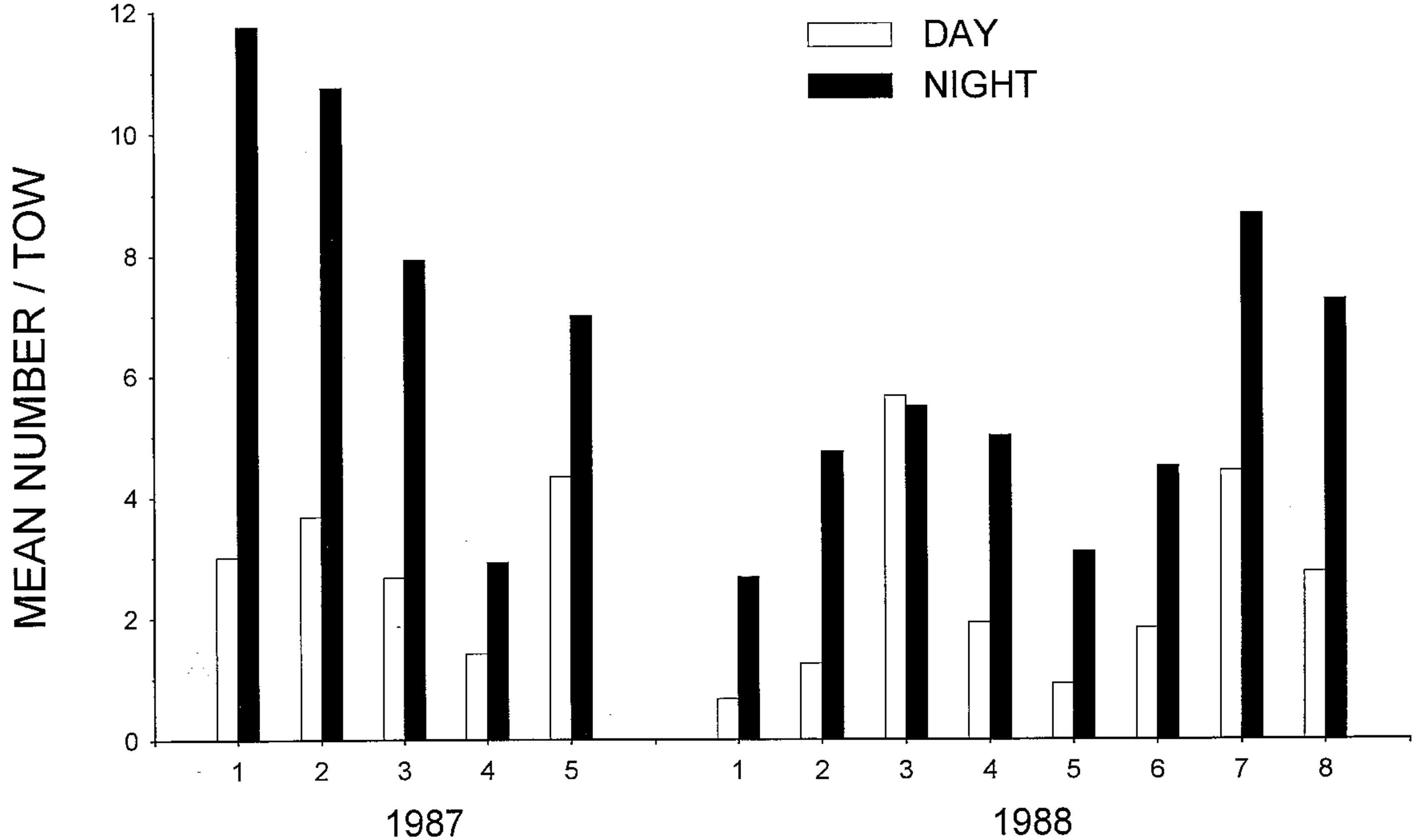


Figure 37. Diel abundance of *Paralichthys dentatus* by cruise.

## *Paralichthys dentatus*

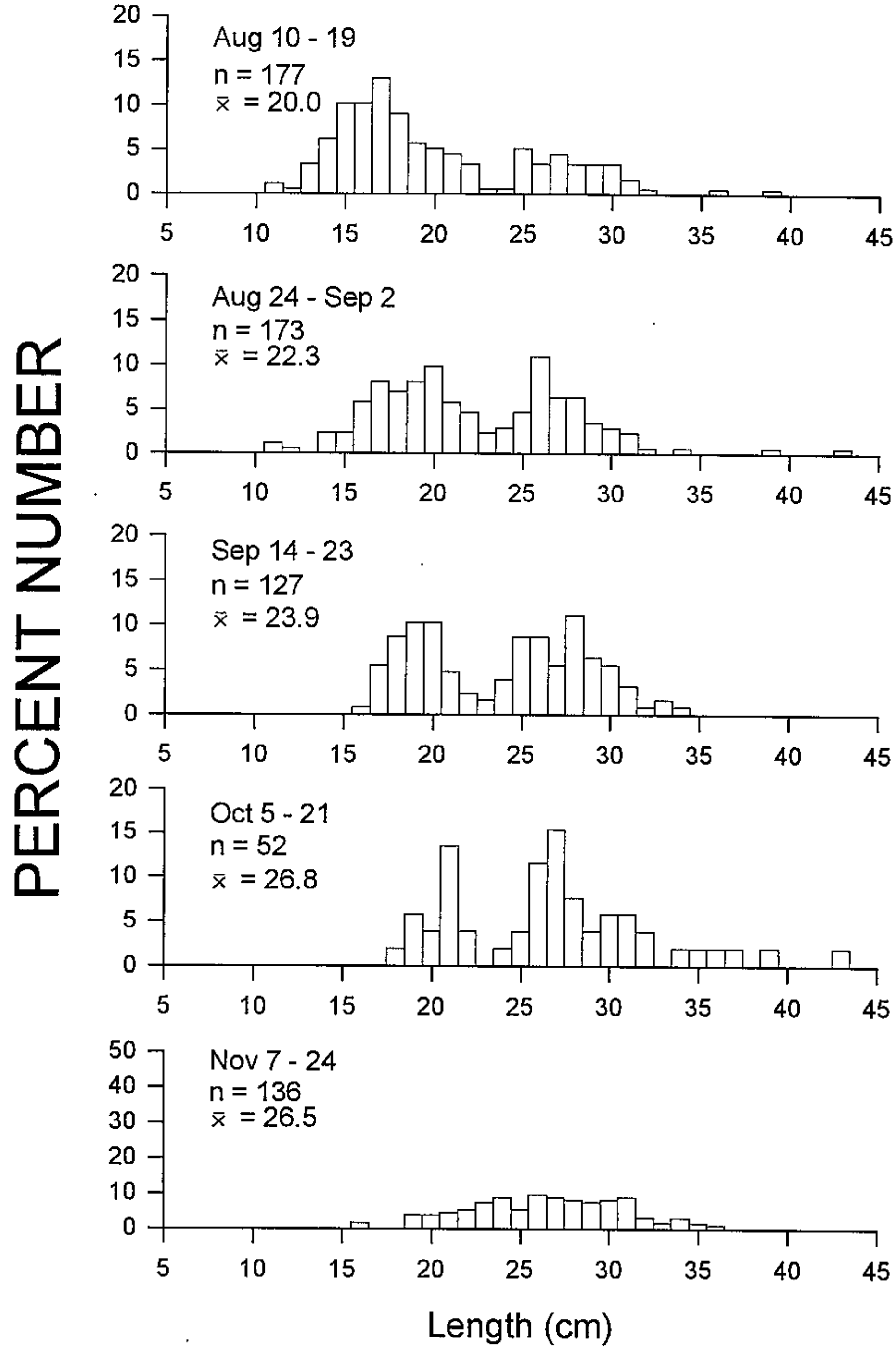


Figure 38. Length-frequency of *Paralichthys dentatus* from 5 SEAMAP cruises in 1987.

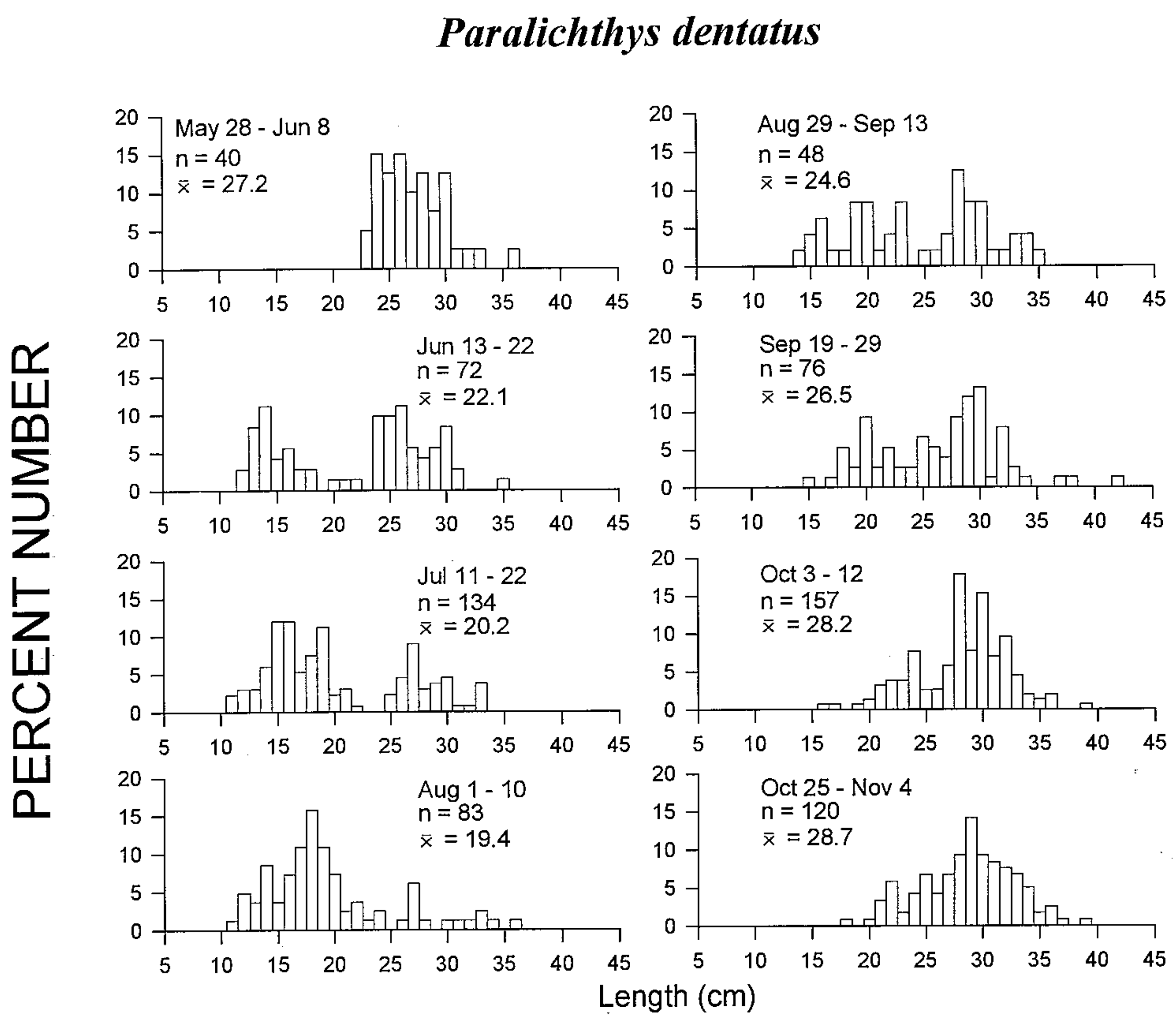


Figure 39. Length-frequency of *Paralichthys dentatus* from 8 SEAMAP cruises in 1988.

Lookout station both years. Modal peaks for Age I and Age II cohorts appear in the length-frequencies for 1987 and 1988, but YOY fish are probably restricted to the estuaries. Length-frequency distributions in 1988 indicated that Age I fish were recruited to the sampling gear on Cruise 2 in June (Figure 39). Those few specimens greater than 35 cm may represent the Age III cohort.

### *Paralichthys lethostigma*

The southern flounder is a resident of the Atlantic and Gulf coasts of the U.S., and ranges from North Carolina to Texas (Norman, 1934; Randall and Vergara, 1978). Older juveniles and adults move offshore to deeper marine waters in the winter, whereas juveniles (YOY) overwinter in the estuaries. Southern flounder prefer muddy substrates in lower salinity estuarine areas and are mainly piscivorous (Powell and Schwartz, 1977; Randall and Vergara, 1978).

Wenner et al. (1990) reported that yearling (Age I) southern flounder had a modal length of 24 cm TL in April and that cohort was still identifiable in June and July with a mode at 25-26 cm TL. After that time, small yearlings and larger YOY overlapped, making clear distinction between the two groups difficult. Growth differentials by sex did not occur until their second year, but were conspicuous by December of their second year, when male yearlings had a mean length of 26.3 cm and the mean length of females was 33 cm. Wenner et al. (1990) identified 4 age-classes of male southern flounder and 8 age-classes of females. The largest male was 476 mm TL and largest female was 703 mm TL, although few males and only 44% of the females were over 300 mm TL. Maturity in males first occurred at 23 cm and females at 32 cm. Spawning occurred in December and January in that study.

Stokes (1977) reported that *P. lethostigma* in estuaries and nearshore waters of the Gulf of Mexico measured from 10 mm TL to 620 mm TL. Males were found to grow more slowly than females, only reaching 320 mm TL, and males only reached 3 years of age, as opposed to 5 for the females. Males ranged in length from 10 to 230 mm TL at Age 0, 231 to 280 mm TL at Age I, and 281 to 320 mm TL at Age II. Lengths of females in the 5 age classes reported were 10-300, 301-450, 451-530, 531-570, and 571-620 mm TL. Sexual development was discovered in specimens as small as 170 mm TL.

Only 319 individuals of *P. lethostigma* were collected on the 13 SEAMAP-SA cruises from 1987 and 1988. The 1987 cruises had a mean catch/tow of more than twice that in 1988 (Appendix 5). The 176 individuals collected in 1987 occurred in 47% of the trawl tows, and the 143 individuals collected in 1988 occurred in 40% of the tows. No significant difference was found in catch/tow among stations either year (1987: $F = 2.1$, $df = 3$, $p > 0.05$; 1988: $F = 2.1$, $df = 3$, $p > 0.05$), although in 1987 mean number of individuals/tow at the Cape Fear station was noticeably higher than at the other stations and represented 48% of the catch for that year (Figure 40). Mean catch/tow was fairly consistent among stations in 1988.

Seasonal abundance differed significantly among cruises in 1987 ($F = 12.2$, $df = 4$, $p < 0.05$), but not in 1988 ($F = 1.4$, $df = 7$, $p > 0.05$). Mean catch/tow increased from Cruise 1 in August to Cruise 5 in November 1987 (Figure 41), reaching the highest mean catch/tow for both years. Cruises 7 and 8 had slightly higher catch rates than the other 1988 cruises, with mean catch/tow on Cruises 1 - 6 being fairly even, with all less than 1 individual/tow. No significant diel differences in abundance occurred in 1987 ($\chi^2 = 2.5$, $p = 0.1$) or in 1988 ($\chi^2 = 0.4$, $p = 0.55$) or among sites either year (1987: $\chi^2 = 2.9$, $p = 0.2$; 1988: $\chi^2 = 1.6$, $p = 0.4$).

Sizes of individuals ranged from 14-58 cm TL (Figures 42 and 43), probably representing Ages 0 - III, the majority of which were Ages I and II. Lengths were found to be significantly different among stations both years (1987: $\chi^2 = 21.4$, $p < 0.001$; 1988: $\chi^2 = 10.1$, $p < 0.05$), with largest fish coming from Georgia. Differences in lengths among cruises were also significant (1987: $\chi^2 = 31.5$, $p < 0.001$; 1988: $\chi^2 = 34.1$, $p < 0.001$), but patterns were poorly defined due to small catches. The recruitment of YOY specimens is notable in July and August of 1988 (Figure 43). The largest specimens were collected in October and November both years.

### *Penaeus aztecus*

Brown shrimp range from Martha's Vineyard, Massachusetts, to the Florida Keys and around the Gulf of Mexico to northwestern Yucatan (Perez-Farfante, 1978; Williams, 1984), occurring most abundantly off North and South Carolina (Cook and Lindner, 1970). *P. aztecus* is the target of a seasonal fishery along the mid- and South Atlantic states, but is most important commercially in the Gulf of Mexico off Texas (Perez-Farfante, 1978; South Atlantic Fishery Management Council, 1981; Renfro and Brusher, 1982). Brown shrimp reportedly enter the commercial fishery off North Carolina in June at a size of ~100 mm (South Atlantic Fishery Management Council, 1981). Tagging studies off North Carolina indicate that brown shrimp move to the south and to deeper, non-trawlable waters once they leave the sounds (Purvis and McCoy, 1974).

Brown shrimp were present in 80.4% of the 1987 and 1988 SEAMAP-SA collections with a mean catch/tow of 81.8 individuals (Appendix 5). Occurrence of brown shrimp was high in 1987 at 79%, but mean catch/tow was relatively low at 27.1 individuals and 0.5 kg. Difference in catch/tow among stations was not significant in 1987 ($F = 1.3$, $df = 3$, $p > 0.05$), although slightly higher numbers of *P. aztecus* were collected at the Cape Lookout and South Carolina stations (Figure 44). Mean catch/tow in 1988 was 116 individuals overall (81.3 % occurrence) and 114 individuals for the last 5 cruises (93.0% occurrence), approximately 4 times the 1987 estimates (Appendix 5). The difference in abundance among stations was significant ($F = 10.9$, $df = 3$, $p < 0.001$), with Cape Lookout producing more than twice the combined total of the other stations. Abundance was lowest off Georgia both years.

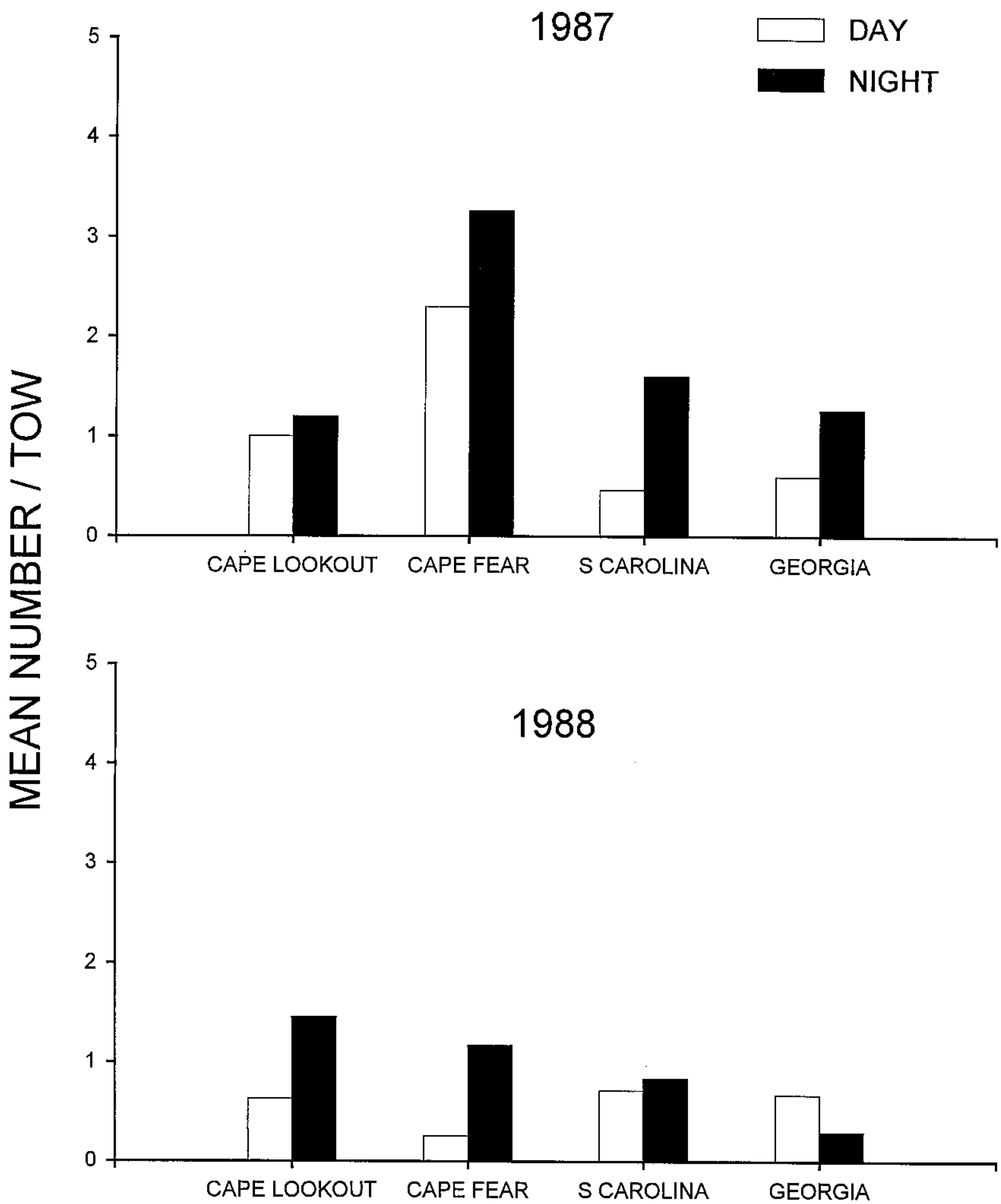


Figure 40. Diel abundance of *Paralichthys lethostigma* by station.

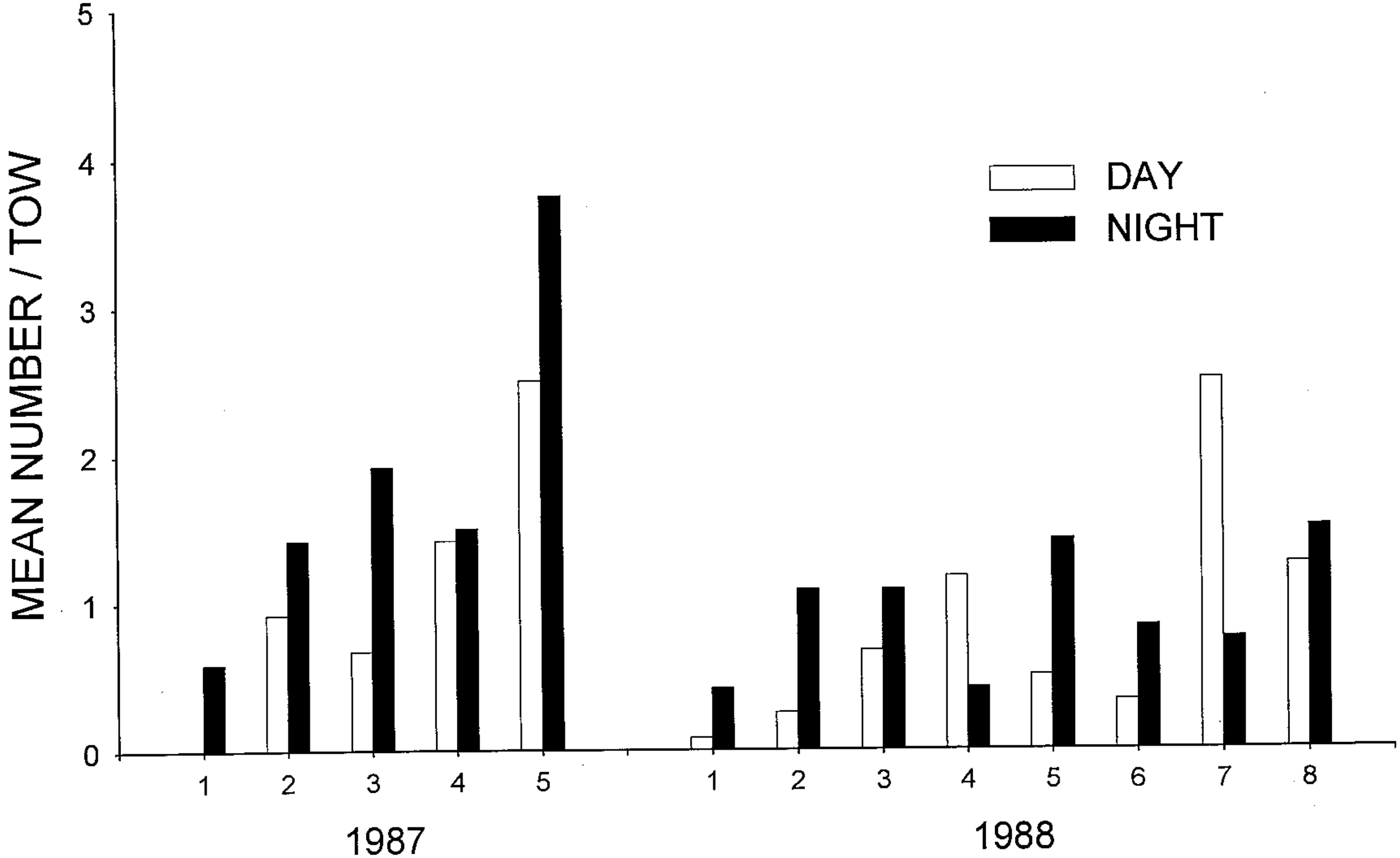


Figure 41. Diel abundance of *Paralichthys lethostigma* by cruise.

## *Paralichthys lethostigma*

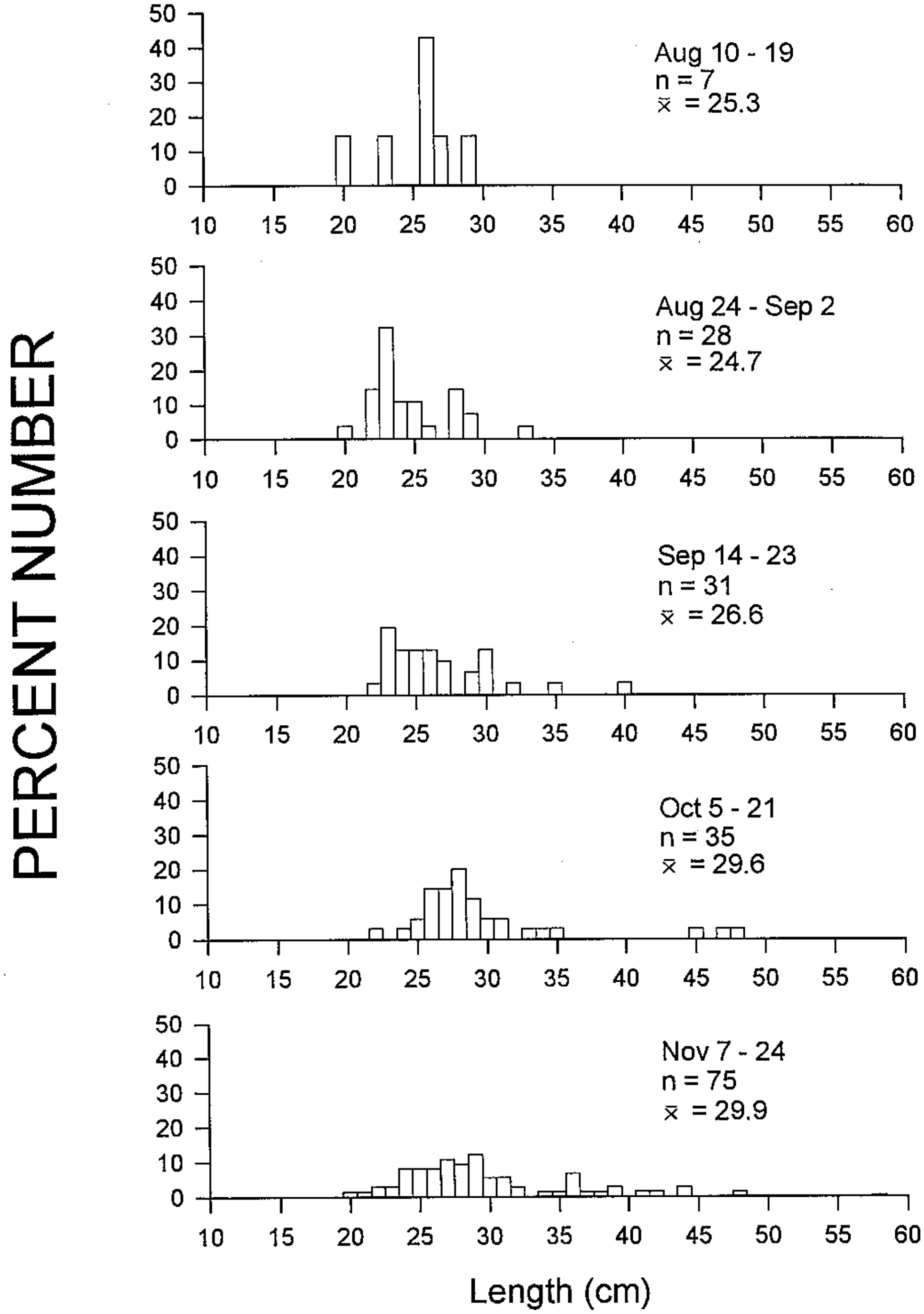


Figure 42. Length-frequencies of southern flounder from 5 SEAMAP cruises in 1987.

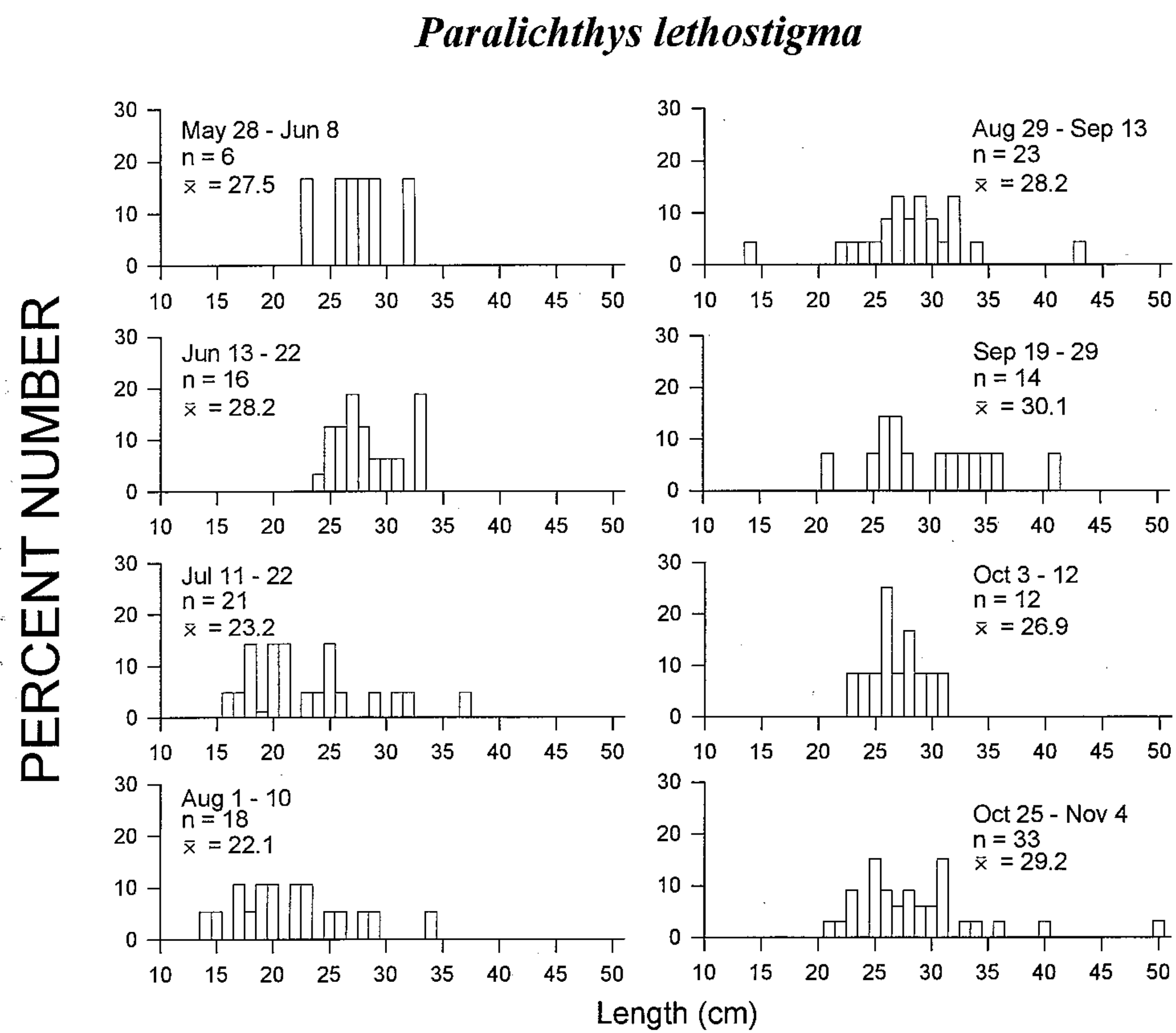


Figure 43. Length-frequencies of southern flounder from 8 SEAMAP cruises in 1988.

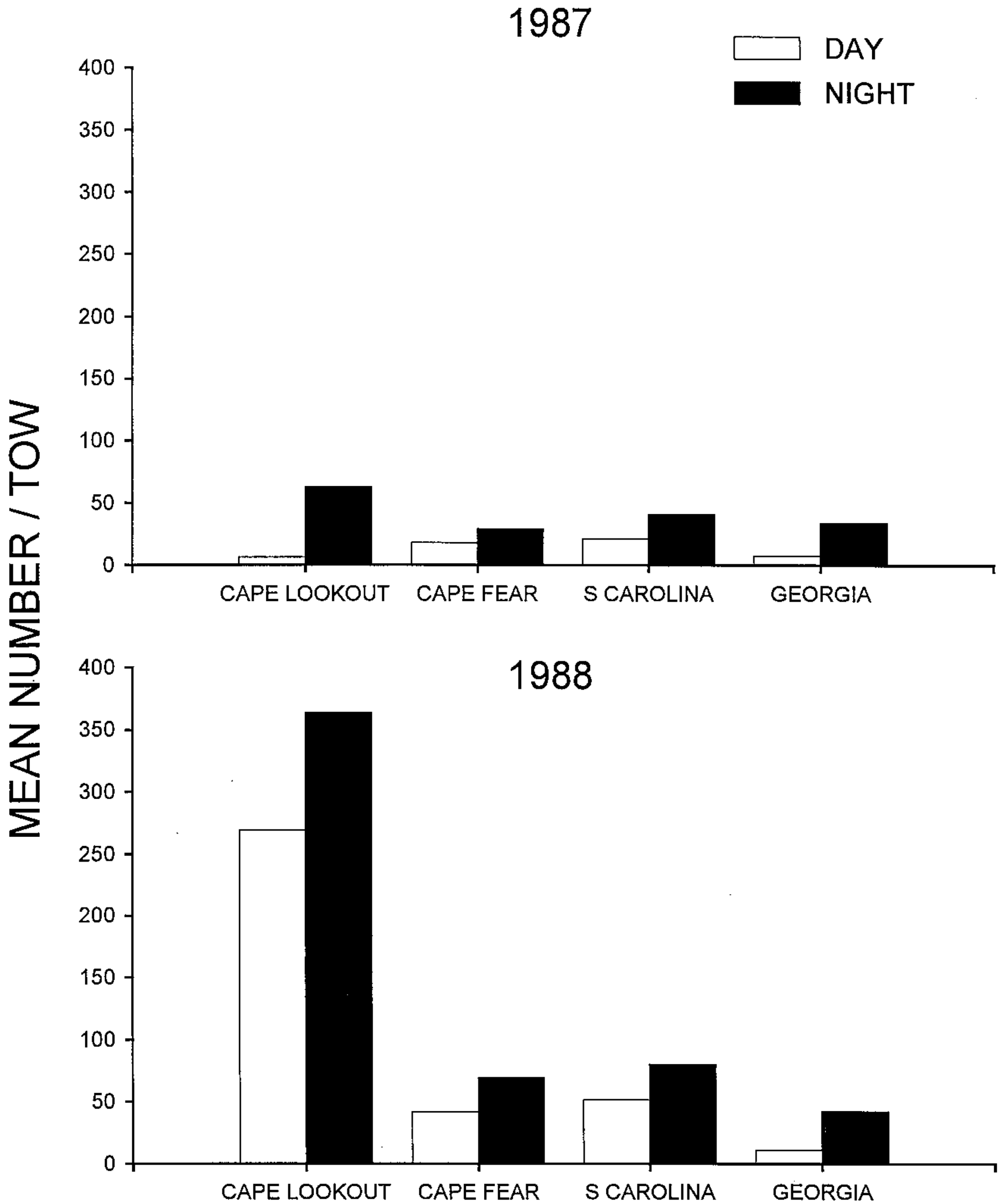


Figure 44. Diel abundance of *Penaeus aztecus* by station.

The differences in number of individuals among cruises were significant in both years (1987: $F = 8.8$, $df = 4$, $p < 0.05$; 1988: $F = 22.5$, $df = 7$, $p < 0.001$). Largest catches of brown shrimp were recorded on Cruise 1 in August in 1987 and Cruise 3 in July in 1988 (Figure 45). The July-August peak in abundance observed in 1988 coincides with the reported offshore migrational period (Purvis and McCoy, 1974; South Atlantic Fishery Management Council, 1981). Brown shrimp enter the commercial shrimp fishery off North and South Carolina in June while migrating to spawning grounds. Spawning of brown shrimp is protracted and the time varies regionally, but generally occurs in fall and winter (Williams, 1984). The decrease in abundance observed in fall 1988 probably signals a tapering off of the spawning migration.

Perez-Farfante (1978) reported that *P. aztecus* are nocturnal and generally burrow into the substrate during the day, making them less vulnerable to trawling gear. This would account for the significant diel differences in catches of brown shrimp (1987: $\chi^2 = 4.3$, $p < 0.05$; 1988: $\chi^2 = 7.9$, $p < 0.005$) recorded during this survey, with 76% of the specimens captured at night in 1987 and 60% captured at night in 1988. There were no significant differences among sites either year (1987: $\chi^2 = 1.2$, $p = 0.5$; 1988: $\chi^2 = 2.0$, $p = 0.4$).

Brown shrimp ranged in size from 5-19 cm, with modal lengths occurring at 11 to 13 cm (Figures 46 and 47). Brown shrimp utilize estuaries as nursery grounds, ingressing as post-larvae in winter and early spring, growing quickly, followed by migration offshore to spawn. At that time they are ~ 10 - 13 cm and are recruited into the commercial shrimp fishery. In mid-September 1987 (Cruise 3) a large percentage of the individuals present in collections measured 10 cm and less, perhaps indicative of a migratory event. There was very little shift in modality after June 1988 (Figure 47). Size differences among stations were highly significant both years (1987: $\chi^2 = 51.5$, $p < 0.001$; 1988: $\chi^2 = 113.1$, $p < 0.001$), with Georgia producing the largest specimens. Lengths were also significantly different among cruises (1987: $\chi^2 = 44.7$, $p < 0.001$; 1988: $\chi^2 = 191.9$, $p < 0.001$), with largest specimens collected in August 1987 and May-June 1988. Although brown shrimp size did not differ significantly between day and night collections in 1987 ($F = 0.5$ , $df = 1$, $p > 0.05$), it did in 1988 ($\chi^2 = 8.6$, $p < 0.05$), with larger shrimp collected during the day.

### *Penaeus setiferus*

White shrimp range from Fire Island, New York, to Saint Lucie Inlet in southern Florida, and in the Gulf of Mexico from Ochlocknee River, Florida, to Campeche, Mexico. The center of abundance along the Atlantic coast of the U.S. is from northeast Florida through South Carolina (Perez-Farfante, 1978; Williams, 1984), where the species constitutes a large commercial fishery (South Atlantic Fishery Management Council, 1981). *P. setiferus* is most abundant within five miles of the coastline in water depths of 30 m or less, but may occur in waters of 82 m or less in depth (Lindner and Anderson, 1956, Perez-Farfante, 1978; Renfro and Brusher, 1982; Williams, 1984).

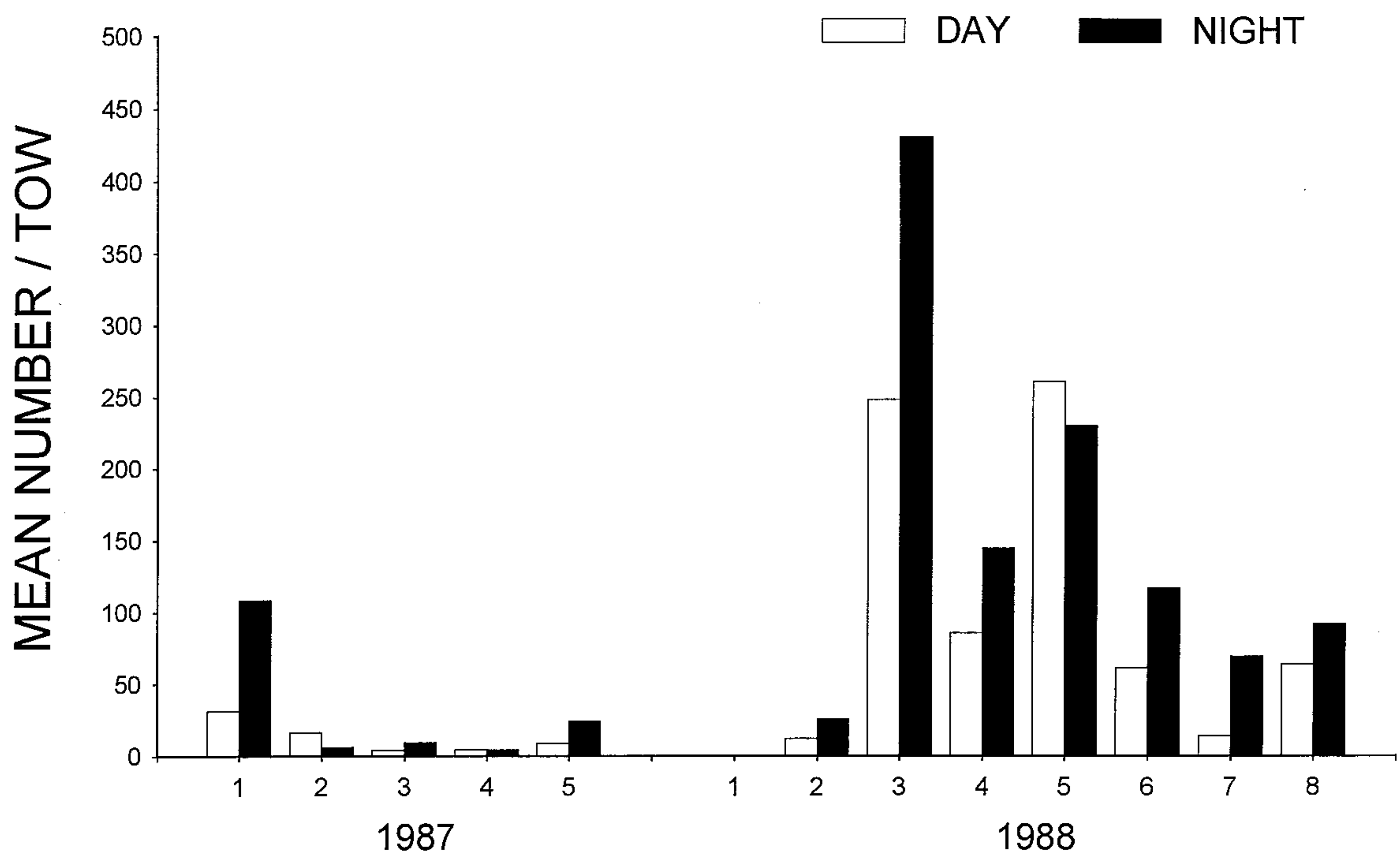


Figure 45. Diel abundance of *Penaeus aztecus* by cruise.

## *Penaeus aztecus*

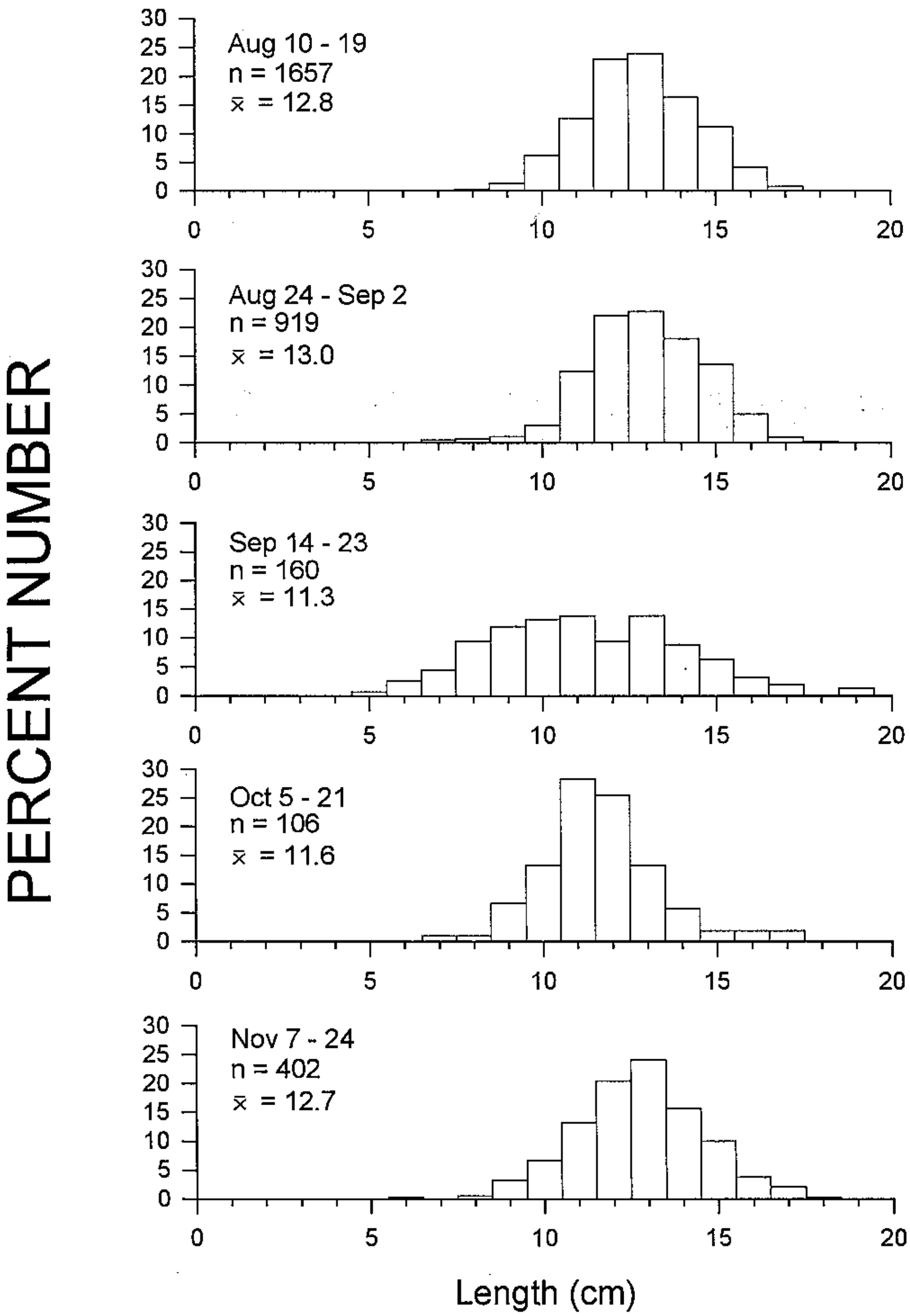


Figure 46. Length-frequencies of *Penaeus aztecus* from 5 SEAMAP cruises in 1987.

## *Penaeus aztecus*

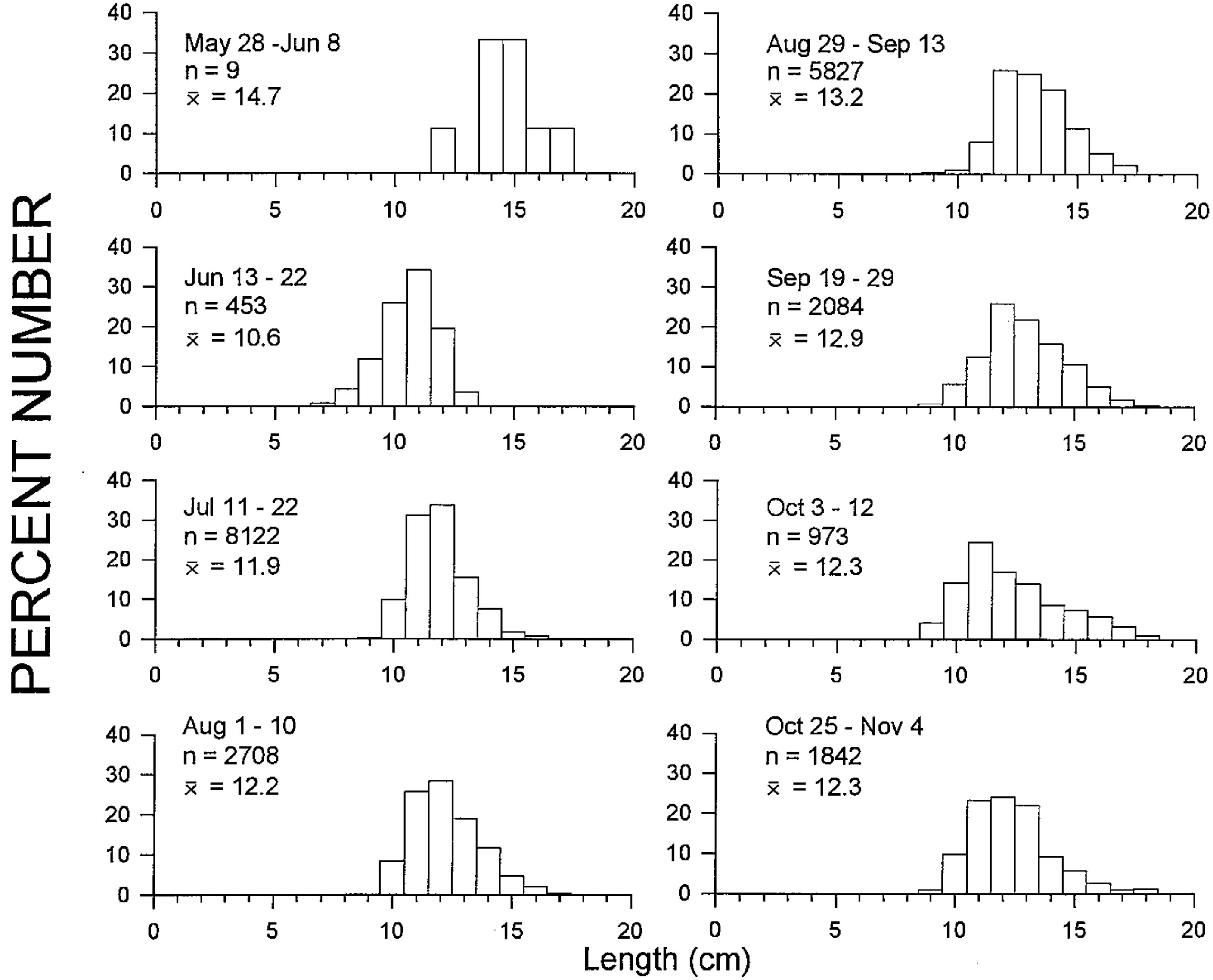


Figure 47. Length-frequencies of *Penaeus aztecus* from 8 SEAMAP cruises in 1988.

The 15,080 individuals of *P. setiferus* collected during the 1987 and 1988 SEAMAP-SA cruises were present in 71.5% of the trawl tows. White shrimp abundance and occurrence was greater in 1987 than in 1988 (Appendix 5). Mean catch/tow of white shrimp was greatest in South Carolina and lowest at Cape Lookout both years (Figure 48). Differences in abundance among stations were not significant in 1987 ( $F = 4.0$, $df = 3$, $p > 0.05$), but were found to be significant in 1988 ( $F = 10.9$, $df = 3$, $p < 0.001$). Abundance at the Cape Fear station decreased in 1988 to less than half of abundance in 1987.

There was a significant difference in mean catch/tow of white shrimp among cruises both years (1987: $F = 48.3$, $df = 43$, $p < 0.001$; 1988: $F = 22.5$, $df = 7$, $p < 0.001$), with the last two cruises of each year having the highest abundance (Figure 49). Increased abundance in the fall is normal for white shrimp, the result of emigration due in part to falling water temperatures and in part to maturation. The individuals present on Cruises 1 and 2 in May and June of 1988 are part of the brood stock that survived the winter and are necessary for spring spawning. White shrimp spawning in the SAB begins in May and continues into September (Lindner and Anderson, 1956; Williams, 1984). Southward migrations and winter aggregations of *P. setiferus* off Cape Canaveral, Florida, are well documented (Shipman, 1980; Lindner and Anderson, 1956; Williams, 1984), and it has been suggested that this aggregation may augment local spawning populations in spring (Lindner and Anderson, 1956). The offshore southward migration was probably massive prior to extensive present-day harvest, but the trawl fishery heavily reduces the population during migration and aggregation off Florida in winter (D. Whitaker, South Carolina Marine Resources Division, pers. comm.). Return migration of white shrimp northward in spring has been documented by tagging studies (Lindner and Anderson, 1956; D. Whitaker, unpublished data), but is probably a minor component compared to local spawners that overwintered in the estuaries or off the beaches. White shrimp are probably spawned within 50 or so miles of their nursery (D. Whitaker, pers. comm.).

White shrimp collected on Cruises 1 and 2 of 1988 came primarily from South Carolina and Georgia. These specimens may have been involved in a northward migration, but most probably represent local populations whose activity levels increased as temperatures warmed in the spring. Theoretically, if white shrimp activity increased as a result of rising water temperature that occur earlier at the southern latitudes and gradually progress northward, it would be difficult to discern northern migration from local seasonal aggregations. White shrimp densities decline north of South Carolina, probably due to normal population fluctuations and not migration.

Diel differences in abundance were not significant either year (1987: $\chi^2 = 0.8$, $p = 0.4$; 1988: $\chi^2 = 0.4$, $p < 0.5$), nor were there significant diel differences in length (1987: $\chi^2 = 0.2$, $p = 0.6$; 1988: $\chi^2 = 3.1$, $p = 0.07$). Abundance was significantly different among sites, with greatest numbers collected from Beach sites both years (1987: $\chi^2 = 4.5$, $p = 0.1$; 1988: $\chi^2 = 4.3$, $p = 0.1$).

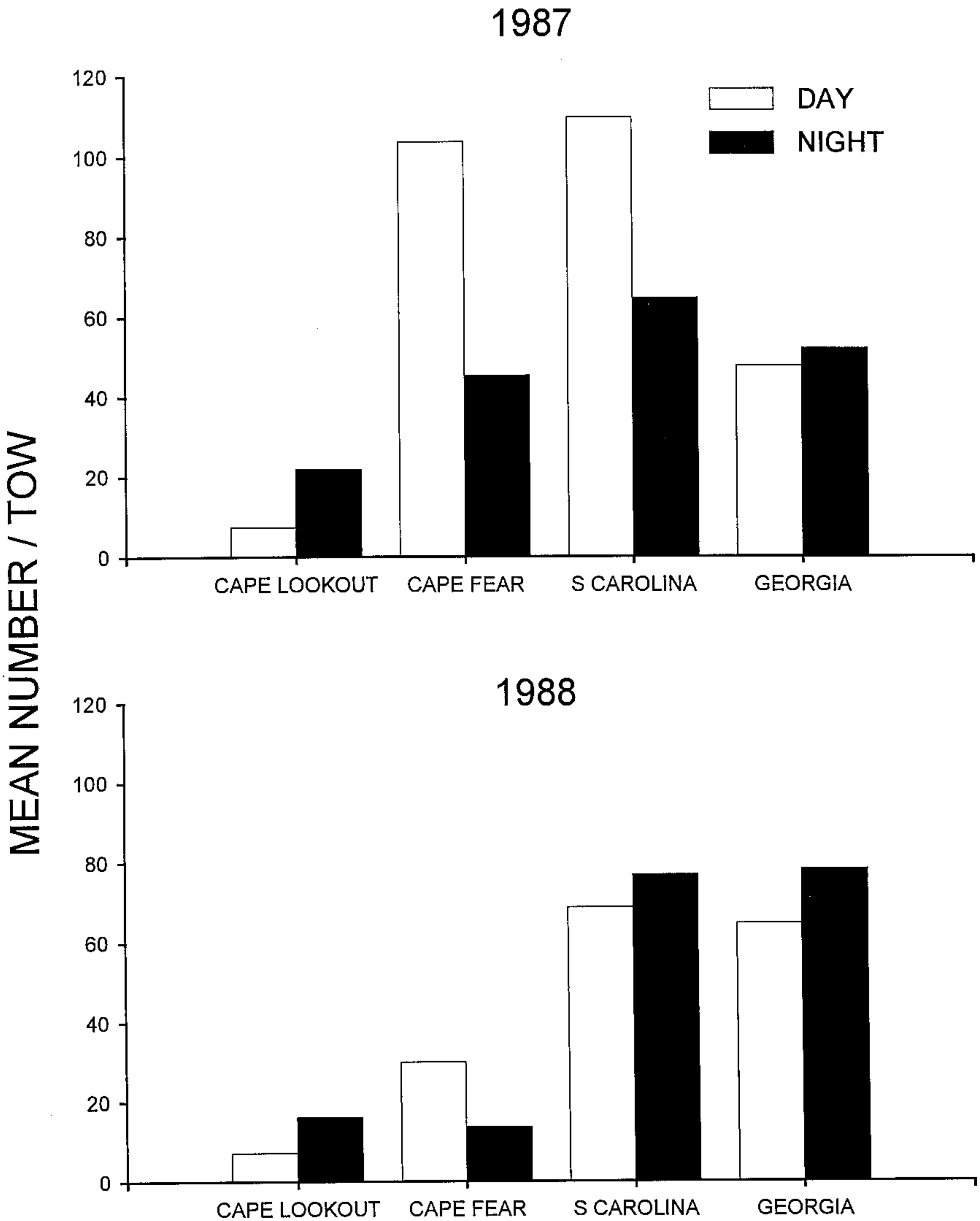


Figure 48. Diel abundance of *Penaeus setiferus* by station.

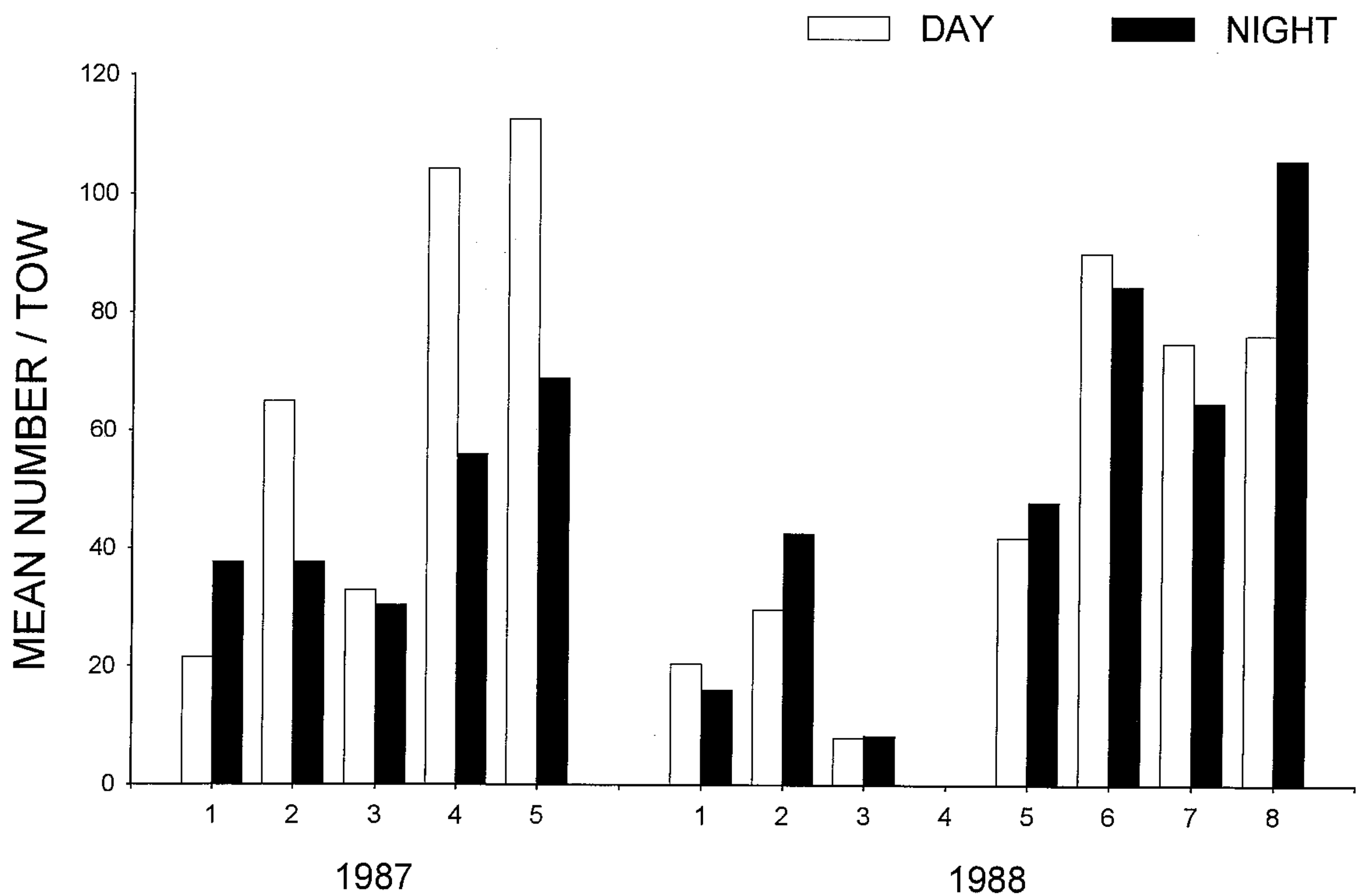


Figure 49. Diel abundance of *Penaeus setiferus* by cruise.

Sizes of individuals ranged from 6-20 cm TL, with an mean length of 13.9 cm TL in 1987 and 14.9 cm TL in 1988 (Figures 50 and 51). Highly significant differences in lengths occurred among stations (1987: $\chi^2 = 147.0$, $p < 0.001$, 1988: $\chi^2 = 86.0$, $p < 0.001$) and among cruises (1987: $\chi^2 = 146.0$, $p < 0.001$, 1988: $\chi^2 = 288.5$, $p <0.001$) both years. Modal lengths of *P. setiferus* remained fairly constant, at approximately 15 cm, throughout the study period.

### *Penaeus duorarum*

Pink shrimp occur from Chesapeake Bay to the Florida keys and throughout the Gulf of Mexico to the Yucatan peninsula, but are most abundant off the southern and northern ends of the west coast of Florida, in the Bay of Campeche, and off North Carolina (Perez-Farfante, 1978; Williams, 1984).

*P. duorarum* was present in 55% of the trawl tows from the 13 SEAMAP-SA cruises in 1987 and 1988 with a mean catch/tow of 25.8 individuals. Mean catch/tow values were 8.5 individuals and 0.1 kg in 1987 and 36.6 individuals and 0.5 kg in 1988 (Appendix 5). The difference in mean number of individuals/tow among stations was significant both years (1987: $F = 7.0$, $df = 3$, $p < 0.01$; 1988: $F = 29.6$, $df = 3$, $p < 0.001$), with North Carolina producing 81% of the individuals in 1987 and 78% in 1988 (Figure 52). Differences in mean number of individuals/tow among cruises were also significant both years (1987: $F = 2.5$, $df = 4$, $p < 0.05$; 1988: $F = 3.7$, $df = 7$, $p < 0.001$). Greatest abundance occurred during October in 1987 and in May and June in 1988, whereas lowest abundance occurred in August both years (Figure 53).

Pink shrimp, beyond the early juvenile stages, usually burrow into the substrate during the day and become active at night (Perez-Farfante, 1978; Renfro and Brusher, 1982; Williams, 1984), making them more susceptible to trawling at night. During the 1987 SEAMAP-SA survey, 74% of the pink shrimp (12.6 individuals/tow) was collected at night, whereas 83% (60.0 individuals/tow for all 8 cruises, 46.1 individuals/tow for last five cruises) was collected at night in 1988. This diel difference was significant both years (1987: $F = 21.3$, $df = 1$, $p < 0.05$; 1988: $F = 45.6$, $df = 1$, $p < 0.001$). Pink shrimp collected during the day were significantly larger than those collected at night in 1987 ($\chi^2 = 7.6$, $p < 0.01$), whereas the difference was not significant in 1988 ($\chi^2 = 0.02$, $p = 0.9$). There was no significant difference in abundance among sites either year (1987: $\chi^2 = 1.4$, $p = 0.1$; 1988: $\chi^2 = 0.4$, $p = 0.8$).

Size frequency distributions ranged from 4-17 cm TL, with the mean length being 11 cm both years (Figures 54 and 55). Significant differences in length were found among stations (1987: $\chi^2 = 92.0$, $p < 0.001$; 1988: $\chi^2 = 217.9$, $p < 0.001$) and among cruises (1987: $\chi^2 = 343.2$, $p < 0.001$; 1988: $\chi^2 = 241.2$, $p < 0.001$) both years. Largest mean lengths occurred at Cape Fear in 1987 and off South Carolina in 1988, and the smallest occurred at Cape Lookout both years.

# *Penaeus setiferus*

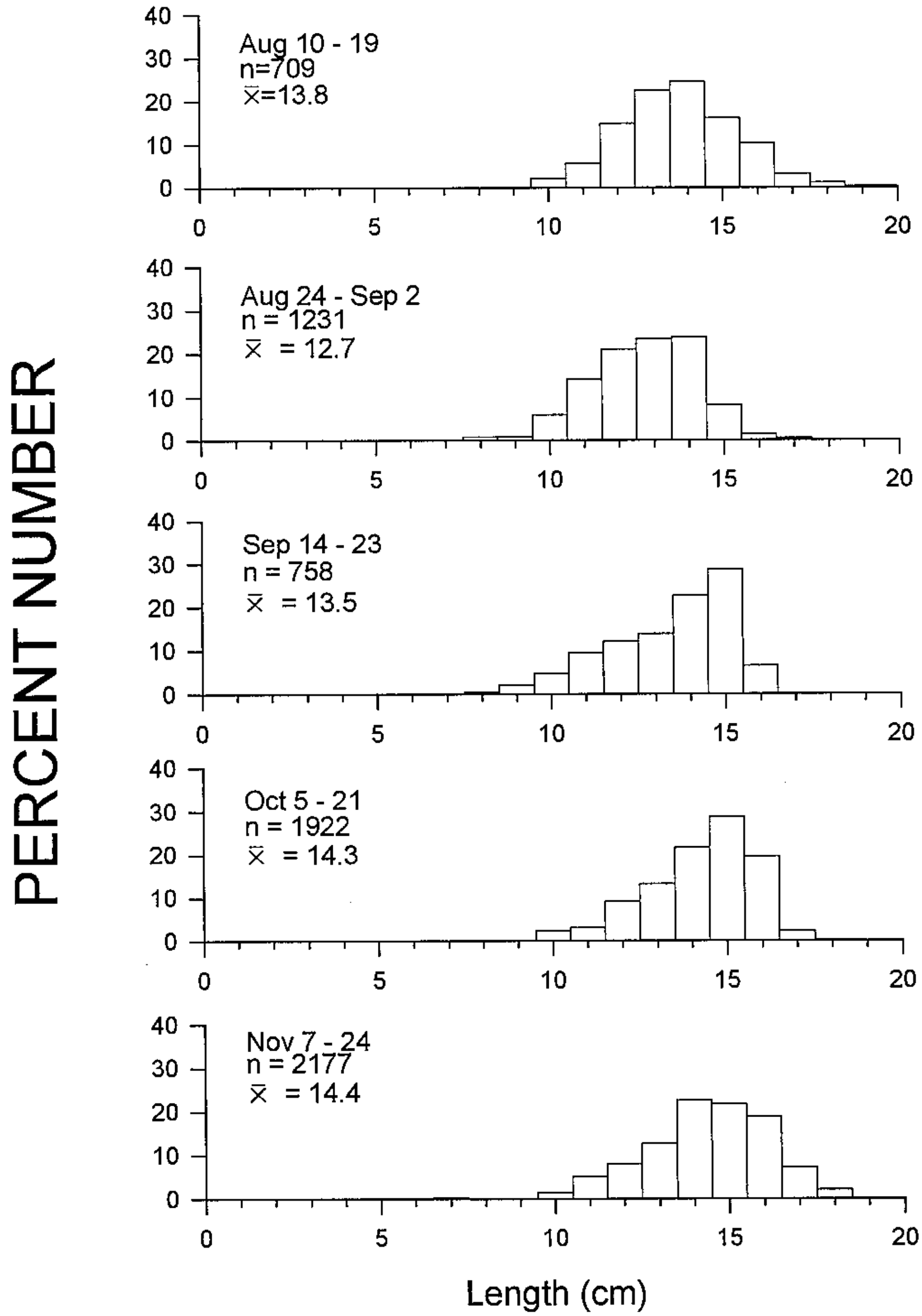


Figure 50. Length-frequencies of *Penaeus setiferus* for 5 SEAMAP cruises in 1987.

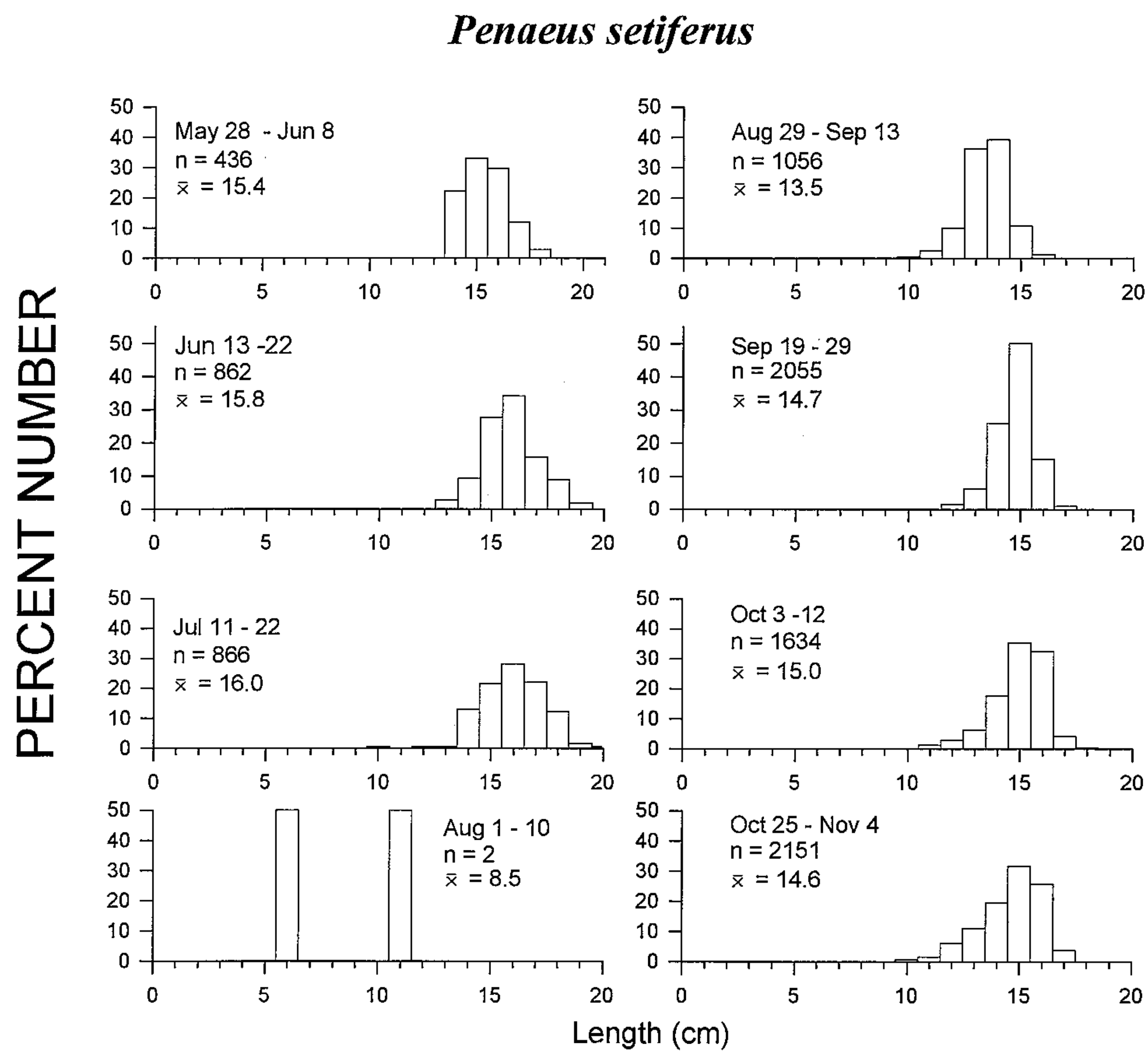


Figure 51. Length-frequencies of *Penaeus setiferus* from 8 SEAMAP cruises in 1988.

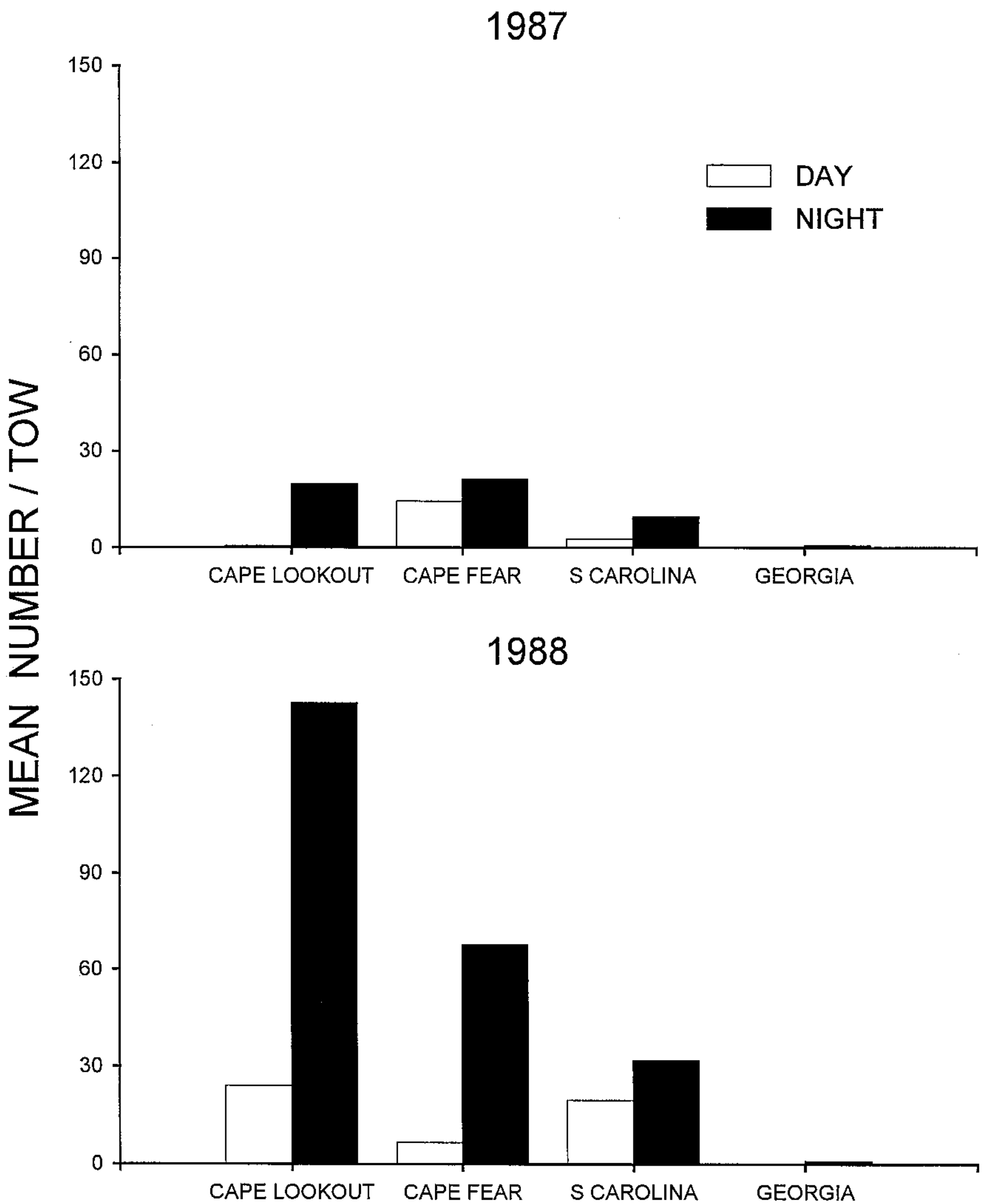


Figure 52. Diel abundance of *Penaeus duorarum* by station.

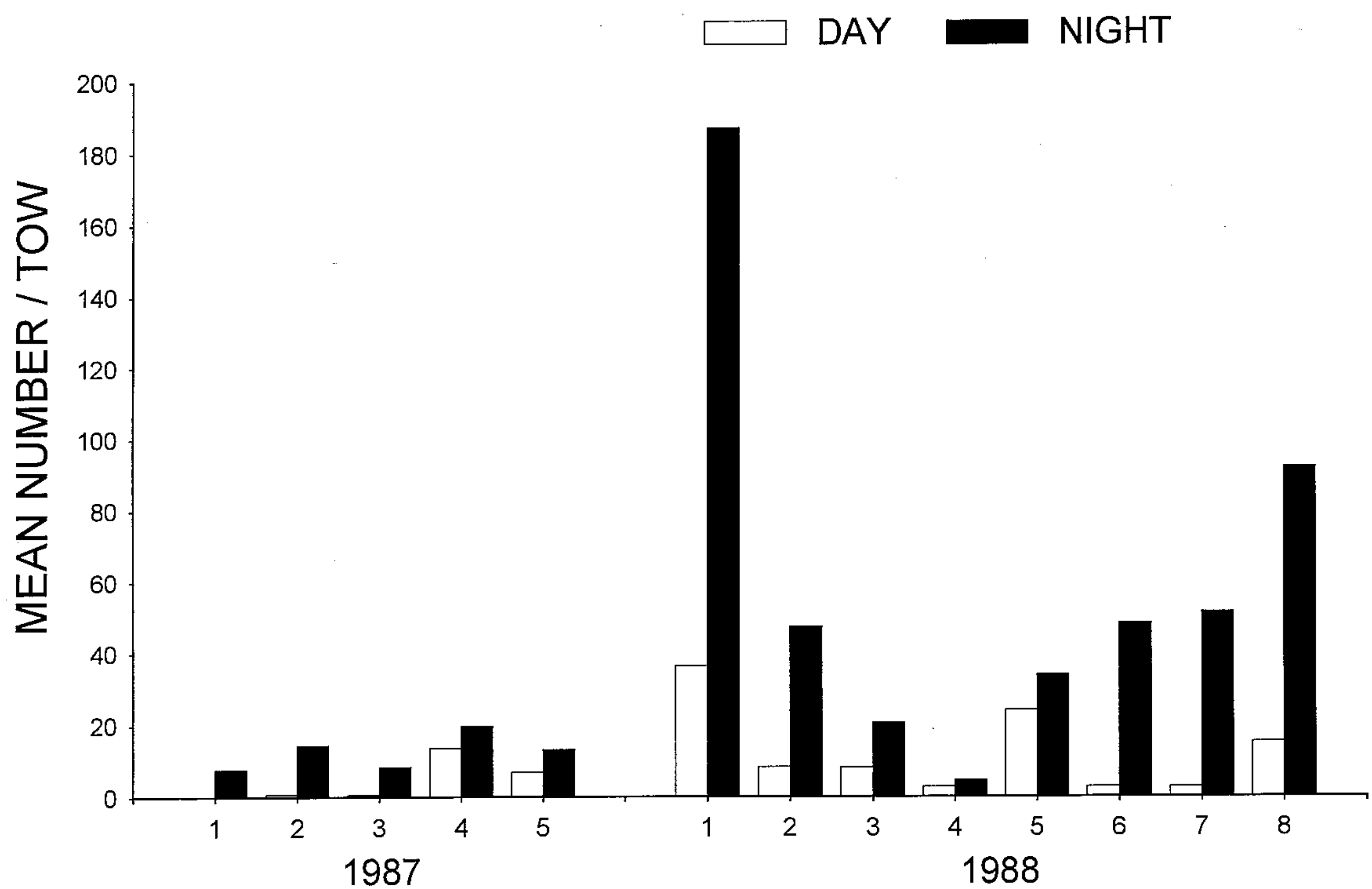


Figure 53. Diel abundance of *Penaeus duorarum* by cruise.

*Penaeus duorarum*

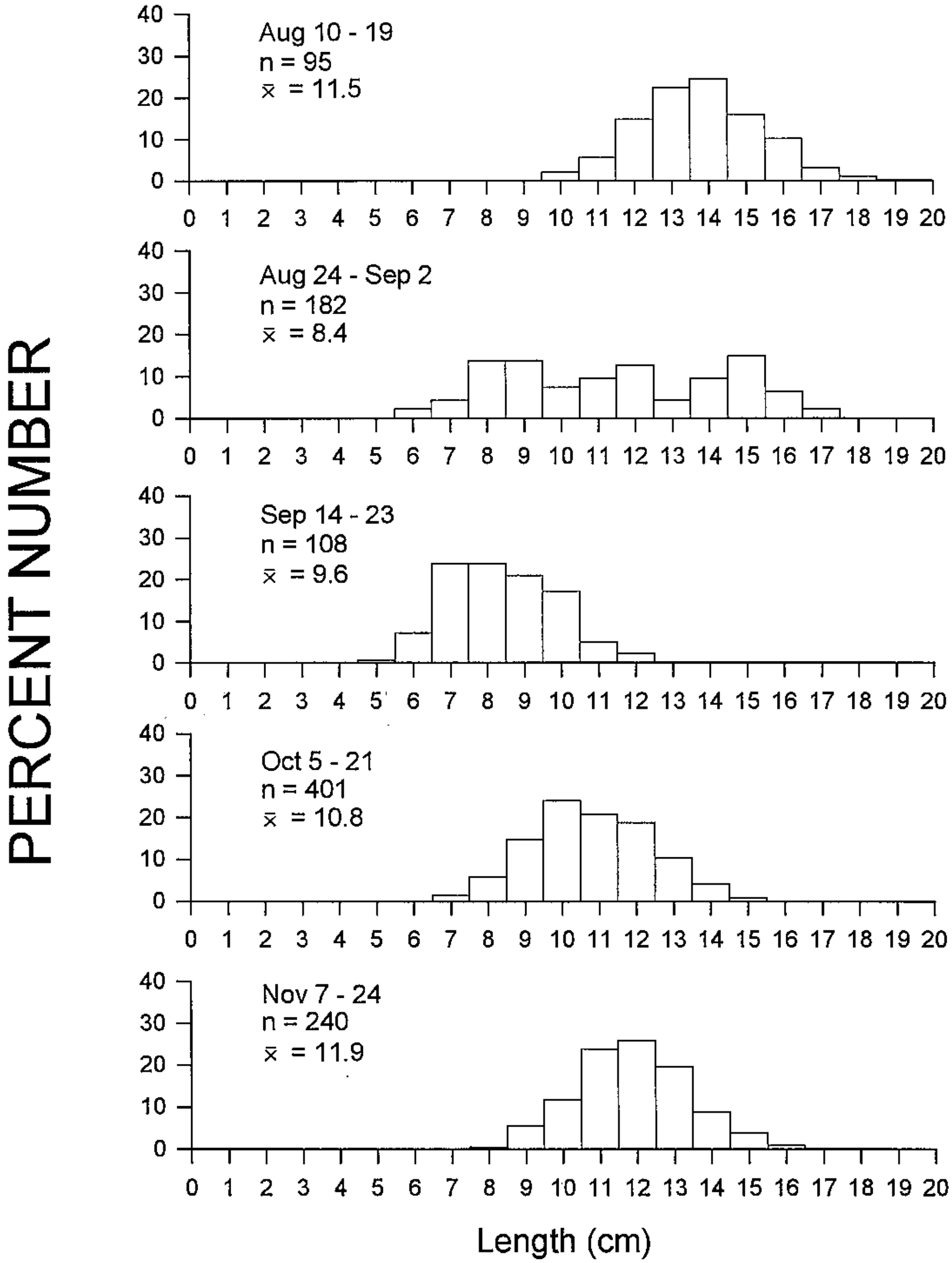


Figure 54. Length-frequencies of *Penaeus duorarum* from 5 SEAMAP cruises in 1987.

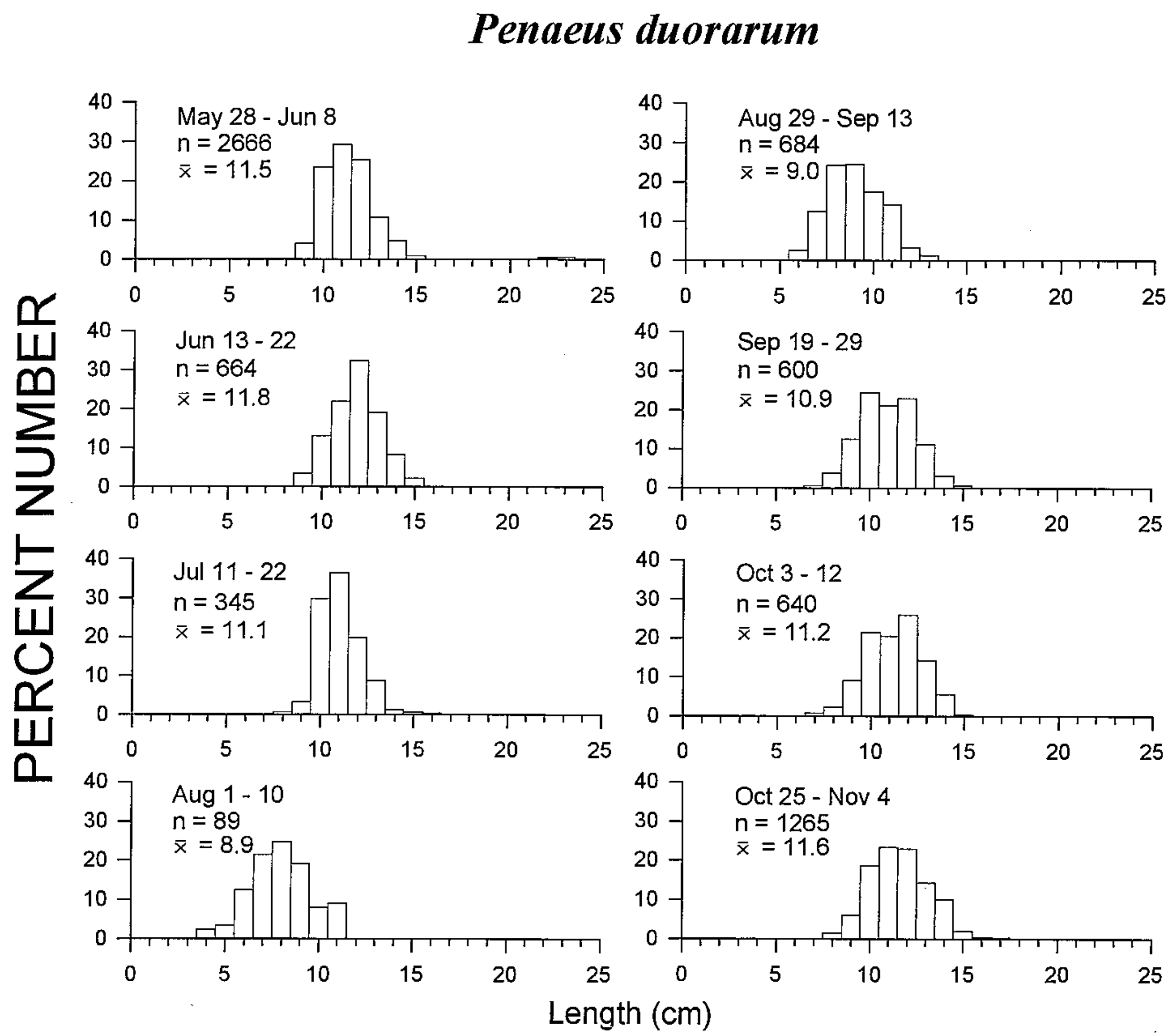


Figure 55. Length-frequencies of *Penaeus duorarum* from 8 SEAMAP cruises in 1988.

## *Callinectes sapidus*

Blue crab occur from Nova Scotia to northern Argentina, with introduced individuals occurring in parts of Europe, the Mediterranean Sea, and Japan (Williams, 1974; Oesterling, 1976; Milliken and Williams, 1984). The blue crab is a euryhaline species found in estuarine and shallow oceanic littoral waters where individuals are common on sandy and muddy bottoms (Holland et al., 1971; Williams, 1974; Oesterling, 1976). Females move into high salinity waters of the lower estuary and nearshore coastal zone for spawning, with larval development taking place offshore, and megalopal stages recruiting into estuaries primarily during early fall (Oesterling, 1976; Williams, 1984; Mense and Wenner, 1989). Because males generally inhabit low- to mid-salinity estuarine areas, offshore catches tend to have a higher percentage of females (Dudley and Judy, 1971; Oesterling, 1976; Williams, 1984). This species supports large commercial and recreational fisheries is second only to the penaeid shrimp fishery in value in the SAB (Eldridge and Waltz, 1977; Williams, 1984; Low et al., 1987).

Blue crab were collected in 67% of the trawl samples from the 13 SEAMAP-SA cruises in 1987 and 1988 with a mean catch/tow of 10.1 individuals.
In 1987 abundance was much higher than in 1988 (Appendix 5). Difference in mean catch/tow among stations was significant in 1987 ($F = 29.9$, $df = 3$, $p < 0.001$) and in 1988 ($F = 57.3$, $df = 3$, $p < 0.001$), with the largest catches taken off from South Carolina where 66% in 1987 and 48% in 1988 of the total catch was taken (Figure 56). Blue crab were almost absent from Georgia coastal waters both years.

The differences in mean number of individuals/tow among cruises were not significant in 1987 ($F = 4.7$, $df = 4$, $p > 0.05$) or 1988 ($F = 1.7$, $df = 7$, $p > 0.05$); the largest catches occurred on Cruise 5 in November of 1987 (Figure 57). Diel differences were not significant either year (1987: $\chi^2 = 0.06$, $p = 0.8$; 1987: $\chi^2 = 0.09$, $p = 0.8$). Differences in catch rates among sites were significant in 1987 ($\chi^2 = 7.1$, $p < 0.05$), with largest catches coming from the Beach sites and smallest catches from the Offbeach sites. No significant differences in abundance were found in 1988 ($\chi^2 = 0.7$, $p = 0.7$).

Total width of the blue crab ranged from 4-19 cm, with an mean width of 14 cm (Figures 58 and 59). Modes among cruises both years were consistently 14-15 cm. A highly significant annual difference in size occurred among stations (1987: $\chi^2 = 62.1$, $p < 0.001$; 1988: $\chi^2 = 62.1$, $p < 0.001$) and among cruises (1987: $\chi^2 = 51.7$, $p < 0.001$, 1988: $\chi^2 = 51.7$, $p < 0.001$). Smallest blue crab specimens came from Cape Lookout both years, and largest individuals were taken off Georgia in 1987 and South Carolina in 1988. The smallest recruits occurred in early summer in 1988. Diel differences in widths were not significant either year (1987: $\chi^2 = 0.3$, $p = 0.6$; 1988: $\chi^2 = 0.2$, $p = 0.7$).

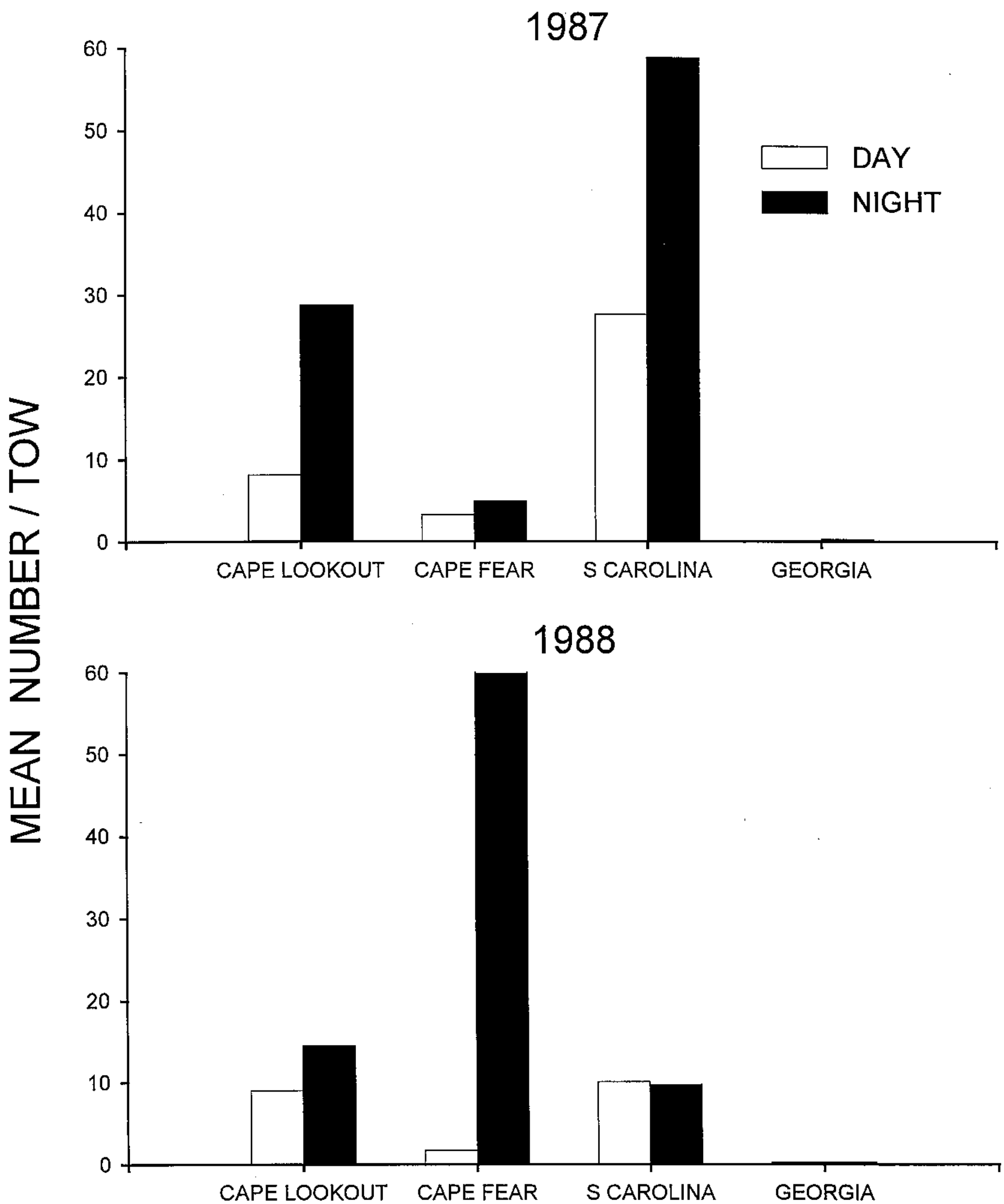


Figure 56. Diel abundance of *Callinectes sapidus* by station.

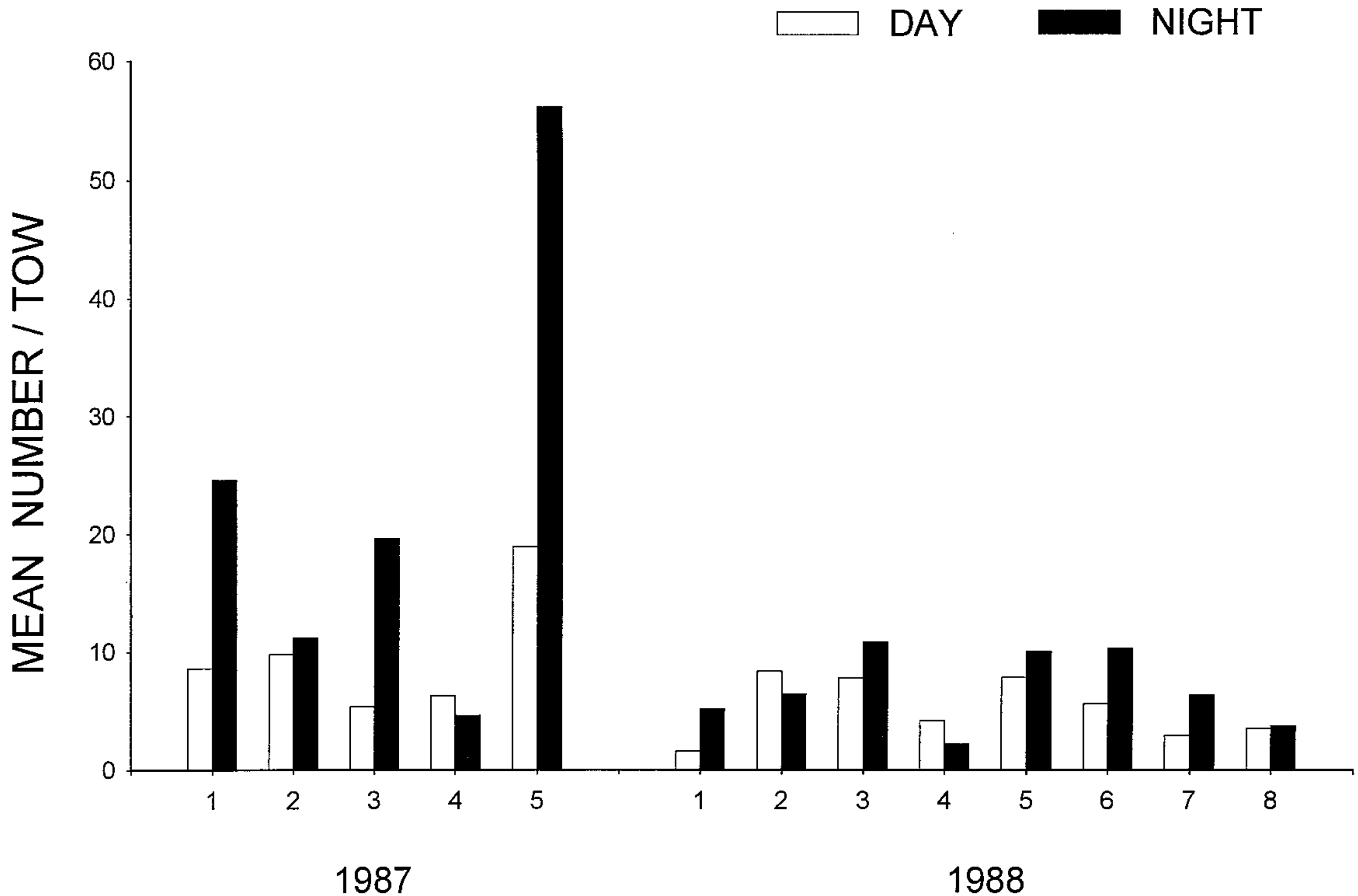


Figure 57. Diel abundance of *Callinectes sapidus* by cruise.

# *Callinectes sapidus*

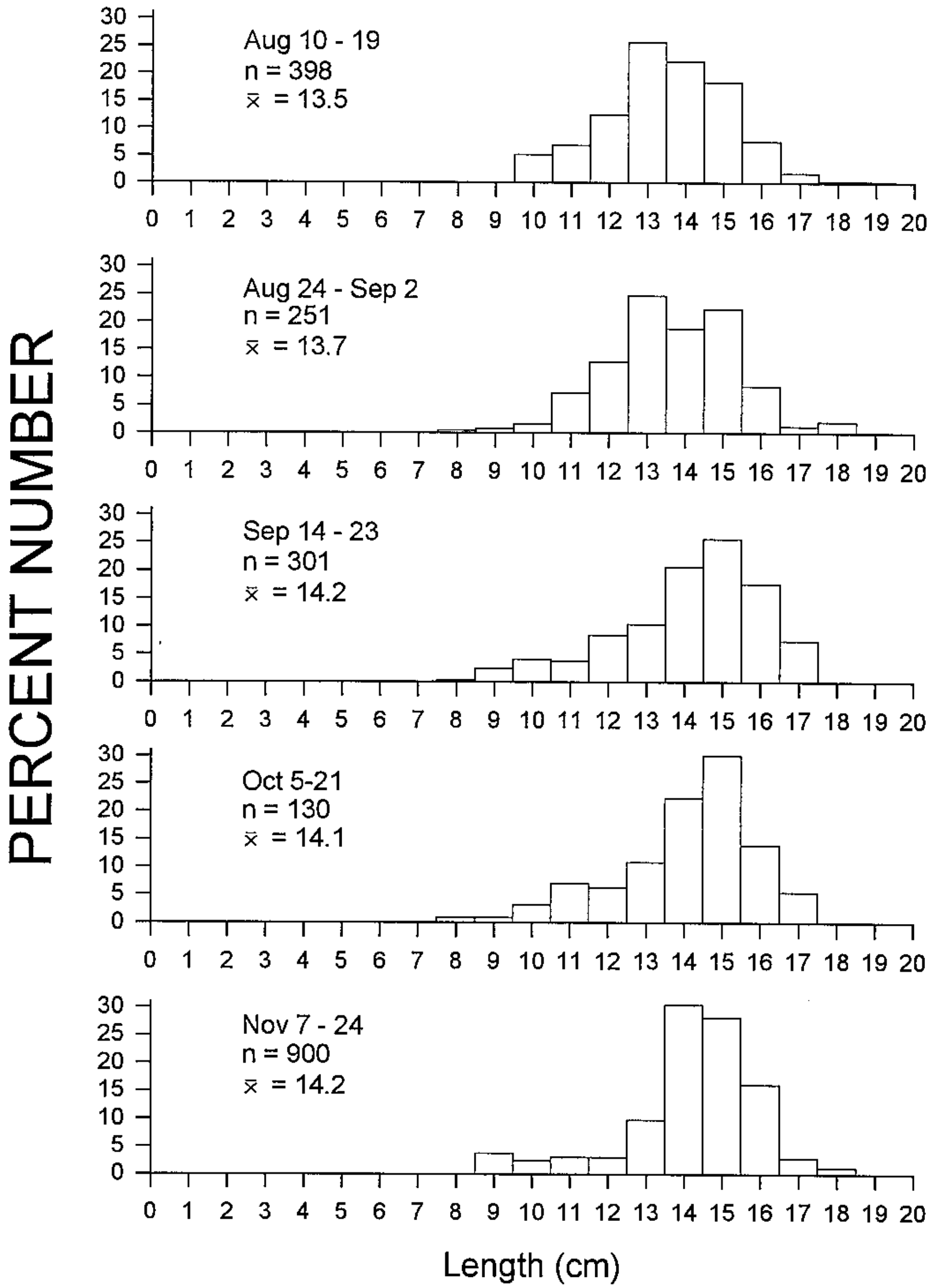


Figure 58. Width-frequencies of *Callinectes sapidus* from 5 SEAMAP cruises from 1987.

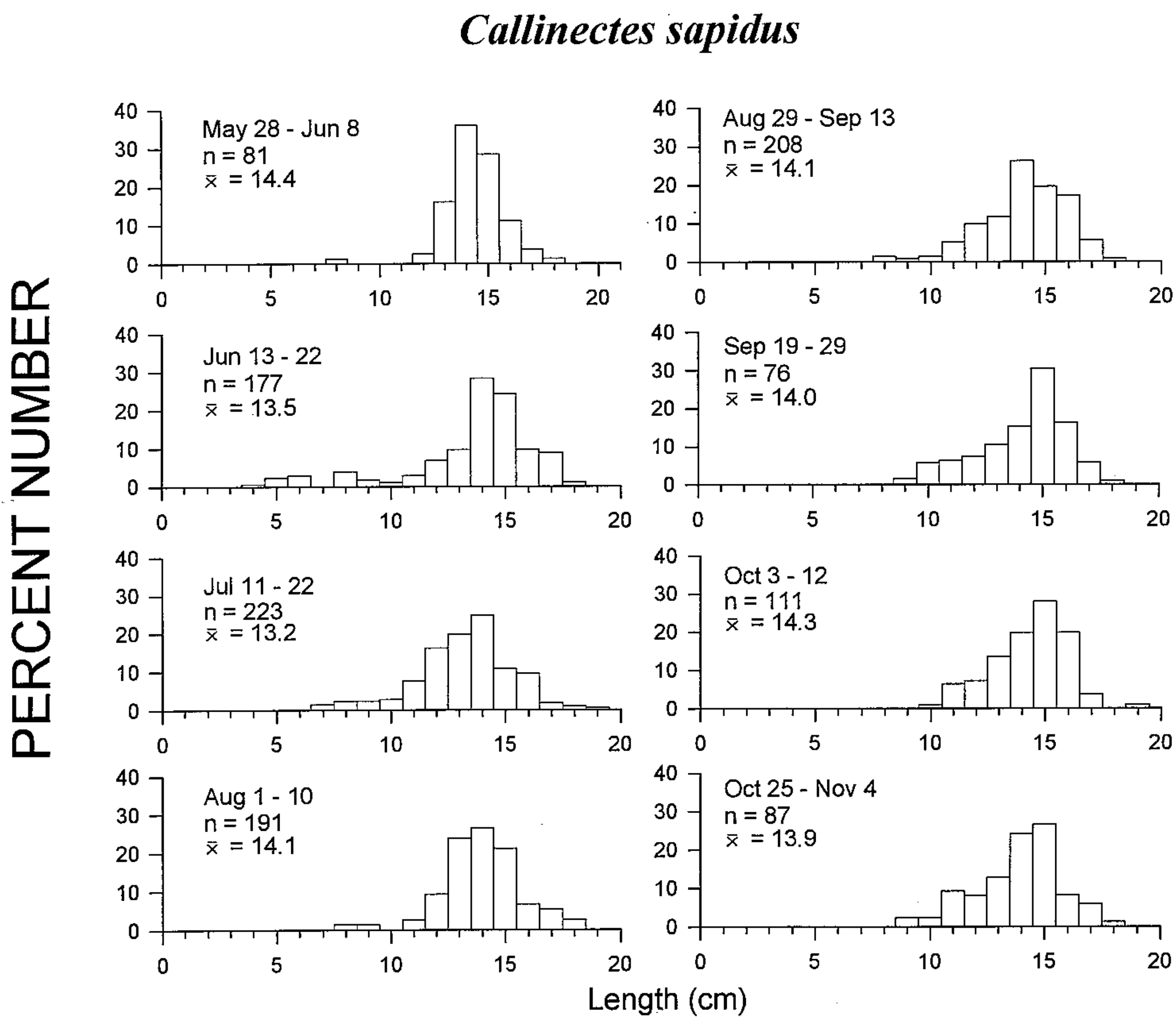


Figure 59. Width-frequencies of *Callinectes sapidus* from 8 SEAMAP cruises from 1988.

**Summary**

Thirteen cruises conducted in 1987 and 1988, with 3 sites at each of 4 stations sampled during the day and at night, produced the following results:

1. No significant differences in mean bottom water temperature or salinity occurred between 1987 and 1988, among sites either year, or in bottom water salinity among stations in 1987. Significant differences in mean bottom water salinity did occur among stations in 1988 and among cruises both years.

2. The number of species collected was independent of year, cruise, station, site, and light-phase. However, the greatest number finfish species occurred at Cape Lookout where the lowest number of crustacean species occurred. Combined catches from both years produces 119 species of finfish, 40 species of decapod and stomatopod crustaceans, and 18 elasmobranch species.

3. No significant differences in biomass occurred between 1987 and the comparable time period in 1988 (the last 5 cruises of 1988) or among sites either year. Differences in biomass among cruises and stations were significant both years, with greatest biomass collected at Cape Fear and in spring and fall of 1988. Finfish produced the majority of the biomass, although in fall of 1988 elasmobranch biomass almost equaled that of finfish.

4. During the 1987 and 1988 SEAMAP-SA surveys, only priority species were enumerated. Coastal waters of the SAB have been called a sciaenid habitat (Wenner and Sedberry, 1989); four sciaenids, *Micropogonias undulatus, Leiostomus xanthurus, Menticirrhus americanus,* and *Cynoscion regalis* constituted over 96% of the total abundance of priority species. *Penaeus aztecus* was the most abundant decapod, primarily due to a very successful recruitment year in 1988.

5. Significant differences in abundance among stations occurred for the sciaenids mentioned above and the bluefish, *Pomatomus saltatrix*. *Scomberomorus cavalla, Chaetodipterus faber*, and *Paralichthys lethostigma* did not show a preference for stations. Differences in abundance of *P. dentatus* were significant among stations in 1987, but not in 1988. Differences in abundance of *S. maculatus* among stations were significant in 1988, but not 1987.

6. Seasonal differences in abundance were significant for all priority species, except blue crab, in one or both years. *Leiostomus xanthurus* and the two *Paralichthys* spp. had seasonally significant differences in abundance in 1987, but not 1988. The differences in seasonal abundance of *Menticirrhus americanus* were not significant in 1987, but were in 1988.

7. *Penaeus setiferus* was the only priority species to show a preference for a site both years, having significantly higher abundance at the Beach site both years. Differences in abundance among sites for *M. americanus, S. maculatus,* and *C. sapidus* were significant in 1987, but not in 1988, with greatest abundance

occurring at Beach sites for each of these species.

8. Significant diel differences in abundance occurred both years for three finfish species, *Micropogonias undulatus, Menticirrhus americanus,* and *P. dentatus*, and two decapod species *Penaeus aztecus* and *P. duorarum*, all of which were more abundant at night. *Micropogonias undulatus*, however, occurred in greater numbers during the day. A diel difference in abundance occurred in 1987 for king mackerel and weakfish and for spot and Spanish mackerel in 1988, with greater abundance occurring during the day for each species.

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## LITERATURE CITED

Anderson, W.W. 1968. Fishes taken during shrimp trawling along the south Atlantic coast of the United States, 1931-35. U.S. Fish and Wildl. Serv., Spec. Sci. Rep. Fish 570, 60 p.

Anderson, E.D. 1980. A preliminary assessment of the status of bluefish (*Pomatomus saltatrix*) along the Atlantic coast of the United States. NMFS, Northeast Fish. Center, Woods Hole Laboratory, Laboratory Reference Document No. 80-30, 29 p.

Anderson, W.D., J.K. Dias, R.K. Dias, D.M. Cupka, and N.A. Chamberlain. 1977. The macrofauna of the surf zone off Folly Beach, South Carolina. U.S. Dept. Comm., NOAA Tech. Rep. NMFS SSRF-704, 23 p.

Atkinson, L.P. 1985. Hydrography and nutrients of the southeastern U.S. continental shelf. In: Atkinson, D.W. Menzel, and K.A. Bush (eds.), Oceanography of the Southeastern U.S. Continental Shelf, Coastal and Shelf Science. vol. 2, L.P.AGU, Washington, D.C. pp. 77-92.

Barbieri, L.R., M.E. Chittenden, Jr., and C.M. Jones. 1994. Age, growth and mortality of Atlantic croaker, *Micropogonias undulatus*, in the Chesapeake Bay region, with a discussion of apparent geographic changes in population dynamics. Fish. Bull. 92:1-12.

Barger, L.E. 1990. Age and growth of bluefish *Pomatomus saltatrix* from the Northern Gulf of Mexico and U.S. South Atlantic coast. Fish. Bull. 88(4):805-809.

Bearden, C.M. 1961. Common marine fishes of South Carolina. Contrib. Bears Bluff Lab. No. 34, 47 p.

Bearden, C.M. 1963. A contribution to the biology of the king whitings, genus *Menticirrhus*, of South Carolina. Contrib. Bears Bluff Lab. No. 38, 27 p.

Bearden, C.M. 1964. Distribution and abundance of Atlantic croaker, *Micropogonias undulatus* in South Carolina. Contrib. Bears Bluff Lab. No. 40, 23 p.

Beatty, H.R., J.M. Boylan, R.P. Webster, and E.L. Wenner. 1992. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY-1991. SEAMAP-SA Final Report, 52 p.

Beatty, H.R., R.P. Webster, and E.L. Wenner. 1989. Temporal and spatial variations in biomass, abundance, and community composition of fishes and invertebrates from the coastal habitat of the South Atlantic Bight, 1987-1988. SEAMAP-SA Final Report, 141 p.

Beaumariage, D.S. 1973. Age, growth, and reproduction of king mackerel, *Scomberomorus cavalla*, in Florida. Fla. Dept. Nat. Resour. Publ. No. 1, 45 p.

Berrien, P., and D. Finan. 1977. Biological and fisheries data on Spanish mackerel, *Scomberomorus maculatus* (Mitchill). NOAA/NMFS Northeast Fish. Ctr. Tech. Ser. Rep. No. 9, 58 p.

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fish. Bull. 53:1-577.

Blanton, J.O. 1981. Ocean currents along a nearshore frontal zone on the continental shelf of the southeastern United States. J. Phys. Ocean. 11(12):1627-1637.

Blanton, J.O., and L.P. Atkinson. 1983. Transport and fate of river discharge on the continental shelf of the southeastern United States. J. Geophys. Res. 88:4730-4738.

Boylan, J.M., R.P. Webster, H.R. Beatty, and E.L. Wenner. 1991. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY-1990. SEAMAP-SA Final Report, 48 p.

Boylan, J.M., R.P. Webster, H.R. Beatty, and E.L. Wenner. 1993. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY-1992. SEAMAP-SA Final Report, 54 p.

Bumpus, D.F. 1973. A description of the circulation on the continental shelf of the east coast of the United States. In: B.A. Warren (ed.), Progress in Oceanography 6, pp. 111-157.

Burgess, W.E. 1978. Ephippidae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. II.

Cain, R.L., and J.M. Dean. 1976. The annual occurrence, abundance, and diversity of fishes in a South Carolina intertidal creek. Mar Biol 36:369-379.

Chao, L.N. 1976. Aspects of the systematics, morphology, life history and feeding of western Atlantic Sciaenidae (Pisces: Perciformes). Ph.D. Dissertation, College of William and Mary, Williamsburg, 342 p.

Chao, L.N. 1978. Sciaenidae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. IV.

Collette, B.B. 1978a. Pomatomidae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. IV.

Collette, B.B. 1978b. Scombridae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. IV.

Collette, B.B., and J.L. Russo. 1984. Morphology, systematics, and biology of the Spanish mackerels (*Scomberomorus*, Scombridae) Fishery Bulletin 82(4):545-692.

Collins, M.R., and B.W. Stender. 1987. Larval king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), and bluefish (*Pomatomus saltatrix*) off the southeast coast of the United States, 1972-1980. Bull. Mar. Sci. 41:822-834.

Collins, M.R., and C.A. Wenner. 1988. Occurrence of young-of-the-year king, *Scomberomorus cavalla*, and Spanish, *S. maculatus*, mackerels in commercial-type shrimp trawls along the Atlantic coast of the Southeast United States. Fish. Bull. 86(2):394-397.

Collins, M.R., D.J. Schmidt, C.W. Waltz, and J. Pinckney. 1989. Age and growth of king mackerel, *Scomberomorus cavalla*, From the Atlantic coast of the United States. Fish. Bull. 87:49-61.

Cook, H.L. , and M.J. Lindner. 1970. Synopsis of biological data on the brown shrimp *Penaeus aztecus* Ives, 1891. FAO Fish Rep. 57:1471-1497.

Crabtree, R.E., and J.M. Dean. 1982. The structure of two South Carolina estuarine tide pool fish assemblages. Estuaries 5:2-9.

Dahlberg, M.D. 1972. An ecological study of Georgia coastal fish. Fish. Bull. 70(2):323-353.

Dawson, C.E. 1958. A study of the biology and life history of the spot, *Leiostomus xanthurus*, Lacepede, with special reference to South Carolina. Contrib. Bears Bluff Lab. No. 28. 48 p.

DeVries, D.A. 1982. Description and catch composition of North Carolina's long haul seine fishery. Proc. Ann. Conf. S.E. Assoc. Fish Wildl. Agen. 34:234-247.

Dudley, D.L., and M.H. Judy. 1971. Occurrence of larval, juvenile and mature crabs in the vicinity of the Beaufort Inlet, North Carolina. U.S. Dept. of Comm., NOAA, NMFS, NOAA Tech. Rep., NMFS SSRF-637, 10 p.

Dugas, R.J. 1975. Variation in day-night trawl catches in Vermillion Bay, Louisiana. Louisiana Wild Life and Fish. Comm., New Orleans. 13 p.

Eldridge, P.J. 1962. Observations on the winter trawl fishery for summer flounder, *Paralichthys dentatus*. M.S. Thesis, College of William and Mary, Williamsburg, Va., 55 p.

Eldridge, P.J., and W. Waltz. 1977. Observations on the commercial fishery for blue crabs, *Callinectes sapidus*, in estuaries in the southern half of South Carolina. S.C. Mar. Resour. Ctr. Tech. Rep. 21, 35 p.

Fable, W.A. Jr., A.G. Johnson, and L.E. Barger. 1987. Age and growth of spanish mackerel, *Scomberomorus maculatus*, from Florida and the Gulf of Mexico. Fish. Bull. 85(4):777-783.

Finucane, J.H., and L.A. Collins. 1986. Reproduction of Spanish mackerel, *Scomberomorus maculatus*, from the southeastern United States. N.E. Gulf Sci. 8(2):97-106.

Finucane, J.H., L.A. Collins, H.A. Brusher, and C.H. Saloman. 1986. Reproductive biology of king mackerel, *Scomberomorus cavalla*, from the southeastern United States. Fish. Bull. 84(4):841-850.

Flores-Coto, C., and S.M. Warlen. 1993. Spawning time, growth and recruitment of larval spot *Leiostomus xanthurus* into a North Carolina estuary. Fish. Bull. 91(4):p 8-22.

Fritzsche, R.A. 1978. Development of fishes of the Mid-Atlantic Bight, Vol. V. Chaetodontidae through Ophidiidae. Fish Wildl. Serv., FWS/OBS-78/12, 340 p.

Fritzche, R.A., and B.J. Crowe. 1981. Contributions to the life history of the southern kingfish, *Menticirrhus americanus* (Linnaeus), in Mississippi. Mississippi Dept. of Wildlife Conserv., Bureau of Mar. Resour., BMR Project No. CO-ST-79-022, 84 p.

Gunter, G. 1950. Correlation between temperature of water and size of marine fishes on the Atlantic and Gulf Coasts of the United States. Copeia 1950:298-304.

Hardy, J.D., Jr. 1978. Development of fishes of the Mid-Atlantic Bight, Vol.III. Aphredoderidae through Rachycentridae. Fish Wildl. Serv. FWS/OBS-78/12, 394 p.

Hayse, J.W. 1990. Feeding habits, age, growth and reproduction of Atlantic spadefish, *Chaetodipterus faber* (Pisces: Ephippidae), in South Carolina. Fish Bull:88:67-83.

Hester, J.M., Jr. 1975. Nekton population dynamics in the Albemarle Sound and Neuse River Estuaries. M.S. Thesis. North Carolina State University, Raleigh, 129 p.

Hildebrand, S.F., and L.E. Cable. 1930. Development and life history of fourteen teleostean fishes at Beaufort, N.C. Fish. Bull. 46:383-488.

Hildebrand, S.F., and L.E. Cable. 1934. Reproduction and development of whitings of kingfishes, drums, spot, croaker, and weakfishes or sea trouts, Family Sciaenidae, of the Atlantic Coast of the United States. Fish. Bull. 48:41-117.

Hill, B.W. 1984. A description and analysis of the timing of Virginia's Weakfish fishery. Fisheries Analysis Center East, Applied Marine Research Laboratory, Old Dominion University Research Foundation Tech. Rep. 84-8, 94 p.

Holland, J.S., D.V. Aldrich,, and K. Strawn. 1971. Effects of temperature and salinity on growth, food conversion, survival, and temperature resistance of juvenile blue crabs, *Callinectes sapidus* Rathbun. Sea Grant Publication TAMU-SG-71-222, 165 p.

Jackson, C.D. 1990. Recruitment of fish larvae to shallow estuarine habitats along a salinity gradient. M.S. Thesis. College of Charleston, Charleston, S.C.

Johnson, A.G., W.A. Fable, Jr., M.L. Williams, and L.E. Barger. 1983. Age, growth and mortality of king mackerel, *Scomberomorus cavalla*, from the southeastern United States. Fish. Bull. 81(1):97-106.

Johnson, G.D. 1978. Development of fishes of the Mid-Atlantic Bight, Vol. IV. Carangidae through Ephippidae. Fish Wildl. Serv., FWS/OBS-78/12, 314 p.

Keiser, R.K., Jr. 1976. Species composition, magnitude and utilization of the incidental catch of the South Carolina shrimp fishery. S.C. Mar. Resour. Ctr. Tech. Rep. No.16., 94 p.

Keiser, R.K., Jr. 1977. The incidental catch from commercial shrimp trawlers of the South Atlantic states. S.C. Mar. Resour. Ctr. Tech. Rep. 26, 38 p.

Kendall, A.W., and L.A. Walford. 1979. Sources and distribution of bluefish, *Pomatomus saltatrix*, larvae and juveniles off the east coast of the United States. Fish. Bull., U.S. 77:213-227.

Klima, E.F. 1959. Aspects of the biology and the fishery for Spanish mackerel, *Scomberomorus maculatus* (Mitchill), of southern Florida. Fla. Board Conserv., Mar. Res. Lab. Tech. Ser. No. 27, 39 p.

Knowlton, C.J. 1972. Fishes taken during commercial shrimp fishing in Georgia's close inshore ocean waters. Georgia Dep. Nat. Resour. Contrib. Ser. 20, 42 p.

Lindner, M.J., and W.W. Anderson. 1956. Growth, migrations, spawning and size distributions of shrimp *Penaeus setiferus*. Fish. Bull. 106(56):553-645.

Low, R., R. Rhodes, E.R. Hens, D. Theiling, E. Wenner, and D. Whitaker. 1987. A profile of the blue crab and its fishery in South Carolina. S.C. Mar. Resour. Ctr. Tech. Rep. No. 66, 37 p.

Mahood, R.K., C.D. Harris, J.L. Music, Jr., and B.A. Palmer. 1974a. Survey of the fishery resources in Georgia's estuarine and inshore ocean waters. Part I. Southern section, St. Andrews Sound and St. Simons Sound estuaries. Ga. Dept. Nat. Resour. Contrib. Ser. No. 22, 104 p.

Mahood, R.D., C.D. Harris, J.L. Music, Jr., and B.A. Palmer. 1974b. Survey of the fishery resources in Georgia's estuarine and inshore ocean waters. Part II. Central section, Doboy Sound and Sapelo Sound estuaries. Ga. Dept. Nat. Resour. Contrib. Ser. No. 23, 99 p.

Mahood, R.K., C.D. Harris, J.L. Music, Jr., and B.A. Palmer. 1974c. Survey of the fishery resources in Georgia's estuarine and inshore ocean waters. Part III. Northern section, Ossabaw Sound and Wassaw Sound estuaries. Ga. Dept. Nat. Resour. Contrib. Ser. No. 24, 100 p.

Martin, F.D., and G.E. Drewry. 1978. Development of fishes of the Mid-Atlantic Bight, Vol. VI. Stromateidae through Ogcocephalidae. Fish Wildl. Serv., FWS/OBS-78/12, 416 p.

Mathews, T.D., and O. Pashuk. 1986. Summer and winter hydrography of the U.S. South Atlantic Bight (1973-1979). J. Coast. Res. 2(3):311-336.

McClain, C.R., J.A. Yoder, L.P. Atkinson, J.O. Blanton, T.N. Lee, J.J. Singer, and F. Muller-Karger. 1988. Variability of surface pigment concentrations in the South Atlantic Bight. J. Geophys. Res. 93(C9):10675-10697.

McGovern, J.C. and C.A. Wenner. 1990. Seasonal recruitment of larval and juvenile fishes into impounded and non-impounded marshes. Wetlands, 10 (2):203-221.

Mense D.J., and E.L. Wenner. 1989. Distribution and abundance of early life history stages of the blue crab, *Callinectes sapidus*, in tidal marsh creeks near Charleston, S.C. Estuaries 12:157-168.

Mercer, L.P. 1985. Fishery management plan for the Weakfish (*Cynoscion regalis*) fishery. N.C. Dept. of Nat. Resour., Atl. States Mar. Fish. Comm. Fishery Management Rep. No. 7, 129 p.

Mercer, L.P. 1989. Fishery management plan for spot (*Leiostomus xanthurus*) fishery. N.C. Dept. of Nat. Resour., Atl. States Mar. Fish. Comm. Fishery Management Rep. No. 11, 81 p.

Merriner, J.V. 1973. Assessment of the weakfish resource, a suggested management plan, and aspects of the life history in North Carolina. Ph.D. Dissertation, North Carolina State University, Raleigh, 201 p.

Merriner, J.V. 1976. Aspects of the reproductive biology of the weakfish, *Cynoscion regalis* (Sciaenidae), in North Carolina. Fish. Bull. 74:18-26.

Milliken, M.R., and A.B. Williams. 1984. Synopsis of biological data on the blue crab, *Callinectes sapidus* (Rathbun). U.S. Dept. of Comm., NOAA, NMFS, NOAA Tech. Rep. NMFS 1, 39 p.

Moore, C.J., M. Bell, and D. Hammond. 1984. Atlantic spadefish. S.C. Mar. Resour. Ctr., Saltwater Conversation 1984(4):19-22.

Music, J.L., Jr., and J.R. Pafford. 1984. Population dynamics and life history aspects of major marine sportfishes in Georgia's coastal waters. Georgia Department of Natural Resources, Coastal Resources Division. Contribution Series 38, Brunswick, Georgia.

Norman, J.R. 1934. A systematic monograph of the flatfishes (Heterosmata), Vol. I. Psettodidae, Bothidae, Pleuronectidae. British Mus., London. 459 p.

Oesterling, M.J. 1976. Reproduction, growth and migration of blue crabs along Florida's Gulf coast. Univ. of Fla., Fla. Sea Grant Publ., SUSF-SG-76-003, 19 p.

Pacheco, A.L. 1962. Age and Growth of spot in lower Chesapeake Bay, with notes on distribution and abundance of juveniles in the York river system. Chesapeake Sci. 3:18-28.

Pearson, J.C. 1928. Natural history and conservation of the redfish and other commercial sciaenids on the Texas Coast. Bull. U.S. Bur. Fish. 44:129-214.

Pearson, J.C. 1941. The young of some marine fishes taken in lower Chesapeake Bay, Virginia with special reference to the gray sea trout *Cynoscion regalis* (Bloch and Schneider). Fish. Bull. 50:79-102.

Perez-Farfante, I. 1978. Penaeidae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. VI.

Pietrafesa, L.J., G.S. Janowitz, and P.A. Wittman. 1985. Physical oceanographic processes in the Carolina Capes. In: L.P. Atkinson, D.W. Menzel, and K.A. Bush (eds.), Oceanography of the Southeastern U.S. Continental Shelf, Coastal and Shelf Sci., Vol. II, p. 77-92. AGU, Washington, D.C.

Poole, J.C. 1966. A review of research concerning summer flounder and needs for further study. N.Y. Fish and Game Journal 13(2):226-231.

Powell, D. 1975. Age, growth, and reproduction in Florida stocks of Spanish mackerel, *Scomberomorus maculatus*. Fla. Mar. Res. Publ. No. 5, 21 p.

Powell, A.B. and F.J. Schwartz. 1977. Distribution of Paralichthid Flounders (Bothidae: Paralichthys) in North Carolina estuaries. Chesapeake Science 18(4):334-339.

Powell, A.B., and F.J. Schwartz. 1979. Food of *Paralichthys dentatus* and *P. lethostigma* (Pisces:Bothidae) in North Carolina estuaries. Estuaries 4:276-279.

Powles, H., and B.W. Stender. 1976. Observations on composition, seasonality and distribution of ichthyoplankton from MARMAP cruises in the South Atlantic Bight in 1973. S.C. Mar. Resour. Ctr. Tech. Rep. 11, 47 p.

Powles, H., and B.W. Stender. 1978. Taxonomic data on the early life history stages of Sciaenidae of the South Atlantic Bight of the United States. S.C. Mar. Resour. Ctr. Tech. Rep. No. 31, 62 p.

Purvis, C.E., and E.G. McCoy. 1974. Pink-brown shrimp discard studies in the Core-Pamlico Sound area. Division of Commercial and Sports Fisheries, NCDNR. Special Scientific Report No. 26, 18 p.

Randall, J.E., and R. Vergara. 1978. Bothidae. In: Fischer, W. (ed). FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. V.

Renfro, W.C., and H.A. Brusher. 1982. Seasonal abundance, size distribution, and spawning of three shrimps (*Penaeus aztecus*, *P. setiferus*, and *P. duorarum*) in the northwestern Gulf of Mexico, 1961-1962. U.S. Dept. of Comm., NOAA, NMFS, NOAA Tech. Memorandum NMFS-SEFC-94, 24 p.

Ross, S.W. 1988. Age, growth, and mortality of Atlantic Croaker in North Carolina, with comments on population dynamics. Trans. Am. Fish. Soc. 117:461-473.

Saloman, C.H., and S.P. Naughton. 1983. Food of king mackerel, *Scomberomorus cavalla*, from the southeastern United States including the Gulf of Mexico. U.S. Dept. of Comm., NOAA, Nat. Mar. Fish. Serv., NOAA Tech.Rep., NMFS-SEFC-126, 25 p.

Schmidt, D.J., M.R. Collins, and D.M. Wyanski. 1993. Age, growth, maturity, and spawning of Spanish mackerel, *Scomberomorus maculatus* (Mitchell), from the Atlantic Coast of the southeastern United States. Fish. Bull. 91:526-533.

Schwartz, F.J., W.T. Hogarth, and M.P. Weinstein. 1982. Marine and freshwater fishes of the Cape Fear estuary, North Carolina, and their distribution in relation to environmental factors. Brimleyana 7:17-37.

Sedberry, G.S. and H.R. Beatty. 1989. A visual census of fishes on a jetty at Murrells Inlet, South Carolina. Journ. Eli. Mitch. Sci. Soc. 105(2):59-74.

Shipman, S. 1980. Penaeid shrimp migration and growth along the Georgia coast. Annual report October 1979 - September 1980. Ga. Dept. Nat. Res., Coast. Res. Div, 46 p.

Smith, J.W., and C.A. Wenner. 1985. Biology of the southern kingfish in the South Atlantic Bight. Trans. Amer. Fish. Soc. 114:356-366.

Smith, R.W., and F.C. Daiber. 1977. Biology of the summer flounder, *Paralichthys dentatus*, in Delaware Bay. Fish. Bull. Vol. 75, No. 4, pp 823-830.

Smith, W., P. Berrien, and T. Potthoff. 1994. Spawning patterns of bluefish, *Pomatomus saltatrix*, in the Northeast Continental Shelf Ecosystem. Bull. Mar. Sci., 54(1):8-16.

Smith, W.G. 1973. The distribution of summer flounder, *Paralichthys dentatus*, eggs and larvae on the continental shelf between Cape Cod and Cape Lookout, 1965-66. Fish. Bull., U.S. 71(2):527-535.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. W. H. Freeman and Co., New York.

South Atlantic Fishery Management Council. 1981. Profile of the penaeid shrimp fishery in the south Atlantic. SAFMC, Charleston, S.C.

Stokes, G.M. 1977. Life history studies of southern flounder (*Paralichthys dentatus*) and gulf flounder (*P. albigutta*) in the Aransas Bay area of Texas. Texas Park and Wild. Dept. Tech. Series #25.

Struhsaker, P. 1969. Demersal fish resources: Composition, distribution, and commercial potential of the continental shelf stocks off southeastern United States. Fish. Ind. Res. 4:261-300.

Sutter, F.C., III, R.O. Williams, and M.F. Godcharles. 1991. Movement patterns and stock affinities of king mackerel in the southeastern United States. Fish. Bull. 89:315-324.

Thomas, D.L. 1971. The early life history and ecology of six species of drum (Sciaenidae) in the lower Delaware River, a brackish tidal estuary. (An ecological study of the Delaware River in the vicinity of Artificial Island, Pt. III). Ichthyological Assoc. Bull. No. 3, 247 p.

U.S. Dept. Comm. NOAA/NMFS Fisheries Statistics Division. 1995. Fisheries of the United States, 1994: Current Fishery Statistics No. 9400, 113 p.

US Dept. of Interior, Fish and Wildlife Service and Dept. of Commerce, Bureau of Census. 1993. 1991 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. US Government Printing Office, Washington, DC.

Wallace, D.H. 1940. Sexual development of the croaker, *Micropogon undulatus* and distribution of the early stages in Chesapeake Bay. Trans. Am. Fish. Soc. 70:475-482.

Warlen, S.M. 1982. Age and growth of larvae and spawning of Atlantic croaker in North Carolina. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agen. 34:204-214.

Warlen, S.M. and J.S. Burke. 1990. Immigration of larvae of fall/winter spawning marine fishes into a North Carolina estuary. Estuaries Vol. 13, No. 4, p 453-461.

Warlen, S.M. and A.J. Chester. 1985. Age, growth, and distribution of larval spot, *Leiostomus xanthurus*, off North Carolina. Fish. Bull. 83(4):587-599.

Webster, R.P., H.R. Beatty, and E.L. Wenner. 1990. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY-1989. SEAMAP-SA Final Report, 66 p.

Weinstein, M.P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, N.C. Fish. Bull. 77:339-357.

Welsh, W.W., and C.M. Breder, Jr. 1923. Contributions to life histories of Sciaenidae of the eastern United States coast. Fish. Bull. 39:141-201.

Wenner, C.A. 1983. Species associations and day-night variability of trawl caught fishes from the inshore sponge-coral habitat, South Atlantic Bight. Fish. Bull 81:537-552.

Wenner, C.A., and G.R. Sedberry. 1989. Species composition, distribution, and relative abundance of fishes in the coastal habitat of the Southeastern United States. U.S. Dept. Comm. NOAA Tech. Rep., NMFS-SSRF-79, 49 p.

Wenner, C.A., C.A. Barans, B.W. Stender and F.H. Berry. 1979a. Results of MARMAP otter trawl investigations in the South Atlantic Bight. I. Fall, 1973. Tech Rep. 33, S.C. Mar. Resour. Cent., Charleston, SC, 79 p.

Wenner, C.A., C.A. Barans, B.W. Stender and F.H. Berry. 1979b. Results of MARMAP otter trawl investigations in the South Atlantic Bight. II. Spring, 1974. Tech Rep. 40, S.C. Mar. Resour. Cent., Charleston, SC, 79 p.

Wenner, C.A., C.A. Barans, B.W. Stender and F.H. Berry. 1979c. Results of MARMAP otter trawl investigations in the South Atlantic Bight. III. Summer, 1974. Tech Rep. 41, S.C. Mar. Resour. Cent., Charleston, SC, 62 p.

Wenner, C.A., C.A. Barans, B.W. Stender and F.H. Berry. 1980. Results of MARMAP otter trawl investigations in the South Atlantic Bight. V. Summer, 1975. Tech Rep. 45, S.C. Mar. Resour. Cent., Charleston, SC, 57 p.

Wenner, C.A., W.A. Roumillat, J.E. Moran, Jr., M.B. Maddox, L.B. Daniel, III, and J.W. Smith. 1990. Investigations on the life history and population dynamics of marine recreational fishes in South Carolina: Part 1. Final Report to U.S. Fish and Wild. Ser. Fed. Aid in Sport Fish Rest. Act.

Wenner, E.L., H.R. Beatty, and D. Stephan. 1987. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY 86-87. SEAMAP-SA Final Report, 55 p.

Wenner, E.L., D.M. Knott, R.F. Van Dolah, and V.G. Burrell, Jr. 1983. Invertebrate communities associated with hard bottom habitats in the South Atlantic Bight. Est. Coast. Shelf Sci. 17:143-158.

Wenner, E.L., M.H. Shealy, Jr., and P.A. Sandifer. 1982. A profile of the fish and decapod crustacean community in a South Carolina estuarine system prior to flow alteration. U.S. Dep. Comm., NOAA Tech. Rep., NMFS SSRF-757, 17 p.

White, M.L., and M.E. Chittenden, Jr. 1977. Age determination, reproduction, and population dynamics of the Atlantic croaker, Micropogonias undulatus. Fish. Bull. 75:109-123.

Wilk, S.J. 1977. Biological and fisheries data on bluefish, *Pomatomus saltatrix*. Sandy Hook Laboratory, Northeast Fish. Center, NMFS, NOAA, U.S. Dept. of Comm., Tech. Ser. Rep. No. 11., 55 p.

Wilk, S.J., W.G. Smith, D.E. Ralph, and J. Sibunka. 1980. Population structure of summer flounder between New York and Florida based on linear discriminant analysis. Trans. Am. Fish. Soc. 109:265-271.

Williams, A.B. 1974. The swimming crabs of the genus *Callinectes* (Decapoda:Portunidae). Fish. Bull. 72(3):685-798.

Williams, A.B. 1984. Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press, Washington, D.C., 550 p.

Windom, H.L., and R.G. Smith, Jr. 1985. Factors influencing the concentration and distribution of trace metals in the South Atlantic Bight. In: Atkinson, D.W. Menzel, and K.A. Bush (eds.),. Oceanography of the Sutheastern U.S. Continental Shelf, Coastal and Shelf Science. vol. 2, L.P.. AGU, Washington, D.C. pp. 141-152.

Wollam, A.B. 1970. Description and distribution of larvae and early juveniles of king mackerel, *Scomberomorus cavalla* (Cuvier), and Spanish mackerel, *Scombermorus maculatus* (Mitchill); (Pisces:Scombridae) in the western North Atlantic. Fla. Dept. Nat. Resour. Mar. Res. Lab. Tech. Ser. No. 61, 35 p.

Zar, J.H. 1984. Biostatistical Analysis. Second ed., Prentice-Hall, Inc., Englewood Cliffs, N.J. 718 p.

Appendix 1. Occurrence of all decapod and stomatopod crustacean species from 1987 and 1988 SEAMAP collections.

| RANK | SPECIES NAME | PERCENT OCCURRENCE |
|---|---|---|
| 1 | *Portunus gibbesii* | 88.1 |
| 2 | *Callinectes similis* | 85.3 |
| 3 | *Penaeus aztecus* | 80.4 |
| 4 | *Squilla empusa** | 80.1 |
| 5 | *Hepatus epheliticus* | 76.3 |
| 6 | *Arenaeus cribrarius* | 76.9 |
| 7 | *Penaeus setiferus* | 71.5 |
| 8 | *Callinectes sapidus* | 66.7 |
| 9 | *Portunus spinimanus* | 66.3 |
| 10 | *Squilla neglecta** | 63.1 |
| 11 | *Ovalipes ocellatus* | 62.5 |
| 12 | *Ovalipes stephensoni* | 58.3 |
| 13 | *Penaeus duorarum* | 55.1 |
| 14 | *Callinectes ornatus* | 53.8 |
| 15 | *Pagurus pollicaris* | 52.9 |
| 16 | *Libinia dubia* | 47.1 |
| 17 | *Libinia emarginata* | 44.2 |
| 18 | *Persephona mediterranea* | 44.2 |
| 19 | *Trachypenaeus constrictus* | 38.5 |
| 20 | *Calappa flammea* | 30.8 |
| 21 | *Menippe mercenaria* | 16.7 |
| 22 | *Xiphopenaeus kroyeri* | 7.4 |
| 23 | *Pilumnus sayi* | 4.5 |
| 24 | *Porcellana sigsbeiana* | 4.5 |
| 25 | *Neopanope sayi* | 4.2 |
| 26 | *Pagurus longicarpus* | 2.9 |

| RANK | SPECIES NAME | PERCENT OCCURRENCE |
| --- | --- | --- |
| 27 | *Sicyonia brevirostris* | 2.9 |
| 28 | *Emerita talpoida* | 2.2 |
| 29 | *Albunea paretii* | 1.3 |
| 30 | *Lysiosquilla scabricauda** | 1.3 |
| 31 | *Portunus sayi* | 1.3 |
| 32 | *Lysmata wurdemanni* | 0.6 |
| 33 | *Porcellana sayana* | 0.6 |
| 34 | *Calappa sulcata* | 0.3 |
| 35 | *Cronius ruber* | 0.3 |
| 36 | *Exhippolysmata oplophoroides* | 0.3 |
| 37 | *Metapenaeopsis sp.* | 0.3 |
| 38 | *Panopeus herbstii* | 0.3 |
| 39 | *Scyllarus chacei* | 0.3 |
| 40 | *Sicyonia laevigata* | 0.3 |

*Stomatopods

Appendix 2. Occurence of finfish species from 1987 and 1988 SEAMAP collections.

| RANK | SPECIES NAME | PERCENT OCCURRENCE |
|---|---|---|
| 1 | *Leiostomus xanthurus* | 93.0 |
| 2 | *Menticirrhus americanus* | 92.6 |
| 3 | *Etropus crossotus* | 88.5 |
| 4 | *Micropogonias undulatus* | 81.7 |
| 5 | *Peprilus paru* | 81.7 |
| 6 | *Scomberomorus maculatus* | 78.2 |
| 7 | *Larimus fasciatus* | 77.9 |
| 8 | *Opisthonema oglinum* | 77.9 |
| 9 | *Anchoa hepsetus* | 77.6 |
| 10 | *Cynoscion regalis* | 76.0 |
| 11 | *Chloroscombrus chrysurus* | 74.4 |
| 12 | *Anchoa mitchilli* | 73.7 |
| 13 | *Citharichthys macrops* | 70.8 |
| 14 | *Paralichthys dentatus* | 70.5 |
| 15 | *Chaetodipterus faber* | 64.4 |
| 16 | *Synodus foetens* | 64.1 |
| 17 | *Stellifer lanceolatus* | 62.5 |
| 18 | *Symphurus plagiusa* | 61.2 |
| 19 | *Scophthalmus aquosus* | 56.7 |
| 20 | *Selene setapinnis* | 56.4 |
| 21 | *Cynoscion nothus* | 54.2 |
| 22 | *Trinectes maculatus* | 54.2 |
| 23 | *Ariopsis felis* | 53.2 |
| 24 | *Prionotus scitulus* | 50.3 |
| 25 | *Brevoortia tyrannus* | 49.7 |
| 26 | *Peprilus triacanthus* | 47.8 |

| RANK | SPECIES NAME | PERCENT OCCURRENCE |
|---|---|---|
| 27 | *Prionotus tribulus* | 46.2 |
| 28 | *Pomatomus saltatrix* | 42.9 |
| 29 | *Paralichthys lethostigma* | 42.6 |
| 30 | *Orthopristis chrysoptera* | 41.7 |
| 31 | *Lagodon rhomboides* | 40.1 |
| 32 | *Anchoa lyolepis* | 37.8 |
| 33 | *Citharichthys spilopterus* | 37.2 |
| 34 | *Centropristis philadelphica* | 35.6 |
| 35 | *Scomberomorus cavalla* | 34.9 |
| 36 | *Prionotus salmonicolor* | 30.1 |
| 37 | *Chilomycterus schoepfi* | 29.5 |
| 38 | *Menticirrhus littoralis* | 28.8 |
| 39 | *Prionotus evolans* | 28.5 |
| 40 | *Selene vomer* | 28.5 |
| 41 | *Sphyraena guachancho* | 27.2 |
| 42 | *Trichiurus lepturus* | 26.9 |
| 43 | *Bairdiella chrysoura* | 25.3 |
| 44 | *Stephanolepis hispidus* | 20.2 |
| 45 | *Trachinotus carolinus* | 17.0 |
| 46 | *Ancylopsetta quadrocellata* | 16.7 |
| 47 | *Sphoeroides maculatus* | 16.0 |
| 48 | *Bagre marinus* | 15.1 |
| 49 | *Eucinostomus gula* | 15.1 |
| 50 | *Porichthys porosissimus* | 13.5 |
| 51 | *Caranx hippos* | 12.8 |
| 52 | *Menticirrhus saxatilis* | 12.5 |
| 53 | *Stenotomus Sp.* | 12.2 |
| 54 | *Prionotus carolinus* | 9.9 |

| *RANK* | *SPECIES NAME* | PERCENT OCCURRENCE |
|---|---|---|
| *55* | *Paralichthys albigutta* | 9.6 |
| *56* | *Caranx crysos* | 9.0 |
| *57* | *Centropristis striata* | 9.0 |
| *58* | *Eucinostomus argenteus* | 8.7 |
| *59* | *Sardinella aurita* | 6.7 |
| *60* | *Ophidion marginata* | 6.4 |
| *61* | *Syngnathus louisianae* | 5.8 |
| *62* | *Hippocampus erectus* | 5.4 |
| *63* | *Decapterus punctatus* | 4.8 |
| *64* | *Rachycentron canadum* | 3.5 |
| *65* | *Lutjanus griseus* | 3.2 |
| *66* | *Urophycis regia* | 3.2 |
| *67* | *Etropus cyclosquamus* | 2.9 |
| *68* | *Mugil curema* | 2.9 |
| *69* | *Paralichthys squamilentus* | 2.9 |
| *70* | *Urophycis earlli* | 2.9 |
| *71* | *Bothus robinsi* | 2.6 |
| *72* | *Ophichthus ocellatus* | 2.6 |
| *73* | *Alectis ciliarius* | 2.2 |
| *74* | *Aluterus schoepfi* | 2.2 |
| *75* | *Myrophis punctatus* | 2.2 |
| *76* | *Diplectrum formosum* | 1.9 |
| *77* | *Hyporhamphus unifasciatus* | 1.9 |
| *78* | *Mycteroperca microlepis* | 1.9 |
| *79* | *Archosargus probatocephalus* | 1.6 |
| *80* | *Cynoscion nebulosus* | 1.6 |
| *81* | *Lutjanus synagris* | 1.6 |

| RANK | SPECIES NAME | PERCENT OCCURRENCE |
|---|---|---|
| 82 | *Membras martinica* | 1.6 |
| 83 | *Ophichthus gomesi* | 1.6 |
| 84 | *Astroscopus y-graecum* | 1.3 |
| 85 | *Brevoortia smithi* | 1.3 |
| 86 | *Gymnachirus melas* | 1.3 |
| 87 | *Hypleurochilus geminatus* | 1.3 |
| 88 | *Hypsoblennius hentzi* | 1.3 |
| 89 | *Ogcocephalus parvus* | 1.3 |
| 90 | *Priacanthus cruentatus* | 1.3 |
| 91 | *Elops saurus* | 1.0 |
| 92 | *Etropus microstomus* | 1.0 |
| 93 | *Menidia beryllina* | 1.0 |
| 94 | *Echeneis neucratoides* | 1.0 |
| 95 | *Syngnathus fuscus* | 1.0 |
| 96 | *Bothus ocellatus* | 0.6 |
| 97 | *Diplodus holbrooki* | 0.6 |
| 98 | *Lagocephalus laevigatus* | 0.6 |
| 99 | *Ophidion grayi* | 0.6 |
| 100 | *Pogonias cromis* | 0.6 |
| 101 | *Strongylura marina* | 0.6 |
| 102 | *Acipenser oxyrhynchus* | 0.3 |
| 103 | *Alosa aestivalis* | 0.3 |
| 104 | *Balistes capriscus* | 0.3 |
| 105 | *Echeneis naucrates* | 0.3 |
| 106 | *Gobiosoma bosci* | 0.3 |
| 107 | *Hemiramphus sp.* | 0.3 |
| 108 | *Lutjanus campechanus* | 0.3 |

| *RANK* | *SPECIES NAME* | PERCENT OCCURRENCE |
|---|---|---|
| *109* | *Mugil cephalus* | 0.3 |
| *110* | *Oligoplites saurus* | 0.3 |
| *111* | *Opsanus pardus* | 0.3 |
| *112* | *Opsanus tau* | 0.3 |
| *113* | *Pagrus pagrus* | 0.3 |
| *114* | *Seriola zonata* | 0.3 |
| *115* | *Serranus sp.* | 0.3 |
| *116* | *Serranus subligarius* | 0.3 |
| *117* | *Trachurus lathami* | 0.3 |
| *118* | *Trachinotus falcatus* | 0.3 |
| *119* | *Upeneus parvus* | 0.3 |

Appendix 3. Occurrence of elasmobranch species from 1987 and 1988 SEAMAP collections.

| RANK | SPECIES NAME | PERCENT OCCURRENCE |
| --- | --- | --- |
| 1 | *Rhizoprionodon terraenovae* | 56.7 |
| 2 | *Dasyatis sabina* | 30.2 |
| 3 | *Dasyatis sayi* | 28.8 |
| 4 | *Raja eglanteria* | 28.2 |
| 5 | *Gymnura micrura* | 20.8 |
| 6 | *Mustelus canis* | 11.5 |
| 7 | *Rhinoptera bonasus* | 10.6 |
| 8 | *Dasyatis americana* | 9.0 |
| 9 | *Sphyrna tiburo* | 5.8 |
| 10 | *Sphyrna lewini* | 5.1 |
| 11 | *Myliobatis freminvillei* | 4.2 |
| 12 | *Narcine brasiliensis* | 1.9 |
| 13 | *Aetobatus narinari* | 1.6 |
| 14 | *Dasyatis centroura* | 1.0 |
| 15 | *Rhinobatos lentiginosus* | 1.0 |
| 16 | *Carcharhinus acronotus* | 0.6 |
| 17 | *Carcharhinus limbatus* | 0.6 |
| 18 | *Carcharhinus plumbeus* | 0.6 |

Appendix 4. Number of finfish, elasmobranch and crustacean species by Station, Cruise, and Site in 1987 and 1988.

| | 1987 | | | | 1988 | | | |
|---|---|---|---|---|---|---|---|---|
| Station | Cape Lookout | Cape Fear | South Carolina | Georgia | Cape Lookout | Cape Fear | South Carolina | Georgia |
| Crustaceans | 23 | 31 | 31 | 26 | 24 | 31 | 31 | 28 |
| Elasmobranchs | 8 | 10 | 11 | 10 | 11 | 11 | 11 | 10 |
| Finfish | 80 | 70 | 73 | 58 | 91 | 82 | 74 | 68 |
| Total | 111 | 111 | 115 | 94 | 126 | 124 | 116 | 94 |

| | 1987 | | | | | 1988 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cruise | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Crustaceans | 29 | 25 | 31 | 28 | 28 | 28 | 26 | 26 | 28 | 22 | 26 | 25 | 27 |
| Elasmobranchs | 7 | 8 | 9 | 10 | 8 | 10 | 10 | 10 | 7 | 13 | 9 | 7 | 9 |
| Finfish | 69 | 70 | 73 | 80 | 68 | 65 | 69 | 60 | 66 | 65 | 63 | 73 | 72 |
| Total | 105 | 103 | 113 | 118 | 104 | 103 | 105 | 96 | 101 | 100 | 98 | 105 | 108 |

| | 1987 | | | 1988 | | |
|---|---|---|---|---|---|---|
| Site | Inlet | Beach | Offbeach | Inlet | Beach | Offbeach |
| Crustaceans | 32 | 30 | 32 | 37 | 29 | 30 |
| Elasmobranchs | 13 | 13 | 12 | 14 | 13 | 13 |
| Finfish | 88 | 81 | 87 | 96 | 77 | 94 |
| Total | 133 | 124 | 131 | 147 | 119 | 137 |

Appendix 5. Target species for the 1987 and 1988 sampling efforts. Effort was 120 trawl tows in 1987 (and the last 5 cruises in 1988) and 192 trawl tows for all of 1988. Estimates for the last five cruises of 1988 are indicated in parentheses.

| | Total | | 1987 | | | 1988 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | x/tow | Number | x/tow | %occur | Number | (Number) | x/tow | (x/tow) | %occur | (%occur) |
| FINFISH | | | | | | | | | | | |
| ***Micropogonias undulatus*** | 177,999 | 570.5 | 31,150 | 259.6 | 77.5 | 146,849 | (18,215) | 764.8 | (236.8) | 84.4 | (79.2) |
| ***Leiostomus xanthurus*** | 98,342 | 315.2 | 26,633 | 221.9 | 90.8 | 71,709 | (29,553) | 373.5 | (246.3) | 94.3 | (97.5) |
| ***Menticirrhus americanus*** | 31,522 | 101.1 | 13,170 | 109.8 | 91.7 | 18,352 | (14,767) | 95.6 | (123.1) | 93.2 | (99.2) |
| ***Cynoscion regalis*** | 9,057 | 29.0 | 1,320 | 11.0 | 83.3 | 7,737 | (3,351) | 40.3 | (27.9) | 81.3 | (82.5) |
| ***Scomberomorus maculatus*** | 3,786 | 12.1 | 996 | 8.3 | 76.7 | 2,790 | (1,883) | 14.5 | (15.7) | 79.2 | (89.2) |
| ***Scomberomorus cavalla*** | 976 | 3.1 | 220 | 1.8 | 37.5 | 756 | (734) | 3.9 | (6.1) | 33.3 | (48.0) |
| ***Chaetodipterus faber*** | 3,198 | 10.3 | 1,535 | 12.8 | 75.8 | 1,663 | (1,626) | 8.7 | (13.6) | 57.3 | (79.2) |
| ***Pomatomus saltatrix*** | 1,972 | 6.3 | 251 | 2.1 | 31.7 | 1,721 | (1,611) | 9.0 | (13.4) | 50.0 | (50.8) |
| ***Paralichthys dentatus*** | 1,395 | 4.5 | 665 | 5.5 | 74.2 | 730 | (464) | 3.8 | (4.0) | 68.2 | (68.3) |
| ***Paralichthys lethostigma*** | 319 | 1.0 | 176 | 1.5 | 46.7 | 143 | (101) | 0.7 | (0.8) | 40.1 | (42.5) |
| DECAPODS | | | | | | | | | | | |
| ***Penaeus aztecus*** | 25,523 | 81.8 | 3,248 | 27.1 | 79.2 | 22,275 | (13,659) | 116.0 | (113.8) | 81.3 | (93.3) |
| ***Penaeus setiferus*** | 15,080 | 48.3 | 6,555 | 54.6 | 83.3 | 8,525 | (7,025) | 44.4 | (58.5) | 64.1 | (71.0) |
| ***Penaeus duorarum*** | 8,057 | 25.8 | 1,023 | 8.5 | 50.0 | 7,034 | (3,335) | 36.6 | (27.8) | 58.3 | (63.3) |
| ***Callinectes sapidus*** | 3,136 | 10.1 | 1,977 | 16.5 | 64.2 | 1,159 | (679) | 6.0 | (5.7) | 68.2 | (68.3) |