FISHES, MACROINVERTEBRATES, AND THEIR ECOLOGICAL INTERRELATIONSHIPS WITH A CALICO SCALLOP BED OFF NORTH CAROLINA

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ABSTRACT

A 1972 study documented the fishery, fish and macroinvertebrate faunas, possible predators, and the ecological interrelationships of the offshore North Carolina calico scallop, *Argopecten gibbus*, bed(s). Environmental data of water temperature, salinities, chlorophyll a, water current direction, sediment grain size, and organic composition were obtained aboard commercial and chartered research vessels. Water temperatures progressed seasonally from 12° to 26° C while bottom salinities varied between 31 and 37‰ yet were not radically different from the surrounding habitats. Chlorophyll a data suggested a fairly stable but low plankton fauna over the bed(s) except for June and late October. Little or no differences in bottom type within or without the bed(s) were noted on the basis of sediment particle size, grain size, skewness, or sorting coefficients. Scallops grew faster in the experimental bed than in the commercial bed but little could be found to account for their differences in size. Some 111 species of fishes were captured over the bed(s). Of a vast moving fish fauna, 33 species dominated the catches. Of 46 species with food in their stomachs, 20.4% feed on scallops with only 9 species considered scallop predators. Bothids, soleids, rajids, labrids, dasyatids, and myliobatids were not active scallop predators. *Halichoeres caudalis* appeared in October when the fishery collapsed economically. Of 12 species of echinoderms, the sea stars *Luidia clathrata* and *Astropecten articulatus* were active scallop predators. While less abundant, 21 additional invertebrates were also suspected predators. *Luidia clathrata* and *A. articulatus* abundance on the beds remained high throughout the season; however, abundance off the beds was somewhat lower. No one factor has yet been found that made the North Carolina calico scallop beds unique, why they existed, or were productive in 1972.

Three commercial species of scallops occur in North Carolina: the Atlantic deepwater scallop, *Placopecten magellanicus* (Gmelin), the shallower offshore calico scallop, *Argopecten gibbus* (Linné), and the inshore bay scallop, *Argopecten irradians* (Lamarck). The offshore calico scallop fishery, while yielding varying quantities of harvestable scallops (Table 1), has alternately experienced good and bad years of production (Lyles 1969; Cummins 1971; Chestnut and Davis 1975). The disappearance of calico scallops from an area, whether off North Carolina, Florida, or elsewhere, is common knowledge (Bullis and Ingle 1959; Hulings 1961; Anonymous 1962; Kirby-Smith 1970; Roe et al. 1971; Porter and Wolfe 1972). Off North Carolina the causes of scallop fluctuations and production have been attributed to mortalities, migration, poor larval transport from elsewhere, introduction of scallop shucking and eviscerating machines, or overfishing (Webb and Thomas 1968; Lyles 1969; Cummins and Rivers 1970; Kirby-Smith 1970; Cummins 1971; Allen and Costello 1972). This report documents the fish and macroinvertebrate faunas, possible predators, and their ecological interrelationships with the scallop bed(s) that supported the 1972 fishery.

TABLE 1.—North Carolina calico scallop production, 1959-75.[1] [No production 1962-64, 1968-69, and 1974-75.]

Year	Meats (pounds)	Value (dollars)	Gear
1959	6,572	2,629	Dredge
1960	111,726	44,691	Trawl
1961	22,427	8,971	Trawl
1965	871,100	244,709	Trawl
1966	1,856,760	368,685	Trawl
1967	1,388,606	308,843	Trawl
1970	1,574,087	498,570	Trawl
1971	1,285,304	432,025	Trawl
1972	1,050,320	492,899	Trawl
1973	556,315	353,757	Trawl

[1]Data supplied by the National Marine Fisheries Service Statistical Office, Beaufort, N.C., and Chestnut and Davis 1975.

NORTH CAROLINA CALICO SCALLOP FISHERY

While *A. gibbus* occurs in the western North Atlantic from the northern side of the Greater Antilles and throughout the Gulf of Mexico to

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Bermuda and possibly Delaware Bay (Waller 1969; Allen and Costello 1972), only three areas produce calico scallops of commercially harvestable quantities: North Carolina, Cape Canaveral off eastern Florida, and the Gulf of Mexico off Apalachicola Bay, Fla. (Drummond 1969; Cummins 1971; E. Willis pers. commun.). Throughout its range it has been found in depths of 2-370 m (Waller 1969). Off North Carolina, calico scallops occur at open water depths of 13-94 m (Cummins et al. 1962; Bullis and Thompson 1965; Porter 1971, 1972a; Allen and Costello 1972).

Until recently, North Carolina calico scallops were hand shucked by shore-based operations (Cummins 1971). In 1970, two shucking machines (Webb and Thomas 1968) were introduced in North Carolina and by 1975 there were eight. The present North Carolina and Florida fisheries prefer this shucking method rather than utilizing offshore vessels equipped with machine shuckers, as was briefly used off Florida (Allen and Costello 1972). Generally, commercial fishing is considered feasible when 20 bushels (in shell) are caught per hour with shell diameter of at least 40 mm (Drummond 1969). Meat size to be acceptable to hand shucking should be 190 meats/kg or 90 meats/pound (Cummins 1971). Machine processed meats can be as small as 495 meats/kg (225 meats/pound).

Off North Carolina, the high cost of hand shucking and the early lack of knowledge concerning a possible calico scallop fishery delayed its development (Chestnut 1951). The fishery seems to have begun in 1959 and has since been described by Cummins et al. (1962), Cummins (1971), Porter (1971, 1972a), and Porter and Wolfe (1972). At first scallop dredges were used to harvest calico scallops. Today, otter trawls are the gear used by the commercial fishery (Rivers 1962). Short tows of 10-15 min often land 60 or more bushels, with an average day's catch being 800-1,500 bushels of shell stock.

STUDY AREA

Cummins et al. (1962) characterized the principal North Carolina calico scallop grounds as an elliptical shaped bed 16 km long near Cape Lookout, with several lesser beds located in 19-37 m depths northeast and southeast of the Cape. The major North Carolina calico scallop fishery in 1971 was located southeast of Cape Lookout; a small bed southeast of the Cape was also fished briefly in September of that year. Exploratory efforts in 1972 by the commercial fleet and the RV *Dan Moore* on the beds southwest of New River and northeast of Cape Lookout (Figure 1) failed to locate commercial quantities of calico scallops. The only beds that supported the 1972 fleet of 13 vessels from February to October were located 16-24 km south of Beaufort, N.C., producing some 1 million pounds of meats (Table 2).

The 1972 study area consisted of the above beds located at lat. 33°35′N between long. 76°35′ and 76°55′W (Figure 2). Depths were 20-25 m and most sampling occurred inside the 28-m contour.

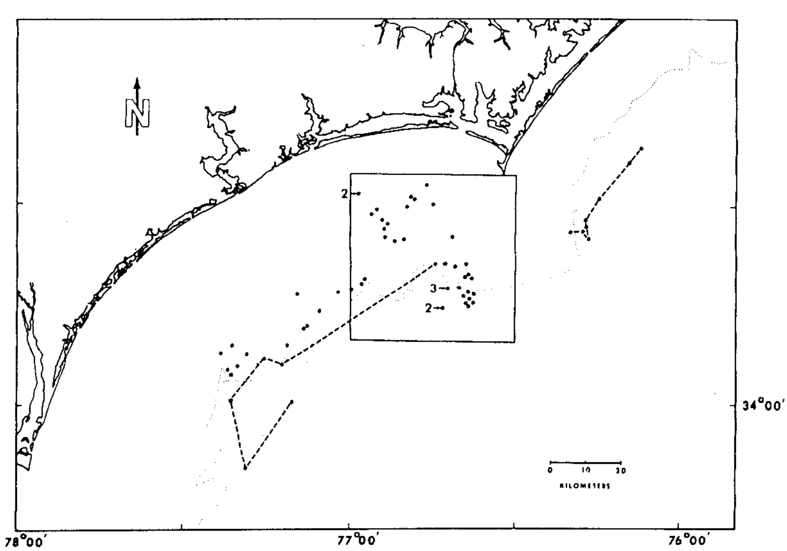

FIGURE 1.—North Carolina calico scallop fishing grounds. Dots refer to areas of poor catch by commercial fishermen during the 1972 season. Dashed lines indicate exploratory trips by one or more trawlers. Solid line refers to the area contained in Figure 2. Dotted line indicates 20-fathom (36.6-m) contour.

TABLE 2.—North Carolina calico scallop production, 1972.[1] [No production in November and December.]

Month	Pounds	Value ($)	Month	Pounds	Value ($)
Jan.	2,800	1,624	July	68,768	46,763
Feb.	24,064	9,626	Aug.	43,624	35,772
Mar.	184,688	72,028	Sept.	33,008	29,047
Apr.	280,800	101,087	Oct.	544	478
May	228,400	93,644	Total	1,050,320	492,899
June	183,624	102,830			

[1]Data supplied by the National Marine Fisheries Service Statistical Office, Beaufort, N.C., and Chestnut and Davis 1975.

METHODS

Sampling Vessels

Two types of vessels were used to sample the offshore North Carolina calico scallop beds. Commercial fishing vessels, from which most of the samples were obtained, were the 25-m MV *Ensign,* a side trawler of Gloucester design and the 15-m MV *Seven Brothers,* a double rigged shrimper design. Research vessels include the RV *Beveridge,* a 17-m shrimp trawler which was chartered monthly to collect additional samples or to maintain anchored equipment, and the Duke University 33-m RV *Eastward,* a side trawler of Gloucester design. One bottom observational cruise was accomplished by using RUFAS (Anonymous 1969) aboard NOAA RV *George M. Bowers.* Two additional samples, 23 April and 27 June, were also obtained while returning from other *Eastward* projects.

All commercial or chartered vessels towed one or two 10-12 m scallop trawls (Rivers 1962) which were modified to have heavily weighted foot lines and heavy-duty chaff gear on the cod end. The trawl on the *Beveridge* was rigged the same as that of the commercial vessels except that the foot line was the standard weighted loop chain design preceded by a light tickler chain. Mesh size of all trawls was the standard flat shrimp type. Sampling tow interval varied on the commercial vessels by season as a function of scallop abundance. *Beveridge* or *Eastward* tows were kept to 15 min. Sample tow distances, by commercial vessels, varied ¼-½ km, whereas *Beveridge* and *Eastward* tows were ¼ km. No effort, by type of vessel, was made to sample with or against the current.

Environmental Data

Water temperatures were obtained with a mercury thermometer immersed in bottom water obtained by a 3.1-liter Kemmerer sampler.

Salinities were determined from the water sample by using a direct reading American Optical Corp.[2] refractiometer.

Chlorophyll a was determined spectrophotometrically for 19 stations (Figure 2) following the methods of Strickland and Parsons (1968) and expressed as milligrams per cubic meter.

A Braincon 381 current meter was anchored and buoyed at the northwestern edge of the commercial grounds. Excessive fouling during much of the sample year by hydroids, sponges, and tunicates prevented precise long-term bottom current data being recorded at the surface of the bed. After rebouying the meter to record currents 30 cm above the bed, current data obtained over a 26-day period, mid-August to mid-September, indicated a northeastward current drift component (Schumacker 1974).

Sediment samples taken by Peterson (*Beveridge*) and Shipek (*Eastward*) grabs (Figure 3) were frozen until grain size and organic determinations could be made. Pretreatment for grain-size analysis included washing each sample in a large volume of fresh water and then decanting after all sediment had settled. Washing was done to reduce weighing errors induced by salt crystals. Following decanting, sediments were oven dried at 85°C and separated into sediment sizes by a U.S. Standard Sieve Series and mechanical sieve shaker. All samples were in the shaker for at least 2 h. Analysis of data followed Morgans (1956).

Percent organic material was determined from 1 to 2 g unwashed subsamples which had been oven dried for 48 h at 85°C. The amount of organics was assumed to be the difference in sample weights before and after firing at 500°C for 2 h. This followed a technique used in the Marine Sediments Laboratories of Oregon State University (J. Paul Dauphin pers. commun.).

An attempt was made to develop a fast method for percent organic determinations of marine sediments through the manufacturer's suggested use of a Coleman Model 33 Carbon-Hydrogen Analyzer, rented from the Duke University Marine Laboratory. Comparison of data, by statistical means, showed no correlation between analyzer and ovenfired organic values from offshore marine sediments.

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

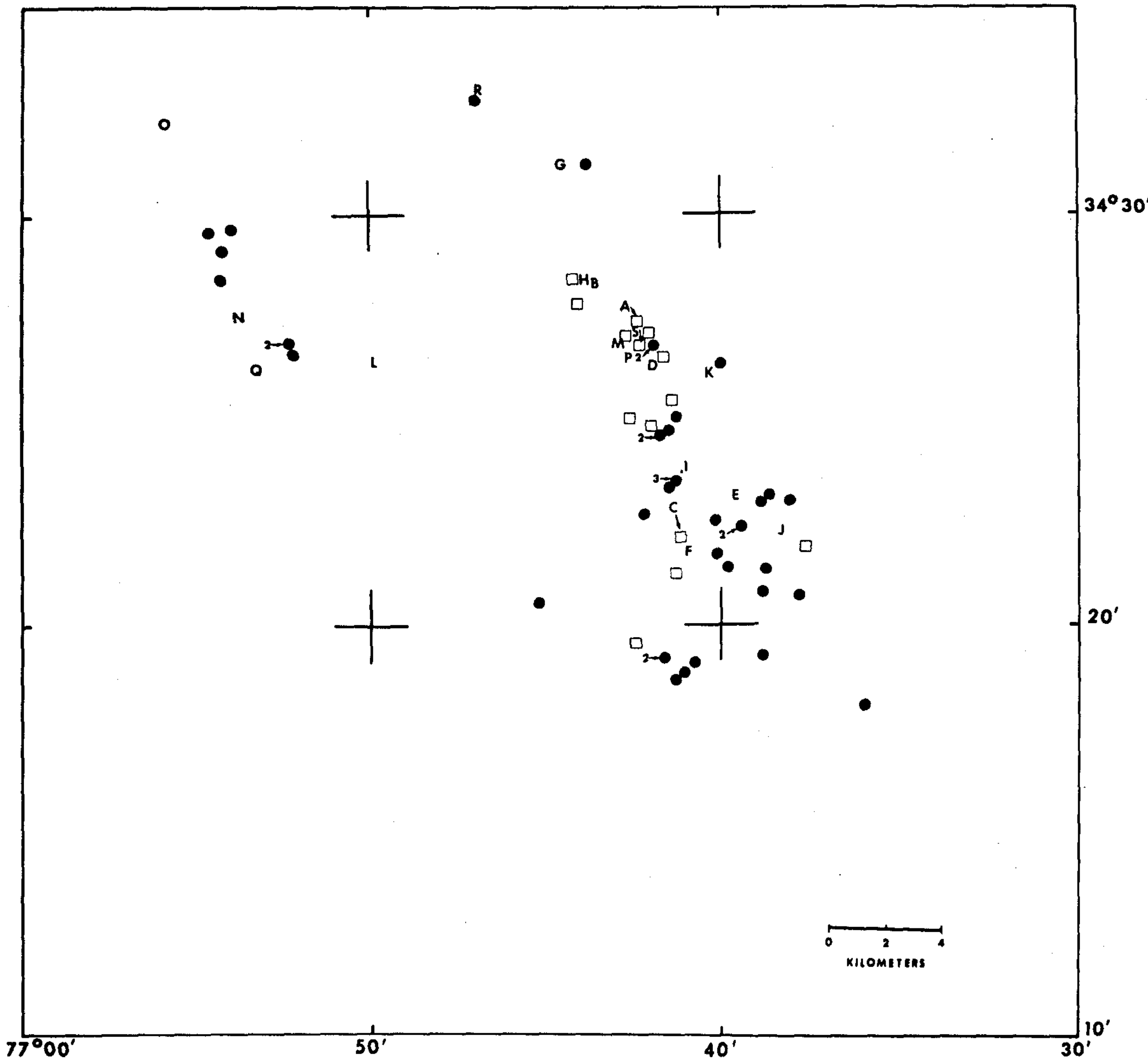

FIGURE 2.—North Carolina calico scallop fishing grounds. Dots refer to known locations of good catches by commercial trawlers. Open squares refer to known locations of good catch by RV *Beveridge*. Letters refer to chlorophyll a sampling stations. For location of enclosed area off North Carolina coast see Figure 1.

Fishes

Fishes of at least 100 mm standard length were tagged using 12-mm Peterson disk tags held in place (in the middorsolateral musculature) by Monel pins. Fish lengths, except for skates and stingrays where wing width was used, were expressed for each species and specimen as standard length. Once tagged, release was immediate over the original collecting site. The ship's loran was used to pinpoint the release site. Other biological data were taken on those additional fishes that had not been too badly damaged by the fishery or scallop catches. Notations of other fishes not captured, such as flyingfishes, completed the field data.

Fish samples from commercial catches and destined for stomach content analyses were kept on ice because of the danger of Formalin contamination of the scallop catch and the cramped ship quarters prevented carrying extra gear afield. Similar fish sampled aboard research vessels were preserved in 20% Formalin. In the laboratory, the entire digestive tract was removed, contents identified, and noted whether the food items were in the stomach or intestine. Positive identification of

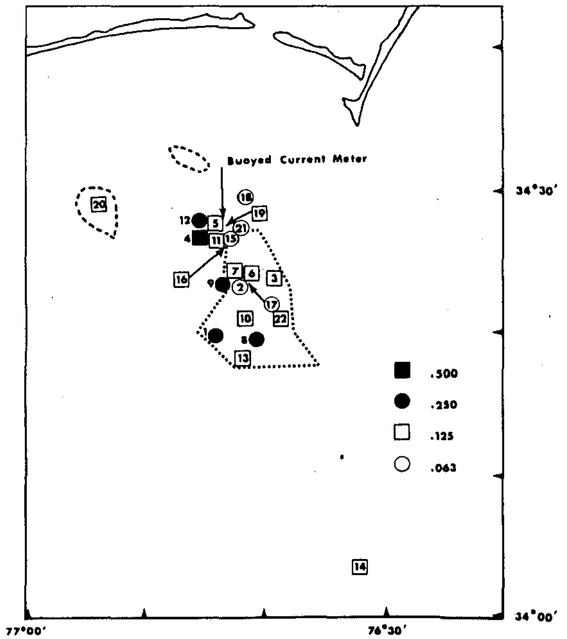

FIGURE 3.—Twenty-two sediment sample stations. Dominant grain size is indicated by station. Broken lines enclose the commercial area, an area fished by the calico scallop fishery.

the food items to species was possible in most cases.

Scallops

Scallops were sampled from two areas—one general and one specific. The general area, hereafter referred to as the commercial area, included wherever the scallop fishery was operating (Figures 1-4). Scallop tissue samples from this area were taken, when possible, once a week; shell length measurements and other appropriate scallop data were taken more frequently. Tissue, gonad and/or spawning condition data will be covered in a paper by Porter and Schwartz (in prep.).

The specific area, hereafter referred to as the experimental area, was an area just northwest of the commercial area. This area was sampled monthly by the *Beveridge* and was marked from June to September 1972 by a large red buoy; this buoy further served to support the Braincon current meter (Figure 3). The seabed interval between this area and the commercial area to the south contained no scallops, which suggested that this area was a small separate bed. Only briefly during the latter part of the commercial scallop season was the experimental area worked by the 1972 fishery.

Sea Stars

Data were accumulated on seasonal distribution of the sea stars present on the scallop beds, their size, and relative abundance. Sea star size is here defined as the radius of a sea star through its longest arm.

About 20 *Astropecten articulatus* and about 20 *Luidia clathrata* were examined weekly, when available, for stomach contents. *Luidia alternata, Goniaster americanus,* and *Echinaster brasiliensis* stomachs were also examined, when available. Stomach analysis examinations which also delineated associated organisms were similar to those of Porter (1972b) and will be reported on elsewhere.

Associated Macroinvertebrates

Unculled bushels of scallops, as caught by the trawlers, were examined periodically by the field investigator to note other associated organisms, amount of shell material, and signs of dead or dying scallops. Counts were made of each organism and the amount of dead shell or trash. A log was also kept of all macroinvertebrate species seen during each cruise.

ENVIRONMENTAL OBSERVATIONS

Bottom water temperatures exhibited a natural progression from about 12°C in February to a high near 26°C in September. These were within the range 9.9°-33°C noted by Waller (1969). Vernberg and Vernberg (1970), in laboratory experiments of North Carolina calico scallops, found none survived after 48 h exposure to water of 10°C.

Bottom salinities throughout the bed, as evidenced during the shifting seasonal fishing effort (Figure 4), remained fairly constant at 35‰ (range 31-37‰, Figure 5). This agreed with observations of others for scallop grounds elsewhere (Anderson et al. 1961; Hulings 1961; Grassle 1967; Pequegnat and Pequegnat[3]).

Kirby-Smith (1970) and Allen and Costello (1972) suggested that upwelling in the vicinity of

[3]Pequegnat, W. E., and L. H. Pequegnat. 1968. Ecological aspects of marine fouling in the northeastern Gulf of Mexico. Texas A&M Univ. Dep. Oceanogr. Proj. 286-F, Ref. 68-22T, 80 p.

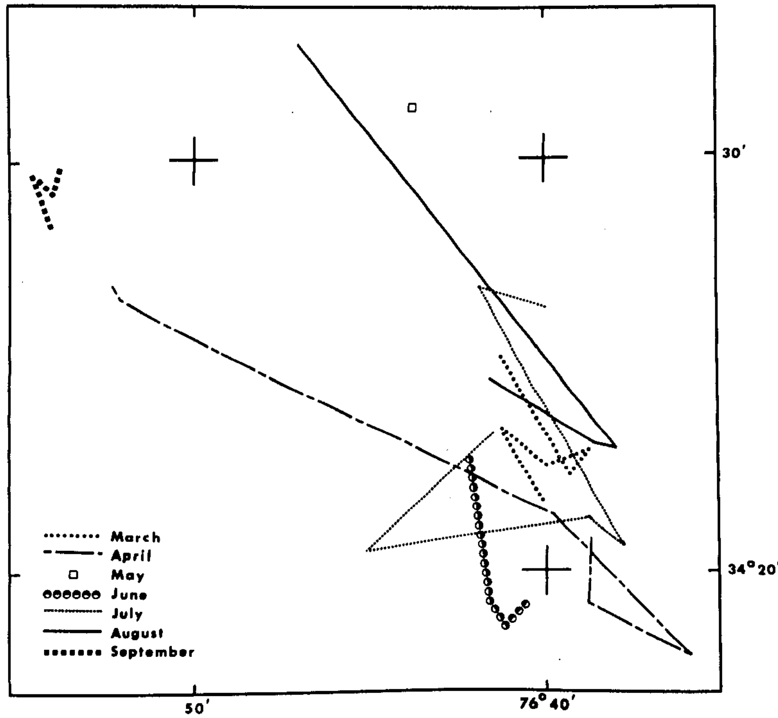

FIGURE 4.—Areas fished by commercial fishery during the 1972 season. Locations taken from ship's log.

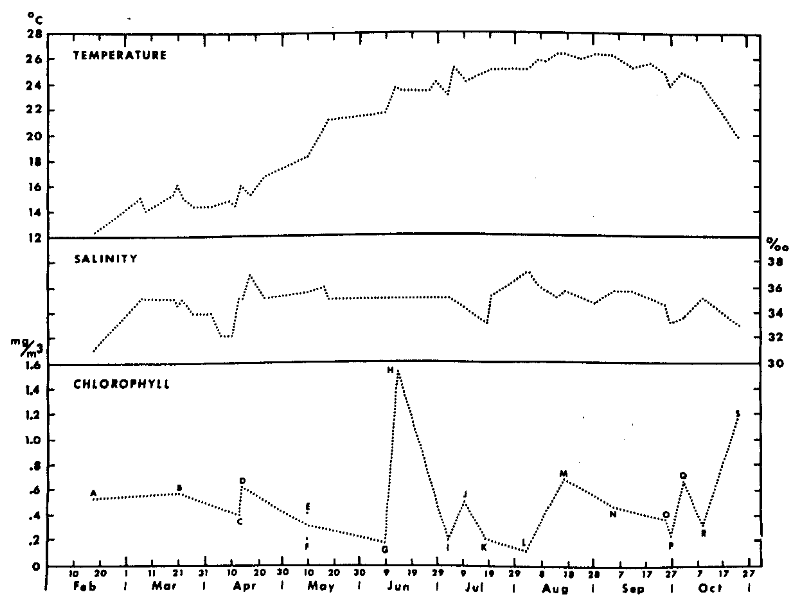

FIGURE 5.—Environmental data collected from the calico scallop grounds. Each data point for water and salinity indicates individual date sampled. Letters on chlorophyll graph refer to station sampled that date, see Figure 2 for locations.

Cape Lookout (Taylor and Stewart 1959; Wells and Gray 1960; Gaul et al.[4]) may produce high plankton concentrations and that these concentrations may occur where scallop abundance is greatest. Chlorophyll a analyses during 1972 (Anonymous[5]) suggested that a fairly stable but

[4]Gaul, R. D., R. E. Boykin, and D.E. Letzring. 1966. Northeast Gulf of Mexico hydrographic survey data collected in 1965. Texas A&M Univ. Dep. Oceanogr. Proj. 286-D, Ref. 66-8T, 202 p.

[5]Anonymous. 1972. Data report for R/V *Eastward* cruise E-12-72, July 3-8, 1972. Duke Univ. Mar. Lab., Beaufort, N.C., 34 p.

low plankton fauna existed over the scallop beds, except during June and late October, when indications of a late spring and early fall bloom occurred (Figure 5).

Twenty-two sediment samples were taken during the 1972 study (Figure 3). Of these, seven were deliberately taken in areas where no scallops were collected by the fishery (Table 3). As the sediments were taken immediately after a trawl tow, they may not be representative of the same bottom covered during the tow. No discernible differences were found between sediments from scallop producing and nonproducing areas (Table 3, Figure 2).

Newton et al. (1971, Sediment Distribution Chart No. 2) characterized the area which was later encompassed by the 1972 commercial scallop fishery (Figures 3, 4) as consisting of two sediment

TABLE 3.—Sediment size analyses, data listed as percent per sample, sediment sorting coefficients, skewness, for scallops sampled in 1972 from producing and nonproducing areas off North Carolina.

Sediment size (mm)	Sediment sample station and sample date							
	1	2		3	4	5	6	7
	18 Feb.	18 Feb.		18 Feb.	18 Feb.	21 Mar.	21 Mar.	21 Mar.
>4	0.572	0.701	1.031	0.102		0.072	0.406	0.0027
2-4	1.734	0.381	0.626	0.165	18.235	0.362	0.381	0.0068
1-2	8.289	1.530	2.715	0.573	22.831	0.651	0.964	0.0139
0.5-1	32.299	2.325	3.903	2.090	25.053	1.505	2.224	0.0303
0.250-0.5	40.606	3.898	5.842	34.711	19.814	13.576	12.670	0.1443
0.125-0.250	13.847	14.748	14.649	49.834	7.782	81.622	40.021	0.2982
0.063-0.125	1.826	69.186	64.396	9.836	3.431	0.001	40.096	0.4646
<0.063	0.826	7.231	6.837	2.688	2.855	2.211	3.239	0.0392
Median particle size[1]	1.17	3.37	3.32	2.22	0.35	2.42	2.80	3.02
Median particle size (mm)	0.44	0.09	0.09	0.21	0.77	0.17	0.14	0.12
Sediment sorting coef[1]	0.675	0.365	0.485	0.555	1.100	0.300	0.635	0.685
Sediment skewness[1]	−0.045	0.015	−0.105	−0.035	0.	−0.020	0.035	−0.155
Percent organic	2.027	1.080		0.844	2.118	0.884	0.790	1.394
Latitude N	34°22′	34°24′		34°24′	34°26.5′	34°27′	34°24′	34°24′
Longitude W	76°44′	76°42′		76°39′	76°45′	76°44′	76°41′	76°42.5′
Depth (m)	25	24		24	22	22	24	25
Scallop producing area	no	yes		no	yes	no	yes	yes

Sediment size (mm)	8	9	10	11		12	13	14
	21 Mar.	21 Mar.	10 May	14 June		14 June	14 June	25 June
>4	0.0019	0.0313		8.026	3.640	0.491	0.012	0.064
2-4	0.0196	0.0347	0.341	8.118	3.855	1.088	0.339	0.074
1-2	0.0595	0.0643	1.062	8.102	7.438	3.318	1.084	0.890
0.5-1	0.2356	0.2678	2.769	19.210	19.475	9.113	5.071	3.936
0.250-0.5	0.5574	0.4873	11.619	2.623	2.810	44.895	27.046	30.632
0.125-0.250	0.1132	0.0854	44.095	28.842	40.369	6.080	61.209	62.931
0.063-0.125	0.0096	0.0207	31.974	13.432	16.683	30.813	5.218	1.231
<0.063	0.0032	0.0085	8.139	11.647	5.730	4.201	0.022	0.242
Median particle size[1]	1.33	1.22	2.78	2.13	2.32	1.80	2.27	1.23
Median particle size (mm)	0.39	0.42	0.14	0.22	0.18	0.28	0.20	0.41
Sediment sorting coef[1]	0.525	0.645	0.650	1.465	1.215	1.060	0.505	0.480
Sediment skewness[1]	−0.085	−0.145	0.070	−0.615	−0.605	0.500	−0.095	−0.090
Percent organic	2.176	2.461	ND[2]	1.638		0.885	0.763	0.840
Latitude N	34°19.5′	34°23.5′	34°21′	34°27′		34°27.5′	34°18.5′	34°3.4′
Longitude W	76°41′	76°43.5′	76°41.5′	76°44′		76°45′	76°42′	76°32.7′
Depth (m)	28	23	26	23		21	29	37
Scallop producing area	yes	yes	yes	no		no	yes	no

Sediment size (mm)	15	16	17	18	19	20	21	22
	27 June	17 Aug.	17 Aug.	17 Aug.	12 Sept.	12 Sept.	23 Oct.	23 Oct.
>4	1.082	0.021	0.044	0.000	0.049	0.000	0.665	0.243
2-4	1.016	0.437	0.146	0.234	0.363	0.001	0.480	0.446
1-2	1.472	1.556	0.756	0.603	1.043	0.007	1.386	1.162
0.5-1	2.573	3.345	2.472	2.646	2.103	0.026	2.515	2.821
0.250-0.5	5.800	24.389	6.758	8.376	6.175	0.209	6.451	11.387
0.125-0.250	14.705	58.881	20.293	23.028	62.728	0.638	20.518	46.534
0.063-0.125	66.049	9.525	62.619	59.094	26.885	0.097	62.462	35.038
<0.063	7.304	1.847	6.912	6.019	0.654	0.022	5.523	2.370
Median particle size[1]	3.35	2.36	3.32	3.26	2.65	2.38	3.27	2.72
Median particle size (mm)	0.09	0.19	0.10	0.10	0.15	0.19	0.10	0.15
Sediment sorting coef[1]	0.425	0.485	0.500	0.555	0.465	0.380	0.505	0.585
Sediment skewness[1]	−0.055	−0.075	−0.100	−0.135	0.065	0.020	−0.095	0.090
Percent organic	0.967	1.151	0.866	1.037	0.593	1.251	1.021	1.119
Latitude N	34°26.3′	34°26′	34°23.5′	34°29.5′	34°27′	34°29′	34°27′	34°21′
Longitude W	76°43′	76°43′	76°41′	76°41.5′	76°42.5′	76°54′	76°42′	76°38.5′
Depth (m)	18	22	23	19	21	20	21	26
Scallop producing area	yes?	yes	yes	no	yes?	yes	yes	yes

[1]See Morgans (1956) for definition.
[2]Not determined.

types, most of the bed being "fine sand - grey" while areas of its western edge were "shell hash - often brown - many types of organic contributors." The latter was typical of our sediment sample 14. The area from which sediment sample 20 was taken was characterized as "Coarse sand - very shelly - iron stained"; the experimental area northwest of the main scallop producing area was characterized as "fine sand - iron stained - less than 25% shell material." Median grain size analyses of our data agreed with Newton et al. (1971) in that parts of the western edge of the calico scallop bed had coarser sediments than other areas encompassed by the main bed (Figure 3); however, no differences were found between the main scalloping area, the experimental area north of the bed, and stations 14 and 20.

Sanders (1958) and Bloom et al. (1972) suggested that optimal sediment conditions for filter feeders were a fine (about 0.18 mm) and a well-sorted, but positively skewed, grain size. Median sediment sizes found within the 1972 North Carolina calico scallop bed averaged below Sanders' 0.18 mm optimal size for filter feeders. Subsequent to this study, plotting the location of the 1973 calico scallop fishery off the North Carolina coast on the Newton et al. (1971) sediment chart, revealed that the 1973 fishery was in an area not of fine sand but very coarse shelly sand. This has been further corroborated by personal observations aboard vessels in the fishery. These data may support the contention of McNulty et al. (1962) that other factors besides grain size are important to the well being of filter feeders.

Sorting coefficient values for most sediment samples ranged from 0.300 to 0.685 (Table 3, a condition considered well sorted), although two samples located northwest of the main fishery had relatively high sorting coefficients (1.100 to 1.465). Sediments in these same two samples were also strongly skewed (−0.615 and 0.500, Table 3). While sorting coefficient values agreed with the conclusions of Sanders (1958) and Bloom et al. (1972), the sediment skewness data did not. Most of the data was only slightly skewed (−0.155 to 0.090) and not strongly positively skewed as they suggested.

Commercial fishermen reported that there were numerous rough areas, including a small low ledge, outside the commercial area which caused great damage to their nets. Porter and Wolfe (1972) described the North Carolina scallop grounds as consisting of sand, shell fragments, and occasionally large pieces of trent marl and coquina. Porter and Wolfe (1972) and Pearse and Williams (1951) described a small bed southwest of New River which was surrounded by bottom containing large heads of lobe star coral, *Solenastrea hyades* (Dana). During 1972, large masses of trent marl were not infrequently brought up in the scallop nets by the commercial fishermen. Ledgelike outcroppings of marl (?) and large heads of the lobe star coral outside the commercial area were observed in 1972 while aboard the *George M. Bowers* through use of its remote underwater television sled RUFAS. While such marl outcrops and coral heads are not uncommon throughout the southern North Carolinian coastal area, known calico scallop beds do not seem to be dependent upon their presence.

CALICO SCALLOP GROWTH

Length measurements were taken on 5,180 scallops during the sampling period (Table 4). Scallop (865) mean growth in the experimental area was faster than that from the commercial area (Table 4); size increase over a 7-mo sampling period was 17.8 mm or 2.5 mm/mo. Comparable growth data obtained from 4,315 scallops landed by the commercial fishery over the 9-mo sampling period were 8.7 mm or 1.1 mm/mo; their sizes ranged from 35 to 65 mm with no live small scallops being noted. The difference in rate of growth was probably related to the original smaller size of the experimental area scallops, which ranged from 28 to 57 mm in length (Table 4). Allen and Costello (1972), reviewing the calico scallop literature, noted growth data of 4.0 mm/mo for scallops having mean sizes of 13.9 to 37.8 mm and 0.3 mm/mo for scallops having mean sizes of 75 to 80 mm.

As mentioned above, the scallops from the ex-

TABLE 4.—Lengths (millimeters) of calico scallops collected monthly from the experimental bed north of the main bed and commercial catch, 1972.

	Experimental bed			Commercial catch		
Month	Average length	Size range	Sample size	Average length	Size range	Sample size
Feb.	35.5	28-44	100	47.3	40-54	545
Mar.	37.4	30-47	150	46.3	37-55	510
Apr.	—	—	—	47.3	35-56	617
May	49.8	43-55	86	47.8	41-62	276
June	44.8	33-54	152	50.7	39-70	1,100
July	—	—	—	47.6	35-61	450
Aug.	45.0	39-57	127	50.8	36-59	400
Sept.	53.3	44-64	150	54.2	48-65	316
Oct.	50.5	42-57	100	55.0	43-65	101
Average length increase	17.8			8.7		

perimental area were consistently smaller than those from the commercial area (Table 4). Median sediment size and texture analyses data from the two areas were virtually identical (Table 3). There was some indication that organic values in the experimental area may be slightly higher than those from the commercial area (Table 3). Carriker (1959) noted that growth of *Mercenaria mercenaria* was faster in his low organic areas than in areas with higher organic percentages. This was the opposite of our findings.

Apparently the growth of the calico scallop is not related to chlorophyll a content for we noted primarily little difference between chlorophyll a content, regardless of sampling area (Figure 5).

FISHES OF THE CALICO SCALLOP BED

Some 4,461 fishes belonging to 49 families and 111 species were collected during the 51 cruises between 9 January and 23 October 1972. One additional species, *Scorpaena isthmensis*, was added to the faunal list during exploratory trips in 1971 and 1973. Pelagic, demersal, and benthic families and species were represented in the catches (Table 5). Of the total fishes landed (4,392) as part of the 1972 scallop catches, 985 were tagged and released to note movements, 1,655 were analyzed for food content, and 1,752 specimens were merely observed and identified. Most of the 112 species encountered were sporadic components of the scallop bed either as they passed north-to-south or east-to-west, depending on the season of the year.

Of the 112 species of fishes associated with the calico scallop bed, 94 or 84.0% can be considered Caribbean in their main distribution and abundance, while 7 (6.2%) were Virginian forms that had moved seasonally south of the Cape Hatteras barrier. Eleven species (9.8%) were those whose distribution ranges extended naturally over a broad north-south geographic area and could not be considered northern or southern faunal components. Controversy still exists whether that portion of the shelf off North Carolina is simply a part of an overall north-south temperate Virginia Province faunal region (Forbes 1856) or an area divided into a nearshore Virginia and offshore Gulf Stream influenced Carolinian Province (Gray and Cerame-Vivas 1963; Wells et al. 1964; Cerame-Vivas and Gray 1966; Gray et al. 1968; Bumpus 1973; Briggs 1974). Struhsaker (1969) and Schwartz (in press) have shown this area to be rich in fishes with an overall 70:30 ratio of southern to northern fishes, a condition far richer than that of the northern Gulf of Mexico, contrary to the findings of Briggs (1974).

Some 33 species dominated the 1972 catches, of which 21 species accounted for 77.1% of the fishes handled: *Stenotomus aculeatus* (413 specimens), *Synodus foetens* (386), *Paralichthys dentatus* (303), *Diplectrum formosum* (254), *Raja eglanteria* (252), *Orthopristes chrysopterus* (249), *Prionotus scitulus* (196), *Monacanthus hispidus* (174), *Centropristes striata* (122), *Balistes capriscus* (120), *Prionotus evolans* (116), *Hemipteronotus novacula* (104), *Leiostomus xanthurus* (104), *Mustelus canis* (95), *Lagodon rhomboides* (91), *Aluterus schoepfi* (85), *Paralichthys albigutta* (77), *Etrumeus teres* (75), *Urophycis regius* (74), *Syacium papillosum* (73), and *Ancylopsetta quadrocellata* (71).

A few species, notably *Raja eglanteria, Centropristes striata, Ancylopsetta quadrocellata,* and *Paralichthys dentatus,* seemed to occupy the beds throughout the year (Table 5). The loss of such species as *Prionotus evolans, Orthopristes chrysopterus,* and *Aluterus schoepfi* from the beds was evident as they moved shoreward during the summer months. *Mustelus canis* and *Urophycis regius* were winter components of the fauna prior to their movement northward or seaward away from the encroaching higher summer water temperatures. Others, such as *Diplectrum formosum, Mullus auratus,* and *Aluterus scriptus* occurred during or appeared late in the summer, apparently transported by meanders of the Gulf Stream (Webster 1961; Roe et al. 1971) from the south when water conditions met their usual tropical temperature requirements for existence. *Rhinoptera bonasus* was a good sample of a north-south transient in April and August as the schools moved past the area to other grounds (Schwartz 1965). *Halieutichthys* was an example of an offshore species apparently moving into shallower water with occasional incursions (Blanton 1971) of deep ocean water onto the shelf. As expected, bottom fishes of the families Bothidae, Soleidae, Triglidae, and hard shell crushers of the Balistidae and Tetraodontidae predominated (Table 5). The most exciting captures were *Letharchus velifer, Serraniculus pumilio, Prionotus ophryas,* and *Scorpaena isthmensis,* as their capture represented sizeable northward range extensions. McEachran and Eschmeyer (1973) have also recently noted the northward extension of *S. isthmensis.*

Nineteen species were tagged for movement

TABLE 5.—A list of fish species encountered during the various calico
T = tagged; F = food analysis; A= additional

Species	1971	Jan.-Feb.			March			April			May			June		
		T	F	A	T	F	A	T	F	A	T	F	A	T	F	A
Carcharhinus obscurus		—	—	—	—	—	—	1	—	—	—	—	—	—	1	—
Mustelus canis		6	3	20	21	7	—	14	23	1	—	—	—	—	—	—
Rhizoprinodon terraenovae		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Squalus acanthias		—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
Squatina dumerili		—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
Rhinobatos lentiginosus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Narcine brasiliensis		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Raja eglanteria		—	1	11	30	114	12	9	8	2	14	—	—	12	1	—
Dasyatis americana		—	—	—	—	—	—	5	1	1	—	—	—	1	—	—
D. centroura		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gymnura micrura		—	—	—	1	—	—	2	1	—	—	—	—	—	—	—
Myliobatis freminvillei		—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Rhinoptera bonasus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Manta birostris		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gymnothorax nigromarginatus saxicola		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Conger oceanicus		—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Letharchus velifer		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ophichthus ocellatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Etrumeus teres		—	—	—	—	—	60	—	—	—	—	—	15	—	—	—
Anchoa hepsetus		—	—	—	—	—	—	—	—	57	—	—	—	—	—	—
Synodus foetens		—	1	13	6	75	70	—	—	16	9	47	10	—	2	—
S. poeyi		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Trachinocephalus myops	4	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Opsanus tau		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Porichthys porosissimus		—	—	—	—	3	—	—	—	—	—	1	—	—	—	—
Gobiesox strumosus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lophius americanus		—	—	—	—	2	—	—	1	—	—	—	—	—	—	—
Antennarius ocellatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
A. scaber	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Halieutichthys aculeatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ogcocephalus sp.		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Urophycis earli		—	—	—	—	—	—	—	—	3	—	—	—	—	—	—
U. regius	1	—	1	2	—	—	54	2	3	12	—	—	—	—	—	—
Rissola marginata		—	—	—	—	—	—	—	—	10	—	—	—	—	—	—
Fistularia tabacaria	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hippocampus erectus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Syngnathus springeri	3	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
Centropristes ocyurus		—	—	15	—	—	—	—	—	—	1	2	—	5	—	—
C. philadelphicus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C. striatus	11	—	2	2	—	—	—	10	7	2	14	5	—	11	6	—
Diplectrum formosum	3	—	—	—	—	—	—	—	—	—	3	1	—	11	52	—
Serranus phoebe		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. subligarius		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Serraniculus pumilio		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rypticus maculatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pristigenys alta	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pomatomus saltatrix		—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
Caranx fusus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Decapterus punctatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lutjanus vivanus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Haemulon aurolineatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
H. plumieri		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Orthopristis chrysopterus		—	7	23	1	5	2	4	11	151	16	21	—	2	1	—
Archosargus probatocephalus		—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Calamus bajonado		—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
C. leucosteus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lagodon rhomboides		—	10	75	—	—	—	—	—	5	—	—	—	—	—	—
Sparisoma radians		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stenotomus aculeatus		—	5	13	3	20	16	11	12	171	10	45	—	4	1	—
Cynoscion nebulosus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C. regalis		—	—	6	—	—	—	—	—	—	—	—	—	—	—	—
Parequetus sp.	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Larimus fasciatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Leiostomus xanthurus		—	3	10	—	—	—	—	1	—	—	1	—	—	—	—
Menticirrhus americanus		—	2	3	2	—	—	—	—	—	—	—	—	—	—	—
M. saxatilis		—	2	6	4	1	7	5	7	1	—	—	—	—	—	—
Micropogon undulatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mullus auratus	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaetodipterus faber		—	—	—	1	—	—	—	—	—	3	1	—	—	—	—
Chromis enchrysurus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Halichoeres bivittatus	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
H. caudalis	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hemipteronotus novacula	17	—	—	—	—	3	3	1	1	—	—	4	5	6	11	—
Astroscopus y-graecum		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Trichurus lepturus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euthynnus alletteratus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

scallop cruises aboard commercial, research, and chartered vessels.
species encountered but not examined or tagged.

Species	July			August			September			October			1972 total			Total 1972
	T	F	A	T	F	A	T	F	A	T	F	A	T	F	A	
Carcharhinus obscurus	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	2
Mustelus canis	—	—	—	—	—	—	—	—	—	—	—	—	41	33	21	95
Rhizoprinodon terraenovae	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
Squalus acanthias	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
Squatina dumerili	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	2
Rhinobatos lentiginosus	—	—	1	—	—	1	—	—	1	—	—	—	—	—	3	3
Narcine brasiliensis	—	—	1	1	—	1	—	—	—	—	—	—	1	—	2	3
Raja eglanteria	8	1	—	18	6	—	1	2	—	—	2	—	92	135	25	252
Dasyatis americana	—	—	—	—	—	—	—	—	—	—	—	—	6	1	1	8
D. centroura	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
Gymnura micrura	—	—	—	—	—	—	—	—	—	—	—	—	3	1	—	4
Myliobatis freminvillei	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Rhinoptera bonasus	1	—	1	4	—	—	—	—	—	—	—	3	5	—	4	9
Manta birostris	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
Gymnothorax nigromarginatus saxicola	—	—	—	—	—	—	—	1	1	—	—	—	—	1	1	2
Conger oceanicus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Letharchus velifer	—	—	—	—	—	1	—	—	1	—	—	—	—	—	2	2
Ophichthus ocellatus	—	—	—	—	—	—	—	—	1	—	—	1	—	—	2	2
Etrumeus teres	—	—	—	—	—	—	—	—	—	—	—	—	—	—	75	75
Anchoa hepsetus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	57	57
Synodus foetens	—	4	—	—	54	32	—	12	5	—	5	25	15	200	171	386
S. poeyi	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	1
Trachinocephalus myops	—	2	—	—	5	1	—	—	—	—	—	—	—	8	1	9
Opsanus tau	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	1
Porichthys porosissimus	—	2	—	—	2	1	—	—	—	—	—	1	—	8	2	10
Gobiesox strumosus	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	1
Lophius americanus	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3
Antennarius ocellatus	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
A. scaber	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Halieutichthys aculeatus	—	—	—	—	—	3	—	—	2	—	—	—	—	—	5	5
Ogcocephalus sp.	—	—	—	—	—	5	—	—	—	—	—	1	—	—	6	6
Urophycis earli	—	—	—	—	—	1	—	—	—	—	—	—	—	—	4	4
U. regius	—	—	—	—	—	—	—	—	—	—	—	—	2	4	68	74
Rissola marginata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	10
Fistularia tabacaria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hippocampus erectus	—	—	—	—	—	2	—	—	1	—	—	—	—	—	3	3
Syngnathus springeri	—	—	1	—	—	1	—	—	1	—	—	—	—	—	5	5
Centropristes ocyurus	—	5	—	1	—	5	—	—	—	—	—	3	7	7	23	37
C. philadelphicus	—	—	3	—	—	3	—	—	4	—	—	1	—	—	11	11
C. striatus	2	4	—	12	7	1	6	19	—	2	7	3	57	57	8	122
Diplectrum formosum	2	11	4	—	3	27	—	—	73	—	—	67	16	67	171	254
Serranus phoebe	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	1
S. subligarius	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	1
Serraniculus pumilio	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
Rypticus maculatus	—	—	2	—	—	—	—	—	—	—	—	—	—	—	2	2
Pristigenys alta	—	—	—	—	—	2	—	—	1	—	—	4	—	—	7	7
Pomatomus saltatrix	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2
Caranx fusus	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
Decapterus punctatus	—	—	—	—	—	2	—	—	—	—	—	—	—	—	2	2
Lutjanus vivanus	—	—	—	—	—	—	—	—	1	—	—	2	—	—	3	3
Haemulon aurolineatus	—	—	—	—	—	2	—	—	3	—	—	1	—	—	6	6
H. plumieri	—	—	—	—	1	3	2	—	1	—	—	—	2	1	4	7
Orthopristis chrysopterus	—	—	—	—	—	—	1	—	—	2	2	—	26	47	176	249
Archosargus probatocephalus	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
Calamus bajonado	—	—	—	1	—	—	—	—	—	—	—	—	1	—	1	2
C. leucosteus	—	—	—	2	4	1	2	11	—	—	—	—	4	15	1	20
Lagodon rhomboides	—	—	—	—	—	1	—	—	—	—	—	—	—	10	81	91
Sparisoma radians	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
Stenotomus aculeatus	1	5	—	6	2	3	—	3	2	42	8	30	77	101	235	413
Cynoscion nebulosus	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
C. regalis	—	—	—	—	—	—	—	—	—	—	—	2	—	—	8	8
Parequetus sp.	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2	2
Larimus fasciatus	—	—	—	—	—	—	—	—	—	—	—	4	—	—	4	4
Leiostomus xanthurus	—	—	—	—	—	—	—	85	—	1	—	—	1	90	10	101
Menticirrhus americanus	—	—	—	—	—	—	—	—	—	—	—	—	2	2	3	7
M. saxatilis	—	—	—	—	—	—	—	—	—	—	—	3	9	10	17	36
Micropogon undulatus	—	—	—	—	—	—	—	—	8	—	—	—	—	—	8	8
Mullus auratus	—	—	—	—	—	1	—	—	1	—	—	1	—	—	3	3
Chaetodipterus faber	—	1	—	4	—	—	—	—	—	2	2	9	10	4	9	23
Chromis enchrysurus	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	1
Halichoeres bivittatus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
H. caudalis	—	—	—	—	—	—	—	—	3	—	—	1	—	—	4	4
Hemipteronotus novacula	2	11	—	—	10	42	—	—	1	—	—	4	9	40	55	104
Astroscopus y-graecum	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	1
Trichurus lepturus	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
Euthynnus alletteratus	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1

Table 5.—Continued.

Species	1971	Jan.-Feb.			March			April			May			June		
		T	F	A	T	F	A	T	F	A	T	F	A	T	F	A
Peprilus alepidotus		—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
P. triacanthus		3	20	—	—	—	—	—	5	3	—	—	—	—	—	—
Scorpaena brasiliensis	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. calcarata	6	6	—	—	1	14	4	2	1	1	—	1	—	—	1	1
Bellator militaris	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Prionotus evolans		—	2	3	8	29	2	1	1	8	—	3	2	—	6	—
P. ophryas		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. roseus	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. scitulus		—	7	1	3	19	9	—	6	8	—	76	15	2	—	—
P. salmonicolor		—	—	1	—	1	1	—	—	7	—	—	25	—	—	—
P. tribulus		—	—	3	—	—	—	—	—	—	—	—	—	—	—	—
Ancylopsetta quadrocellata		—	—	5	—	10	2	4	1	—	6	1	—	14	1	—
Bothus sp.		—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Citharichthys macrops		—	—	2	—	2	—	—	—	6	—	—	3	6	—	—
Cyclopsetta fimbriata	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Etropus microstomus		—	—	—	—	1	1	—	—	—	—	—	—	—	—	—
E. rimosus		—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Paralichthys albigutta		—	11	—	8	11	9	9	—	1	1	—	—	—	—	—
P. dentatus		—	21	—	20	39	32	48	6	—	22	—	2	36	2	—
P. lethostigma		—	—	9	28	4	4	—	—	1	—	—	—	—	—	—
P. squamilentus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Scophthalmus aquosus		—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
Syacium papillosum	3	3	—	—	—	7	1	—	3	—	4	—	1	10	—	—
Gymnachirus melas	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Trinectes maculatus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alutera schoepfi		—	—	—	3	8	—	—	—	—	—	—	—	—	—	—
A. scriptus		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Balistes capriscus	1	1	—	—	1	3	1	4	—	—	6	4	—	30	36	—
Monacanthus hispidus		—	—	1	2	7	—	1	—	—	5	—	1	28	7	—
Lactophrys quadricornis		—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Sphoeroides dorsalis		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. maculatus		—	18	50	6	145	19	—	5	7	—	1	2	—	—	—
S. spengleri		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chilomycterus antillarum		—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
C. schoepfi		—	—	—	—	4	1	1	—	—	—	1	—	—	—	—
Subtotal		20	120	281	149	534	312	135	105	478	115	215	81	178	129	2
Total	69		421			995			718			411			309	

studies. Of those tagged, *Paralichthys dentatus* (184 specimens), *Monacanthus hispidus* (107), *Raja eglanteria* (92), *Stenotomus aculeatus* (77), *Balistes capriscus* (66), *Centropristes striata* (57), *Mustelus canis* (41), *Ancylopsetta quadrocellata* (40), *Aluterus scriptus* (35), and *Paralichthys lethostigma* (35) accounted for 74.3%. Of the 985 fishes tagged, 17 (1.7%) were recaptured involving 11 species: *Centropristes striata, Balistes capriscus, Aluterus schoepfi, Centropristes ocyurus, Calamus bajonado, Monacanthus hispidus, Paralichthys albigutta, P. dentatus, Rhinoptera bonasus, Raja eglanteria,* and *Stenotomus aculeatus. Paralichthys dentatus* and *Balistes capriscus* accounted for 6 and 2 of the recaptures respectively, while all others were single recaptures. Most recaptures were returned from near their release point on the bed. The longest period at liberty was 8 days. This, in the light of the intense fishing of the 13 boats that composed the 1972 fleet and the few recaptures, suggested that the fish population over the scallop bed was large, constantly moving, and subject to constant recruitment from elsewhere.

Stomach analysis of 1,655 of the 33 most frequently encountered fishes (Table 6) revealed that the stomachs of most of the fishes over the bed usually contained food even though all samples were made only during daylight hours; 89.4% had scallops or other food as part of the stomach contents. *Sphoeroides maculatus, Stenotomus aculeatus, Diplectrum formosum, Orthopristes chrysopterus, Monacanthus hispidus, Balistes capriscus, Centropristes striata, Mustelus canis,* and *Synodus foetens* (in descending order of species whose stomachs contained scallops) were found to be scallop predators (Table 6). Small as well as large individuals of these species had parts or whole scallops in their stomachs and digestive tracts (Table 6). These species fed either by cracking the scallop shell with their beaklike jaws (*Balistes, Sphoeroides*) or by finding dying or cracked (possibly a result of the fishing activity) individuals (*Stenotomus, Diplectrum, Orthopristes*). It was surprising that bottom feeders of the families Bothidae (*Paralichthys albigutta, P. lethostigma*), Soleidae (*Trinectes maculatus*), Rajidae (*Raja eglanteria*), Labridae (*Hemip-*

Species	July			August			September			October			1972 total			Total 1972
	T	F	A	T	F	A	T	F	A	T	F	A	T	F	A	
Peprilus alepidotus	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3
P. triacanthus	—	—	—	—	—	—	—	—	—	—	—	—	3	25	3	31
Scorpaena brasiliensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. calcarata	1	3	—	—	3	—	—	1	1	—	—	1	10	24	8	42
Bellator militaris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Prionotus evolans	3	7	—	3	12	5	—	7	1	1	8	4	16	75	25	116
P. ophryas	—	—	—	—	—	1	—	—	3	—	—	—	—	—	4	4
P. roseus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. scitulus	—	16	—	—	19	1	—	2	5	—	—	7	5	145	46	196
P. salmonicolor	—	—	—	—	—	8	—	—	3	—	—	—	—	1	45	46
P. tribulus	—	—	—	—	—	—	—	—	1	—	—	—	—	—	4	4
Ancylopsetta quadrocellata	9	2	—	6	3	1	1	1	4	—	—	—	40	19	12	71
Bothus sp.	—	—	—	—	—	1	—	—	1	—	—	1	—	—	4	4
Citharichthys macrops	—	—	—	—	1	10	—	—	4	—	—	—	6	3	25	34
Cyclopsetta fimbriata	—	—	—	—	—	—	—	—	1	—	—	1	1	—	2	3
Etropus microstomus	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2
E. rimosus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Paralichthys albigutta	—	—	—	10	3	1	3	—	5	2	—	3	33	25	19	77
P. dentatus	24	4	—	17	1	—	11	2	1	6	6	3	184	81	38	303
P. lethostigma	—	—	—	1	—	—	5	—	—	1	—	3	35	4	17	56
P. squamilentus	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
Scophthalmus aquosus	1	—	—	—	—	—	—	—	—	—	—	—	1	—	2	3
Syacium papillosum	1	1	—	1	4	33	—	—	3	—	—	1	19	15	39	73
Gymnachirus melas	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	1
Trinectes maculatus	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
Alutera schoepfi	3	—	—	12	26	2	6	14	—	3	8	—	27	56	2	85
A. scriptus	35	11	—	—	1	1	—	—	—	—	—	—	35	12	1	48
Balistes capriscus	8	4	—	10	5	—	6	1	—	—	—	—	66	53	1	120
Monacanthus hispidus	34	13	—	28	32	5	7	—	1	2	—	—	107	59	8	174
Lactophrys quadricornis	—	—	1	—	—	—	—	—	—	—	—	—	—	—	2	2
Sphoeroides dorsalis	—	—	2	—	—	1	—	—	—	—	—	2	—	—	5	5
S. maculatus	—	1	—	—	18	1	—	6	8	—	4	—	6	198	87	291
S. spengleri	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
Chilomycterus antillarum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
C. schoepfi	—	—	—	—	1	—	—	1	—	—	—	3	1	7	4	12
Subtotal	136	108	17	137	223	219	51	169	161	64	52	201	985	1,655	1,752	
Total		261			579			381			317			4,392		4,392
														Grand total		4,461

teronotus novacula), and other Balistidae (*Aluterus schoepfi*) were not active scallop predators.

Our observations agree with Roe et al. (1971), who noted that *Sphoeroides* is an active predator of calico scallops. While *Dasyatis centroura* is a possible predator (Struhsaker 1969) neither it, the dasyatids *D. americana* and *Gymnura micrura*, nor the myliobatid, *Rhinoptera bonasus*, fed on scallops.

MACROINVERTEBRATE ASSOCIATES AND PREDATORS

Field observations yielded 60 species of macromolluscs, 25 crustaceans, 12 echinoderms, 4 coelenterates, and 1 annelid as associates of the bed (Table 7). These species, their numbers, and abundances varied by season throughout the bed. Species found in 50 or more percent of the samples which may be considered the macroinvertebrates common to the beds were: *Eucrassatella speciosa*, *Arcinella cornuta*, *Cassis madagascariensis*, *Pleuroploca gigantea*, *Octopus vulgaris*, *Loligo pealei*, *Calappa falmmea*, *Hepatus epheliticus*, *Astropecten articulatus*, *Luidia alternata*, *L. clathrata*, *Hemipholis elongata*, *Toxopneustes variegatus*, and *Encope emarginata*.

Luidia clathrata and *Astropecten articulatus* occurred abundantly throughout the bed during all seasons and were predators of scallops (Table 7). The following were found less abundantly and were suspected predators of calico scallops: *Asterias forbesii*, *Busycon carica*, *B. contrarium*, *B. spiratum*, *Fasciolaria hunteria*, *F. tulipa*, *Loligo pealei*, *Murex fulvescens*, *M. pomum*, *Octopus vulgaris*, *Pleuroploca gigantea*, *Polinices duplicatus*, *Strombus alatus*, *Arenaeus cribrarius*, *Calappa flammea*, *Hepatus epheliticus*, *Libinia emarginata*, *Ovalipes quadulpensis*, and *Portunus spinimanus*.

The most common sea stars on the 1972 calico scallop grounds were *Astropecten articulatus*, *Luidia alternata*, and *L. clathrata*. *Goniaster americanus*, *Echinaster brasiliensis*, *Asterias forbesi*, and *Gorgonocephalus arcticus* were noted in lesser numbers (Table 7). Identifications were

TABLE 6.—Analysis of 1,655 stomach contents from 46 species of fishes captured on the scallop grounds during commercial operations between February and October 1972.

Species	Cruises occurred in	Specimens examined	Size range	Number eating		
				Scallops	Other food	Empty
Carcharhinus obscurus	2	1	960		1	
Mustelus canis	8	33	440-972	13	15	5
Squatina dumerili	2	1	1,160		1	
Raja eglanteria	20	135	136-580	7	127	1
Dasyatis americana	4	1	676		1	
Gymnura micrura	4	1	415		1	
Gymnothorax nigromarginatus saxicola	2	1	276		1	
Synodus foetens	23	200	98-426	11	163	26
Trachinocephalus myops	6	8	170-216	1	2	5
Opsanus tau	2	1	246		1	
Porichthys porosissimus	6	8	146-210		8	
Lophius americanus	4	3	560-716	1	1	1
Urophycis regius	2	4	110-208	1	1	2
Centropristis ocyurus	4	7	112-172	6	1	
C. striata	15	57	92-325	21	28	8
Diplectrum formosum	9	67	46-282	37	23	7
Pomatomus saltatrix	3	1	138		1	
Haemulon plumieri	6	1	230		1	
Orthopristis chrysopterus	14	47	116-216	36	6	5
Calamus senta	6	15	120-225		15	
Lagodon rhomboides	4	10	87-122		10	
Stenotomus aculeatus	22	101	90-256	64	27	10
Leiostomus xanthurus	4	90	144-188	1	86	3
Menticirrhus americanus	2	2	170-262		2	
M. saxatilis	5	10	190-280	1	8	1
Chaetodipterus faber	9	4	286-290		4	
Hemipteronotus novacula	17	40	128-172	7	26	7
Peprilus alepidotus	2	3	118-156		3	
P. triacanthus	2	25	97-156	1	4	20
Scorpaena calcarata	15	24	64-142	1	23	
Prionotus evolans	19	75	196-342	2	61	12
P. salmonicolor	6	1	186-222		1	
P. scitulus	19	145	134-268	2	136	7
Ancylopsetta quadrocellata	28	19	170-290		19	
Citharichthys macrops	11	3	120-142		3	
Etropus microstomus	3	1	158		1	
Paralichthys albigutta	21	25	200-289		25	
P. dentatus	42	81	153-370		81	
P. lethostigma	14	4	210-500		4	
Syacium papillosum	8	15	86-300	1	13	1
Aluterus schoepfi	14	56	342-390		56	
A. scriptus	3	12	90-222	1	5	6
Balistes capriscus	18	53	105-356	20	28	5
Monacanthus hispidus	14	59	92-222	23	20	16
Sphoeroides maculatus	21	198	68-268	77	94	26
Chilomycterus schoepfi	6	7	72-142	2	4	1
Total, number				337	1,143	175
percent				20.4	69.0	10.6

based upon Gray et al. (1968) and Downey (pers. commun.).

Roe et al. (1971) suggested that *Asterias forbesi* may be a major predator on the calico scallops of the Cape Canaveral grounds. The low total percent of its occurrence on the 1972 North Carolina calico scallop grounds (Table 7) precludes this assumption for the 1972 fishery. Stomachs of *A. forbesi* were not examined because it everts its stomach when feeding (Hyman 1955:369). Hyman (1955) made no mention of the feeding habits of sea stars belonging to the Goniasteridae, Echinasteridae, or the Gorgonocephalidae. Stomachs of species belonging to these families (*Goniaster americanus, Echinaster brasiliensis,* and *Gorgonocephalus arcticus*) contained no recognizable material. What they were feeding upon is not known but, in light of their small numbers on the scallop beds and the lack of scallops in their stomachs, it is assumed that they were not significant scallop predators on the 1972 bed.

Luidia alternata frequented the calico scallop bed yet was not as common as either *L. clathrata* or *Astropecten articulatus* (Table 7). Stomach contents yielded no calico scallops. Several specimens were found in the field feeding upon smaller *A. articulatus.* One large living specimen, held in an experimental tank under controlled environmental conditions with living calico scallops, showed no interest in the scallops but was seen feeding upon *A. articulatus* and *L. clathrata.* It did attempt unsuccessfully to feed on a *Asterias forbesi*

TABLE 7.—Macroinvertebrate fauna of offshore calico scallop beds in 1972 by season and areas of good and poor catches. N = number of samples, data listed as percent of N.

Taxa	Mar.-Apr. N = 14	May-June N = 10	July-Aug. N = 14	Sept.-Oct. N = 10	Total N = 48	Good scallop catches N = 40	Poor scallop catches N = 8
COELENTERA							
Renillidae:							
Renilla reniformis	7				2	2	
Actiniaria (sea anemones)	14	20			8	10	
Madreporaria (corals)				20	4	5	
ANNELIDA							
Aphroditidae:							
Aphrodita hastata	7				2	2	
MOLLUSCA							
Arcidae:							
Arca imbricata			7		2	2	
A. zebra	14	10	7	10	10	12	
Anadara floridana	36	20	21		21	25	
Noetia ponderosa			14		4	5	
Mytilidae:							
Brachidontes modiolus	14	30	36		21	25	
Pteriidae:							
Pteria colymbus	14			10	6	15	
Pectinidae:							
Aequipecten muscosus				10	2	2	
Argopecten gibbus	93	100	71	80	85	100	13
Lyropecten nodosus		10	21	10	10	10	13
Pecten reveneli	21	30	21	30	25	28	13
Ostreidae:							
Ostrea permollis			7	20	6	7	
Chamidae:							
Arcinella cornuta	43	40	79	30	50	55	25
Chama macerophylla		10			2	2	
Crassatellidae:							
Eucrassatella speciosa	43	40	86	10	48	50	38
Cardiidae:							
Dinocardium robustum	7	10	14	20	13	13	13
Laevicardium multilineatum	21	10	21	10	17	15	25
Veneridae:							
Chione intapurpurea	7	10	43	30	23	18	50
C. latilirata	29	20	64	40	40	35	63
Macrocallista maculata	57	20	43	20	38	43	13
M. nimbosa		10			2	2	
Solenidae:							
Ensis directus				10	2	2	
Tellinidae:							
Tellina magna			7		2		13
T. nitens				10	2	2	
Solecurtidae:							
Solecurtus cumingianus	7				2	2	
Trochidae:							
Calliostoma euglyptum			7	10	4		25
Turbinidae:							
Astraea phoebia			7		2		13
Turbo castanea		10	14	30	13	15	13
Architectonicidae:							
Architectonica nobilis		10		10	4	5	
Cerithiidae:							
Cerithium litteratum							
Xenophoridae:							
Xenophora conchyliophora	14	30	7	20	17	20	
Strombidae:							
Strombus alatus	14	50	57	30	38	45	
S. costatus			7		4	2	
Cypraeidae:							
Cypraea cervus			14		4	5	
Naticidae:							
Natica canrena			7	10	4	5	
Polinices duplicatus	36	20	50	20	33	35	25
P. duplicatus eggs	7				2	2	
Sinum maculatum	7	10	7	20	10	12	
Cassididae:							
Cassis madagascariensis	21	80	79	50	56	60	38
C. madagascariensis eggs		20			4	5	
Cypraecassis testiculus			7		2	2	
Phalium granulatum	21	20	36	20	25	25	25
P. granulatum eggs		10			2	2	
Cymatidae:							
Distorsio clathrata	7	20	21		13	15	
Tonnidae:							
Oocorys abyssorum							
Tonna galea	7	40	7		13	15	

Table 7.—Continued.

Taxa	Mar.-Apr. $N = 14$	May-June $N = 10$	July-Aug. $N = 14$	Sept.-Oct. $N = 10$	Total $N = 48$	Good scallop catches $N = 40$	Poor scallop catches $N = 8$
Ficidae:							
Ficus communis	7	20	14		10	12	
Muricidae:							
Eupleura caudata			7		2	2	
Murex dilectus			7		2		13
M. fulvescens	29	30	71		35	40	13
M. fulvescens eggs			14		4	5	
Murex pomum	21	30	29	40	29	28	38
Thais haemastoma floridana				10	2	2	
Melongenidae:							
Busycon canaliculatum			7		2	2	
B. carica		20	7	20	10	10	13
B. contrarium	29	10		20	15	15	13
B. contrarium eggs	21				6	7	
B. spiratum	21	20	14	30	21	23	13
B. spiratum eggs	14				4	5	
Fasciolariidae:							
Fasciolaria lilium hunteria	7	40	57	20	31	30	38
F. l. hunteria eggs			14		4	5	
F. tulipa	21	30	21	10	21	23	13
F. tulipa eggs	7				27	2	
Pleuroploca gigantea	43	70	50	70	56	55	63
P. gigantea eggs		10	7	4	5		
Olividae:							
Oliva sayana Ravenel	43	10	50	20	33	35	25
Cancellariidae:							
Cancellaria reticulata	7						
Conidae:							
Conus delessertii	7	30	14		13	15	
Octopodidae:							
Octopus vulgaris	71	70	93	60	75	75	75
Loliginidae:							
Lolliguncula brevis	7				2	2	
Loligo pealeii	71	50	93	60	71	70	75
ARTHROPODA							
Stomatopoda:							
Gonodactylus aerstedi	21	20	14		15	17	
Penaeidae:							
Penaeus sp.	29	20	7	20	19	22	
Sicyonia brevirostris	21	10	29	30	23	21	13
Scyllaridae:							
Scyllarides nodifer	7	20		10	8	10	
Porcellaridae:							
Porcellana sayana	14				4	5	
Paguridae:							
Pagurus sp.	7			10	4	5	
P. annulipes		60	64	40	40	40	38
P. pollicaris		40	64	40	35	35	38
Raninidae:							
Ranilia muricata	14		7		6	7	
Calappidae:							
Calappa angusta	7			10	4	5	
C. flammea	64	60	79	60	67	73	38
Hepatus epheliticus	43	70	64	70	60	65	38
Osachila sp.				10	2		13
Portunidae:							
Ovalipes quadulpensis	21				6	7	
O. ocellatus	21	30	36	10	25	25	25
Portunus gibbesii	57	40	36	30	42	45	25
P. spinimanus	7			30	8	10	
Callinectes sapidus							
Arenaeus cribrarius	7	10			4	5	
Cancridae:							
Cancer irroratus	7				2	2	
Majidae:							
Libinia emerginata	36	50	36	40	40	43	25
Stenocionops furcata coelata				10	2	2	
Parthenopidae:							
Parthenope serrata	14				4	5	
P. pourtelesii				10	2	2	
Xiphosura:							
Xiphosura polyphemus	43	50	50	10	40	40	38
ECHINODERMA							
Astropectinidae:							
Astropecten articulatus	100	90	93	80	92	93	88
Luididae:							
Luidia alternata	57	90	86	20	65	70	38
L. clathrata	100	100	93	90	96	98	88

Table 7.—Continued.

Taxa	Mar.-Apr. $N = 14$	May-June $N = 10$	July-Aug. $N = 14$	Sept.-Oct. $N = 10$	Total $N = 48$	Good scallop catches $N = 40$	Poor scallop catches $N = 8$
Goniasteridae:							
Goniaster americanus	7	40	7		13	13	13
Echinasteridae:							
Echinaster brasiliensis	14	30	14	30	21	23	13
Asteriidae:							
Asterias forbesi	7	30			8	10	
Gorgonocephalidae:							
Gorgonocephalus arcticus		10		10	4	3	13
Amphiuridae:							
Hemipholis elongata	79	70	64	60	69	73	50
Arbaciidae:							
Arbacia punctulata	7	60	64	60	46	45	50
Toxopneustidae:							
Toxopneustes variegatus	36	80	79	60	63	65	50
Scutellidae:							
Encope emarginata	64	50	71	30	56	60	38
Cucumariidae:							
Thyone briareus	29			10	10	12	

and was noted to have killed a large *Strombus alatus*. Hyman (1955:369) pointed out that species of *Luidia* eat mainly other echinoderms. At this time, we do not consider *L. alternata* a calico scallop predator.

Luidia clathrata was a predator of calico scallops (Table 8). Between March and June we found small numbers of scallop valves (ranging from 0.9 to 11.6 and 21.1 to 45.3 mm) in *L. clathrata* stomachs (Table 9). Maximum predation took place (April) just as calico scallop spawning began. Why large scallops (21-45 mm lengths) were fed on only in March and April is not known. The data does indicate that numbers of *Luidia* (Table 10) large enough (110 to 160 mm?) to swallow the available scallops (28 to 70 mm length) were more available during March through June. Preliminary observations on *L. clathrata* kept in the laboratory indicated that they will feed readily on calico scallops, digestion occurring within 24 h. Hulings and Hemlay (1963) found *L. clathrata* to engulf sediments and utilize whatever was available as food.

Wells et al. (1961) suggested that *A. articulatus* was a nonselective feeder, while Porter (1972b)

TABLE 9.—Average number of calico scallop valves found per month in stomach samples of sea stars *Astropecten articulatus* and *Luidia clathrata* sampled in 1972 on the producing calico scallop beds off North Carolina.

	Astropecten articulatus		*Luidia clathrata*	
Month	No./100 stomachs[1]	No. stomachs examined	No./100 stomachs[1]	No. stomachs examined
Feb.	1	85	0	71
Mar.	7	226	6	87
Apr.	7	151	28	178
May	158	67	17	66
June	29	314	7	311
July	8	86	3	36
Aug.	2	154	0	56
Sept.	7	89	0	43
Oct.	3	67	0	20

[1]Approximate number.

TABLE 10.—Monthly lengths (millimeters) for sea stars captured on the calico scallop beds in 1972.

	Astropecten articulatus			*Luidia clathrata*		
Month	Average arm length	Size range	Sample size	Average arm length	Size range	Sample size
Feb.	61.6	34-101	109	92.7	46-142	72
Mar.	63.3	24-111	433	95.6	58-155	134
Apr.	60.0	18-124	176	91.2	27-166	227
May	58.9	35-122	125	88.2	40-140	110
June	61.1	25-134	497	88.8	50-160	315
July	64.8	28-103	112	89.6	61-122	42
Aug.	64.5	28-120	169	84.6	28-112	85
Sept.	83.1	35-136	113	87.0	51-134	44
Oct.	62.2	23-124	101	89.6	23-124	22

TABLE 8.—Lengths (millimeters) of calico scallop valves removed from stomachs of sea stars *Astropecten articulatus* and *Luidia clathrata* collected on the calico scallop beds during the 1972 catch season.

Sea star	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Astropecten articulatus:									
Average valve length	1.8	2.4	1.9	2.3	3.0	2.9	2.3	2.9	4.5
Size range	1.8	1.6-3.8	0.7-4.3	0.9-3.6	0.7-6.4	2.3-3.6	1.4-2.6	1.7-2.6	3.3-5.6
Number valves found	1	8	10	62	39	5	4	5	2
Luidia clathrata:									
Average valve length	—	4.3	1.9	2.4	3.3	4.2	—	—	—
		33.9	43.7		21.1				
Size range	—	2.4-11.6	0.9-6.9	1.4-3.5	1.0-6.4	4.2-4.2	—	—	—
		30.0-40.4	41.0-45.3		21.1				
Number valves found	—	5	39	9	14	1	—	—	—
		8	6		1				

showed that large numbers of recently set calico scallops may be eaten by *A. articulatus* and that though continued examination of their stomach contents, knowledge may be gained concerning when and where calico scallop setting takes place. During May and June 1972, numerous small scallop valves appeared in the stomachs of this sea star (Table 10). Valve numbers/100 stomachs were not nearly as many as the 3,000/100 stomachs reported by Porter (1972a) for June 1971. It is inferred from this that the 1972 scallop set on the sampled grounds was relatively small. Note that numbers of dead scallop shells increased from July through October when the fishery collapsed (Table 11). Also, the presence of *L. clathrata* decreased while *A. articulatus* presence increased during the March to October period (Table 11).

Stomach content data (Table 10) suggested that if there were scallop spawnings following the initial May spawning as we have theorized, then the set from these and the May spawnings either did not survive after June or the setting occurred in an area not covered by the sampling. Stomach analysis data of sea stars continues to be worked up and evaluated.

TABLE 11.—Average monthly numbers of dead shells and sea stars per bushel catch (*N*) occurring on the calico scallop beds in 1972.

Month	*N*	Dead shells	*Luidia clathrata*	*Astropecten articulatus*
Mar.	13	23	8	5
Apr.	8	19	5	4
May	2	19	1	2
June	8	22	1	2
July	7	106	2	6
Aug.	11	220	3	3
Sept.	4	134	1	8
Oct.	1	290	2	55

DISCUSSION

We had expected to find that the calico scallop bed(s) that sustained the 1972 North Carolina fishery to have been distinct in either physical, chemical, or biological features. Instead, few differences were found which could be pinpointed as factors that made the bed(s) more unique than the surrounding shelf areas. We noted that bottom texture within and without the beds studied were nearly identical (Table 3). Likewise, no extremes of water temperatures, salinities, or phytoplankton population (as measured by chlorophyll a levels) seemed to exist in 1972. While the fish and invertebrate faunas were diverse and speciose, they too were little different from that noted from the nearby reefs or areas (Pearse and Williams 1951; Wells et al. 1964; Cerame-Vivas and Gray 1966). Seasonal shifts in the fishes and invertebrates inhabiting the bed(s) occurred but these were directly related to seasonal water temperatures, salinities, or their natural migrating movements (Tables 5, 7). Most populations of fishes apparently moved over the bed(s) constantly, some 24 species (of 33 most abundant) feed on scallops. Of the macroinvertebrates, 3 species of sea stars and 19 other macroinvertebrates were predators. Whether the fishes and sea stars or other macroinvertebrate predators, which were definite predators of calico scallops, were attracted to the area because of the scallops or the activities of the fishery, which created available food in the form of broken scallops, remains unresolved. One interesting correlation was noted in that the painted wrasse, *Halichoeres caudalis,* appeared over the bed, in September and October, as increased numbers of dead scallops occurred just prior to the demise of the 1972 fishery on 28 October. This relationship has also been noted for the Cape Canaveral calico scallop beds of Florida (George Miller pers. commun.).

While we document the fish and macroinvertebrate faunas and the ecology of a North Carolina bed(s) that sustained the 1972 fishery, we are still at a loss as to what creates the vacillations of scallop availability in a bed or why one bed prevails over another during any one or succeeding years. Note that while the experimental bed was fished and did possess scallops throughout 1972, it as well as the commercial bed failed to support scallops in the years 1973 through 1976. We cannot ultimately conclude that the 1972 bed and fishery collapsed as a sole result of overfishing but that the levels of scallops available after 28 October could not economically support the fleet. Sampling the planktonic stages of calico scallops may resolve the repopulation aspects of the beds for we still do not know whether we are simply at the northern edge of its range, which may be dependent on larval drift and recruitment from more southern areas, or are dealing with a population dependent upon native larvae for repopulation. Additional field observations of the shelf water mass movements and how they affect the survival, growth, and existance of scallops needs refinement while laboratory experiments which vary a number of ecological parameters will hopefully resolve what permits a calico scallop bed to exist.

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In galley: we anticipate Rick Dawson's revision of *Stenotomus* and list our *S. caprinus* as *S. aculeatus*.

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