STOCK ASSESSMENT OF ADULT FISHES IN THE CORE SOUND, N.C. AREA

by

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ABSTRACT

Three marketable sciaenids (spot, croaker, and weakfish) dominated the Core Sound long haul seine fishery, comprising 71.2 and 76.9% of the total sample by number and weight during May-October 1979 and 67.1 and 65.1% by number and weight during April-September 1980. Spot, croaker, and weakfish in the long haul samples ranged from 86 to 292 mm FL, 96 to 385 mm TL, and 154 to 645 mm TL. A total of 1,412 spot were aged using scales. Mean back-calculated lengths of spot for 1979 and 1980, respectively, were: age 1, 134 and 135 mm FL; age 2, 204 and 202 mm; age 3, 224 and 231 mm; and age 4, 293 and 289 mm. The marketable catch of spot was composed of mostly age one and two fish, while croaker catches were dominated by one year olds, and weakfish catches by one and two year olds. In 1979 Core Sound pound net catches, southern, summer, and Gulf flounders, and harvestfish comprised 90% of the samples by number, with the three flounders comprising 93.1% of the samples by weight. Southern flounder ranked first, comprising 80.7% by number and 93.7% by weight of the flounder catch. *Paralichthys lethostigma* ranged from 225 to 630 mm TL; *P. dentatus* and *P. albigutta* ranged from 200 to 504 mm and 250 to 387 mm TL. Percent age composition of the southern flounder catch in 1979 for ages 1-4 was 20.9, 36.9, 41.7, and 0.7%. Core Sound crab pot catches in March and April 1979 were dominated by female blue crabs, which comprised 57.0 - 99.5% of the samples, with an overall mean of 84.6%. Sponge crabs appeared quite suddenly in early April, and by late April comprised 69.1% of the female catch. The mean monthly percentage of legal-sized ($\geq$ 127 mm CW) female crabs taken by crab trawl was 90.0%. Sponge crabs comprised 90.9, 59.5, 70.4, and 48.4% of the legal-sized female catch in the crab trawl in August 1979 and May, July, and August 1980. Four species - spot, croaker, weakfish, and bluefish - comprised the majority of sink net landings in 1979. Croaker sampled from sink net catches ranged from 264 to 365 mm TL, and spot ranged from 221 to 302 mm FL. Most of the croaker were most likely approaching or had reached age three. Almost 90% of the spot were ages one and two.

INTRODUCTION

Core Sound is a shallow, saline body of water about 3 km wide and 40 km long adjoining southern Pamlico Sound to the north and Back Sound, behind Cape Lookout, to the south. It has an area of about 24,000 ha and an average depth of 1 - 1.2 m with a maximum of about 3 m (Roelofs and Bumpus 1953). Connected to the Atlantic Ocean by Drum and Barden Inlets, salinities usually range from 20 - 30°/oo and the bottom is primarily sand and/or seagrass (*Zostera marina* and *Halodule wrightii*).

Core Sound supports several important fisheries, including shrimp trawling, long haul seining, pound netting, purse seining, crab potting and trawling, clamming, and scalloping. In 1978 and 1979, Core Sound landings, excluding menhaden, comprised 5.4 and 6.5% of the total North Carolina landings and 8.7 and 10.8% of their value. Despite the significant contributions these fisheries make to North Carolina's landings, only the shrimp and scallop fisheries, and to a much lesser degree the pound net fishery, have been studied in recent years (McCoy 1973; Purvis and McCoy 1972, 1974; Wolff 1977; Spitsbergen 1979). Higgins and Pearson (1928) examined in detail the long haul and pound net fisheries in Pamlico and Core Sounds in 1925. Related past research in Core Sound includes studies of adult blue crab movements (Judy and Dudley 1970) and seasonal abundance and distribution of juvenile blue crabs (Dudley and Judy 1973) and a nursery area survey along the Outer Banks (Wolff 1976).

This study was initiated to gather such information as size, age, and species composition and traditional fishing areas, seasons, and gear for those important fisheries which have gone unstudied, including the long haul seine, pound net, crab pot, and sinking gill net ("sink net") fisheries. These data are extremely vital if fishery managers, faced with ever increasing demands on limited resources, are to make intelligent, informed decisions on managing these resources and their users.

DESCRIPTION OF THE FISHERIES

Long Haul Seine Fishery

The long haul seine is about 1100-1450 m long, 3 m deep, and composed of several sections. Sections toward the ends of the net, called wing nets, contain 5.1 - 5.7 cm bar mesh and are progressively detached during the hardening up process. The center sections, called back nets, contain 1.9 - 2.9 cm bar mesh. The seine, which is pulled by two 9.2 - 13.7 m boats for distances of 2 - 4 km, is fished in 2.4 - 3 m of water over smooth bottom and bunted or hardened up in 1 - 1.2 m of water. More detailed descriptions of the long haul fishery, the gear and its use, and the history of the fishery were given in Guthrie et al. (1973) and DeVries (in press).

The long haul seine fishery in Core Sound lasts from about April to mid-November. From April through August almost all haul seining occurs in the northern half of the sound, especially in Cedar Island Bay and Shell Cove (Figure 1). These two areas are strongly influenced by Pamlico Sound and are usually several parts per thousand fresher than the rest of Core Sound. During September hauling activity increases in the central part of the sound. In October and November, when vast numbers of migratory spot are present, long hauling occurs throughout the sound wherever suitable bottom is available. The seines are almost always pulled towards, and hardened up along the western shore or in the large bays there.

About six or seven long haul crews, each usually comprised of six men, fish Core Sound throughout the season, although there is seldom more than one crew present on any one day from April through August. In late summer, two or three other crews begin hauling Core Sound regularly, and during the fall spot run in October and November an additional seven or eight crews from Harkers Island join the fishery. These additional crews usually use smaller boats, shorter seines, and fish primarily in southern Core Sound and Back Sound.

Pound Net Fishery

Pounds nets in Core Sound are usually fished from late September or early October through late November or December, depending on weather conditions and fish availability.

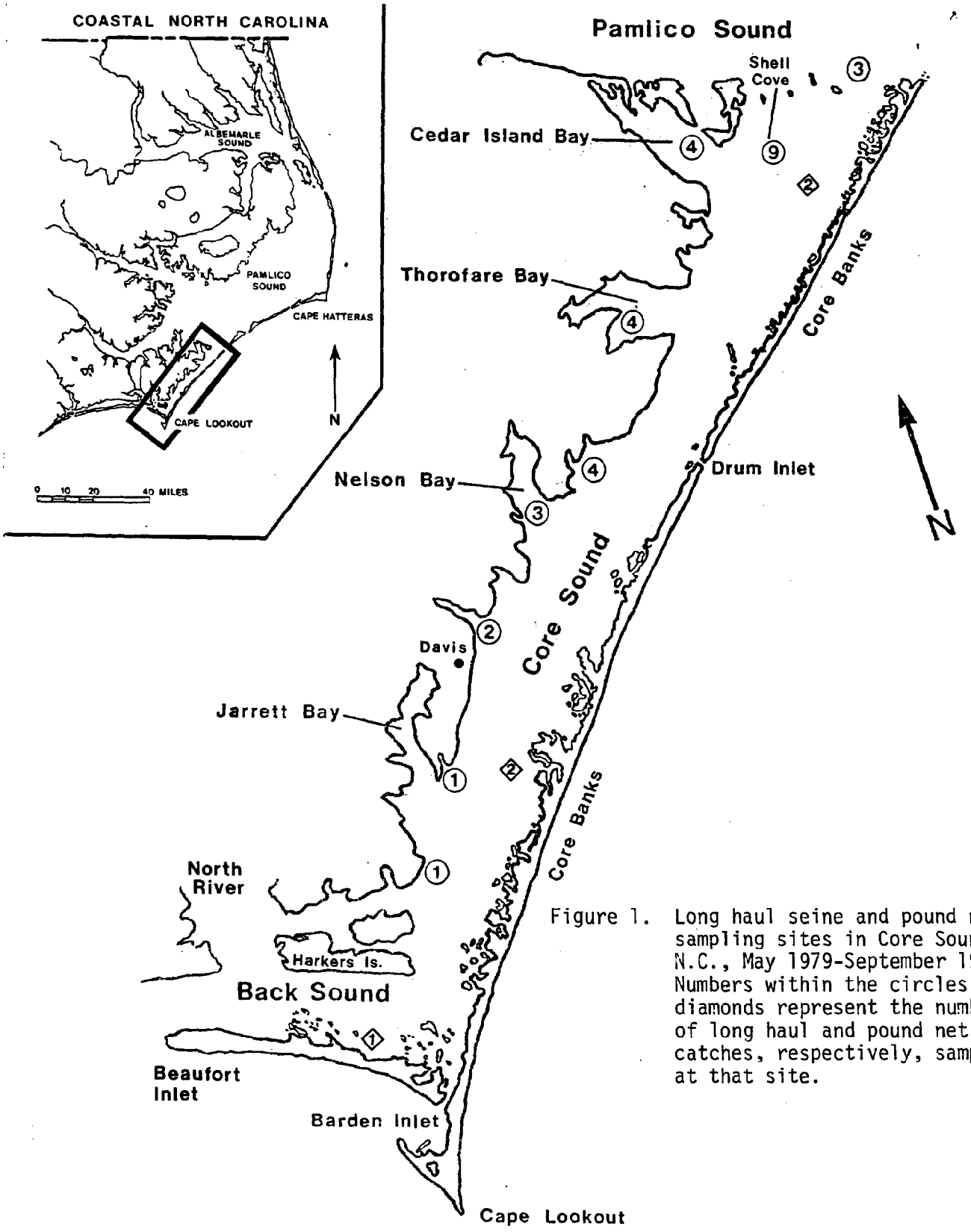

Figure 1. Long haul seine and pound net sampling sites in Core Sound, N.C., May 1979-September 1980. Numbers within the circles and diamonds represent the number of long haul and pound net catches, respectively, sampled at that site.

Wolff (1977) described the gear and the fishing methods. One of the nets sampled in this study was constructed of 15.2 cm stretched mesh in the leads and 7.6 cm stretched mesh in the hearts and pounds. These mesh sizes are probably typical for most Core Sound pound nets, although one Back Sound net had 30.5 cm stretched mesh in the leads to minimize problems with strong currents and rafts of filamentous green algae. The nets are fished in depths from <1 to about 2 m. Sets contain from 1 to 25 leads and pounds in a continuous row, although the longer sets sometimes have one small break about midway to allow boats to pass through.

Fishermen begin placing new stakes and nets in August and September. Although few, if any, nets are fished after December, many are not taken up until later in the winter or early spring. The greatest number of pound nets are located from Drum Inlet to the northern end of the sound and most of these are on the eastern side, although some are placed in the middle of the sound and a few smaller sets can be found on the western shore (Figure 1). Wolff (1977) noted that over two-thirds of the pound net sets registered in 1976-77 were located between Portsmouth Island (Ocracoke Inlet) and Nelson Bay in Core Sound. Most of the nets south of Drum Inlet are also on the banks side and several small stands are located throughout the southern side of Back Sound.

Pound nets are usually fished by two, and occasionally three men. Often two boats are used. A large 7.6 - 10.7 m inboard-powered boat is used to get to and from the net and to transport large catches to the fish house and a 4.9 - 6.1 outboard-powered skiff is used to fish the pounds and transport the catch to the larger boat.

The nets are fished from daily to weekly, depending on the weather, size of the catches, and market conditions. The largest catches usually occur during and immediately after periods of strong northerly winds. The only species culled at the nets are sting rays and horseshoe crabs.

Blue Crab Fishery

The blue crab (*Callinectes sapidus*) pot fishery may last most of the year in Core Sound, although effort peaks in March, April, and May. Very limited winter potting may occur around Drum Inlet (Figure 2).

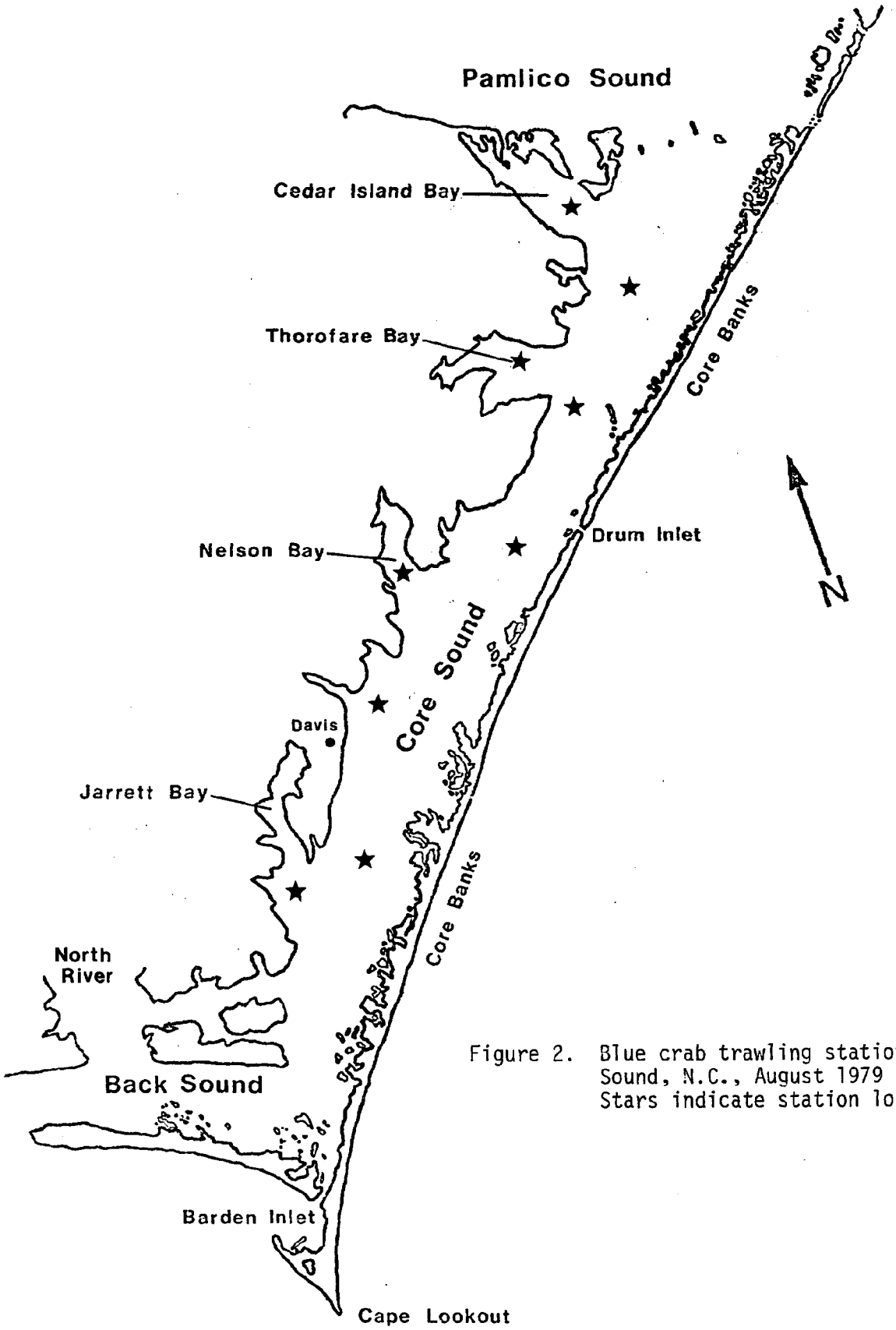

Figure 2. Blue crab trawling stations in Core Sound, N.C., August 1979 - August 1980. Stars indicate station locations.

Potting occurs throughout the sound and in the larger bays on the mainland side. The start of shrimping and decreasing crab prices in late spring each year signals the end of crabbing in the sound for all but a few fishermen in the northern portion. Few want to risk the loss of many $10 pots to shrimp trawls.

Fishing pressure is greatest by far from Thorofare Bay north. This area is fished primarily by fishermen from Cedar Island, probably the most important crabbing center on Core Sound.

Normally one or two men will fish 100 - 300 pots from daily to weekly, depending on the weather, market conditions, and the catches. Crab potters typically use a 4.9 - 6.1 wood or fiberglass, outboard (occasionally inboard) skiff.

A relatively minor crab trawl fishery operated during the spring from about Nelson Bay north. In addition, a minor peeler crab trawl fishery operates in the creeks and grass beds behind Core Banks each spring. The peeler crabs are caught in small 2.4 - 3.7 m trawls pulled by small skiffs and held for shedding and sale in the soft crab market.

Sink Net Fishery

The sink net fishery is concentrated in the Atlantic Ocean from Cape Lookout to Beaufort Inlet, from near shore to several kilometers offshore in depths from 6.1 to 27.4 m over smooth sand bottom. Occasionally fishermen will travel as far as Bogue Inlet, 40 km east of Beaufort Inlet, to fish, and some of the larger boats sometimes fish the east side of Cape Lookout and Core Banks, particularly in the fall. Each boat carries 2-4 men and 365 -1550 m of monofilament gill net (typically 4.1 cm bar mesh although sizes may vary slightly) about 40 meshes deep and weighted to sink. The boats are usually 6.1 - 13.7m multi-purpose vessels. Most fishermen set and retrieve nets manually; very few use hydraulic net reels or net haulers. The season usually lasts from November through March, although the fishery operates very intermittently during that period because the fishermen require fairly calm seas and concentrations of fish. Nets are usually set only after there is some indication of a school of fish on an electronic fish finder. All fishing occurs during the day and fishermen return home each night.

METHODS

Long Haul Seine Fishery

From one to seven long haul catches were sampled monthly from May to October 1979 and April to September 1980. At least one unculled 36 kg fish basket sample (and two or three whenever possible) was obtained from each catch as it was being transferred from the net to the "run" or "buy" boat. Five catches were sampled at the fish house by shoveling the unculled catch in the run boat into a 36 kg fish basket. All fish in the sample were identified to species and measured to the nearest millimeter fork length (FL) or total length (TL), depending on the shape of the tail for a given species, or disc width (DW) for skates and rays. Component weights to the nearest 0.2 kg were taken for Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*),weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), and all remaining species combined, and total weight was determined by summing the components. Additional species observed in the catch but not present in the samples were noted. When time permitted, scales were taken from the area below the lateral line just posterior to the pectoral fin from croaker, spot, and weakfish. Additional scale samples were obtained from another Division project studying the long haul fishery in Pamlico Sound. Scales were washed with water and examined on a microfiche reader at 36x magnification.

Pound Net Fishery

Pound net catches were sampled in October and November 1979. At least four unculled 36 kg fish basket samples were shoveled or dipnetted from each catch. In two cases the entire catch was processed. Processing was the same as that for long haul seine catches, except that component weights were taken for southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), Gulf flounder (*P. algibutta*), and all other species combined. Species observed in the catch but not present in the samples were noted. Blind side otoliths (sagittae) were taken from all *P. lethostigma* over 99 mm TL collected during Division sampling throughout the state, from whole carcasses obtained at a local fish house, and from fish gigged by Division personnel.

Otoliths, which were stored dry,were placed in a black-bottomed watch glass containing water and examined with a dissecting microscope using reflected light. The white, opaque rings were considered annuli (Powell 1974) and measurements were made to the outer edge of these rings slightly anterior to the right lateral edge (with the otoliths lying concave side up and the anterior or most pointed end oriented away from the observer). Measurements were made with an ocular micrometer. All juvenile *P. lethostigma* collected by trawl during Division sampling were measured to the nearest millimeter TL, and monthly length frequencies were developed and used to validate ageing by otoliths.

Blue Crab Fishery

In March and April 1979, approximately 20 pots were sampled from the strings of each of two fishermen, one in northern and one in southern Core Sound, twice a month. All crabs were measured to the nearest millimeter carapace width (CW), and sex, female maturity, and spawning condition were noted. Soak time of the pots to the nearest 24 hr was also noted, and catch per soak time (C/f) was computed. After April and for the rest of the year, crab potting dropped to such a very low level because of increased shrimp trawling activity that sampling was stopped. Because of the reduced fishery and very real problems in developing reliable C/f information using commercial pot data, crab pot sampling was not resumed in 1980.

In August 1979 a monthly trawling program was initiated to examine annual changes in relative abundance of blue crabs. Ten stations were established in a variety of habitats and depths throughout the sound (Figure 2). Sampling was conducted at night with a 6.1 m, 1.9 cm bar mesh, two seam otter trawl with a heavily chained foot rope and a tickler chain. Tow duration was 15 min the first month, but for logistical reasons, was reduced to 10 min in all subsequent months. Sampling occurred in August and October 1979 and May-August 1980. All blue crabs were processed in the same manner used in crab pot sampling. Bottom and surface temperature and salinity were taken with each sample.

Sink Net Fishery

This very intermittent fishery was sampled in March, November, and December, 1979. When possible, sink net catches were sampled and processed in the same manner as long haul catches. For the first two catches sampled, measurements were taken on 50 - 135 spot and/or croaker taken at random from the catch. Scale samples were obtained from most catches. Mesh size of the gill nets sampled was recorded.

RESULTS AND DISCUSSION

Long Haul Seine Fishery

Species composition

Fifty samples were taken from 31 long haul catches, 18 during May - October 1979 and 13 during April - September 1980. Twenty catches were sampled in northern, nine in central, and two in southern Core Sound (Figure 1).

Sixty-one species of fish, six species of invertebrates, and one species of sea turtle were observed in the long haul catches (Tables 1 and 2). Despite the large diversity overall, five species of fish - spot, croaker, weakfish, menhaden, and pinfish (*Lagodon rhomboides*) - comprised 93.1% by number of the samples during May - October 1979 and 88.5% during April - September 1980. Three marketable sciaenids (spot, croaker, and weakfish) dominated the fishery, comprising 71.2 and 76.9% of the total sample by number and weight during May - October 1979 and 67.1 and 65.1% by number and weight during April - September 1980. Menhaden is the only other species which contributed significant numbers and weight to the catches. Pinfish, although numerically abundant, contributed little weight because of their small size.

Monthly percent composition in numbers and weight for spot, croaker, weakfish, menhaden, and all other species combined was quite variable and no clear trends were discernable (Table 3). A very large proportion of the total weight of all fish sampled in October was contributed by spot, corresponding with the annual migration and large catches of marketable spot

Table 1 . Species composition by number and weight of samples taken from 18 Core Sound long haul seine catches during May - October 1979.

Species	No.	%	Weight (kg)	%	No. catches in which species was observed	Size range (mmFL)[2]
Leiostomus xanthurus	3785	43.9	431.5	43.4	18	86-292
Micropogonias undulatus	1295	15.0	134.7	13.5	17	96-385[3]
Cynoscion regalis	1058	12.3	199.1	20.0	16	154-645[3]
Brevoortia tyrannus	947	11.0	104.9	10.6	17	95-261
Lagodon rhomboides	943	10.9			18	82-210
Orthopristis chrysoptera	165	1.9			15	93-230
Peprilus alepidotus	104	1.2	124.1[1]	12.5[1]	12	58-165
Pomatomus saltatrix	72	0.8			16	101-520
Bairdiella chrysoura	64	0.7			11	106-208[3]
Menticirrhus americanus	45	0.5			14	210-382[3]
Opisthonema oglinum	20	0.2			4	140-190
Dasyatis sabina	13	0.2			15	178-321[4]
Selene vomer	13	0.2			9	44-120
Peprilus triacanthus	13	0.2			7	128-196
Monacanthus hispidus	13	0.2			4	70- 92[3]
Cynoscion nebulosus	11	0.1			12	140-448[3]
Prionotus evolans	9	0.1			4	172-212[3]
Chaetodipterus faber	8	0.1			6	70-122
Caranx hippos	8	0.1			3	96-133
Callinectes sapidus	5	0.1			10	35-105[5]
Citharichthys spilopterus	5	0.1			2	105-130[3]
Paralichthys dentatus	4	<.1			8	108-441[3]
Synodus foetens	4	<.1			3	227-297
Prionotus tribulus	3	<.1			4	105-230[3]
Etropus crossotus	3	<.1			3	108-129[3]
Rhinoptera bonasus	2	<.1			9	510-515[4]
Chloroscombrus chrysurus	2	<.1			3	63- 70
Paralichthys lethostigma	2	<.1			3	238-318[3]
Opsanus tau	2	<.1			2	156-186[3]
Chilomycterus schoepfi	1	<.1			8	242[3]
Prionotus scitulus	1	<.1			3	157[3]
Penaeus duorarum	1	<.1			1	128[3]
Limulus polyphemus					5	
Sphoeroides maculatus					5	
Mustelus canis					4	
Carcharhinus plumbeus					3	
Paralichthys spp.					3	
Raja eglanteria					2	
Dasyatis sayi					2	

Table 1. (continued)

Species	No.	%	Weight (kg)	%	No. catches in which species was observed	Size range (mmFL)[2]
Rachycentron canadum					2	
Aluterus schoepfi					2	
Penaeus aztecus					1	
Dasyatis spp.					1	
Dorosoma cepedianum					1	
Anchoa hepsetus					1	
Strongylura marina					1	
Trachinotus carolinus					1	
Lutjanus griseus					1	
Diapterus auratus					1	
Eucinostomus spp.					1	
Archosargus probatocephalus					1	
Scomberomorus maculatus					1	
Caretta caretta					1	

[1]Total weight and % weight for all species except *Leiostomus*, *Micropogonias*, *Cynoscion regalis*, and *Brevoortia*.

[2]Except where noted.

[3]Total length

[4]Disc width

[5]Carapace width

Table 2. Species composition by number and weight and size ranges of samples taken from 13 Core Sound long haul seine catches during April - September 1980.

Species	No.	%	Weight (kg)	%	No. catches in which species was observed	Size range (mm FL)[2]
Micropogonias undulatus	2261	38.0	182.1	35.6	11	115-354[3]
Leiostomus xanthurus	1359	22.8	84.8	16.6	13	90-260
Brevoortia tyrannus	679	11.4	30.7	6.0	12	111-220
Lagodon rhomboides	558	9.4			12	68-235
Cynoscion regalis	411	6.9	66.0	12.9	13	162-384[3]
Orthopristis chrysoptera	122	2.1			9	82-250
Pomatomus saltatrix	109	1.8			10	156-426
Bairdiella chrysoura	56	0.9	147.6[1]	28.9[1]	6	116-212[3]
Peprilus triacanthus	52	0.9			8	97-182
Peprilus alepidotus	50	0.8			3	111-193
Callinectes sapidus	35	0.6			9	80-171[4]
Monacanthus hispidus	35	0.6			8	60-149[3]
Paralichthys dentatus	26	0.4			9	142-338[3]
Selene vomer	26	0.4			5	52-140
Etropus crossotus	26	0.4			2	80-121[3]
Prionotus evolans	24	0.4			6	108-206[3]
Dasyatis sabina	21	0.4			10	149-306[5]
Menticirrhus americanus	17	0.3			12	133-332[3]
Citharichthys spilopterus	14	0.2			3	77-119[3]
Mustelus canis	10	0.2			5	193-400[3]
Paralichthys lethostigma	9	0.1			6	206-385[3]
Opisthonema oglinum	9	0.1			4	141-186
Chilomycterus schoepfi	6	0.1			4	138-188[3]
Cynoscion nebulosus	6	0.1			4	247-423[3]
Prionotus tribulus	6	0.1			3	64-164[3]
Synodus foetens	6	0.1			2	166-273
Prionotus scitulus	4	0.1			2	142-160[3]
Caranx crysos	2	<.1			2	90-164
Stenotomus caprinus	2	<.1			1	124-125
Dasyatis sayi	1	<.1			6	305[5]
Caranx hippos	1	<.1			3	191
Dasyatis americana	1	<.1			1	292[5]
Diplodus holbrooki	1	<.1			1	91
Scomberomorus maculatus	1	<.1			1	278
Selene setapinnis	1	<.1			1	44
Sphoeroides maculatus	1	<.1			1	132-151[3]
Rachycentron canadum					3	
Carcharhinus plumbeus					2	
Portunus spinimanus					2	
Limulus polyphemus					1	
Portunus spp.					1	
Carcharhinus leucas					1	

Table 2. (continued)

Species	No.	%	Weight (kg)	%	No. Catches in which species was observed	Size range (mm FL)[2]
Negaprion brevirostris					1	
Gymnura spp.					1	
Rhinoptera bonasus					1	
Mycteroperca microlepis					1	
Alectis crinitis					1	
Archosargus probatocephalus					1	
Menticirrhus saxatilis					1	
Mugil cephalus					1	
Trichiurus lepturus					1	
Ancylopsetta quadrocellata					1	
Paralichthys albigutta					1	
Caretta caretta					1	

[1]Total weight and % weight for all species except *Leiostomus, Micropogonias, Cynoscion regalis* and *Brevoortia.*

[2]Except where noted

[3]Total length

[4]Carapace width

[5]Disc width

Table 3 . Monthly and mean percent composition (by number and weight) of Core Sound long haul seine catches for May-October 1979 and April-September 1980.

	1979						1980						Unweighted	
	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	mean	Species
N	1306	442	126	84	250	1577	160	199	379	187	193	241		
%N	57.5	33.3	27.4	19.0	32.4	47.1	29.8	32.1	29.5	12.1	15.0	36.2	31.0	*Leiostomus*
Wt.(kg)	91.2	38.6	21.5	13.6	17.7	249	8.4	15.2	12.0	13.4	23.6	12.2		*xanthurus*
%Wt.	37.7	25.5	23.3	18.0	26.9	67.9	22.2	27.5	33.2	8.4	13.8	23.6	27.3	
N	213	362	72	156	97	395	341	140	573	691	397	119		
%N	9.4	27.2	15.7	35.2	12.6	11.8	63.5	22.6	44.6	30.8	17.9	11.8	25.3	*Micropogonias*
Wt.(kg)	16.6	37.6	20.4	25.4	7.7	27.0	21.8	12.7	7.9	78.0	53.1	8.6		*undulatus*
%Wt.	6.8	24.9	22.1	33.6	11.7	7.4	57.5	23.0	21.9	49.2	31.0	16.6	25.5	
N	562	350	3	72	11	60	28	59	92	193	29	10		
%N	24.8	26.3	0.7	16.3	1.4	1.8	5.2	9.5	7.2	12.5	2.2	1.5	9.1	*Cynoscion*
Wt.(kg)	106.8	54.4	4.8	16.8	3.2	13.2	5.4	12.9	10.2	28.3	5.2	3.9		*regalis*
%Wt.	44.1	36.0	5.1	22.2	4.8	3.6	14.4	23.4	28.2	17.9	3.0	7.4	17.5	
N	121	137	107	93	267	222	28	59	92	193	29	10		
%N	5.3	10.3	23.3	21.0	34.6	6.6	0.2	31.3	12.8	19.9	0.2	1.4	13.9	*Brevoortia*
Wt.(kg)	9.3	9.8	24.3	12.7	24.0	24.9	0.2	7.9	2.0	19.1	0.1	1.4		*tyrannus*
%Wt.	3.8	6.4	26.2	16.8	36.5	6.8	0.6	14.3	5.6	12.0	0.1	2.6	11.0	
N	68	38	152	38	147	1093	7	27	78	170	669	287		
%N	3.0	2.9	33.0	8.6	19.0	32.7	1.3	4.4	6.1	11.0	59.9	43.1	18.1	All other
Wt.(kg)	18.1	10.9	21.5	7.0	13.3	52.6	2.0	6.6	4.0	19.7	89.5	25.9		species
%Wt.	7.5	7.2	23.3	9.3	20.1	14.3	5.4	11.9	11.0	12.4	52.2	49.8	18.7	combined
No. catches sampled	3	3	2	1	2	7	1	1	3	2	4	2		

in the sound then. The October landings in 1978, 1979, and 1980 comprised 77.4, 90.0, and 72.2% of the total annual Core Sound spot landings (Table 4). Mean monthly percent composition (Table 3) probably presents the best picture of overall annual order of importance. By mean percent number, spot ranked first, croaker second, menhaden third, and weakfish fourth. By mean percent weight, spot ranked first, croaker second, weakfish third, and mehnaden fourth. These rankings of spot, croaker, and weakfish by weight agree with the landings data for Core Sound, 1978-1980 (Table 4).

Table 4 also indicates the importance of Core Sound spot landings to the total North Carolina spot landings; during 1978-1980 they comprised 22.2, 29.2, and 24.3% of the state total. In contrast, croaker and weakfish from Core Sound comprised only 0.9 - 2.0% of the total croaker and weakfish landings during 1978-1980.

The number of species observed each month tended to increase as the season progressed, especially in 1979, when 42 and 34 species were noted in August and September, compared to 11 and 15 in April and May (Table 5). Ross and Carpenter (1980) observed a similar peak in diversity in Pamlico Sound long haul catches in July and August. The overall diversity of Core Sound catches was much higher than Pamlico Sound catches. Sixty-one species of fish were observed in 31 Core Sound catches during May-October 1979 and April-September 1980, whereas 39 species were observed in 44 Pamlico Sound catches during April-August 1979 (Ross and Carpenter 1980). This greater diversity is probably linked to the presence of inlets and numerous seagrass beds and the higher salinities in Core Sound.

Except for spot, croaker and weakfish, species important to recreational fishermen were present in only trace amounts in Core Sound long haul seine catches. Those recreational species noted in the samples and their overall numerical percent composition were: bluefish (*Pomatomus saltatrix*), 1.2%; southern kingfish (*Menticirrhus americanus*), 0.4%; summer flounder (*P. dentatus*), 0.2%; southern flounder (*P. lethostigma*),0.08%; spotted seatrout (*Cynoscion nebulosus*), 0.07%; and Spanish mackerel (*Scomberomorus maculatus*),0.007%. Other recreational species never taken in a sample but observed in the catches are listed in Tables 1 and 2.

Size and age composition

Overall size ranges for all species taken in the samples are given in

Table 4. Monthly Core Sound spot landings and annual landings of spot, croaker, and weakfish from Core Sound and all of North Carolina, 1978-1980, for all gears (Data are in kg).

Species	Month	1978[1]	1979[1]	1980[1]
Spot	Jan		208	238
	Feb			924
	Mar		773	391
	Apr	3,020	666	2,549
	May	136	1,599	8,357
	Jun	2,604	15,473	10,359
	Jul	2,100	6,842	7,685
	Aug	27,364	14,662	15,536
	Sep	49,930	31,471	77,226
	Oct	379,062	871,544	565,759
	Nov	22,002	21,742	93,290
	Dec	3,728	3,576	903
	Total Core Sound	489,946	968,556	783,217
	% of total N.C. spot landings	22.2	29.2	24.3
	Total N.C. spot landings	2,212,624	3,312,769	3,220,530
Croaker	Total Core Sound	160,497	128,604	195,739
	% of total N.C. croaker landings	1.8	1.4	2.0
	Total N.C. croaker landings	9,046,900	9,325,040	9,592,026
Weakfish	Total Core Sound	93,823	60,498	138,692
	% of total N.C. weakfish landings	1.9	0.9	1.5
	Total N.C. weakfish landings	4,921,024	6,694,659	9,227,861

[1]Preliminary landings, data subject to revision in the Fishery Statistics of the United States.

Table 5. Monthly frequency of species occurrence in Core Sound long haul seine catches, May - October 1979 and April - September 1980. Numbers in parentheses indicate the number of catches sampled each month.

	1979						1980					
	May (3)	Jun (3)	Jul (2)	Aug (1)	Sep (2)	Oct (7)	Apr (1)	May (1)	Jun (3)	Jul (2)	Aug (4)	Sep (2)
Limulus polyphemus					1	4						1
Callinectes sapidus	1	2	1	1	1	4	1		2	1	3	2
Peneaus aztecus		1										
Peneaus duorarum		1										
Portunus spinimanus											1	1
Portunus spp.												1
Carcharhinus leucas										1		
Carcharhinus milberti	1				1				1	1		
Mustelus canis	2				1	1		1	3	1		
Negaprion brevirostris												1
Raja eglanteria		1				1						
Dasyatis americana												1
Dasyatis sabina	3	2	1	1	2	6	1	1	2		4	2
Dasyatis sayi	1		1							1	4	1
Dasyatis spp.		1										
Gymnura spp.												1
Rhinoptera bonasus	3	2				4					1	
Brevoortia tyrannus	3	3	1	1	2	7	1	1	3	2	3	2
Dorosoma cepedianum						1						
Opisthonema oglinum	2		1			1					2	2
Anchoa hepsetus						1						
Synodus foetens					1	2					1	1
Opsanus tau				1		1						
Strongylura marina			1									
Mycteroperca microlepis											1	
Pomatomus saltatrix	2	3	2	1	2	6		1	1	2	4	2
Rachycentron canadum			2						1		2	
Alectis crinitus											1	
Caranx crysos											1	1
Caranx hippos					2	1					2	1

Table 5 . (continued)

	1979						1980					
	May (3)	Jun (3)	Jul (2)	Aug (1)	Sep (2)	Oct (7)	Apr (1)	May (1)	Jun (3)	Jul (2)	Aug (4)	Sep (2)
Chloroscombrus chysurus					1	2						
Selene vomer			1	1	2	5				1	3	1
Selene setapinnis											1	
Trachinotus carolinus						1						
Lutjanus griseus						1						
Diapterus auratus						1						
Eucinostomus spp.						1						
Orthopristis chysoptera	1	2	2	1	2	7		1	1	2	3	2
Archosargus probatocephalus						1					1	
Diplodus holbrooki											1	
Lagodon rhomboides	3	3	2	1	2	7	1	1	3	2	3	2
Stenotomus caprinus											1	
Bairdiella chrysoura	3	1	1		2	4	1		2	1	2	
Cynoscion nebulosus	1	3	2		1	5	1	1		1	1	
Cynoscion regalis	3	3	1	1	2	6	1	1	3	2	4	2
Leiostomus xanthurus	3	3	2	1	2	7	1	1	3	2	4	2
Menticirrhus americanus	3	2		1	2	6	1	1	3	2	3	2
Menticirrhus saxatilis											1	
Micropogonias undulatus	3	3	2	1	2	6	1	1	3	2	2	2
Chaetodipterus faber						6					1	2
Mugil cephalus										1		
Trichiurus lepturus											1	
Scomberomorus maculatus						1					1	
Peprilus alepidotus	3	3			1	5		1	1	2	2	2
Peprilus triacanthus					1	6		1	2	2	2	1
Prionotus evolans		2		1	2	4				2	2	2
Prionotus scitulus						3					1	1
Prionotus tribulus		1	1			2			2	1		
Ancylopsetta quadrocellata										1		
Citharichthys spilopterus						2				1	1	1
Etropus crossotus						3					1	1
Paralichthys albigutta												1

Table 5. (continued)

	1979						1980					
	May (3)	Jun (3)	Jul (2)	Aug (1)	Sep (2)	Oct (7)	Apr (1)	May (1)	Jun (3)	Jul (1)	Aug (4)	Sep (2)
Paralichthys dentatus	2	2	1		1	2	1	1	3	2	1	1
Paralichthys lethostigma	1		1					1	1	1	2	1
Paralichthys spp.		1										2
Aluterus schoepfi				1		1						
Monacanthus hispidus		1	1			2			1	2	4	1
Sphoeroides maculatus					1	4					1	
Chilomycterus schoepfi	2		1	1		4				2	2	
Caretta caretta						1						1

Tables 1 and 2. Monthly length frequency distributions for spot, croaker, weakfish, and menhaden are presented in Figures 3 - 6 and for many other of the more abundant species in Tables 6 and 7. Because of the very large area fished by a long haul seine and the small mesh in the back nets, this gear is quite unselective (above a minimum size determined by the gear) for most demersal species. This lack of selectivity makes long haul catch data an excellent source of information on the life history and population dynamics of those demersal species. Because pelagic and some benthic species are much more likely to swim over or under the net, data on those species from long haul catches is much less useful.

Spot in the long haul catches ranged from 86 to 292 mm FL (Figure 3), with 94.5% <240 mm and 99.3% <260 mm. Of the 5.5% ≥240 mm, 92% were collected in October 1979. In 1925 Higgins and Pearson (1928) found spot ranging from 109 to 269 mm FL in Pamlico and Core Sound long haul catches, with 95.4% <240 mm and 99.5% <260 mm. Sholar (1979), in a study of long hauling in Pamlico Sound, found that spot <190 mm FL were usually classified as scrap and utilized as crab pot bait. In this study, 68.7% of the spot were <190 mm, compared to Sholar's (1979) value of 59%. Although the percent scrap by number is quite high, by weight, because of the small size of the fish, the value would certainly be much smaller.

Croaker in Core Sound ranged from 96 to 385 mm TL, with 97.0% <270 mm and 98.5% <290 mm (Figure 4). Of the fish ≥270 mm, 94.7% were taken in July and August 1979 and August 1980, suggesting that large individuals are present in greater numbers then. In contrast, Higgins and Pearson (1928) and Ross and Carpenter (1980) collected significantly higher percentages of croaker from 270 to 320 mm in Pamlico Sound long haul catches. Using 240 mm TL as the minimum marketable size (Sholar 1979), 90.4% of the croaker from Core Sound were not marketable - a much higher value than Sholar's (1979) 48% from Pamlico Sound.

Weakfish in Core Sound long haul catches ranged from 154 to 645 mm TL, with 96.8% <330 mm and 99.1% <370 mm (Figure 5). In comparison, Ross and Carpenter (1980) found 85.2% <330 mm and 95.3% <370 mm in Pamlico Sound long haul samples, suggesting that greater numbers of large weakfish may be available there. Using 220 mm TL as the minimum marketable size (Sholar 1979), only 24.7% of Core Sound

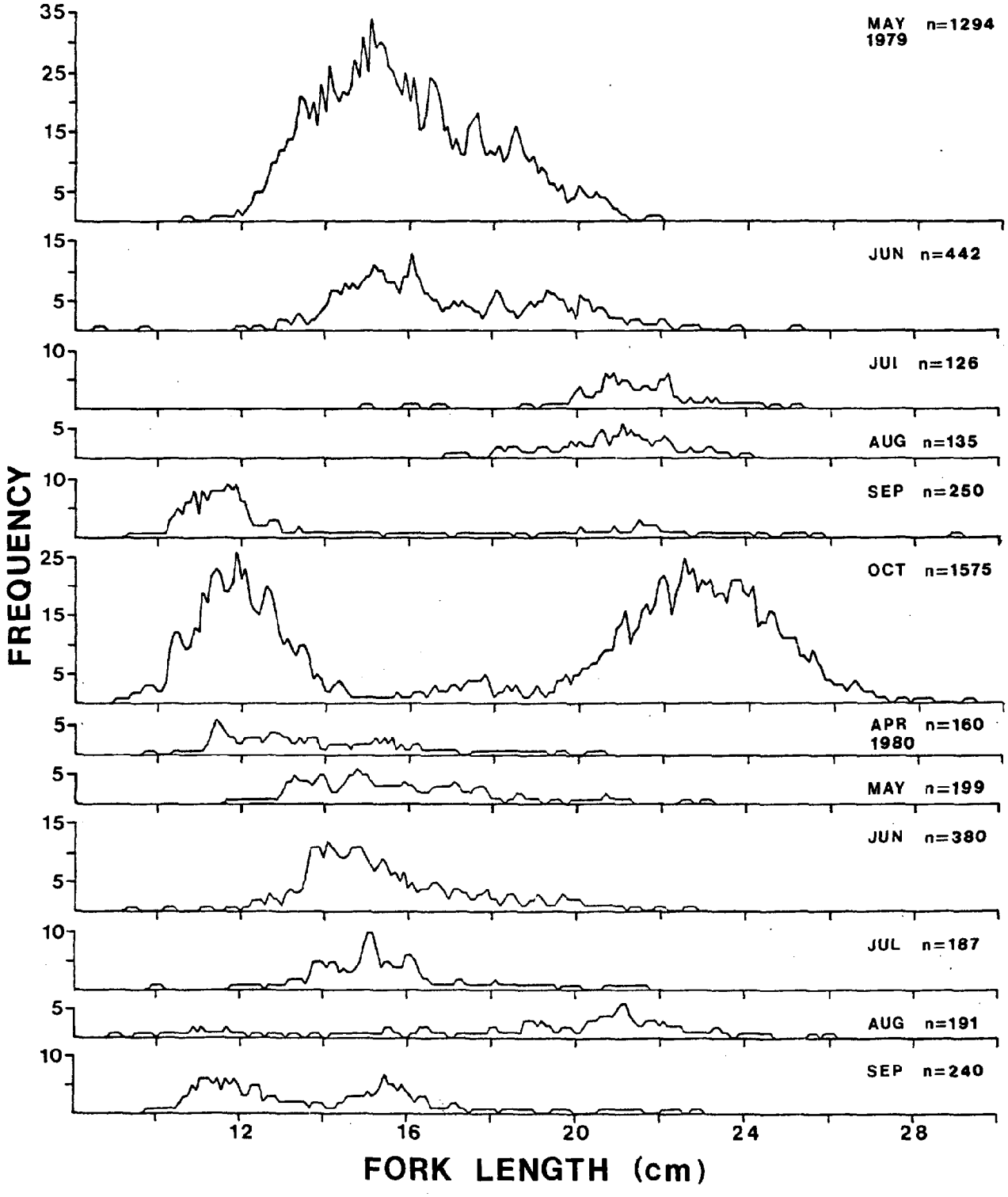

Figure 3. Monthly length frequencies (moving averages of three) of *Leiostomus xanthurus* captured in long haul seines in Core Sound, N.C., May 1979 - September 1980.

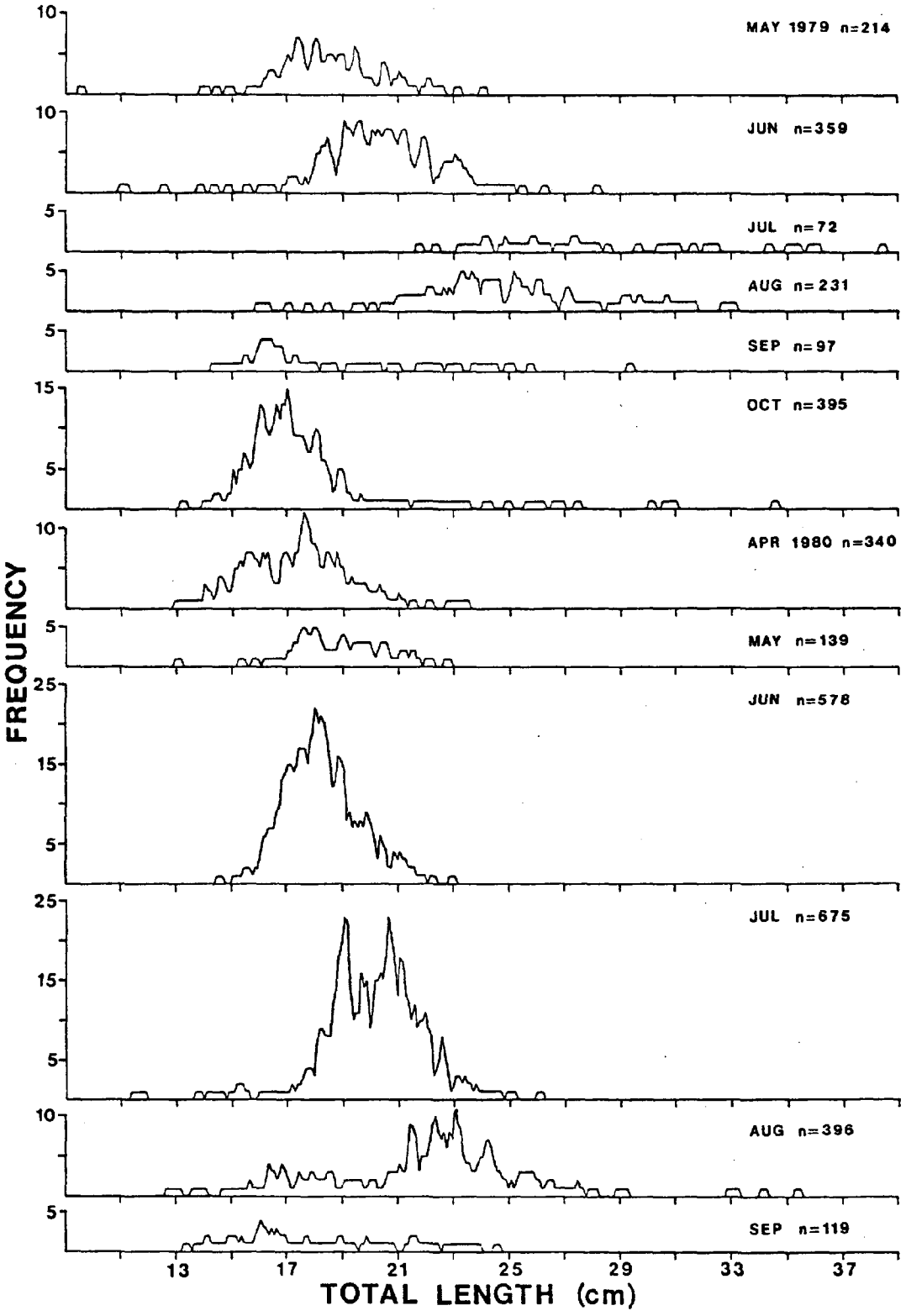

Figure 4. Monthly length frequencies (moving averages of three) of *Micropogonias undulatus* captured in long haul seines in Core Sound, N.C., May 1979 - September 1980.

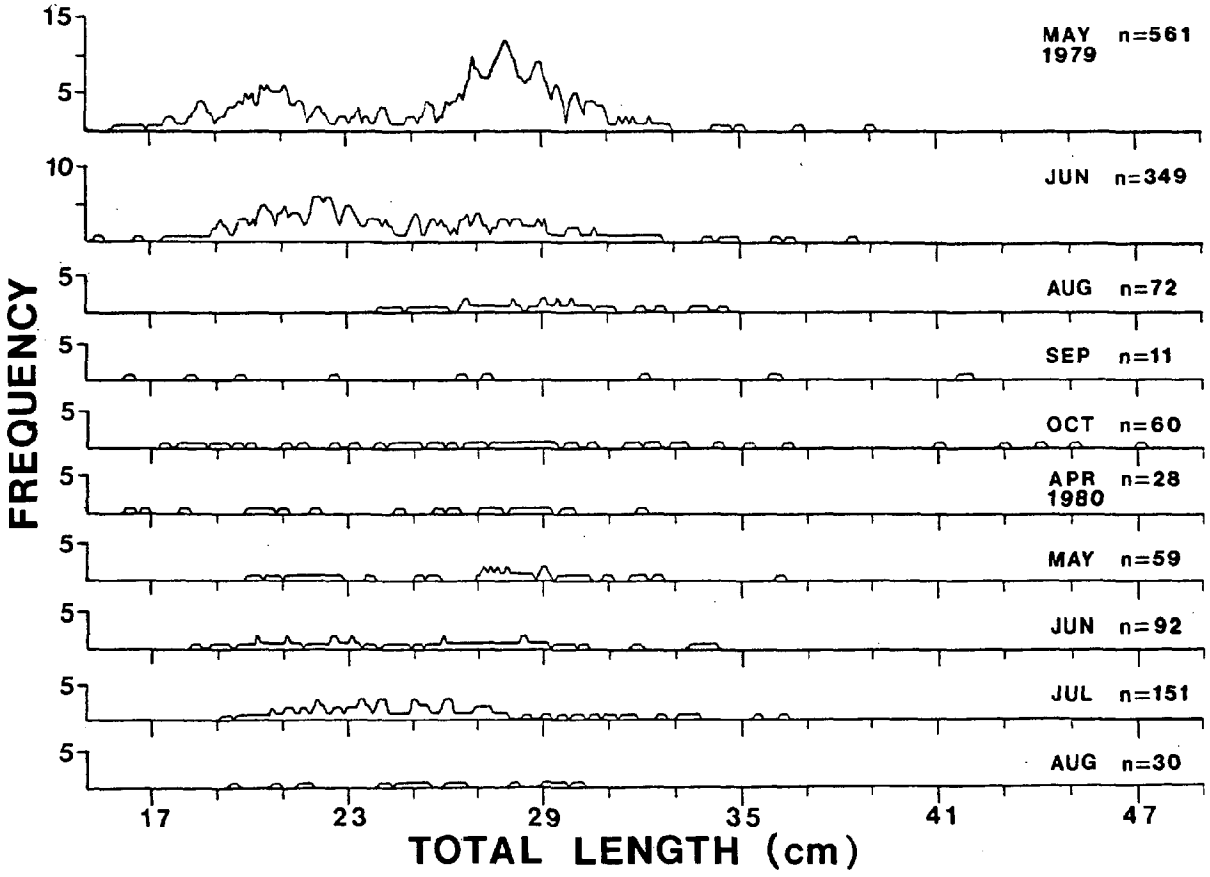

Figure 5. Monthly length frequencies (moving averages of three) of *Cynoscion regalis* captured in long haul seines in Core Sound, N.C., May 1979 - August 1980.

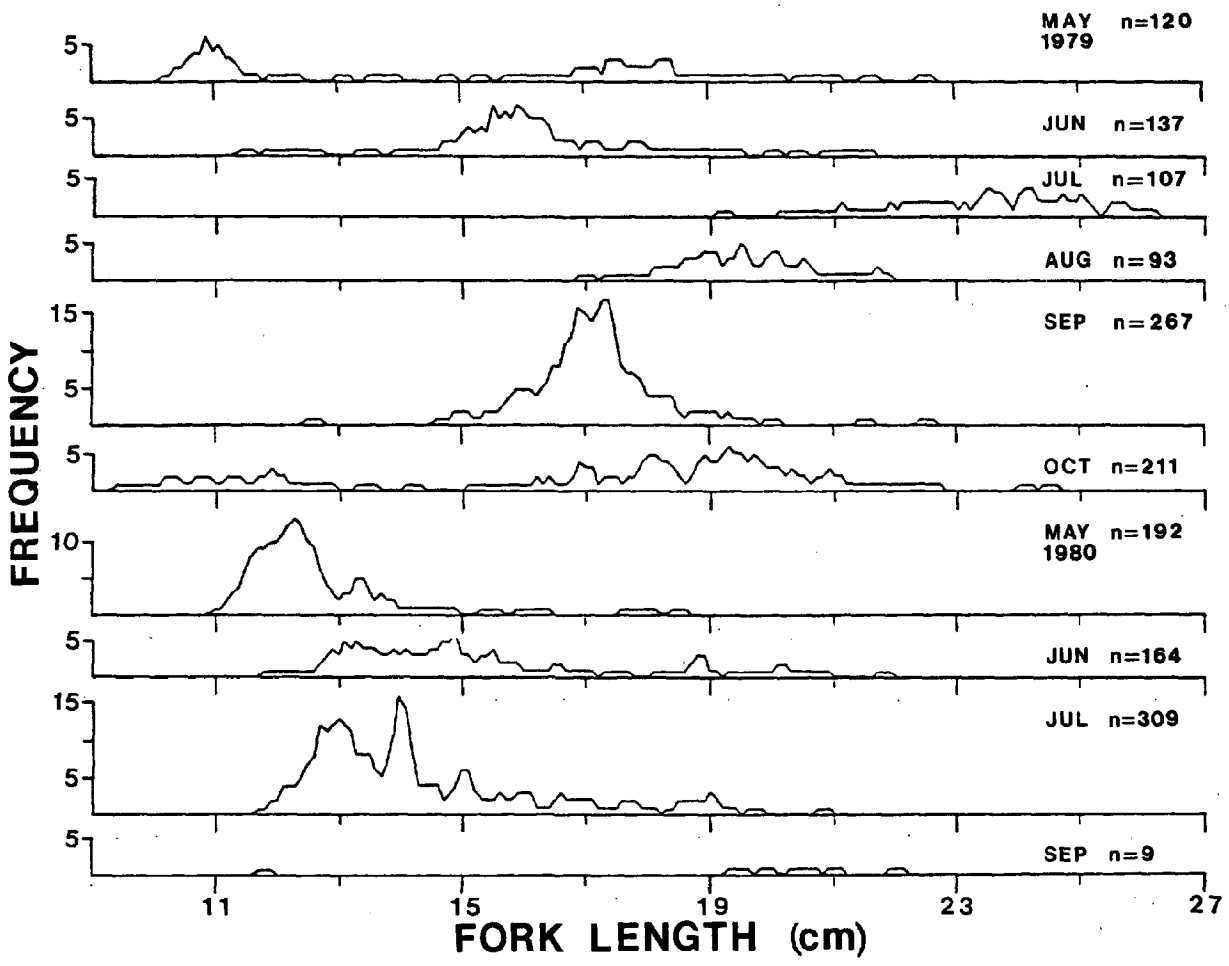

Figure 6. Monthly length frequencies (moving averages of three) of *Brevoortia tyrannus* captured in long haul seines in Core Sound, N.C., May 1979 - September 1980.

Table 6. Length frequencies of species (excluding spot, croaker, weakfish, and menhaden) comprising 0.1% or more of the samples from 11 Core Sound long haul seine catches during May-September 1979.

Species	Length (mm)																	
	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	270-289	290-309	310-329	330-349	350-369	370-389	390-409	>409
Lagodon rhomboides (FL)	4	12	29	22	90	14	1	1										
Pomatomus saltatrix (FL)			1	1	3	1	4	7	12	7	6	5	1	1		1		2
Orthopristis chrysoptera (FL)		4	17	8	5	7	3	5										
Bairdiella chrysoura (TL)				5	15	6	5											
Menticirrhus americanus (TL)						4	6	2	5	7	3	2	2	5	1			
Peprilus alepidotus (FL)		1	5	7	6													
Opisthonema oglinum (FL)			4	5	11	1												
Dasyatis sabina (DW)						3	1		1		1	3						
Cynoscion nebulosus (TL)			1								1	2			1	1	1	
Monacanthus hispidus (TL)	10	2																
Caranx hippos (FL)		1	5	2														

Table 7 . Monthly length frequencies of fish (excluding croaker, spot, weakfish, and menhaden) comprising 0.3% or more of the samples from 19 Core Sound long haul seine catches during October 1979 and April-September 1980. DW = disc width, FL = fork length, and TL = total length.

Month / Length Range (mm)	*Dasyatis sabina* (DW) A	M	J	J	A	S	O
<90							
90-109							
110-129							
130-149						1	
150-169					1		
170-189					2		1
190-209	1			1			2
210-229					1	2	
230-249					3	2	1
250-269	1	1	1			1	
270-289						1	
290-309					1	1	
310-329							
330-349							
350-369							
370-389							
390-409							
>409							

Month / Length Range (mm)	*Pomatomus saltatrix* (FL) M	J	J	A	S	O
<90						2
90-109						
110-129						1
130-149						
150-169			1		2	2
170-189				8	4	3
190-209	1			8	7	3
210-229	2		2	4	2	2
230-249	2	1	1	5	1	4
250-269	5		2	1	1	1
270-289			3	2	3	2
290-309	1		2	1		
310-329				5		2
330-349	1			8	3	
350-369				11		
370-389				6		
390-409				2		
>409				1		

Month / Length Range (mm)	*Selene vomer* (FL) J	A	S	O
<90	6			6
90-109			1	3
110-129			9	2
130-149		1	9	
150-169				
170-189				
190-209				
210-229				
230-249				
250-269				
270-289				
290-309				
310-329				
330-349				
350-369				
370-389				
390-409				
>409				

Month / Length Range (mm)	*Orthopristis chrysoptera* (FL) J	J	A	S	O
<90			1		
90-109			2	17	14
110-129			21	28	43
130-149		2	20	10	31
150-169		5		3	10
170-189		3	1	1	7
190-209		2	1		10
210-229			2	1	
230-249	1				1
250-269			1		
270-289					
290-309					
310-329					
330-349					
350-369					
370-389					
390-409					
>409					

Month / Length Range (mm)	*Lagodon rhomboides* (FL) A	M	J	J	A	S	O
<90				4	36		
90-109				3	61	21	282
110-129					27	31	161
130-149	1	2	8	12	23	7	12
150-169		1	10	25	88	18	17
170-189					106		23
190-209			1		6		4
210-229					5		
230-249					1		
250-269							
270-289							
290-309							
310-329							
330-349							
350-369							
370-389							
390-409							
>409							

Month / Length Range (mm)	*Bairdiella chrysoura* (TL) A	M	J	J	A	S	O
<90							
90-109							1
110-129						3	7
130-149	2		2	2	6		4
150-169				7	15		11
170-189	1		1	4	10		10
190-209	1						
210-229			1		1		
230-249							
250-269							
270-289							
290-309							
310-329							
330-349							
350-369							
370-389							
390-409							
>409							

Month / Length Range (mm)	*Menticirrhus americanus* (TL) J	J	A	S	O
<90					
90-109					
110-129					
130-149		1			
150-169					
170-189			3		
190-209	2				
210-229	1				
230-249			1		
250-269		1	2	1	
270-289		1	1		1
290-309	1				2
310-329				1	2
330-349				1	3
350-369					
370-389					
390-409					
>409					

Month / Length Range (mm)	*Peprilus alepidotus* (FL) M	J	J	A	S	O
<90						29
90-109						33
110-129	1	5	7		2	22
130-149		6	11	1	1	
150-169		1	3	3	2	1
170-189	1		4		1	
190-209			1			
210-229						
230-249						
250-269						
270-289						
290-309						
310-329						
330-349						
350-369						
370-389						
390-409						
>409						

Month / Length Range (mm)	*Peprilus triacanthus* (FL) M	J	J	A	S	O
<90						
90-109			2			
110-129		2	6			1
130-149		10	22			4
150-169	1	4	2		1	3
170-189		1			1	2
190-209						1
210-229						
230-249						
250-269						
270-289						
290-309						
310-329						
330-349						
350-369						
370-389						
390-409						
>409						

Month / Length Range (mm)	*Prionotus evolans* (FL) J	A	S	O
<90				
90-109	1			
110-129	1			
130-149				
150-169	1	3		
170-189	1	13	1	
190-209		2	1	1
210-229				1
230-249				
250-269				
270-289				
290-309				
310-329				
330-349				
350-369				
370-389				
390-409				
>409				

Month / Length Range (mm)	*Stropus crossotus* (TL) A	S	O
<90			1
90-109		12	1
110-129	1	12	2
130-149			
150-169			
170-189			
190-209			
210-229			
230-249			
250-269			
270-289			
290-309			
310-329			
330-349			
350-369			
370-389			
390-409			
>409			

Month / Length Range (mm)	*Paralichthys dentatus* (TL) M	J	J	A	S	O
<90						
90-109						1
110-129						
130-149			1			
150-169						
170-189						
190-209						2
210-229						
230-249						
250-269	1	1		1	1	
270-289	1	1		2	1	
290-309	2	1	2	1		
310-329			2	3	1	
330-349			1			
350-369				1		
370-389						
390-409						
>409						

Month / Length Range (mm)	*Monacanthus hispidus* (TL) J	J	A	S	O
<90					
90-109	3		3		1
110-129			21		
130-149			5		
150-169			2	1	
170-189					
190-209					
210-229					
230-249					
250-269					
270-289					
290-309					
310-329					
330-349					
350-369					
370-389					
390-409					
>409					

weakfish were unmarketable, although Sholar (1979) and Ross and Carpenter (1980) had even lower values of 13 and <10% from Pamlico Sound. Compared to spot and croaker, significantly fewer weakfish from Core Sound long haul catches ended up as crab pot bait.

Because spot is by far the most important species in the Core Sound long haul fishery in terms of total landings (Table 4), age and growth studies were concentrated on this species. To get sufficient quantities of data from all sizes of fish throughout the year, scale samples were obtained from Pamlico and Core Sound haul seine, offshore trawler, Division trawl, and offshore sink net catches. A total of 1,412 fish (920 from 1979, 492 from 1980) was aged. Annuli were identified using the criteria given by Sundararaj (1960). A second reading (several months after the first) of scales from 200 fish randomly selected from 1979 samples resulted in 90.5% agreement.

An examination of monthly frequency distributions of marginal increments (Figure 7) revealed that the marks are annuli that form during March - May, in general agreement with Sundararaj (1970) and Pacheco (1962). Back-calculated lengths at age were determined using the Lee method (Lagler 1956). The correction factor (27 for both years) was calculated by regressing fork length on scale radius for 120 fish chosen at random and equally weighted over the entire length range in 1979 and for all 492 fish aged from 1980 samples. Length frequencies of back-calculated lengths at the first, second, and third annulus for 1979 and 1980 (Figure 8) show a considerable overlap in sizes at age, as Sundararaj (1960) also found, and a somewhat bimodal distribution of sizes at the first annulus. This bimodality may represent two peaks in spawning as length frequencies of trawled age 0 spot from North Carolina in 1979 (Ross and Carpenter 1980, Figure 2) showed bimodal distributions in July-September.

Weighted mean back-calculated lengths for 1979 and 1980, respectively, were: age 1, 134 and 135 mm FL; age 2, 204 and 202 mm; age 3, 224 and 231 mm; and age 4, 293 and 289 mm (Table 8). These lengths agree closely with Sundararaj's (1960) values of 144, 200, and 223 mm TL at ages 1, 2, and 3. Only two age 5 spot were collected and the back-calculated lengths at the fifth annulus were 336 and 323 mm.

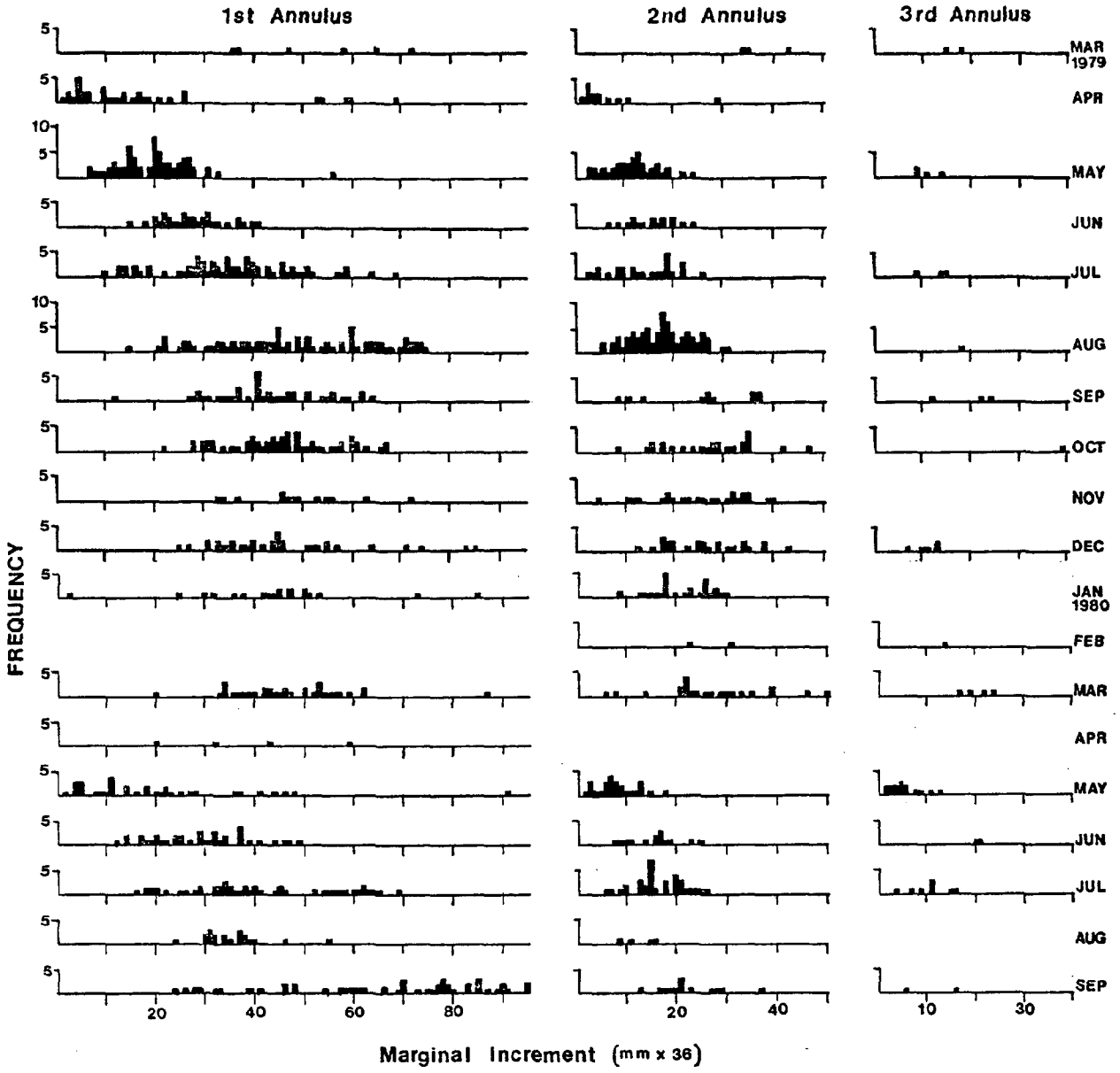

Figure 7. Monthly marginal increments for *Leiostomus xanthurus* with one, two, and three annuli.

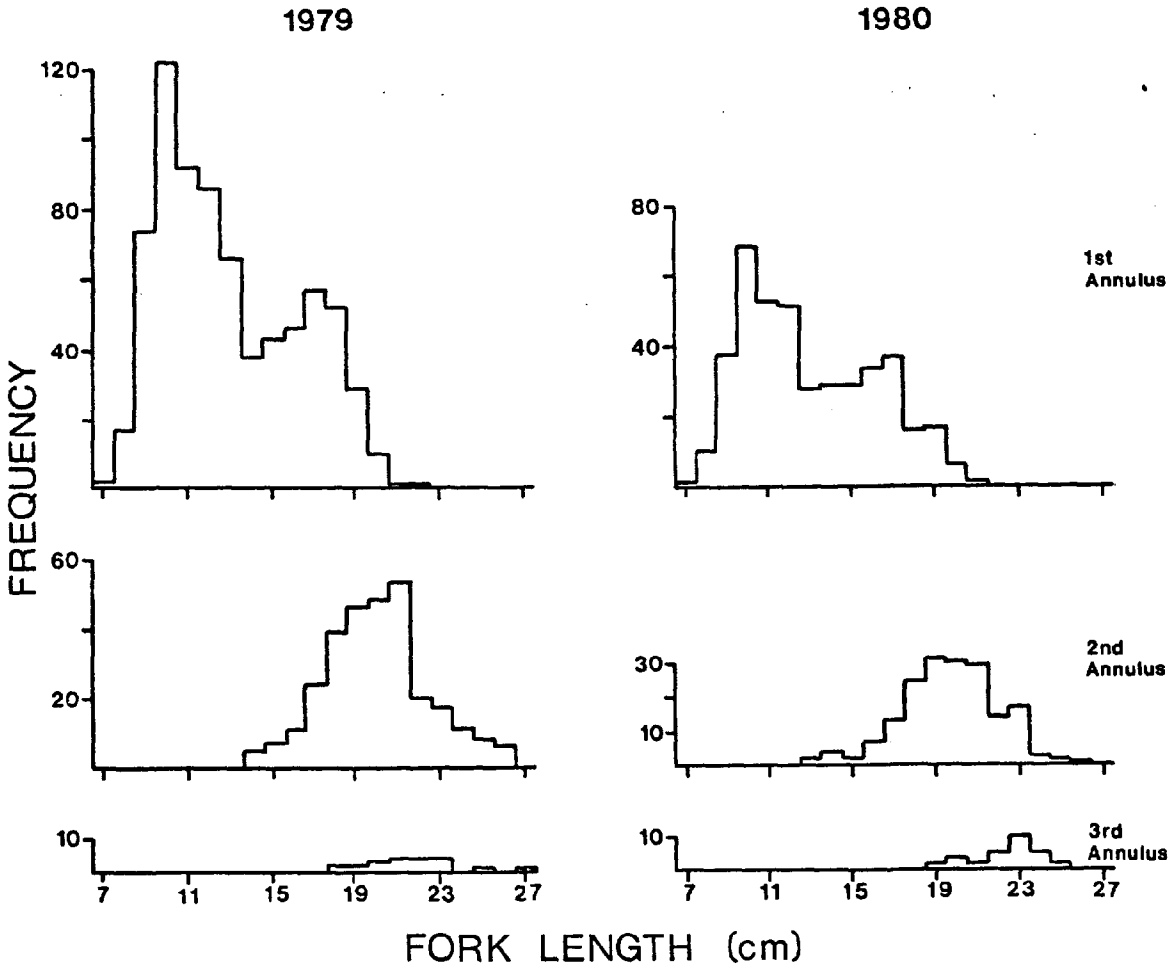

Figure 8. Back-calculated lengths at the first, second, and third annulus for *Leiostomus xanthurus* in 1979 and 1980. The direct proportion method was used for all back-calculations.

Table 8 . Mean back-calculated fork lengths and 95% confidence limits for spot collected in North Carolina waters during 1979 and 1980.

Year	Age group	n	Back-calculated lengths at successive annuli (mm) 1	2	3	4	5
1979	1	440	139±3				
	2	274	128±3	205±3			
	3	21	113±7	184±12	219±10		
	4	2	119	195	244	278	
	5	1	213	268	296	322	336
	Weighted mean length		134	204	224	293	
1980	1	241	141±4				
	2	147	127±4	204±4			
	3	32	121±10	192±10	228±7		
	4	2	104	216	260	282	
	5	1	181	247	282	304	323
	Weighted mean length		135	202	231	289	

To determine the age composition of the catches, the percent age composition by 25 mm size intervals was determined for each year for all spot aged. These percent compositions by size interval were then applied to a total length frequency of all Core Sound long haul catches each year using the same 25 mm intervals. The number at a given age for each interval was then summed to give the total number at that age and this total was divided by the total number of spot taken in the long hauls to give percent composition for a given year.

The calculated percent age composition of spot in Core Sound long haul catches, May - October 1979, was: age 0, 26.9% (n=1028); age 1, 49.7% (n=1900); age 2, 21.7% (n=828) age 3, 1.7% (n=65); and age 4, 0.17% (n=3). For April - September 1980, the age composition was: age 0, 19.3% (n=262); age 1, 66.5% (n=904); age 2, 11.6% (n=157); age 3, 2.5% (n=34); and age 4, 0.1% (n=2). Sholar (1979) calculated values of 4.8, 68.8, 24.7, and 1.7% for spot ages 0-3 from Pamlico Sound. The differences between 1979 and 1980 may reflect changes in year class strength, but more likely represent the lack of October samples in 1980, the month when the vast majority of large fish are taken.

One fact is very clear - almost all marketable spot are age 1 or 2. With only two year classes supporting the fishery, it is probably fairly unstable. Assuming the presence of only one stock, the failure of one year class could severely affect the fishery and two consecutive failures could eliminate it temporarily.

Recruitment of age 0 spot can be seen in the August 1980 length frequency when many fish 100-140 mm FL were present (Figure 3). By September in both years these recruits formed dominant modal groups.

Core Sound croaker catches appear to be dominated by age 1 fish. White and Chittenden (1977) reported that croaker, upon reaching age 1 in October, were 140-180 mm TL using length frequency data, 140-220 mm TL using observed lengths, and 110-210 using back-calculated lengths. They reported that age 1 fish in September (one month before reaching age 2) were 200-310 mm TL, while observed lengths at age 2 in October were 190-360 and back-calculated lengths were about 270 mm TL.

Percent age composition of the croaker catch for May - October 1979 was: age 0, 32.5% (n=444); age 1, 61.9% (n=845);and age 2, 5.6% (n=77). For April - September 1980, the age composition was: age 0, 8.1% (n=182); age 1, 91.1% (n=2045); and age 2, 0.8% (n=17). Percent age composition was estimated by applying White and Chittenden's (1977) sizes at age and assuming the dominant modal group seen in most months in the length frequencies (Figure 4) was comprised exclusively of age 1 fish. Sizes below which all fish were considered age 0 were: May 79, 130 mm; June 79, 150 mm; August 79, 190 mm; September 79, 200 mm; October 79, 200 mm; July 80, 160; August 80, 190; and September 80, 200 mm. Sizes above which all fish were considered age 2 were: June 79, 269 mm; July 79, 269 mm; August 79, 279 mm; September 79, 289 mm; October 79, 289 mm; and August 80; 269 mm.

Age compositions calculated in this study differ from Sholar's (1979), values of 1.5, 59.0, 35.6, and 4.0% for Pamlico Sound croaker ages 0-3. Also both the April and May length frequencies in Ross and Carpenter (1980, Figure 5) contain a dominant modal group 240-320 mm TL, strongly suggesting the presence of many age 2 fish. The lack of age 2 fish in Core Sound catches might be explained by some unknown preference of older, larger fish for Pamlico Sound. The Core Sound croaker fishery is probably quite unstable because one year class so completely dominates the catches. The failure of one year class could temporarily eliminate the fishery. Even with abundant year classes a directed croaker fishery in Core Sound is probably not very profitable because so few age 1 fish reach marketable size there.

Based on length frequency data, almost all weakfish taken in Core Sound haul seines were ages 1 and 2. Merriner (1973) reported that back-calculated length ranges at ages 1 and 2 for North Carolina weakfish were 190-210 mm TL and 253-269 mm TL, and that peak spawning occurs from late April through June. Applying Merriner's lengths at age to the Core Sound length frequencies (Figure 5), particularly those for May and June 1979, the two distinct modal groups can be identified as two age groups - fish just reaching ages 1 and 2. After June 1979, sample sizes were too small to distinguish any one age group, although in most months the size range covered was very close to that seen in May and June 1979 when age 1 and 2 fish predominated. Fish which were probably age 3 (those about 310-390 mm TL) comprised a very small part of the

catch and older fish larger than 390 mm TL were present in only trace amounts. Weakfish were recruited to the haul seine fishery at about age 1 and 170 mm TL.

The marketable catch of weakfish was comprised almost solely of individuals ages 1 and 2 which were present in about equal proportions. In contrast, Sholar (1979) reported percent compositions of 76.7, 15.0, 4.5, and 3.8% for ages 1 - 4. The much higher proportion of one year olds Sholar (1979) found might be explained by differences in year class strength or differences in abundance by size or age group between Core and Pamlico Sounds.

In summary, only one or two year classes comprised the large majority of Core Sound long haul catches of spot, croaker, and weakfish in 1979 and 1980. This narrow age structure often produces unstable fisheries because changes in abundance of only one year class can dramatically affect landings. Because there are three primary species in the Core Sound fishery, there may be some buffering effects. Fluctuations in spot abundance would have the most dramatic effect, as it is by far the most important in annual landings.

Pound Net Fishery

Species composition

Thirty-one species of fish and one species of invertebrate were observed in 5 pound net catches sampled during mid-October and early November 1979 (Table 9). Two catches were sampled in Northern Core Sound, two in southern Core Sound, and one in Back Sound (Figure 1).

The four most abundant species, southern flounder, harvestfish (*Peprilus alepidotus*), summer flounder, and Gulf flounder, comprised 62.4, 12.7, 9.1, and 5.8% of the samples by number for a total of 90% (Table 9). The paralichthids, the primary targets of the fishery, were even more dominant in terms of weight, comprising 93.1% of the samples.

P. lethostigma dominated the flounder catch, comprising 80.7% by number and 93.7% by weight, followed by *P. dentatus* with 11.5 and 3.5% by number and weight, and *P. albigutta* with 7.5 and 2.8%. Wolff (1977), in samples from Albemarle, southwestern Pamlico, Core, and Back sounds, found similar percent compositions for *P. lethostigma, P. dentatus,* and *P. albigutta* of 95.8, 3.5, and 0.7% by number.

Table 9 . Species composition by number and weight and size ranges of samples taken from five Core Sound pound net catches in October and November 1979.

Species	No.	%	Wt. (kg)	%	No. catches in which species was observed	Size range (mm FL)[1]
Paralichthys lethostigma	943	62.4	1252.4	87.2	5	226-630[2]
Peprilus alepidotus	192	12.7			3	86-193
Paralichthys dentatus	138	9.1	46.9	3.3	5	200-504[2]
Paralichthys albigutta	88	5.8	39.9	2.6	3	250-387[2]
Archosargus probatocephalus	35	2.3			3	186-413
Pomatomus saltatrix	32	2.1	Wt. for all remaining		5	282-461
Sciaenops ocellatus	24	1.6	species:		5	355-434[2]
Scophthalmus aquosus	12	.8	99.6	6.9	3	141-253[2]
Micropogonias undulatus	8	.5			5	248-387[2]
Lagodon rhomboides	6	.4			3	229-280
Leiostomus xanthurus	6	.4			3	283-305
Chilomycterus schoepfi	6	.4			2	145-245[2]
Selene vomer	3	.2			1	110-115
Aluterus schoepfi	2	.1			3	273-335[2]
Trachinotus carolinus	2	.1			2	215-221
Mugil cephalus	2	.1			3	309-416
Astroscopus spp.	2	.1			2	290-310[2]
Prionotus evolans	2	.1			1	221-282[2]
Brevoortia tyrannus	1	.1			1	242
Dorosoma cepedianum	1	.1			1	291
Lobotes surinamensis	1	.1			2	265[2]
Cynoscion regalis	1	.1			1	500[2]
Peprilus triacanthus	1	.1			2	189
Prionotus tribulus	1	.1			1	285
Ancylopsetta quadrocellata	1	.1			1	233[2]
Monacanthus hispidus	1	.1			1	169[2]
Dasyatis sabina					1	
Gymnura spp.					1	
Chaetodipterus faber					1	
Pogonias cromis					2	
Trinectes maculatus					1	
Limulus polyphemus					1	

[1]Except where noted.

[2]Total length

One species notably lacking in the catches in any number was spot, which are taken in extremely large numbers in Core Sound during October by long haul seiners (see above). The few spot taken in the pound nets were very large (283-305 mm FL). Possible reasons for the low catch of spot are that the mesh in the leads is too large to "lead" most of the spot or the fish are concentrated in the deeper areas of the sound where there are no pound nets. The only recreationally-important species besides flounders present in more than trace amounts were sheepshead (*Archosargus probatocephalus*), bluefish, and red drum (*Sciaenops ocellatus*), although these comprised only 1.6 - 2.3% by number.

Size and age composition

Southern flounder from Core Sound pound nets ranged from 225 to 630 mm TL although 98.2% of the fish were 270-610 mm TL (Figure 9). Wolff (1977) reported a similar range of 225-705 mm TL. A Texas study collected *P. lethostigma* as large as 620 mm (Stokes 1977). The largest specimen in the ageing samples was a 760 mm fish collected in the Cape Fear River area. Summer flounder ranged from 200 to 504 mm TL, with 94.2 % between 250 and 390 mm (Figure 10). Gulf flounder had the narrowest range, from 250 to 387 mm TL (Figure 10). Wolff (1977) reported ranges of 185-415 and 315-415 mm TL for *P. dentatus* and *P. albigutta*. Stokes (1977) reported a maximum length of 420 mm TL for *P. albigutta* in Texas. The mean weights of *P. lethostigma*, *P. dentatus* and *P. albigutta* were 1.33, 0.34, and 0.45 kg.

There is some evidence to indicate that a very large portion of the southern flounder catch is composed of females. Wolff (1977)found no male *P. lethostigma* larger than 405 mm TL and few larger than 355 mm TL in an examination of 124 specimens (64 females, 60 males), while the mean length of females in that sample was 456 mm. Similarly, Stokes (1977) found no males exceeding 320 mm TL in Texas waters. If Wolff's (1977) figures are typical, at least 76.9% of the *P. lethostigma* catch may have been female, using 355 mm as the maximum size of males. Even using 405 mm as the cutoff, at least 65.6% would have been female, not counting any females which were below that cutoff length.

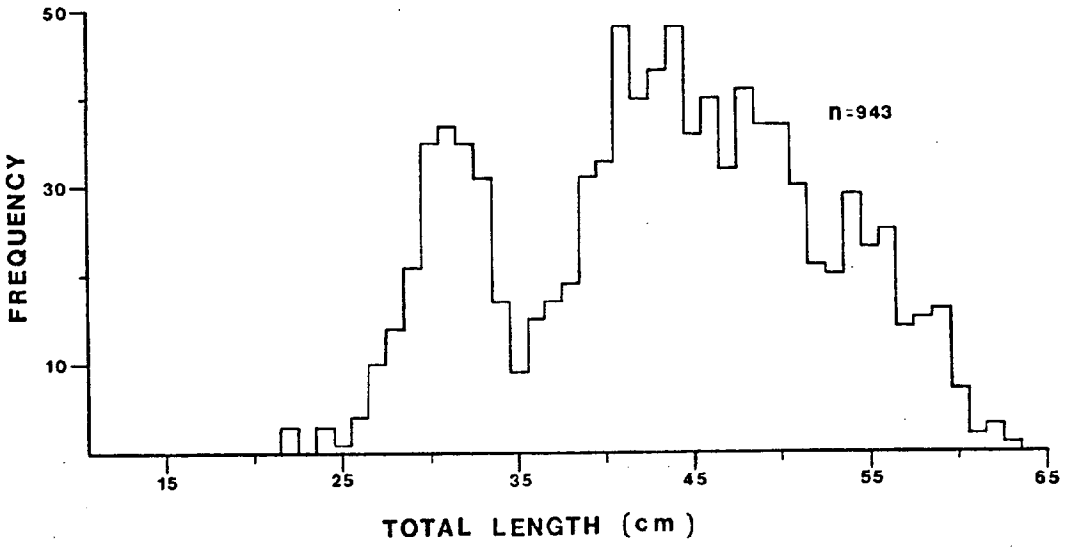

Figure 9. Length frequency of *Paralichthys lethostigma* captured in pound nets in Core and Back Sounds, N.C., October and November 1979.

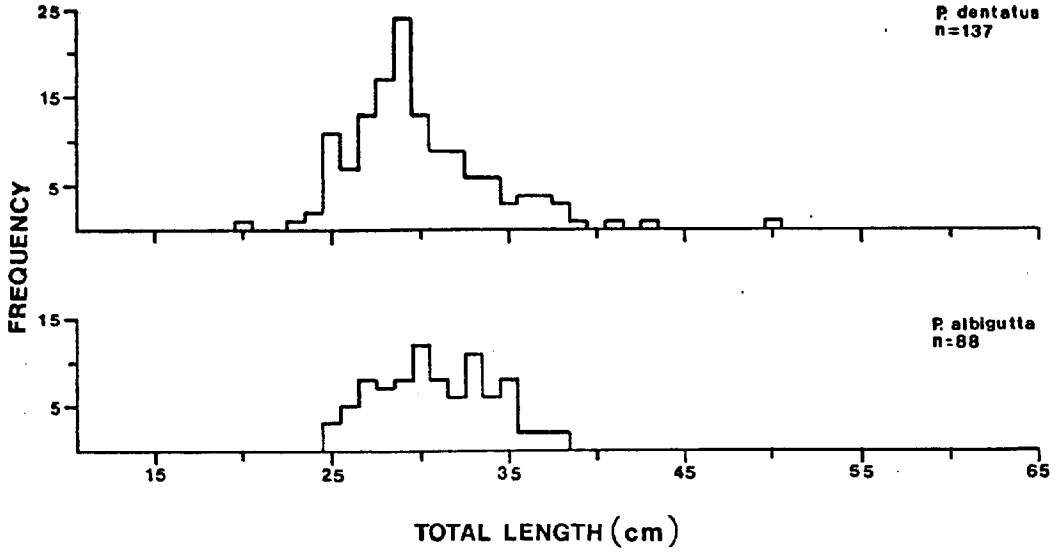

Figure 10. Length frequency of *Paralichthys dentatus* and *P. albigutta* captured in pound nets in Core and Back Sounds, N.C., October and November 1979.

Otoliths were examined from 718 *P. lethostigma* ranging from 99 to 760 mm TL collected throughout North Carolina during March 1979 - September 1980. A regression of total length on otolith radius (n=464, 99-687 mm TL) produced an r^2 value of 0.96, indicating otolith growth was proportional to growth in length and therefore, the otoliths were suitable for use in ageing and back-calculation. Monthly frequency distributions of marginal increments (Figure 11) indicated that the marks were being formed annually during the spring or early summer, but lack of data for that period precluded determining a more precise date. Lengths at age were back-calculated using the direct proportion method, as preliminary back-calculations using the Lee method were somewhat smaller than the empirical data indicated they should be. Powell (1974) encountered the same problem with *P. dentatus*.

Frequency distributions of back-calculated lengths at the first and second mark were distinctly bimodal (Figure 12). The upper mode of the first mark (Figure 12b) corresponded very closely to the lower mode of the second mark (Figure 12c) and the upper mode of the second mark (Figure 12c) corresponded to the mode of the third mark (Figure 12d). The upper mode of the first and the lower mode of the second mark corresponded with the lowest, very distinct mode at about 30-33 cm in the pound net *P. lethostigma* length frequency (Figure 9) and with a distinct mode at 30-31 cm seen in a length frequency of trawl-caught *P. lethostigma* from the Neuse River in January 1980 (Figure 13).

The lower mode in the back-calculated length frequency at the first mark (Figure 12b) also corresponded fairly closely to the lengths of individuals at or approaching age 1 as determined by length frequency data. Southern flounder collected by trawl throughout North Carolina estuarine waters ranged from about 90-190 mm TL in October and November 1979, when they were within a month or two of reaching age 1 (Figure 14). Also, in March 1979 and March and April 1980, a group of fish which probably reached age 1 a few months earlier ranged from about 90 to 200 mm TL. Similarly, *P. lethostigma* collected in northwestern Pamlico Sound during October - December 1974 and January 1975 Purvis 1976, Table 8) ranged from about 105 - 195 mm TL. Powell (1977) estimated that southern flounder were 130 mm TL in December at the end of their first year, and he collected specimens ranging from 110 to 190 mm TL during

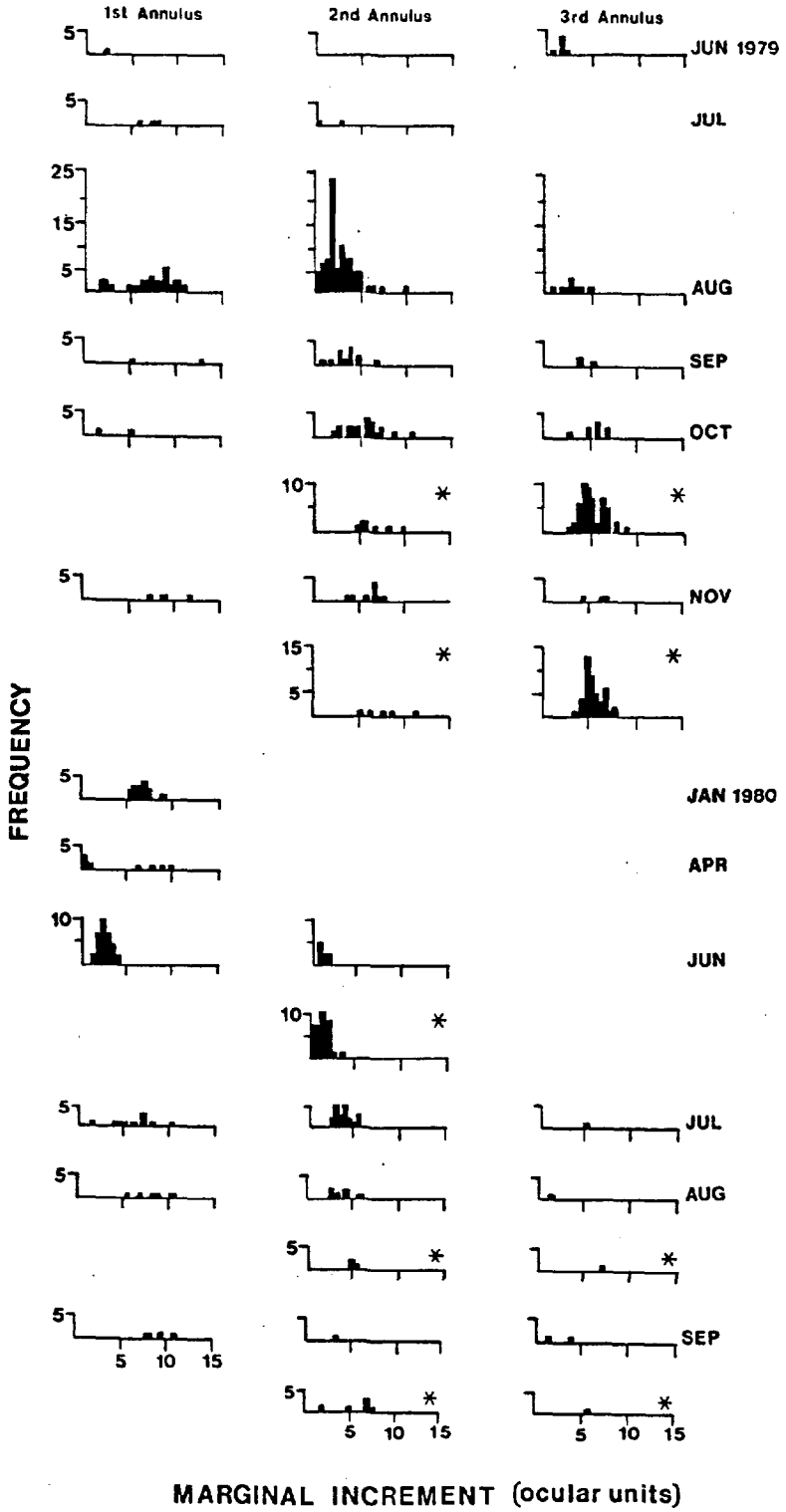

Figure 11. Monthly marginal increments for *Paralichthys lethostigma* otoliths with one, two, and three annuli. Panels with an asterisk (*) indicate data analyzed as if the first apparent annulus was actually the second because the first annulus was ≥ 15 ocular units from the focus. See the text for further explanation.

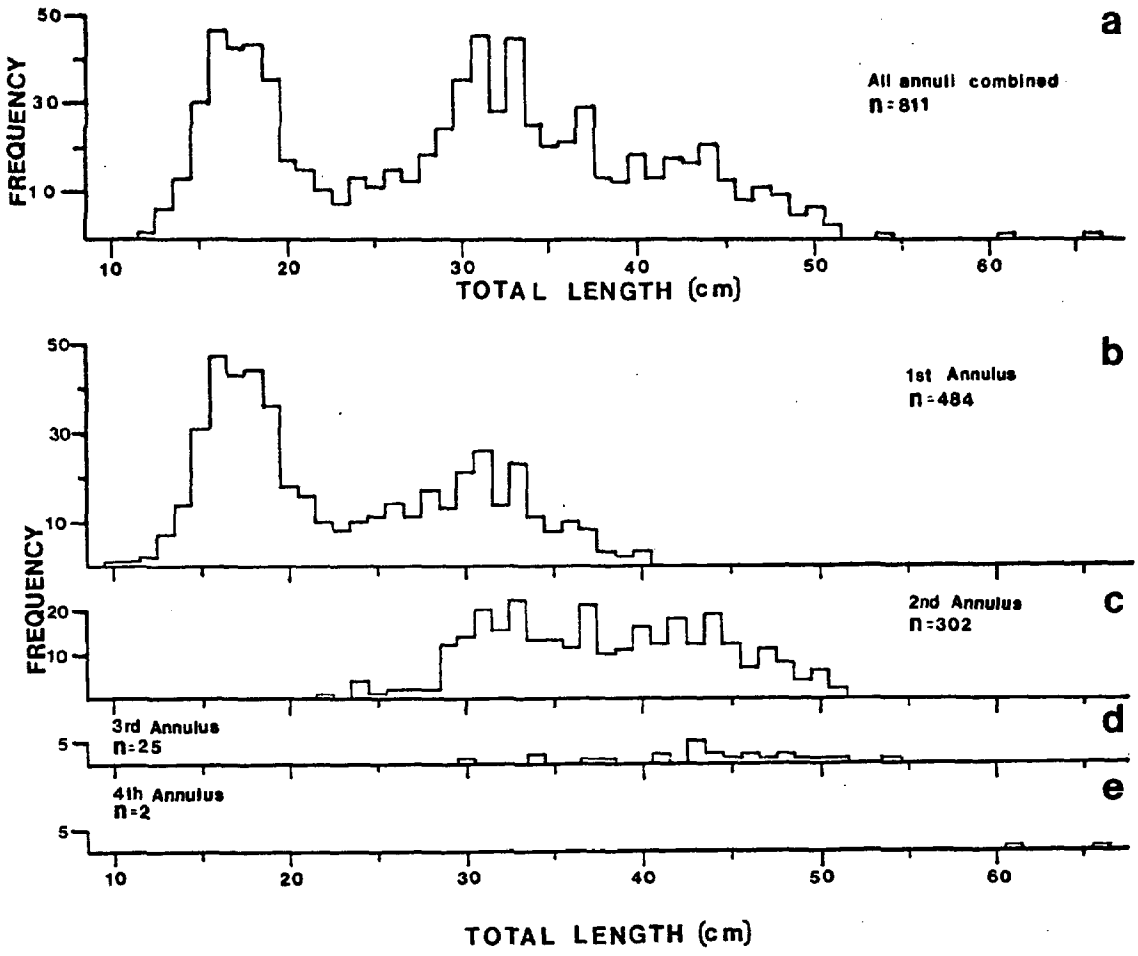

Figure 12. Back-calculated lengths for *P. lethostigma* collected May 1979-September 1980. a. All annuli combined. b. 1st annulus. c. 2nd annulus. d. 3rd annulus. 3. 4th annulus. The possibility of missing first annuli was not considered in these histograms.

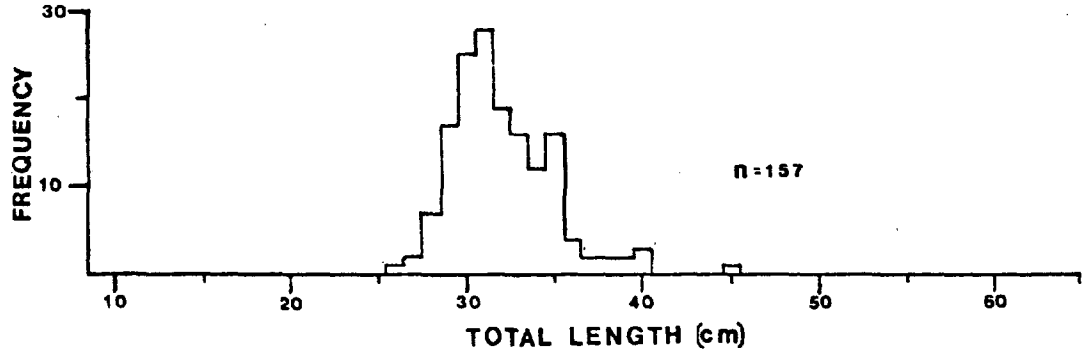

Figure 13. Length frequency of *Paralichthys lethostigma* captured in a crab trawl in the Neuse River, N.C., January 1980. Most flounder less than 280 mm TL (legal size limit) were culled from the catch before it was sampled.

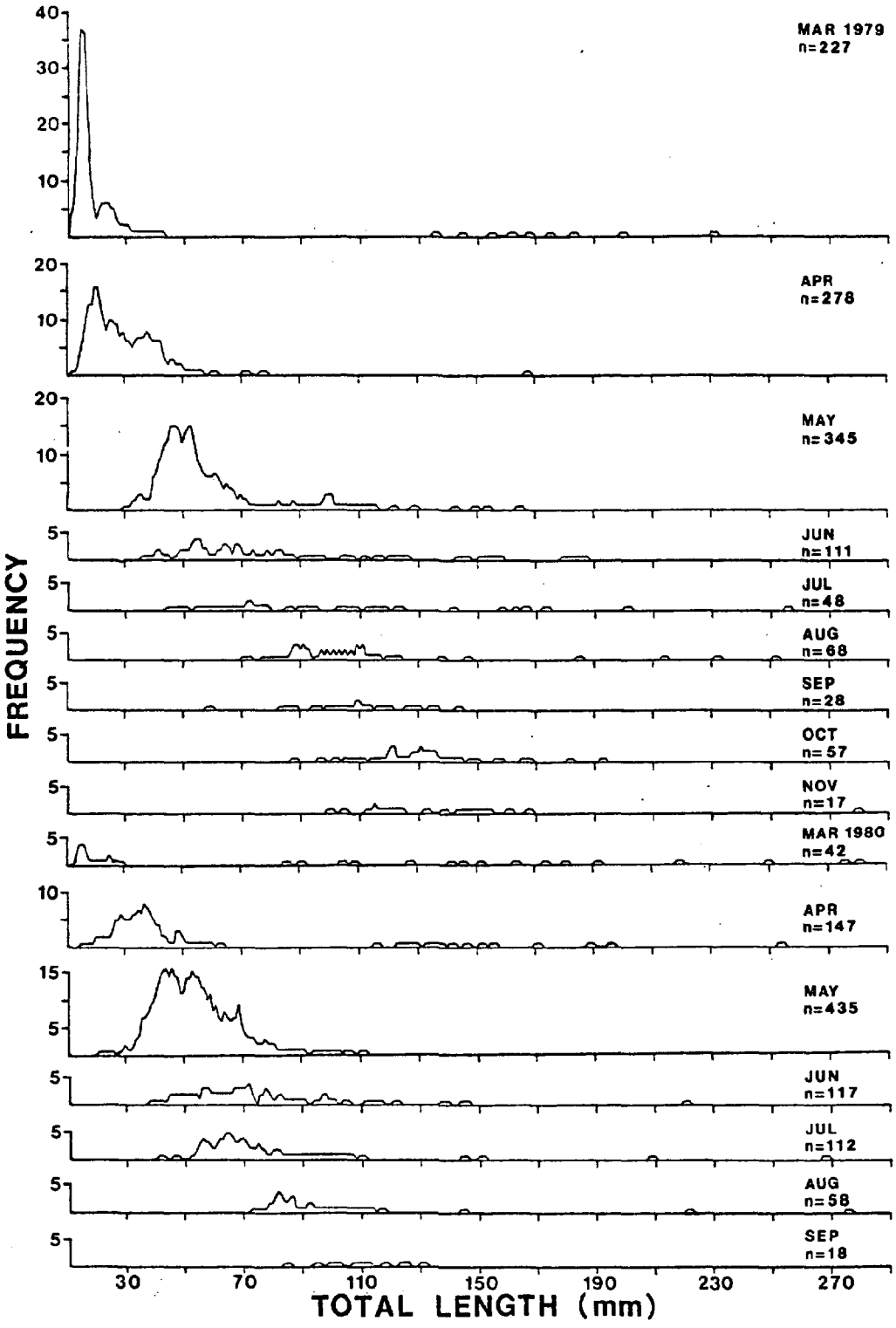

Figure 14. Monthly length frequencies (moving averages of three) of *Paralichthys lethostigma* taken in Division trawls throughout North Carolina, March 1979 - September 1980.

September - March. This correspondence between the lower mode in the back-calculated lengths at the first mark and the lengths at age 1 determined by length frequencies, and the bimodality present in the back-calculated length frequencies, is evidence that some *P. lethostigma* either lose or never form their first annulus.

Length frequencies of back-calculated lengths at the first mark by size groups (100-299, 300-399, 400-499, and ≥500 mm TL) showed a distinct mode at 160 mm, with very few larger than 200 mm, for fish 100-299 mm TL, while fish ≥500 mm had a mode around 310-330 mm, with very few less than 250 mm. Back-calculated lengths at the first mark for the intermediate groups (300-399 and 400-499 mm TL) were bimodally distributed and corresponded to the modes found for the upper (≥500 mm) and lower (100-299 mm) groups. These data indicate that the larger fish often lose their first annulus, probably as a result of being obscured as the otoliths grow and thicken. Those fish which seemed to be missing an annulus often had a larger, more opaque central core than those with a first annulus which back-calculated to lengths agreeing with empirical data.

Based on the premise that some flounder were missing the first annulus, criteria were developed to help assign ages to fish which fell in between the distinct modes in the overall back-calculated length frequency (Figure 12a). Using the apparent distinct break point of 230-240 mm (Figure 12a), all fish with a back-calculated length at the first annulus of <236 mm were considered to have a valid first annulus. Those with lengths >235 mm were assumed to be missing the first annulus and one year was added to their age. Additionally, following Powell (1977), January 1 was considered the birthdate and any fish captured from then through April was advanced one year, even though the new annulus had not yet formed.

Percent age composition of the 1979 *P. lethostigma* samples from the pound nets for ages 1 - 4 was 20.9, 36.9, 41.7, and 0.4%. Age composition was computed (after ages were assigned using the criteria previously mentioned) using the method outlined in the long haul seine section for computing age composition of spot samples. Although technically ages 1 - 4, flounder taken in the pound nets in October and November were within a month or two of reaching ages 2 - 5. The presence of three well-represented age classes of southern flounder in the pound net samples indicates the fishery should be

fairly stable, but more susceptible to growth overfishing than the haul seine fishery, which is directed towards the shorter-lived sciaenids.

Blue Crab Fishery

Crab pot catch composition

Samples were taken from 12 strings of crab pots (228 pots total) - 10 in Core Sound, 1 in Back Sound, and 1 in North River - during late March and April 1979. A total of 2,393 crabs ranging from 71 to 192 mm CW were sampled. Length frequencies by sex indicated that males tended to be smaller than females (Figure 15), although the data are somewhat misleading because at a given body size, males had shorter lateral spines than females.

Females predominated in all samples, comprising from 57.0 to 99.5% of the catches (Table 10). The overall mean percent composition for females was 84.6%. These data agree with the findings of that females migrate to high salinity waters and ocean inlet areas to spawn, while males tend to remain in less saline areas (Van Engel 1958, and Dudley 1970). In samples from pots around Ocracoke Inlet, females comprised 96% of the catch (Wolff 1978). In contrast, the mean sex composition of samples taken in low salinity water in the Neuse River near Oriental, N.C. was 74.2% males and 25.8% females (Ross and Carpenter 1980).

Egg bearing or sponge crabs appeared quite suddenly in early April. The frequency of females with sponge increased from 0% in late March to 42.7% in early April to 69.1% in late April. Sponge crabs in Core Sound seem to appear earlier than those in Chesapeake Bay, where few may be seen before the end of April, and the peak occurs in late May or early June (Van Engel 1958).

Overall, 69.6% of 184 sublegal (<127 mm CW) females were immature. The percentages of immature females 110-119 (n=66), 120-129 (n=99), and 130-139 mm CW (n=238) were 82.8, 22.2, and 2.1%, indicating that the 127 mm (five-inch) minimum size limit is quite effective in eliminating immature females from the catch, at least in the spring. The percentage of sublegal crabs was highly variable among areas, but the mean proportion did increase from late March to late April. The highest frequencies of sublegal crabs were

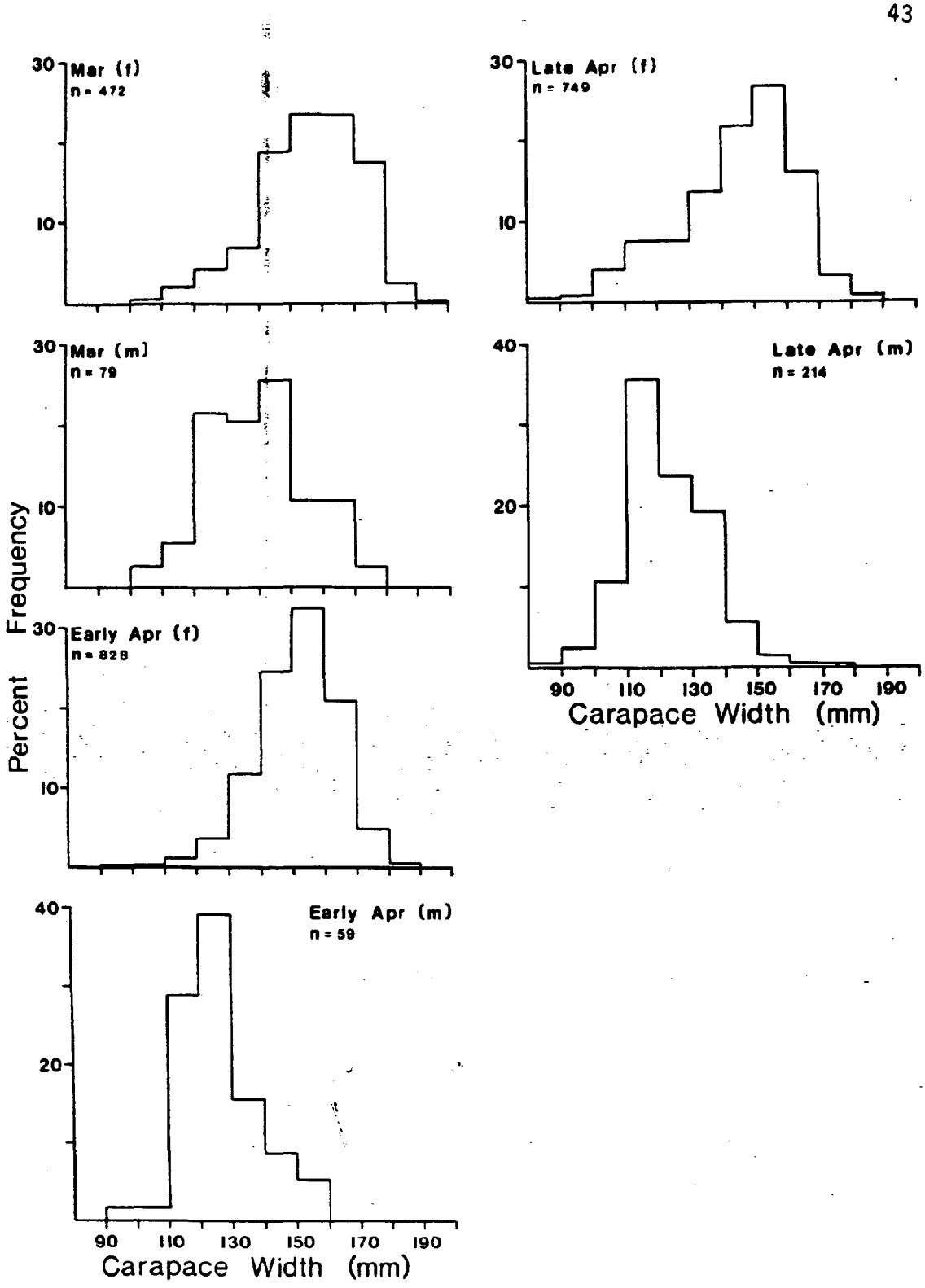

Figure 15. Percent width frequencies by sex of blue crabs taken from crab pots in Core Sound in March and April 1979. Sex is indicated by (f)=female and (m)=male.

Table 10. Catch, effort, size, and sex data for crab pots sampled in Core Sound and adjacent areas in March and April 1979.

Date	Location	No. crabs	No. pots	Soak time (hr)	c/f	No./% <127mm	No./% sponge	No./% male	No./% female
3/20	Off Davis	92	21	24	4.4	6/6.2	0	20/21.7	72/78.3
3/27	Off Thorofare	188	20	24	9.5	2/1.1	0	1/0.5	188/99.5
3/28	Back Sound	131	20	48	6.6	13/9.9	0	19/14.5	112/85.5
3/28	North River	134	20	48	6.7	23/17.2	0	34/25.4	100/74.6
	Mean values for 3/20-3/28					/8.6		/15.5	/84.5
4/6	Jarrett Bay	241	18	24	13.4	25/10.4	183/84.3	24/10.0	217/90.0
4/6	Off Oyster Creek	108	11	24	9.8	20/18.5	45/53.6	24/22.2	84/77.8
4/11	Off Thorofare	227	20	24	11.4	5/2.2	21/9.4	4/1.8	223/98.2
4/11	Off Thorofare	312	20	24	15.6	18/5.8	72/23.6	7/2.2	305/97.8
	Mean values for 4/6 & 4/11					/9.2	/42.7	/9.1	/91.0
4/25	Off Davis Is.	147	18	24	11.6	42/27.9	75/72.1	43/29.3	104/70.7
4/25	Jarrett Bay	323	20	48	16.2	130/40.2	110/58.7	139/43.0	184/57.0
4/27	Off Thorofare	273	20	48	13.7	34/12.5	210/81.1	14/5.1	259/94.9
4/27	Off Thorofare	224	20	48	11.2	41/18.3	131/64.5	21/9.4	203/90.6
	Mean values for 4/25 & 4/27					/24.7	/69.1	/21.7	/78.3

found in southern Core Sound, with the Jarrett Bay sample in late April containing the greatest amount, 40.5% of the sample.

The most common incidental species found in crab pots were the channeled pear conch or whelk (*Busycon canaliculatum*) and spider crabs (*Libinia spp.*), although neither comprised more than a trace of the catch. Other occasional incidentals included toadfish (*Opsanus tau*), southern flounder, bluefish, hermit crabs, and sand dollars (*Mellita quinquiesperforata*).

An attempt to develop an index of relative abundance using catch per pot per 24 hr soak time failed because of the difficulty in always finding fishermen who had fished their pots only 24 hr. Because crabbers fished their pots anywhere from daily to weekly and catch is almost certainly not linearly related to soak time, catch per effort is probably not comparable for different soak times.

Crab trawl catch composition

Crab trawl stations were sampled monthly in August and October 1979 and May - August 1980. Eight to ten stations were sampled each month except August 1979, when five were trawled (Table 11). A total of 658 crabs ranging from 24 to 180 mm CW were collected.

Monthly length frequencies by sex and for sexes combined (Figure 16) did not show growth of any particular group of crabs. They did indicate that very few crabs greater than 170 mm were taken and that the large (>150 mm), more valuable males or "jimmy crabs" were very scarce in the catches. The length frequencies also showed a greater proportion of small crabs in May and October, possibly corresponding to spring and late summer spawning peaks.

As in the pot samples, females predominated each month (Table 11). The mean monthly percentage of females was 73.5%, but this figure does not really describe the composition accurately, because it does not consider movements or changes in composition related to size. The mean monthly percentages of female crabs <127 mm (legal size) and >127 mm was 62.7 and 90.0%. These figures indicate the presence of fairly high proportions of small, juvenile males and their substantial decrease in proportions with increases in size.

Table 11. Size and sex composition, maturity, and C/f data for blue crabs taken by otter trawl August 1979-August 1980 in Core Sound.

Date	No. samples	No. crabs (No./%) Male	Female	No./%≥127mm Male	Female	C/f for crabs ≥127mm[1]	No. sponge
30 Aug 79	4	24/24.5	74/73.5	5/13.2	33/86.8	7.6	30
22 Oct 79	9	41/38.3	66/61.7	3/16.7	15/83.3	2.0	0
27 May 80	10	33/28.7	82/71.3	1/2.3	42/97.7	4.3	25
30 Jun 80	8	14/28.6	35/71.4	3/16.7	15/83.3	2.25	2
29 Jul 80	8	24/15.0	136/85.0	4/3.9	98/96.1	12.75	69
26 Aug 80	9	29/21.5	106/78.5	5/7.5	64/92.5	7.7	31
Mean Percentage		/26.1	/73.6	/10.1	/90.0		

[1]All tows were 10 min. except 30 August 79, which was 15 min.

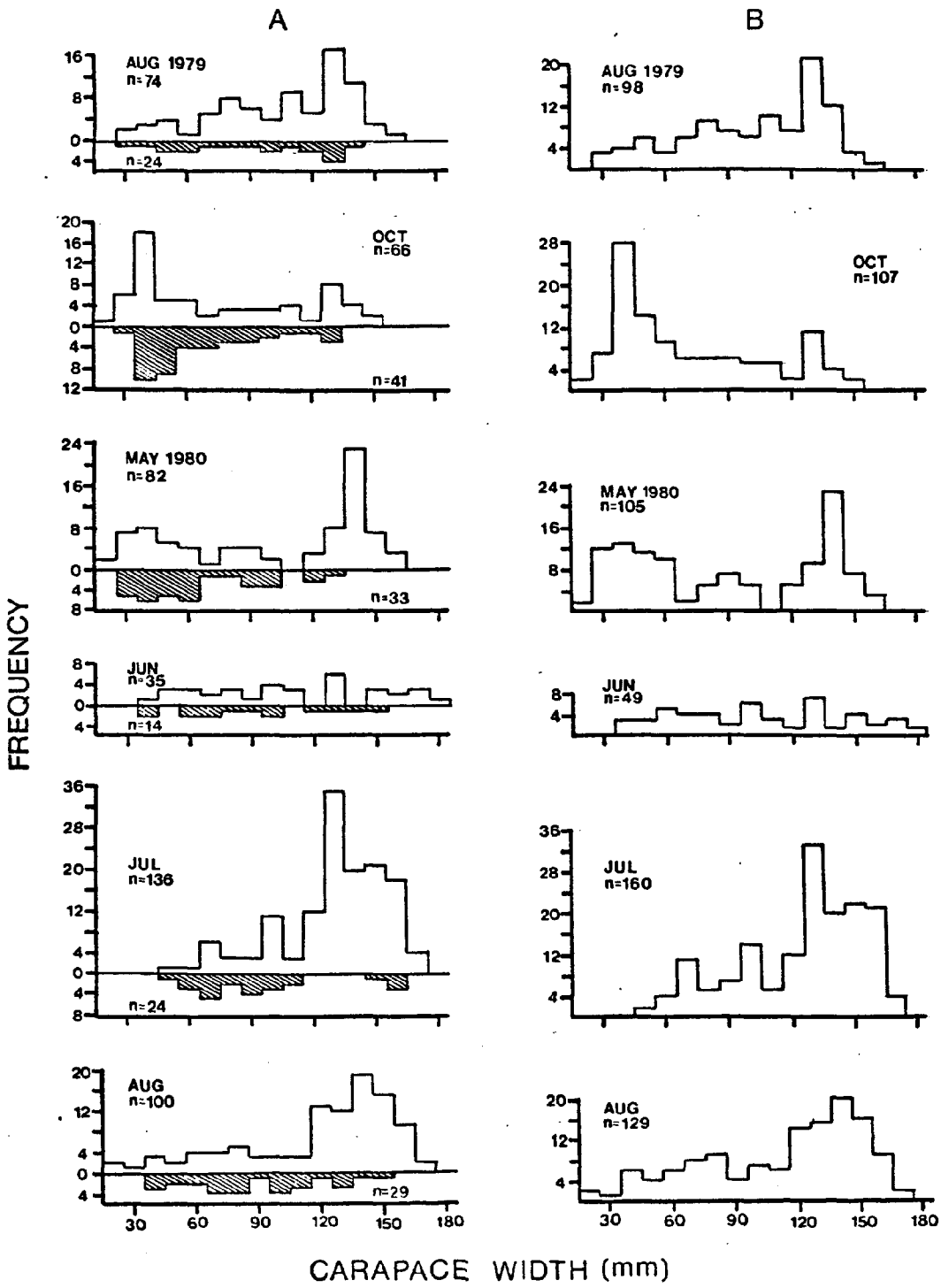

Figure 16. Monthly width frequencies of blue crabs taken by trawl in Core Cound, N.C., August 1979 - August 1980. A. Sexes separate - open portion=females, cross-hatched=males. B. Sexes combined.

These changes in sex composition probably result from emigration of males to more brackish waters and the immigration of spawning females.

Sponge crabs were most abundant in August 1979 and May, July, and August 1980, when they comprised 90.9, 59.5, 70.4, and 48.4% of the legal-sized female catch, compared to 9.9 and 13.3% in October 1979 and June 1980. The data indicate two peaks in sponge crab abundance - April and May (based on 1979 pot and 1980 trawl samples) and July and August (based on 1979 and 1980 trawl data). Van Engel (1958) noted that crabs in Chesapeake Bay have similar, though slightly later, split spawning peaks. The smallest sponge crab collected in Core Sound was a 67 mm specimen taken in June 1980, although 95.5% were ≥105 mm. Similarly, a comparison of length frequencies of immature and mature females showed a fairly distinct break at about 110 mm, with the largest immature crab collected being 112 mm. Again, the data indicate that the 127 mm size limit very adequately protects immature crabs.

One of the major objectives of the crab trawling program - to examine annual changes in relative abundance and correlate it with juvenile abundance - was not realized because only one year of data had been collected when the project was ended one year early. To determine any correlations with juvenile abundance, a minimum of three years' data are necessary. Monthly C/f values for legal-sized crabs ranged from 2/10 min tow in October to 12.75/10 min tow in July. This type of sampling is probably the simplest, most effective way to monitor annual changes in relative abundance of blue crabs. It probably needs to be done only two or three months each year, as long as a sufficient number of samples from a variety of habitats are taken. The most important considerations should be consistency in sampling and development of a time series of data.

Sink Net Fishery

Species composition

Four species - spot, croaker, weakfish, and bluefish - comprised the majority of sink net landings, although daily species composition varied widely. Typically one, or at most two, of these species completely dominated the catches on any one day. In 1979, croaker landings were highest (477,270 kg), followed by weakfish (127,958 kg), spot (121,200 kg), and bluefish (49,124 kg).

Other species observed in the catches in very small numbers included butterfish (*Peprilus triacanthus*), menhaden, and smooth dogfish (*Mustelus canis*). At times spiny dogfish (*Squalus acanthias*), are very abundant and taken in large numbers, although there is no market for them locally. Sink netters also are known to catch *Menticirrhus spp.*, spotted seatrout (*Cynoscion nebulosus*), harvestfish, small paralichthid flounders, and little tunny (*Euthynnus alletteratus*), and a few fish for Spanish and king mackerel (*Scomberomorus maculatus* and *S. cavalla*) during late summer and early fall.

Size and age composition

The 256 croakers sampled from five sink net catches in March, November, and December 1979 ranged from 264 to 365 mm TL, although 95.3% were 280 - 350 mm TL. Based on length frequencies from 1979 long haul samples (Ross and Carpenter 1980), these fish were most likely approaching, or had recently reached age 3. This dependence on one age group makes the fishery very susceptible to sharp fluctuations in annual landings, although a slight decrease in mesh size would make another age group vulnerable.

Lengths of 410 spot ranged from 221 to 302 mm FL, with 95.6% of the fish ranging from 230 to 289 mm. Percent age composition, calculated by expanding percent composition of 47 fish taken from the same sink net catches, for ages 1 - 4 was 28.5, 59.8, 9.8, and 2.0%. The age composition of spot, with four age classes represented, is quite different from that of croaker, with only one. These age compositions are not good indicators of the actual population age structure because the catches are much more a function of the net's selectivity than of the fish actually available to the fishermen.

The four bluefish present in one of the November samples ranged from 213 to 306 mm FL. Twenty-one weakfish present in the December sample ranged from 264 to 416 mm TL with most about 310 - 370 mm TL.

RECOMMENDATIONS

1. Begin collecting accurate effort statistics on the long haul seine, pound net, crab pot, and sink net fisheries in order to monitor changes in relative abundance, to use to determine if any relationship exists between

juvenile and adult abundance, and to use in surplus yield models.

2. Continue monitoring relative abundance of juvenile fish and crustaceans to provide data for use in juvenile-adult correlations.
3. Continue to monitor size and age composition of the dominant species in the long haul seine, pound net, and sink net fisheries each year to detect shifts in size or age structure which might indicate changes in abundance or growth overfishing.
4. Examine aspects of reproduction in spot, croaker, and southern flounder, particularly sizes and ages at maturity and spawning seasons.
5. Conduct tagging, meristic, and electrophoretic studies on spot, croaker, and weakfish to determine the number, range, and proportions of the stocks utilized by the fishery.
6. Continue age and growth studies on croaker and weakfish to more accurately assess age composition of the long haul seine and sink net fisheries, and determine size and age composition by sex of the pound net *P. lethostigma* catch.
7. Determine the discard ratio in weight for spot, croaker, and weakfish, using Sholar's (1979) minimum marketable sizes.
8. Calculate the various dynamic pool model parameters for *P. lethostigma* and attempt to model the pound net fishery.
9. Conduct an inshore flounder tagging program for two or three years to determine migration routes, exploitation rates, and stock identification.
10. Conduct a blue crab tagging study to determine exploitation rates.
11. Continue monitoring mesh sizes used in the long haul seine, pound net, and sink net fisheries.

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LITERATURE CITED

DeVries, D. A.
In press. Description and catch composition of North Carolina's long haul seine fishery. Proc. 34th Annual Mtg. Southeastern Assoc. Fish Wildl. Agencies.

Dudley, D. L., and M. H. Judy.
1973. Seasonal abundance and distribution of juvenile blue crabs in Core Sound, N.C. 1965-68. Chesapeake Sci. 14(1):51-55.

Guthrie, J. F., R. L. Kroger, H. R. Gordy, and C. W. Lewis.
1973. The long haul fishery of North Carolina. Mar. Fish. Rev. 35(12):27-33.

Higgins, E., and J. C. Pearson.
1928. Examination of the summer fisheries of Pamlico and Core Sounds, N.C., with special reference to the destruction of undersized fish and the protection of the gray trout *Cynoscion regalis* (Bloch and Schneider). Rept. U.S. Comm. Fish. 1227, App. 11, Bur. Fish, Doc. (1019):29-64.

Judy, M. H., and D. L. Dudley.
1970. Movements of tagged blue crabs in North Carolina waters. Comm. Fish. Rev. 32(11):29-35.

Lagler, K. F.
1956. Freshwater fishery biology. Wm. C. Brown Co., Dubuque, Iowa, 421 p.

McCoy, E. G.
1972. Dynamics of North Carolina commercial shrimp populations. N.C. Dept. Nat. Econ. Res., Div. Comm. and Sport Fish., Spec. Sci. Rep. No. 21, 53 p.

Merriner, J. C.
1973. Assessment of the weakfish resource, a suggested management plan, and aspects of life history in North Carolina. Ph.D. Thesis, North Carolina State Univ., Raleigh, 201 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(1):18-28.

Powell, A. B.
1974. Biology of the summer flounder, *Paralichthys dentatus*, in Pamlico Sound and adjacent waters, with comments on *P. lethostigma* and *P. albigutta*. M.S. Thesis, Univ. North Carolina, Chapel Hill, 145 p.

_____and F. J. Schwartz.
1977. Distribution of paralichthid flounders (Bothidae:*Paralichthys*) in North Carolina estuaries. Chesapeake Sci. 18(4):334-339.

Purvis, C. E.
1976. Nursery area survey of northern Pamlico Sound and tributaries. Compl. Rep., Proj. No. 2-230-R. N.C. Dept. Nat. Econ. Res., Div. Mar. Fish., 62 p.

_____and E. G. McCoy.
1972. Overwintering pink shrimp, (*Penaeus duorarum*), in Core and Pamlico Sounds, N.C. N.C. Dept. Nat. Econ. Res., Div. Comm. and Sport Fish., Spec. Sci. Rep. No. 22, 29 p.

_____and E. G. McCoy.
1974. Pink-brown shrimp discard studies in the Core-Pamlico Sound area. N.C. Dept. Nat. Econ. Res., Div. Comm. and Sport Fish., Spec. Sci. Rep. No. 26, 19 p.

Roelofs, E. W., and D. F. Bumpus.
1953. The hydrography of Pamlico Sound. Bull. Mar. Sci. Gulf Carib. 3(3):181-205.

Ross, S. W., and R. K. Carpenter.
1980. Estuarine stock assessment. *In* A plan for management of North Carolina's estuarine fisheries-Phase I. Semiannual report for North Carolina's Office of Coastal Zone Management Fisheries Assistance Program grant, Mar.-Nov. 1979, p. 2-34. N.C. Dept. Nat. Res. Comm. Devel., Div. Mar. Fish.

Sholar, T. M.
1979. Adult stock assessment. *In* A plan for management of North Carolina's estuarine fisheries-Phase I. Semiannual report for North Carolina's Office of Coastal Zone Management Fisheries Assistance Program grant, Oct. 1978-Feb. 1979, p. 11-27. N.C. Dept. Nat. Res. Comm. Devel., Div. Mar. Fish.

Spitsbergen, D. L.
1979. A study of the bay scallop (*Argopecten irradians*) in North Carolina waters. Compl. Rep., Proj. No. 2-256-R. N.C. Dept. Nat. Res. Comm. Devel., Div. Mar. Fish., 44 p.

Stokes, G. M.
1977. Life history studies of southern flounder (*Paralichthys lethostigma*) and Gulf flounder (*P. albigutta*) in the Aransas Bay area of Texas. Texas Parks Wildl. Dept., Tech. Ser. No. 25, 37 p.

Sundararaj, B. I.
1960. Age and growth of the spot, *Leiostomus xanthurus* Lacepede. Tulane Stud. Zool. 8(2):41-62.

Van Engel, W. A.
1958. The blue crab and its fishery in Chesapeake Bay. Part I. Reproduction, early development, growth, and migration. Comm. Fish. Rev. 20(6):6-17.

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

Wolff, M.
1976. Nursery area survey of the Outer Banks region. Compl. Rep., Proj. No. 2-222-R. N.C. Dept. Nat. Econ. Res., Div. Mar. Fish., 27 p.

_____
1977. Preliminary stock assessment, North Carolina: flounder (*Paralichthys sp.*). Compl. Rep. Proj. No. 2-294-R. N.C. Dept. Nat. Res. Comm. Devel., Div. Mar. Fish., 19 p.

_____
1978. Preliminary stock assessment, North Carolina: hard blue crabs, *Callinectes sapidus*. Compl. Rep. Proj. No. 2-292-R. N.C. Dept. Nat. Res. Comm. Devel., Div. Mar. Fish., 17 p.