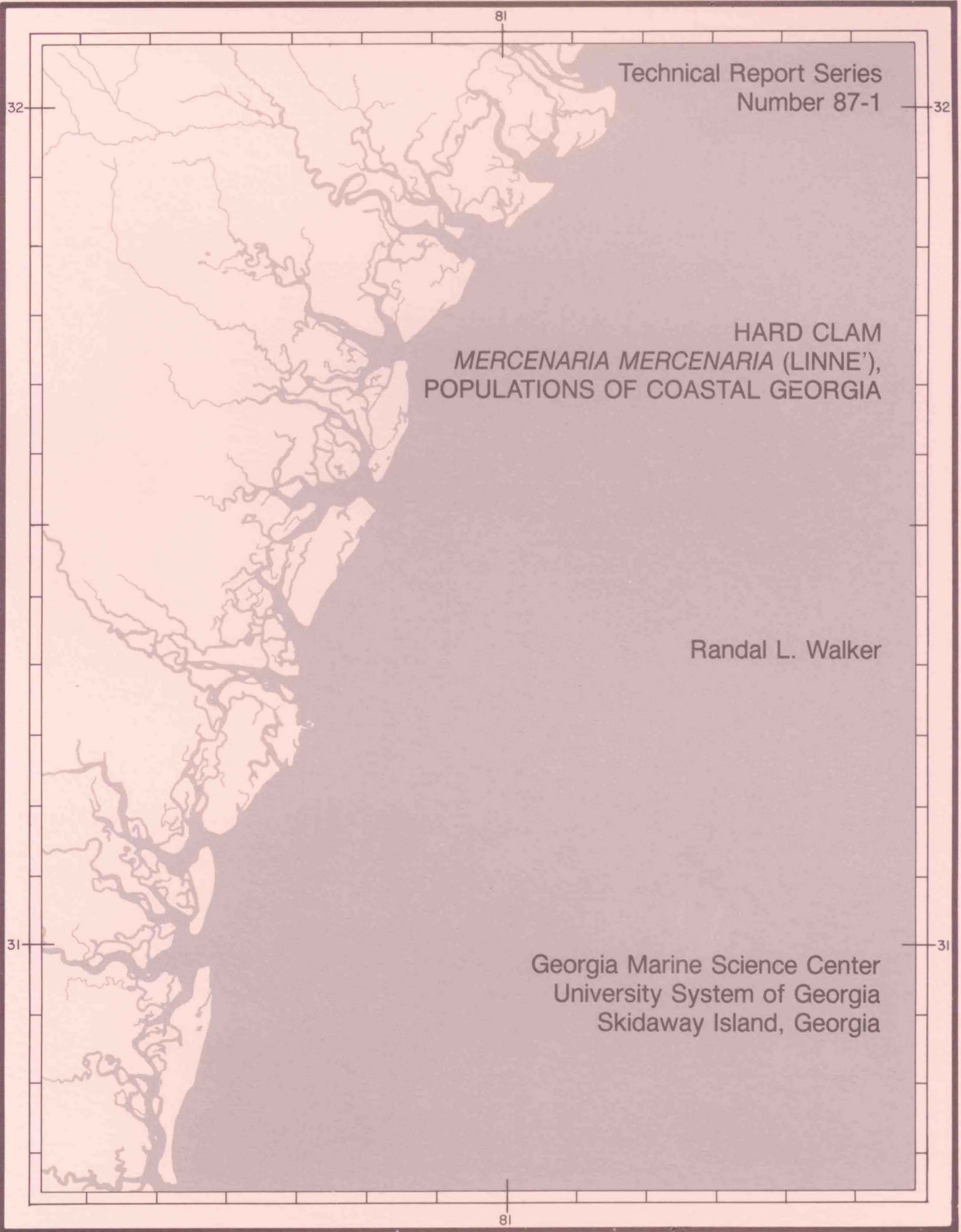


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HARD CLAM
MERCENARIA MERCENARIA (LINNE'),
POPULATIONS OF COASTAL GEORGIA

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Hard Clam, *Mercenaria mercenaria* (Linne'),
populations of coastal Georgia

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Abstract

The growth rate, density, age structure, size structure and commercial size structure of 40 populations of the hard clam, *Mercenaria mercenaria* (Linne'), throughout the coastal waters of Georgia are described. The hard clam grows to a commercial size in 2 to 3 years throughout the coastal area of Georgia except under extreme environmental conditions. In non-fished or unexploited clam populations, a wide range of clam sizes (up to 11.8 cm) and ages (up to 40 years) may occur. The range of clam sizes and ages, however, narrows in the presence of fishing pressures.

Keywords: aquaculture, bivalve, clam, coast, estuary, fishery, mollusc, recruitment, resource, saltmarsh, stock, survey

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Introduction

The hard clam, *Mercenaria mercenaria* (Linne'), fishery in the State of Georgia dates back to 1880 with peak landings of clams occurring in 1908 (Table 1). Since the 1930's, clam landings have been sporadic or virtually non-existent in Georgia. However, with the increase in consumer demand for clams and the decline in clam landings in traditional northern U.S. clamming areas due to pollution and overharvesting (National Marine Fisheries Service, 1977), there has been an increasing interest in Georgia clamming among local as well as out-of-state fishermen. This, coupled with the mariculture potential of hard clam, *Mercenaria mercenaria*, (Walker, 1983; Walker, 1984a; 1984b), has led to a re-emergence of the fishery in Georgia with steady landings reported since 1981.

Although the coastal waters of Georgia contain unexploited populations of hard clams (Godwin, 1967, 1968; Walker et al., 1980; Walker and Tenore, 1984; Walker and Rawson, 1985), most of these populations occur in small areas and are difficult to locate and harvest. They are, however, indicative of the existence of extensive pollution-free marshes suitable for shellfish production and culture. Hard clams grow year round in southeastern U.S. waters (Eldridge et al., 1979; Walker, 1984a), and clam densities above 25 m⁻² are common in Georgia (Walker and Tenore, 1984). Densities up to 101 m⁻² have been observed in intertidal regions of small creeks, headwaters of major creeks, and in shell deposits associated with oyster bars (Walker et al., 1980; Walker and Tenore, 1984; Walker and Rawson, 1985).

At present, the majority of Georgia clams represent natural unexploited populations. As fishing pressures increase, they will undergo dramatic changes in population dynamics. Therefore, in the interest of future

Table 1. Hard clam, *Mercenaria mercenaria*, production in pounds of meat landed from 1882 to 1985 in Georgia. Data from Department of Natural Resources (1979-1986) and Lyles (1964-1978).

| | | | |
|------|--------|-------|--------|
| 1880 | 24,000 | 1957 | 0 |
| 1887 | 0 | 1958 | 1,000 |
| 1888 | 0 | 1959 | 0 |
| 1889 | 3,000 | 1960 | 0 |
| 1890 | 4,000 | 1961 | 0 |
| 1897 | 3,000 | 1962 | 0 |
| 1902 | 10,000 | 1963 | 0 |
| 1908 | 43,000 | 1964 | 0 |
| 1918 | 7,000 | 1965 | 0 |
| 1923 | 0 | 1966 | 0 |
| 1927 | 1,000 | 1967 | 0 |
| 1928 | 1,000 | 1968 | 0 |
| 1929 | 2,000 | 1969 | 1,000 |
| 1930 | 2,000 | 1970 | 17,000 |
| 1931 | 1,000 | 1971 | 0 |
| 1932 | 1,000 | 1972 | 0 |
| 1935 | 0 | 1973 | 6,000 |
| 1936 | 0 | 1974 | 0 |
| 1937 | 0 | 1975 | 0 |
| 1938 | 0 | 1976 | 10,885 |
| 1939 | 0 | 1977 | 0 |
| 1940 | 0 | 1978 | 0 |
| 1945 | 0 | 1979 | 0 |
| 1950 | 0 | 1980 | 0 |
| 1951 | 0 | 1981 | 5,855 |
| 1952 | 0 | 1982 | 9,725 |
| 1953 | 0 | 1983 | 3,482 |
| 1954 | 0 | 1984 | 3,474 |
| 1955 | 0 | 1985 | 6,966 |
| 1956 | 0 | 1986* | 2,655 |

*Partial Landings from January to March, 1986

comparisons, it is important at this time to obtain baseline studies on the various disturbed and undisturbed clam populations in Georgia.

The purpose of this study is to assess the status of clam populations in the coastal waters of Georgia. It describes distribution, densities, growth rates, population age structure, population size structure and commercial size structure for unharvested versus harvested clam populations in the coastal waters of Georgia.

Methodology

Clams were collected from 40 populations of coastal Georgia (13 from Wassaw Sound, 15 from Harris Neck, 1 from Crooked River, 1 from Cumberland Island, 7 from Christmas Creek, and 3 from Ossabaw Island) by taking three 0.44 m² quadrat samples per site. A 66 x 66 cm square PVC frame was randomly thrown on the creek bottom and clams were dug by hand, placed in field sampling bags and marked as to locality. Clams were returned to the laboratory, where they were counted, measured for shell length (longest possible measurement, i.e., anterior-posterior), and aged by shell sectioning techniques (see Rhoads and Lutz, 1980; Rhoads and Pannella, 1970). Growth curves for each clam were constructed by back-plotting shell length to each summer annual ring increment.

Clams at each station were categorized according to the following commercial size groups: juveniles, <38 mm; pre-legal littlenecks, 38 to 44.4 mm; littlenecks, 44.4 to 67.0 mm; cherrystones, 68 to 77 mm; and chowders >78 mm in shell lengths. This classification scheme is similar to Godwin's (1967) scheme except that his littleneck size class (38 to 68 mm) was divided

into legal littlenecks, those >44.4 mm and pre-legal littlenecks, those <44.4 mm (Walker 1984b).

Results

The growth rates of the various clam populations are given in Figures 5-44. In 95% of populations sampled, the mean time for clams within a population to reach marketable size (44.4 mm in shell length or 25.4 mm in shell width) is 2 to 3 years, while individual clams obtain this size in 2 to 7 years. The exceptions to this are Sapelo Sound Station number 9 and Cumberland Island Station number 1 in which 5 and 4 years of growth were required before commercial size was obtained (Figures 30 and 45 respectively).

Population shell size and age structure are given in Figures 5-44. Clams were aged to 40 years with an overall mean age of 10.8 years. Overall, clams less than 10 years accounted for 60% of the harvested animals, whereas clams 11 to 20, 21 to 30 and those greater than 30 years old accounted for 25%, 13% and 2% respectively. As clam populations were fished, the percentage of older clams was reduced. Conversely, the percentage of juveniles increased as fishing pressure increased (Figure 45). Most populations appear to be healthy as exhibited by the presence of younger individuals. Christmas Creek Station number 4 (Figure 41) is the major exception in that within this dense population, only two individual clams were less than 10 years old. In essence, there has been virtually no recruitment to this population in 12 years. Wassaw Sound Station number 3 had only 3 individuals less than ten years of age, with the majority of the clams being over 20 years of age (Figure 7). In terms of shell lengths, clams were sized to 11.83 cm with an overall mean shell length of 7.21 ± 1.12 S.D. cm.

In terms of commercial size grouping (Figures 46-51), juveniles accounted for 3% of the overall population with pre-littlenecks, littlenecks, cherrystones, and chowders accounting for 4%, 32%, 28% and 33% respectively (Figure 52). Chowders dominated in 40% of the populations with cherrystones and littlenecks dominating at 38% and 22% of the clam populations respectively (Figure 52). In terms of effects of fishing pressure on clam populations, chowders dominated in non-fished stations (N=27) with decreasing percentages in areas lightly fished (N=11) to lesser percentages in intensely fished areas (N=2). The percentage of littlenecks increases with increase in fishing pressure (Figure 52).

Mean clam densities ranged from less than 1 to 151 clams per square meter (Table 2), whereas individual samples ranged from 0 to 216 clams per square meter. Overall average density of the 40 clam populations sampled was 22 clams per square meter. Large differences in clam numbers per sample per station were observed.

Discussion

The results of this study show that the growth rate of the various clam populations in coastal Georgia result in a marketable product in 2 to 3 years. These findings agree with those growth rates observed in other naturally occurring clam populations in Georgia (Walker, 1984b, Quitmyer *et al.*, 1985; Walker and Stevens, *in press*). Furthermore, they agree with growth rates obtained from hatchery-reared clam seed in Georgia (Walker, 1984a, b), in South Carolina (Eldridge *et al.*, 1976, 1979) and in Florida (Menzel, 1964).

Of the 40 clam populations, only Cumberland Island Station number 1 and Sapelo Sound Station number 9 required over three years of growth to obtain a

Table 2. Habitat type, substrate type, mean density of clams, *Mercenaria mercenaria* standard deviation per m², and relative commercial harvesting pressure per station.

| Area/Station | Habitat Type | Substrate Type | Mean Density per m ² | Commercial Harvesting |
|-----------------------------|-------------------------|----------------|---------------------------------|-----------------------|
| Wassaw Sound | | | | |
| 1 | Intertidal Flat | Shell/Sand | 8.8 ± 7.7 | Intense |
| 2 | Intertidal Flat | Shell/Sand | 20.3 ± 8.9 | Intense |
| 3 | Creek | Mud | 13.5 ± 18.4 | None |
| 4 | Feeder Creek | Shell/Mud | 3.0 ± 1.5 | None |
| 5 | Feeder Creek | Shell/Mud | 47.3 ± 30.9 | Light |
| 6 | Feeder Creek | Shell/Mud | <1 | None |
| 7 | Feeder Creek | Shell/Mud | 3.2 ± 4.5 | None |
| 8 | Feeder Creek | Shell/Mud | 18.0 ± 8.9 | None |
| 9 | Feeder Creek | Shell/Mud | 6.8 ± 4.1 | None |
| 10 | Feeder Creek | Sand/Shell | 36.0 ± 45.0 | Light |
| 11 | Creek | Shell | 14.0 ± 10.2 | Light |
| 12 | Creek | Shell/Sand | 10.0 ± 8.0 | None |
| 13 | Creek | Shell/Mud | 12.8 ± 15.2 | None |
| St. Catherines Sound | | | | |
| 1 | Major Creek | Shell/Mud | 10.1 ± 5.6 | Light |
| 2 | Major Creek | Mud | 11.5 ± 8.3 | Light |
| 3 | Sound - Intertidal Flat | Shell/Sand | 2.1 ± 1.6 | Light |
| Sapelo Sound | | | | |
| 1 | Feeder Creek | Shell/Mud | 4.0 ± 3.5 | None |
| 2 | Creek | Shell/Mud | <1 | Light |
| 3 | Creek | Shell/Mud | 10.1 ± 5.7 | Light |
| 4 | Creek | Shell/Mud | 3.0 ± 1.4 | None |
| 5 | Creek | Shell/Mud | 23.0 ± 14.1 | None |
| 6 | Feeder Creek | Shell/Mud | 8.1 ± 6.7 | None |
| 7 | Feeder Creek | Shell/Mud | 7.0 ± 4.8 | None |
| 8 | Feeder Creek | Shell/Mud | 50.0 ± 21.3 | None |
| 9 | Intertidal Flat | Shell | 21.0 ± 8.9 | None |
| 10 | Intertidal Flat | Shell/Mud | 20.0 ± 16.1 | None |
| 11 | Creek | Shell/Mud | 46.6 ± 25.7 | None |
| 12 | Feeder Creek | Shell/Mud | 11.0 ± 10.8 | None |
| 13 | Feeder Creek | Shell/Mud | 6.1 ± 5.8 | None |
| 14 | Creek | Shell/Mud | 4.2 ± 2.6 | Light |
| 15 | Creek | Shell/Mud | 5.3 ± 3.3 | Light |
| Crooked River | | | | |
| 1 | River | Sand | <1 | Light |

Table 2. (Cont'd).

| Area/Station | Habitat Type | Substrate Type | Mean Density per m ² | Commercial Harvesting |
|-------------------|-----------------|----------------|---------------------------------|-----------------------|
| Christmas Creek | | | | |
| 1 | Feeder Creek | Shell/Mud | 34.1 ± 19.6 | None |
| 2 | Feeder Creek | Shell/Mud | 6.1 ± 3.9 | None |
| 3 | Feeder Creek | Shell | 73.5 ± 27.2 | None |
| 4 | Feeder Creek | Mud/Shell | 151.0 ± 10.2 | None |
| 5 | Feeder Creek | Shell to Mud* | 85.7 ± 92.6 | None |
| 6 | Feeder Creek | Shell/Mud | 14.3 ± 7.7 | None |
| 7 | Feeder Creek | Shell/Mud | 67.7 ± 52.1 | None |
| Cumberland Island | | | | |
| 1 | Intertidal Flat | Sand/Grass | 10 to 15** | None |

* Creek bottom had only small area of shell; most of creek bottom was mud. High density of clams (95 per sample) occurred in shell bottom; whereas, 4 and 14 clams occurred per sample in mud.

** Estimated. These animals were collected while accompanying commercial clambers. Out of the 1817 clams harvested, 66 were juveniles, 2 pre-littlenecks, 1741 littlenecks, 6 cherrystones and 1 chowder.

mean marketable size. In the Sapelo Sound Station, clams occur on top of an oyster wrack well above the mean low water mark. Clams here occur in a dense substrate of dead oyster shells and are estimated to be above the mean low water within the intertidal zone for 6 hours per tidal cycle. At the Cumberland Island Station, clams occur in a substrate of sand and *Spartina alterniflora* short form roots. Clams here are estimated to be uncovered approximately 8 hours per tidal cycle and may be harvested by hand at a mean high tide (mean tidal amplitude in Georgia is 2.1 m, Johnson *et al.*, 1974). It is interesting to note that clams at Cumberland Island Station 1 required 4 years versus 5 years at the Sapelo Sound Station to obtain commercial size. One can hypothesize that substrate (i.e., clams growing in dense shell substrate) inhibits clam growth more than increased exposure time. For instance, in Sapelo Sound Stations 9 and 10, the two populations occur within 12 meters of each other. Station 10 occurs on the same oyster wrack, but clams here occur in a shelly mud substrate and are estimated to be exposed for 2 1/2 hours per tidal cycle. Yet clams at Station 10 grew almost twice as fast as those at Station 9 with only an 1/2 hour greater exposure time. Furthermore at clam populations in Beach Creek (St. Catherines Stations 1 and 2), both populations occur within approximately 4 meters of each other. Clams at Station 1 occur in a shelly-sand substrate at the mean low water mark, whereas those at Station 2 occur in mud up on the creek bank and are estimated to be uncovered by the tide for approximately 6 hours per cycle. Yet clams at Station 2 have a higher mean size per year than those at Station 1. Thus it appears that substrate in certain cases may be more inhibitory to clam growth than exposure time.

The life span of the hard clam, *Mercenaria mercenaria*, is estimated to be 40 years (Hopkins, 1930; Comfort, 1957). Clams were aged to 40 years in this study, to 34 years in clam populations in the vicinity of Little Tybee Island (Walker, 1984b), and to 25 years at King's Bay, Georgia (Quitmyer et al., 1985). In other studies of hard clam populations, clams were aged to 29 years at Cape Lookout, North Carolina (Peterson et al., 1983), to 32 years at Core Sound, North Carolina (Peterson et al., 1985), to 20 years in Virginia (Haven and Loesch, 1973), to 15 years in Fishers Island, New York (Malinowski, 1985), and to 8 to 9 years in Barnegat Bay, New Jersey (Kennish, 1978). The southern hard clam, *Mercenaria campechiensis* was aged to 22 years in Boca Ciega Bay, Florida (Saloman and Taylor, 1969).

The clam populations of coastal Georgia consist mostly of chowders. This is in agreement with the results of a clam resource survey of Wassaw Sound (Walker et al., 1980) and the State (Godwin, 1968; Walker and Rawson, 1985). The results differ from a clam resource survey in South Carolina where littlenecks were found to dominate (Anderson et al., 1978). The difference in findings between states can be explained by the presence and absence of a viable clam fishery. In South Carolina, a viable fishery exists and the larger and older clams have probably been fished out over time. Reductions of larger size and age classes of clams due to fishing pressure can be seen in this study (Figures 45 and 53). In non-fished areas, chowders dominate. In heavily-fished areas, the percentages of chowders and cherrystones decrease and the percentages of smaller clams and littlenecks increase. The low percentage of juvenile clams in our study can be attributed to sampling error. Clams were collected by hand, which is often an ineffective method of collecting smaller individuals.

Theoretically, during the incipient stages of fishing, older and larger clams are caught first. With time and according to the level of harvesting pressure, smaller, younger clams come to dominate. This has been observed in the New York area. In heavily fished areas of Great South Bay, clams were found to be under four years of age (i.e., age that clams are marketable size), whereas in areas that are closed to fishing, the populations contain older and larger clams with few juveniles or littlenecks (Greene, 1978). In Barnegat Bay, New Jersey, no clams were found under 9 years of age (Kennish, 1980) and Peterson *et al.*, (1985) attribute this absence of older clams to fishing pressure.

In the clam populations of coastal Georgia, mean clam densities ranged from 0 to 151 adult clams per square meter. These densities agree with densities reported in other clam resource surveys in Georgia (Godwin 1967, 1968; Walker *et al.*, 1980; Walker and Rawson, 1985). Reported clam densities from other areas throughout the United States are given in Table 3. In Georgia, clams frequently occur in dense numbers, however, the overall area of the bed is usually small. For instance, in Wassaw Sound, Georgia, a clam population with a mean of 50 clams per square meter covered an area of approximately 90 m². In this population, the mean density was reduced to 20 clams per square meter after 3 days of illegal harvesting (Walker, 1984b).

The clam populations of coastal Georgia are representative of harvested and unharvested populations. In unharvested populations in Georgia, chowders generally dominate (Godwin, 1968; Walker *et al.*, 1980; Walker and Rawson, 1985) and the population is comprised of older individuals (Walker, 1984b; Walker and Stevens, in press). MacKenzie (1979) describes unharvested clam populations as those which exhibit sparse and sporadic setting, declining

Table 3. Hard clam, *Mercenaria mercenaria*, densities reported for natural clam populations.

| Location | No. m ⁻² | Reference |
|--------------------------------------|---------------------|-------------------------------|
| Maquoit Bay, ME | *860 | Dow and Wallace, 1951 |
| Barnstable Harbor, MA | 1 | Sanders <i>et al.</i> , 1962 |
| Narragansett Bay, RI | 4 | Russell, 1972 |
| Greenwich Bay, RI | 2 to 12 | Stickney and Stringer, 1957 |
| Greenwich Bay, RI | 215 | Stringer, 1955 |
| Long Island Sound, CT | 0.9 | MacKenzie, 1977 |
| Northport Bay, NY | 6.5 | MacKenzie, 1977 |
| Great South Bay, NY | 18.4 | MacKenzie, 1977 |
| Islip, NY | | Buckner, 1979 |
| Open Areas | 16 | |
| Closed Areas | 30 | |
| Patchogue Bay, NY | 81 | Greene, 1978 |
| East Patchogue Bay, NY | 16 | Greene, 1978 |
| Patchogue Bay, NY | 50 | Greene, 1978 |
| Barret Beach, NY | 16 | Greene, 1978 |
| East Islip, NY | 11 | Greene, 1978 |
| Goose Creek, NY | 10 | Kaplan <i>et al.</i> , 1975 |
| Raritan Bay, NJ | 14 | MacKenzie, 1977 |
| Raritan Bay, NJ | 5 to 11 | Campbell, 1965 |
| Little Egg Harbor, NJ | 34 | Carriker, 1961 |
| Chinocoteague Bay, MD | 1 | Wells, 1957 |
| Poquoson Flats, VA | 5 | Loesch and Haven, 1973 |
| Johnson Creek, NC | 6.4 | Peterson <i>et al.</i> , 1983 |
| Back Sound, NC | 2 to 10 | Peterson <i>et al.</i> , 1984 |
| Santee River, SC | 18 to 24 | Rhodes <i>et al.</i> , 1977 |
| North Inlet, SC | 6 | Dame, 1979 |
| Coastal Georgia | 0.1 to 21 | Godwin, 1968 |
| Christmas Creek, GA | 151 | This Study |
| Wassaw Sound, GA | 0 to 100 | Walker <i>et al.</i> , 1980 |
| Coastal Georgia | 0 to 91 | Walker and Rawson, 1985 |
| Colorado Lagoon, CA | 556 | Crane <i>et al.</i> , 1975 |
| Southampton Waters, Great Britain | 6 to 8 | Ansell, 1963 |
| Southampton Waters, Great Britain | 0.3 to 12.3 | Hibbert, 1976 |

*This population was undergoing heavy mortality due to overcrowding.

setting densities of spat, increased predation of juveniles, and populations comprised mostly of older clams. Malinowski (1985) concludes that even in populations with low rates of annual recruitment (due to sporadic setting and/or to predation) into the adult age classes, the population will ultimately result in dense assemblages of clams. From the data presented in this study, Malinowski's characterization of old populations is more applicable to Georgia populations than MacKenzie's. Sporadic and low setting densities are the rule in Georgia (personal observation) regardless of whether the population is being harvested or not. Recruitment is a gradual event in Georgia with spawning possibly occurring over most of the year (Pline, 1984). Gonadal studies in Georgia show that spawning occurs over a 10-month period (Pline, 1984), but peaks in fall and spring. This may account for the absence of any major sets occurring in Georgia. Thus it appears that in Georgia, a relatively few individuals recruit to the population each year resulting in dense numbers of older clams over time.

Beal (1983) hypothesized that dense assemblages of neighboring large clams (80 m^{-2}) may protect smaller clams from predation. Kennish (1978) observed clam populations that were without juveniles. He hypothesizes that this indicated an inverse association between adults and juveniles. He further states that adult populations may preclude successful settlement of young clams because of competition for food. Therefore successful recruitment of *Mercenaria mercenaria* may be regulated by a density-dependent factor, i.e., when density of adults is high, juveniles are forced to settle unoccupied areas (Kennish, 1978). Unfortunately, Kennish (1978) gave no density estimates, and his population was comprised of individuals less than 9 years old. If one looks at the four most dense populations in the Christmas Creek

area (Stations 3, 4, 5 and 7, with 74, 151, 86 and 68 clams m^{-2} respectively), only Population 4 would support Kennish's conclusions that dense adult populations preclude successful recruitment. In Population 4, only 1.5% of the clams are less than 12 years old, which suggests that adults preclude recruitment. Yet in Populations 3, 5 and 7, there are clams in nearly all year classes, indicating there has been recruitment every year for the last 10 years into each of these populations. The majority of the populations would support Beal's hypothesis that dense assemblages of large clams protect smaller clams. Populations 3, 5 and 7 are approximately equivalent to his experimental density of 80 m^{-2} , whereas Population 4 is almost twice that density. It is possible that both investigators are correct, but that the density of adult clams needed to preclude successful recruitment is much greater than that envisioned by Kennish.

Conclusions

The hard clam grows to a commercial size in 2 to 3 years throughout the coastal area of Georgia, except under extreme environmental conditions. In non-fished or unexploited clam populations, a wide range of clam ages (up to 40 years) and clam sizes (up to 11.8 cm) may occur, however, in lightly fished to heavily fished populations, the range of sizes and ages is narrowed. The range decreases with increased fishing pressure. It is hoped that the data provided in this report will provide baseline information for future comparisons to determine the impact of a viable fishery upon presently unexploited hard clam populations.

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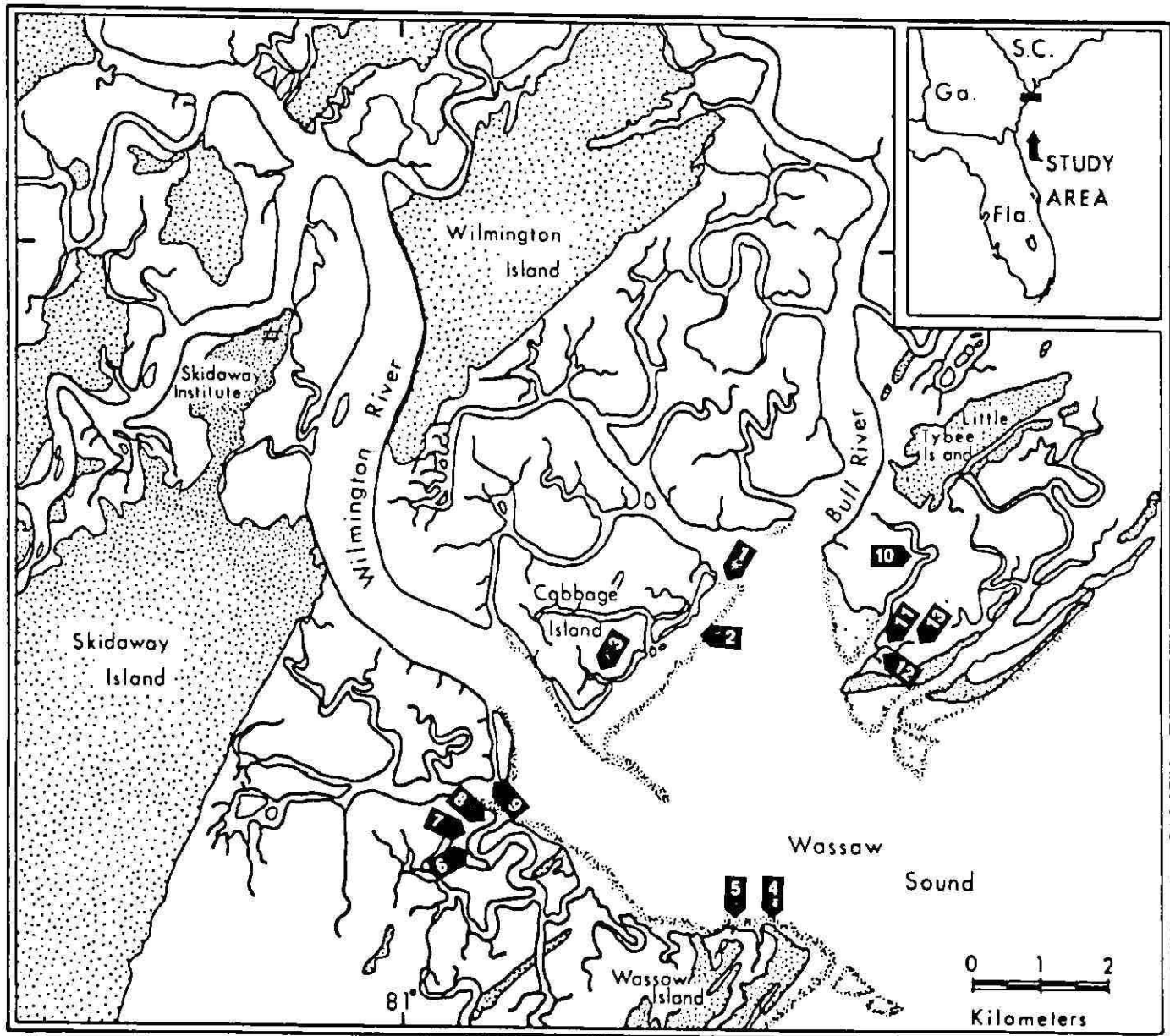
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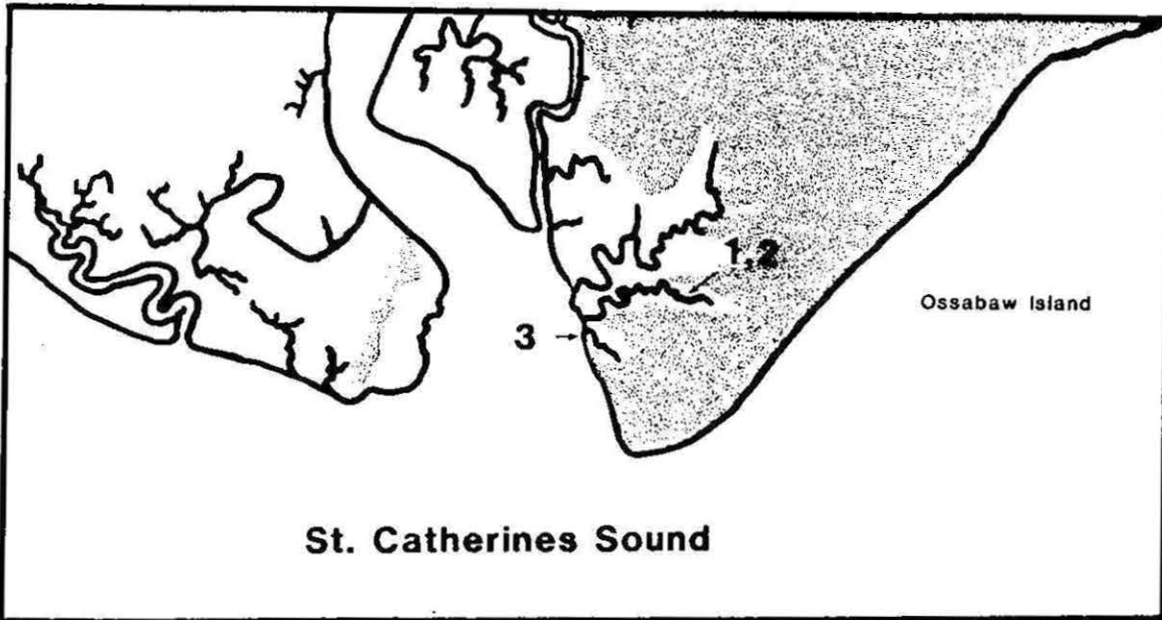
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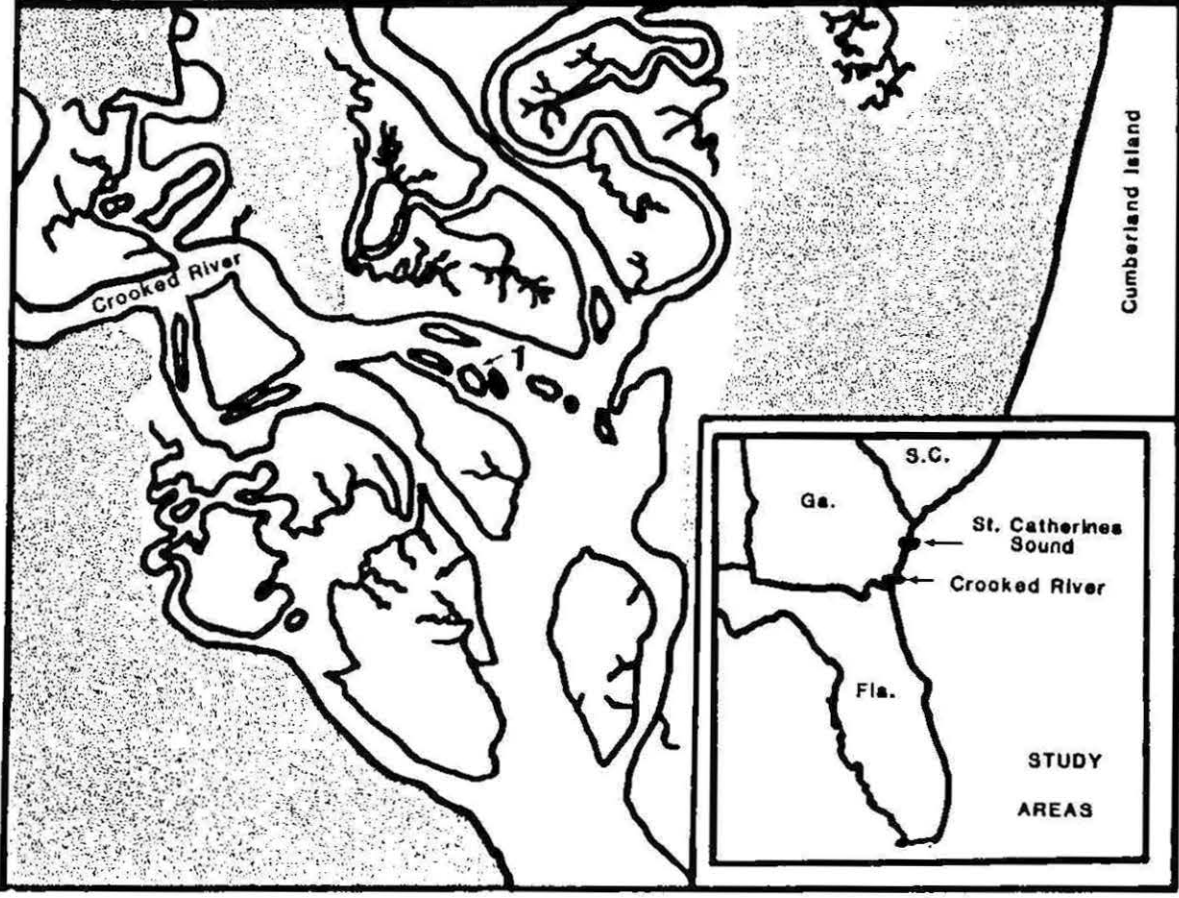
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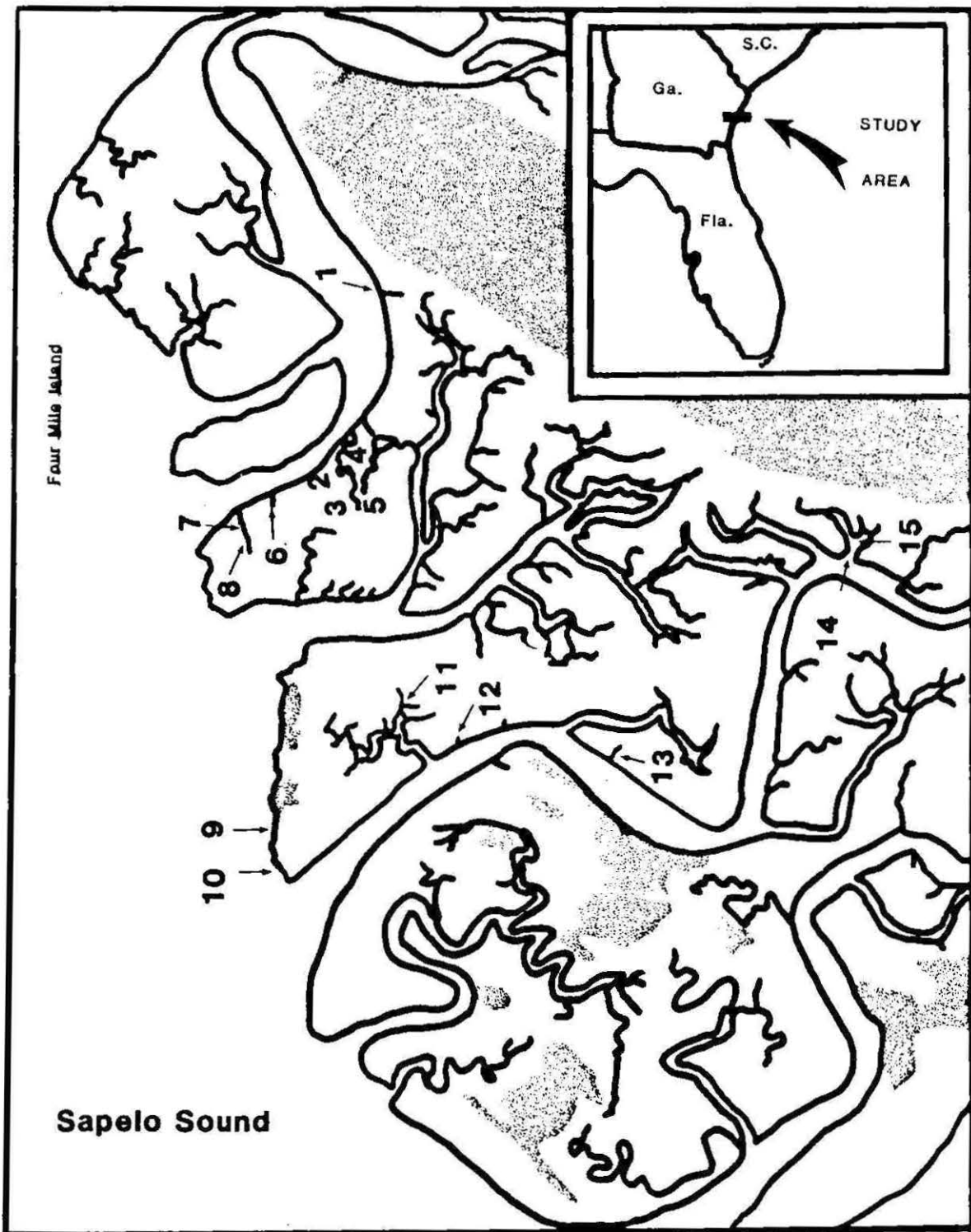
FIGURES 1 - 52

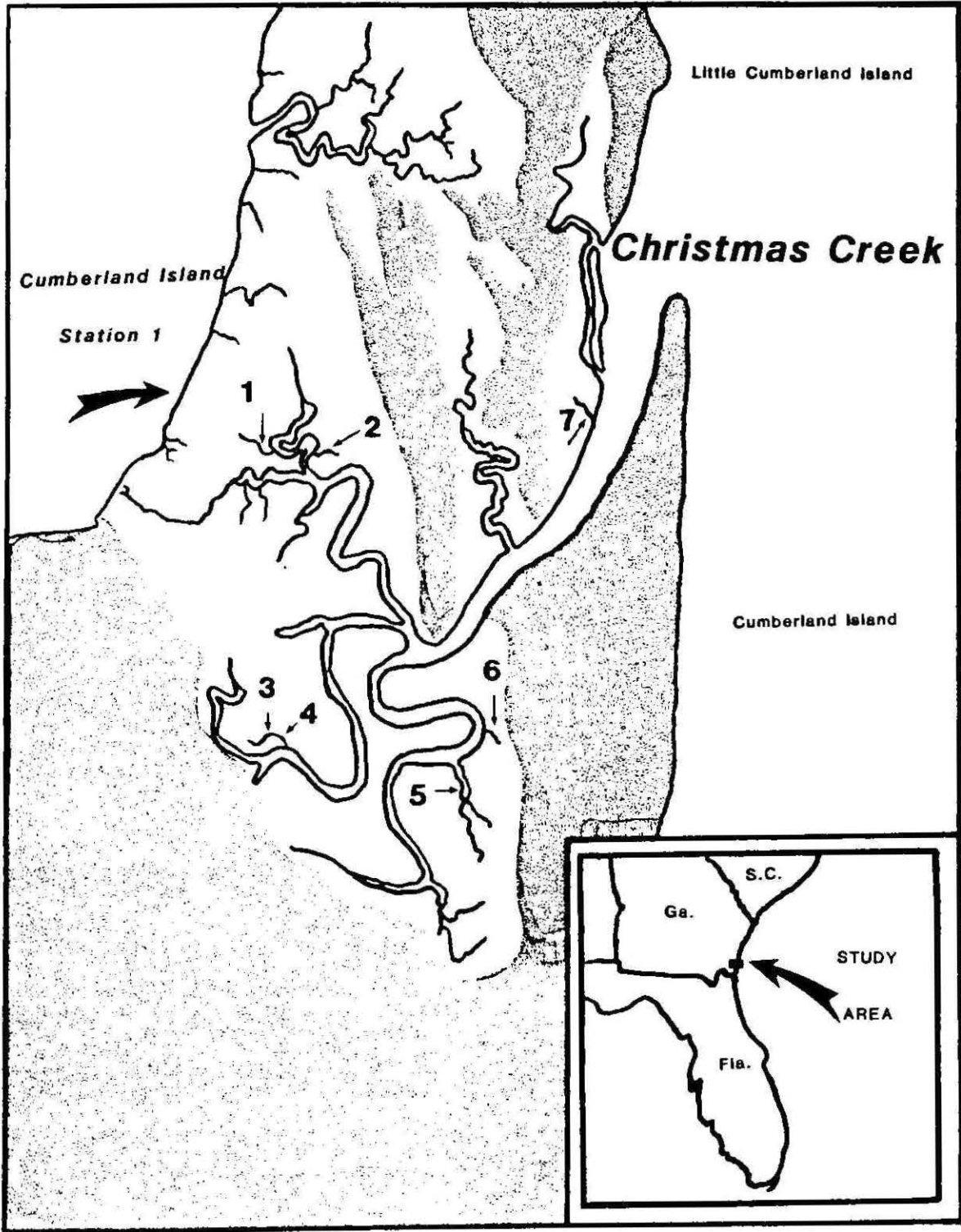




St. Catherines Sound



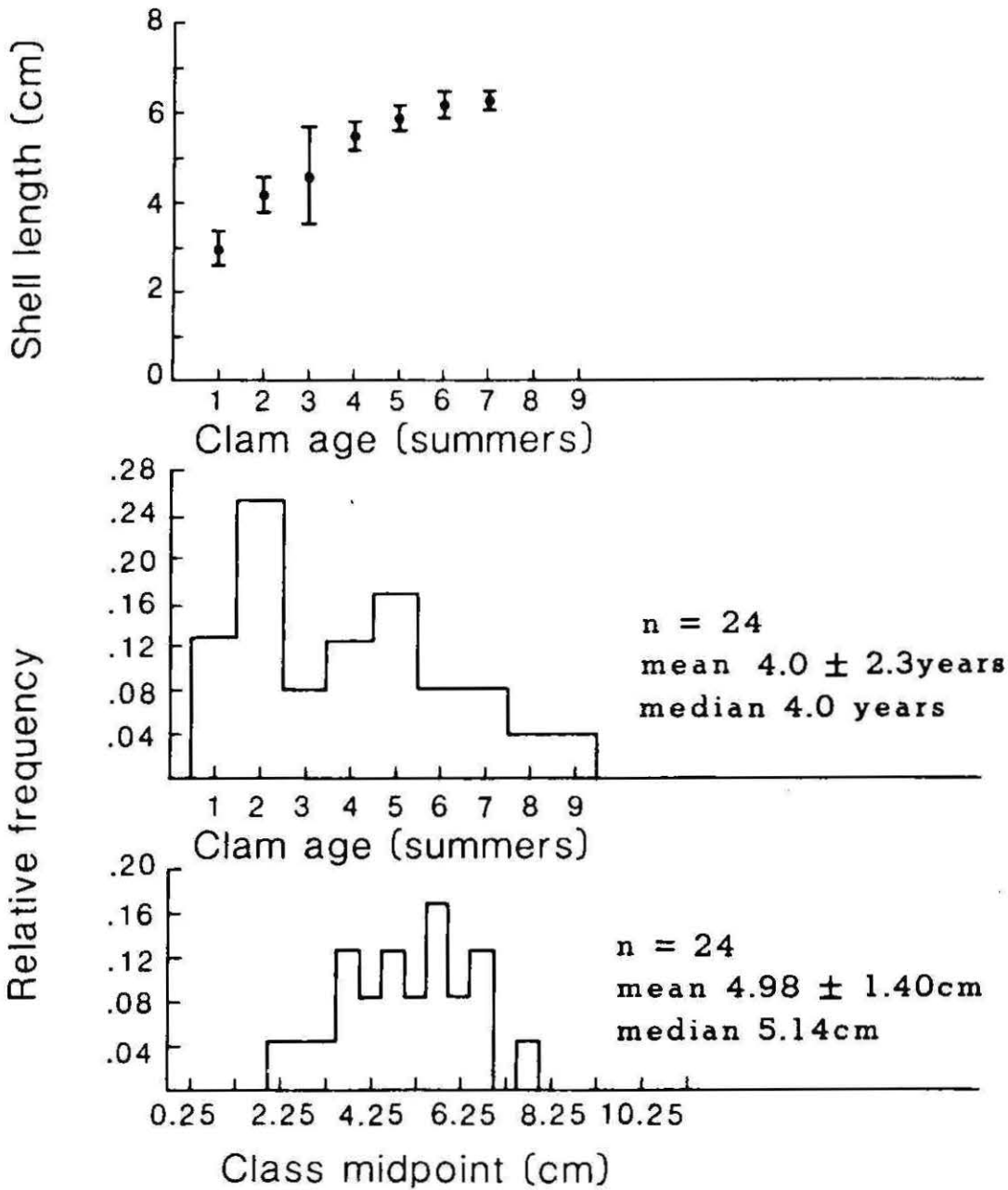




Wassaw Sound

Cabbage Island

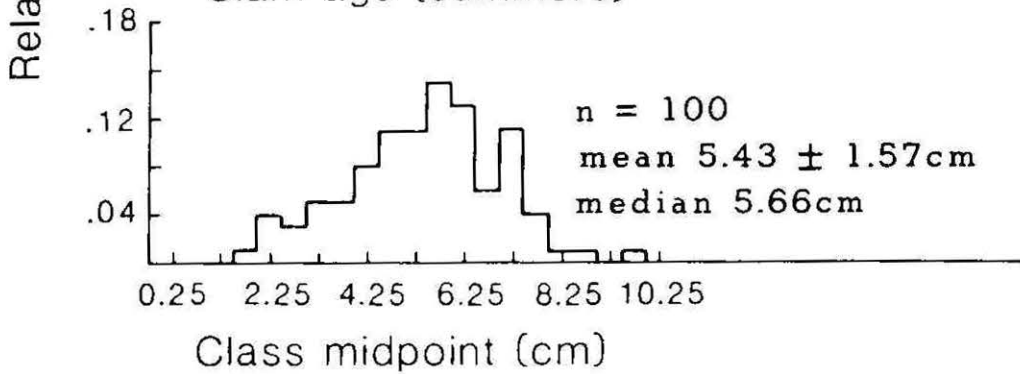
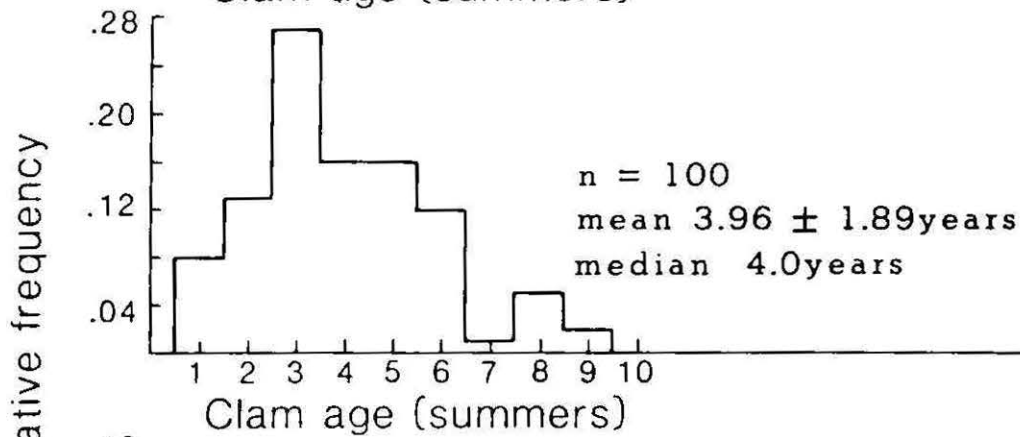
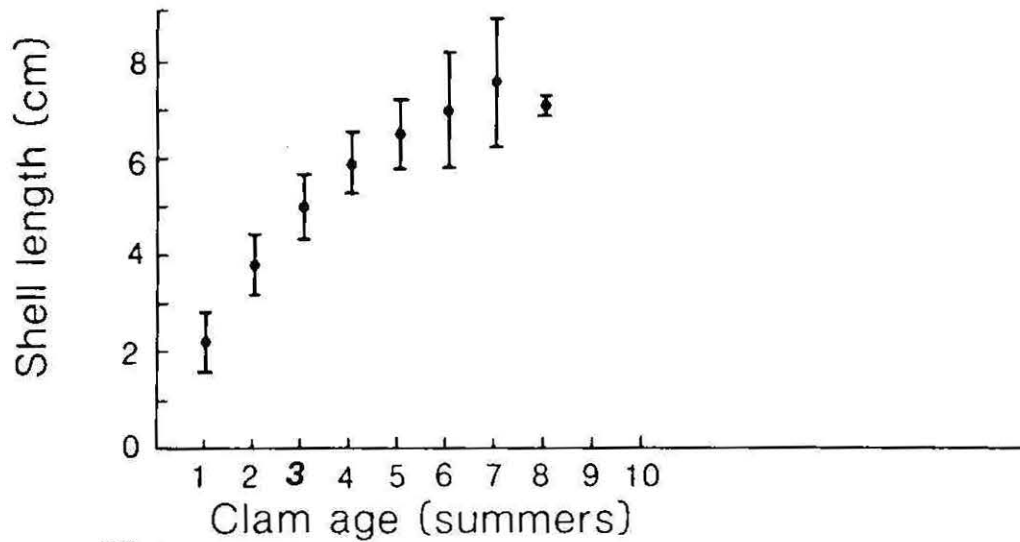
Clam Station 1



Wassaw Sound

Cabbage Island

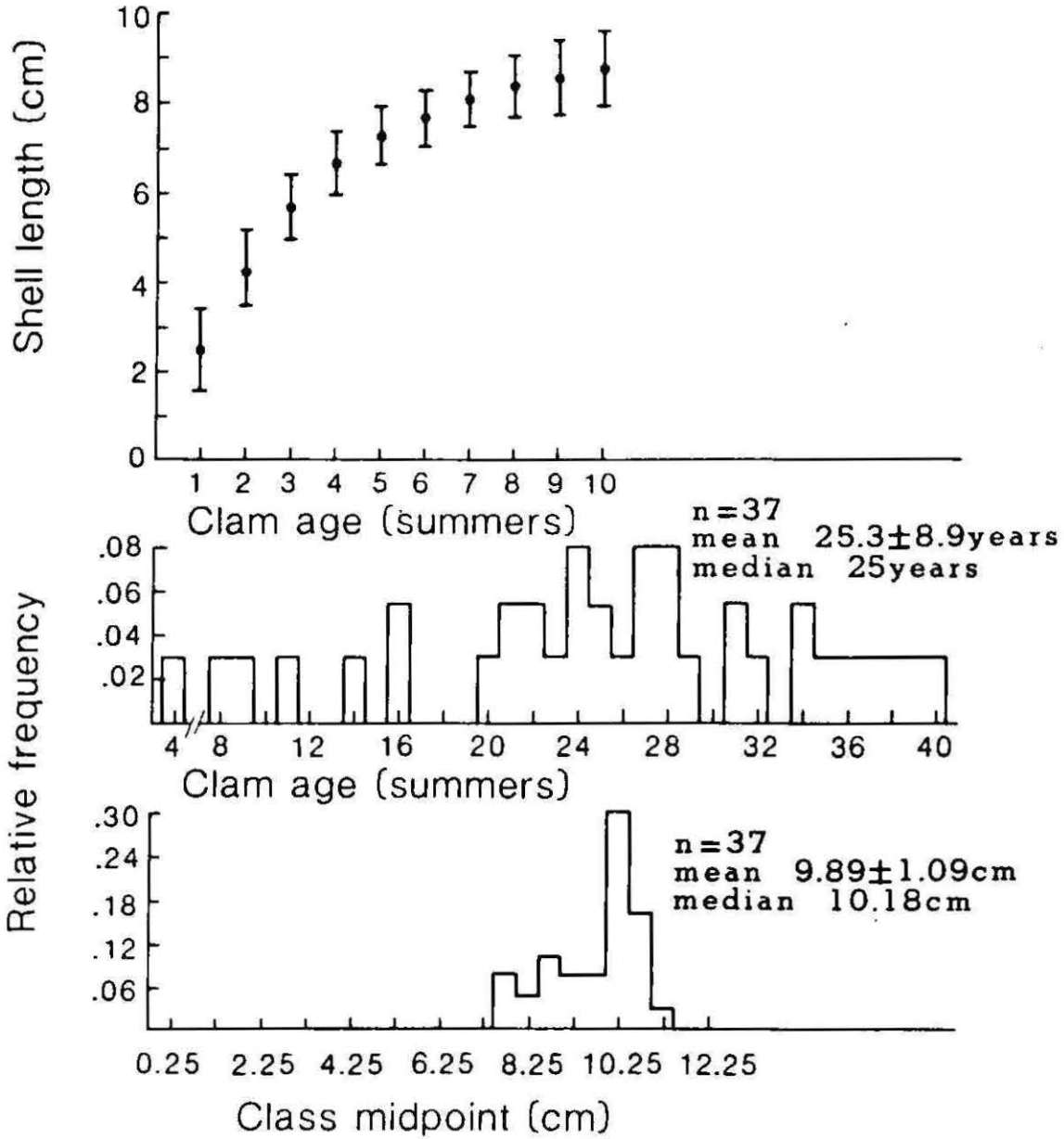
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Wassaw Sound

Cabbage Island

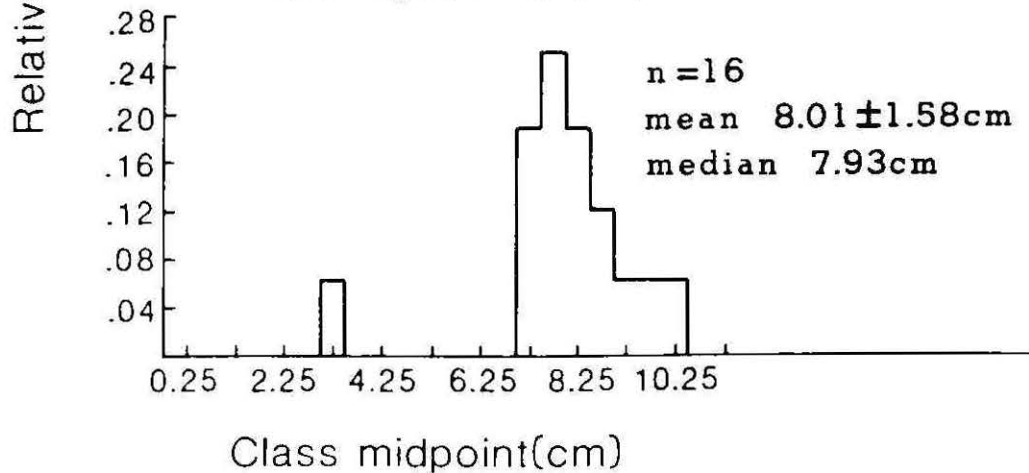
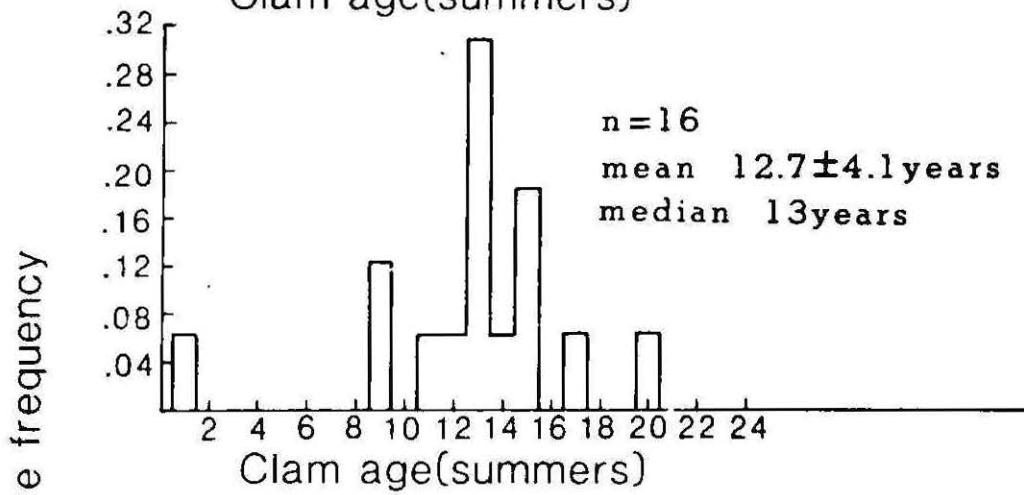
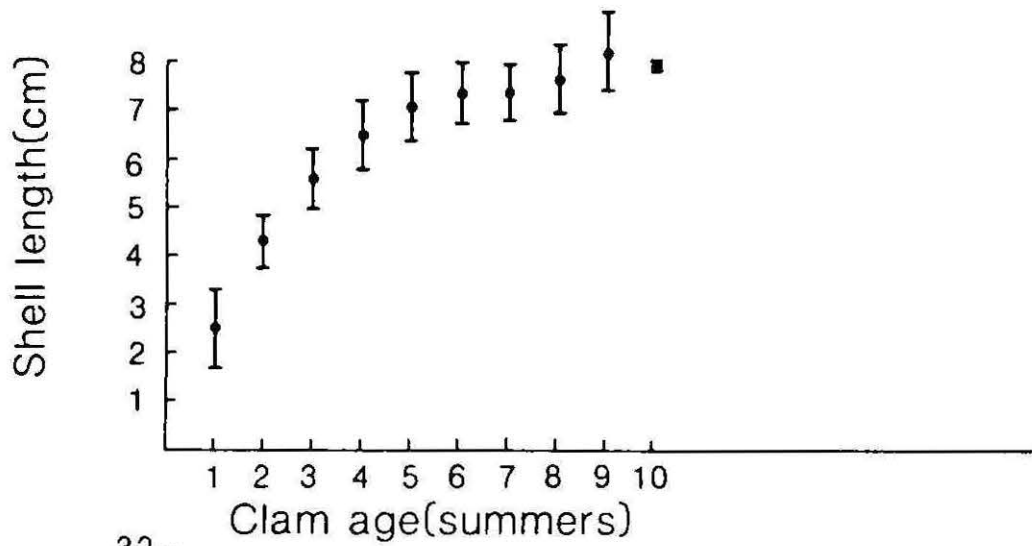
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Wassaw Sound

Wassaw Island

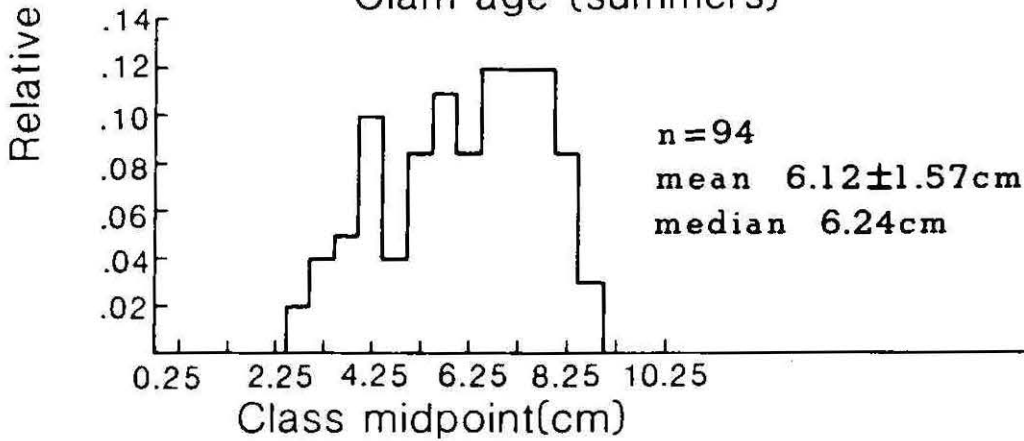
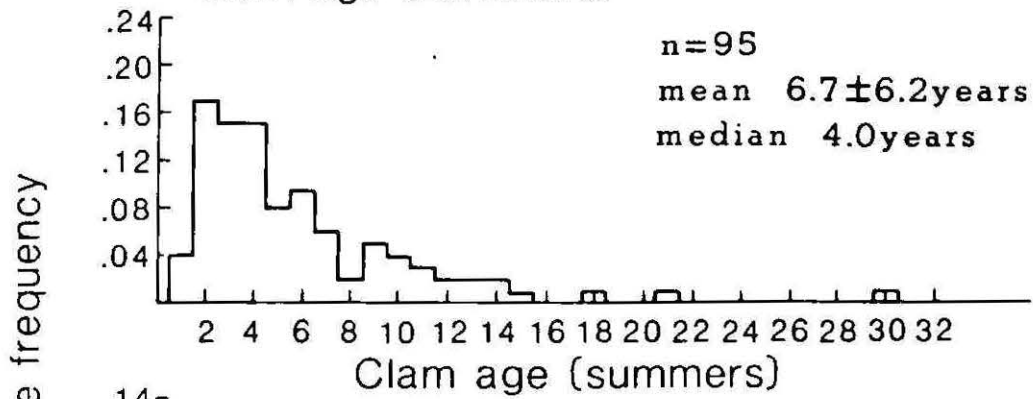
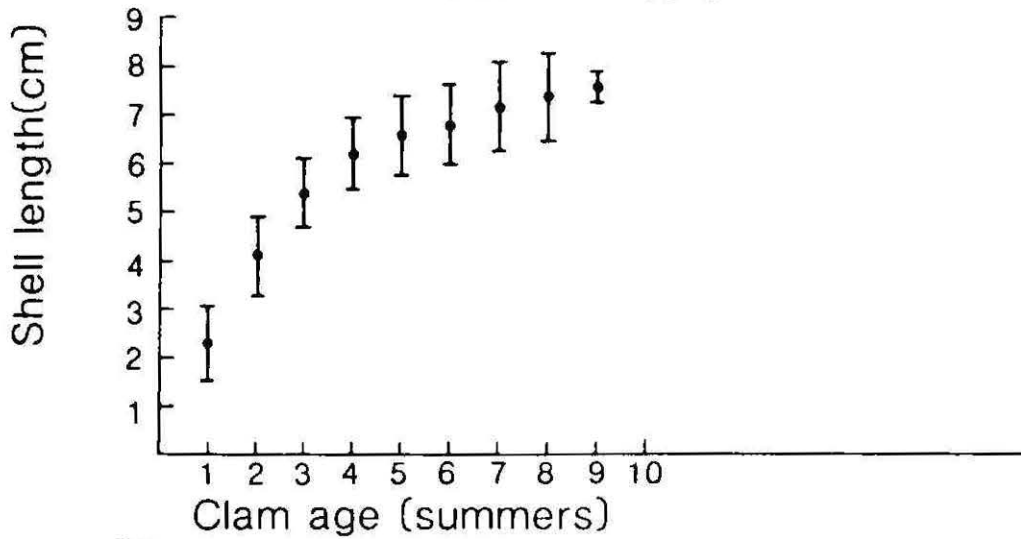
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Wassaw Sound

Wassaw Island

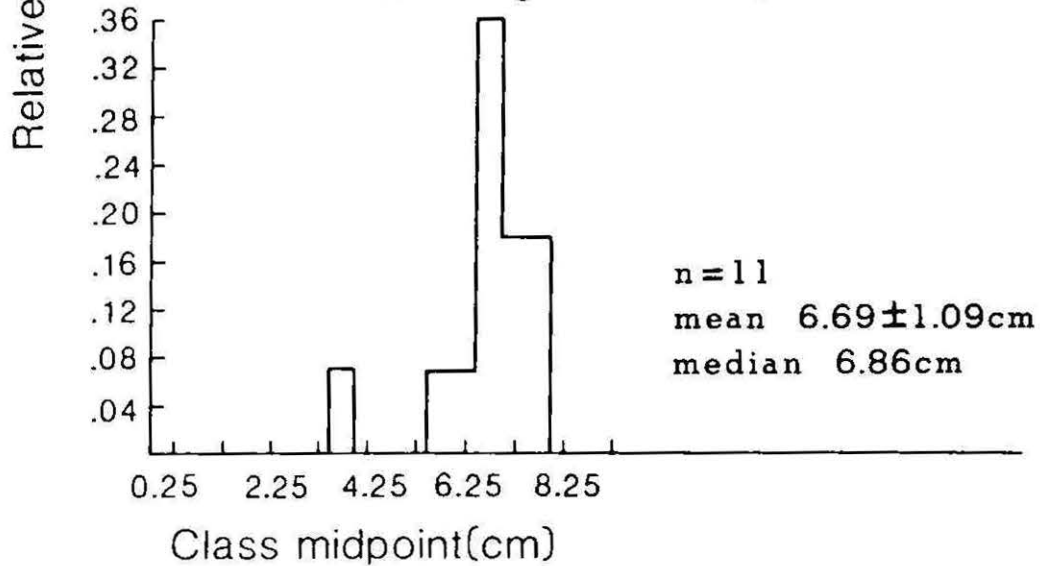
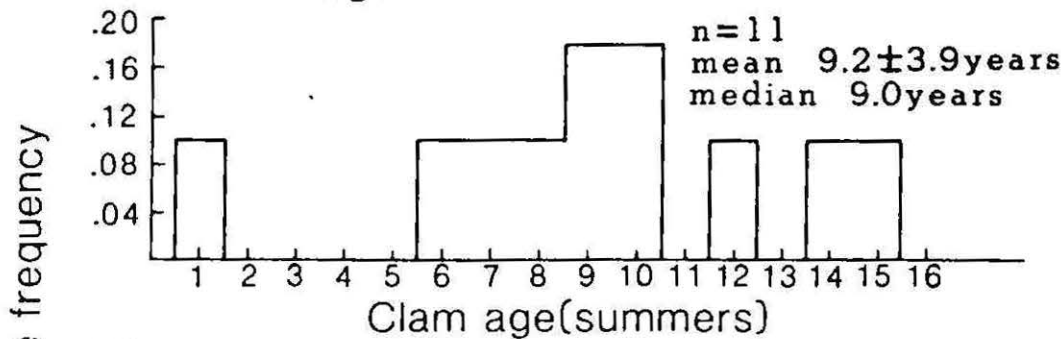
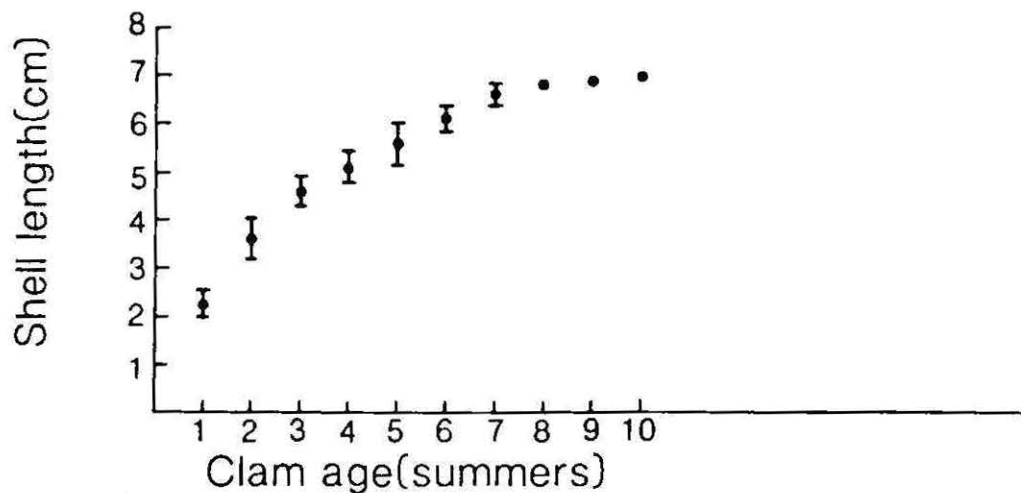
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Wassaw Sound

Wassaw Island

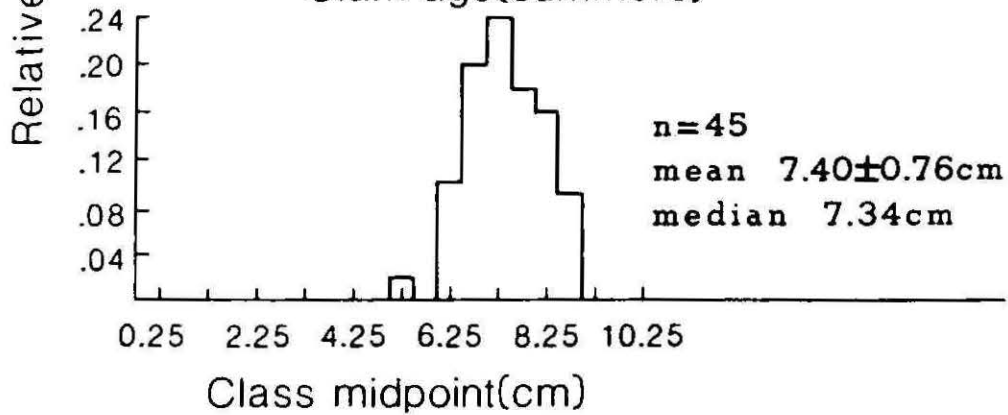
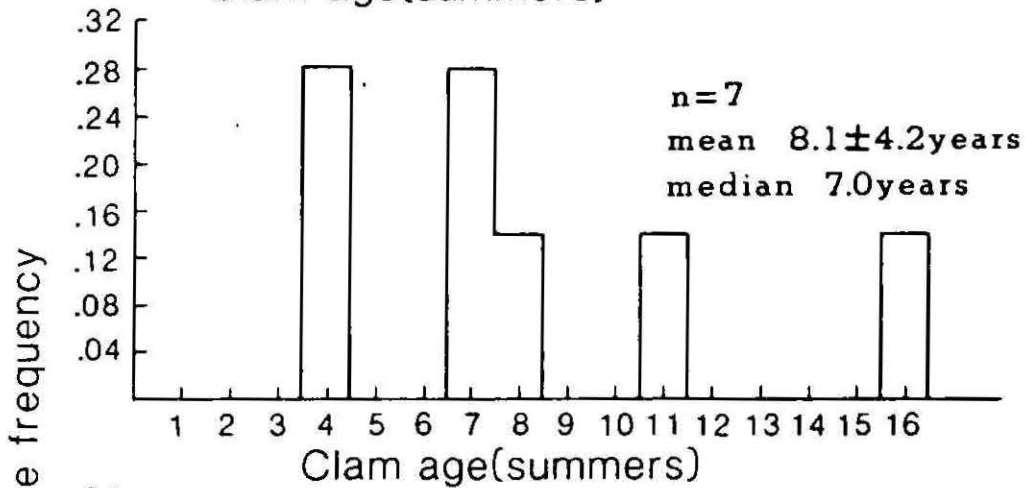
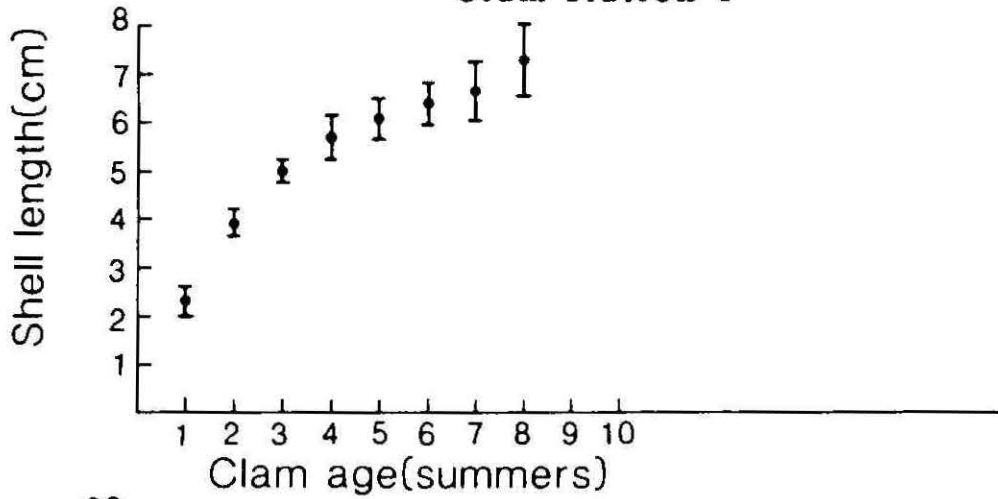
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Wassaw Sound

Wassaw Island

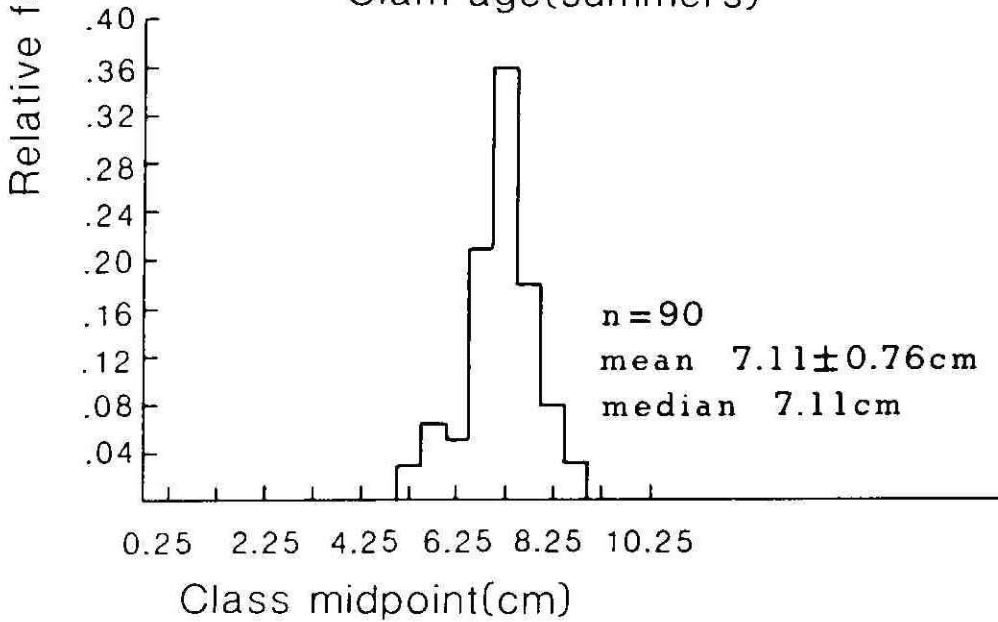
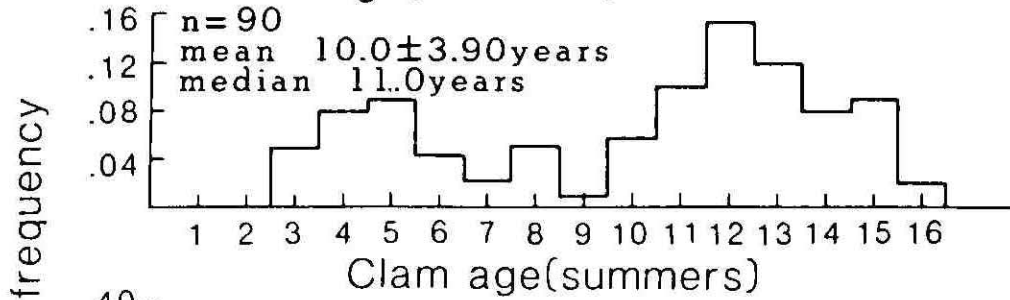
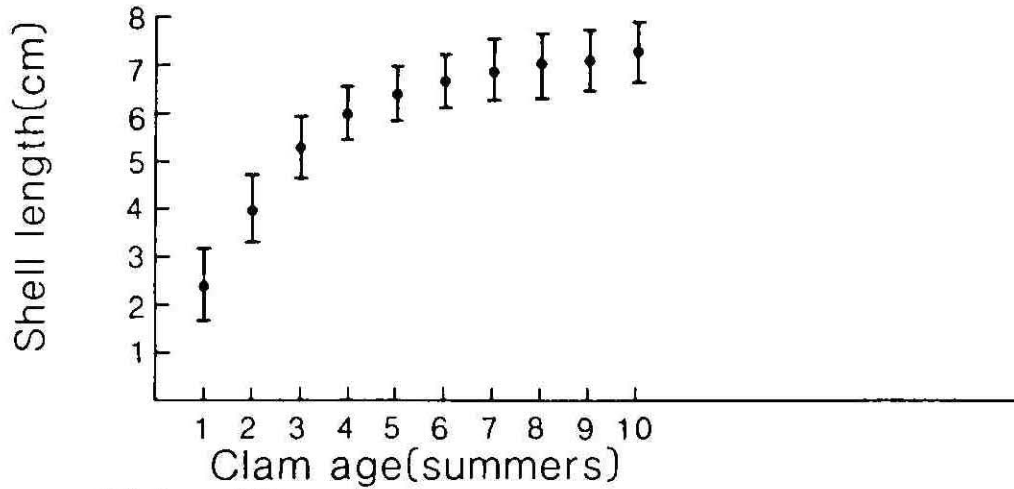
Clam station 7



Wassaw Sound

Wassaw Island

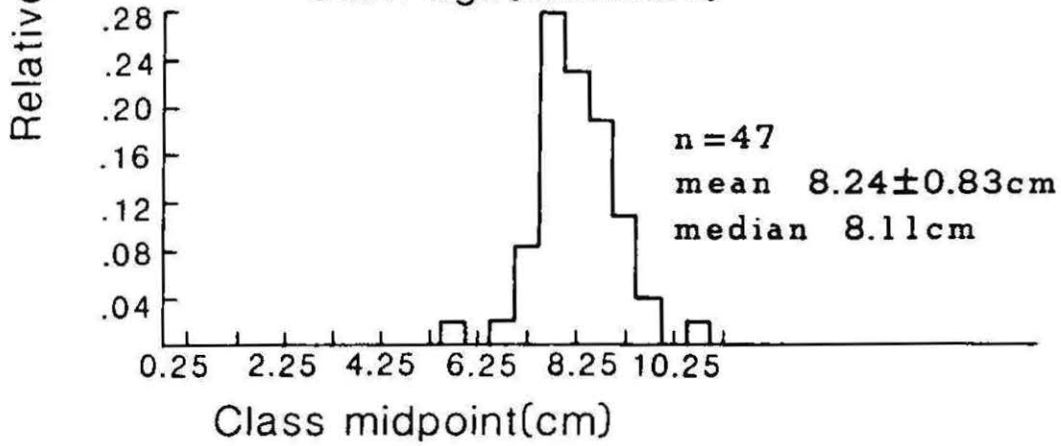
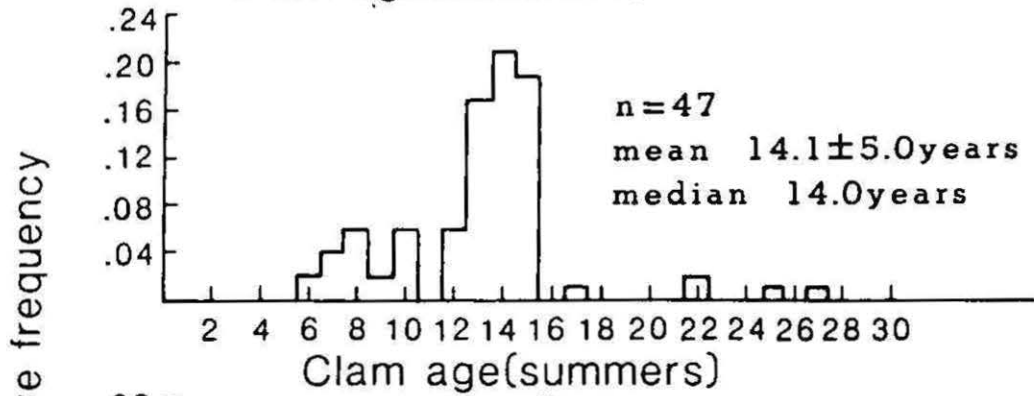
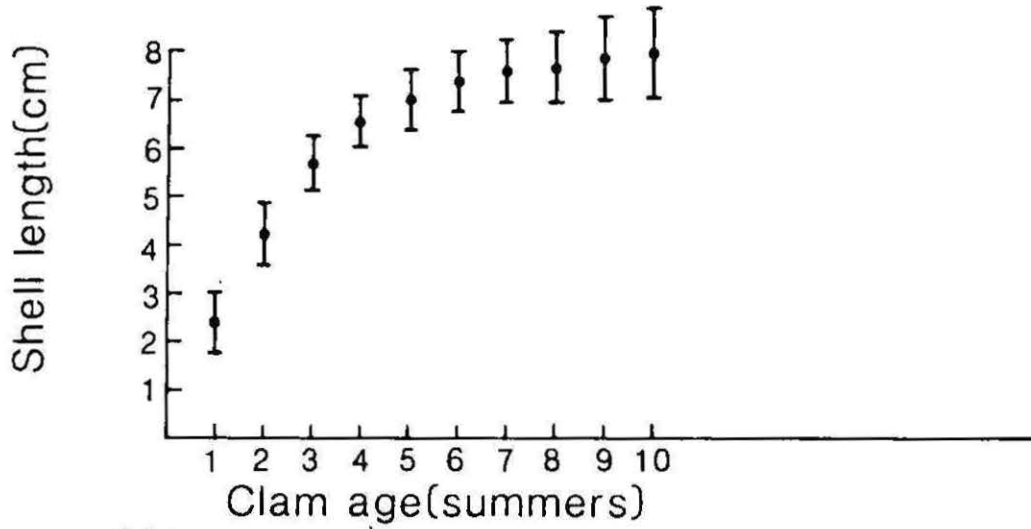
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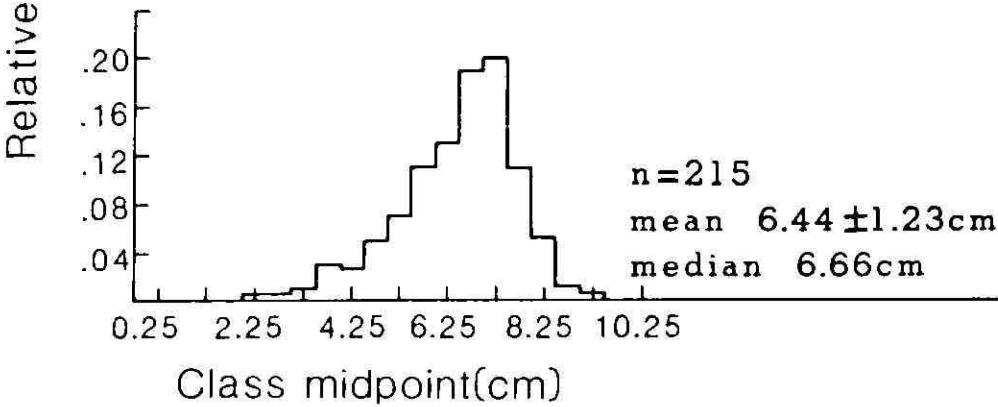
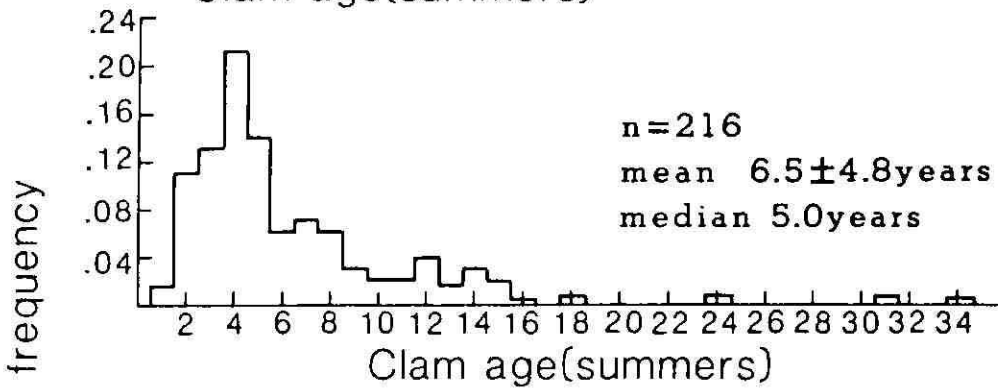
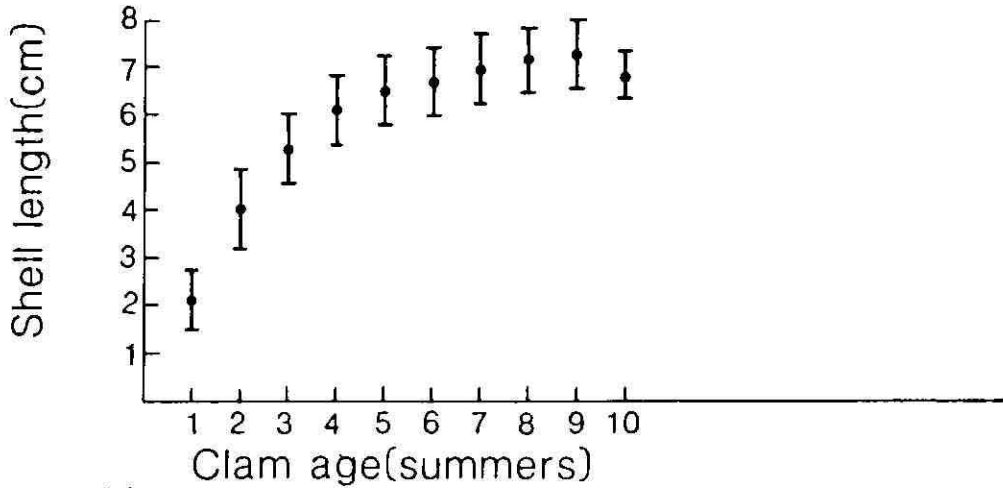
Wassaw Sound

Skidaway Island

Clam station 9



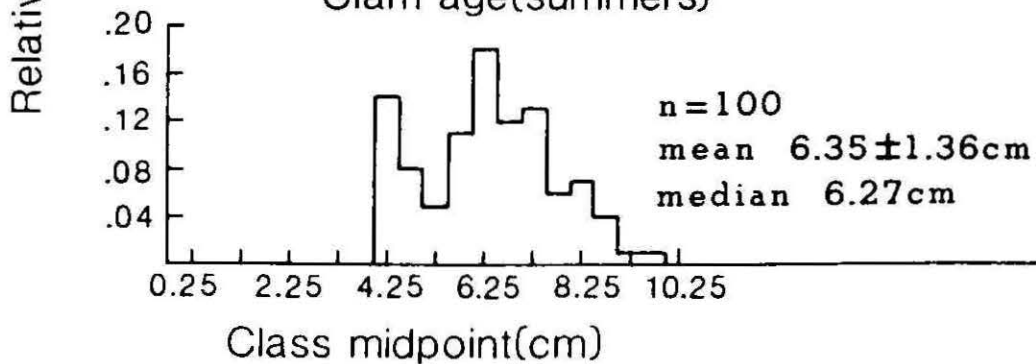
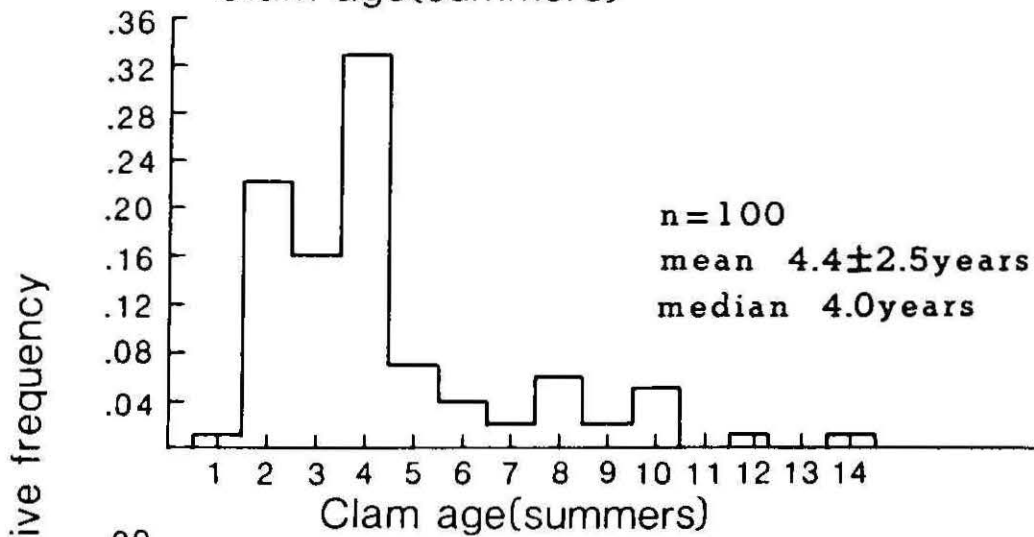
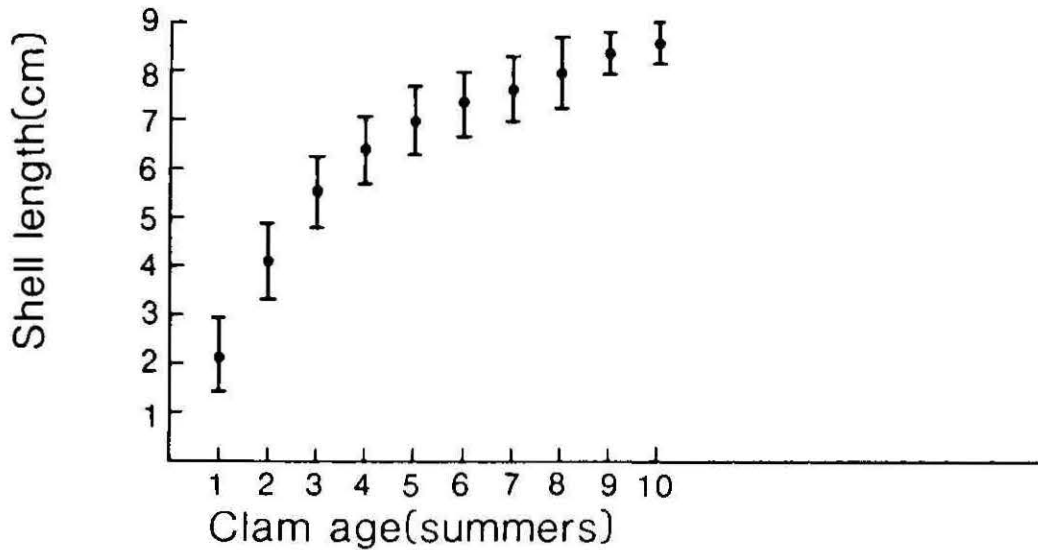
Wassaw Sound
Little Tybee Island
 Clam station 10



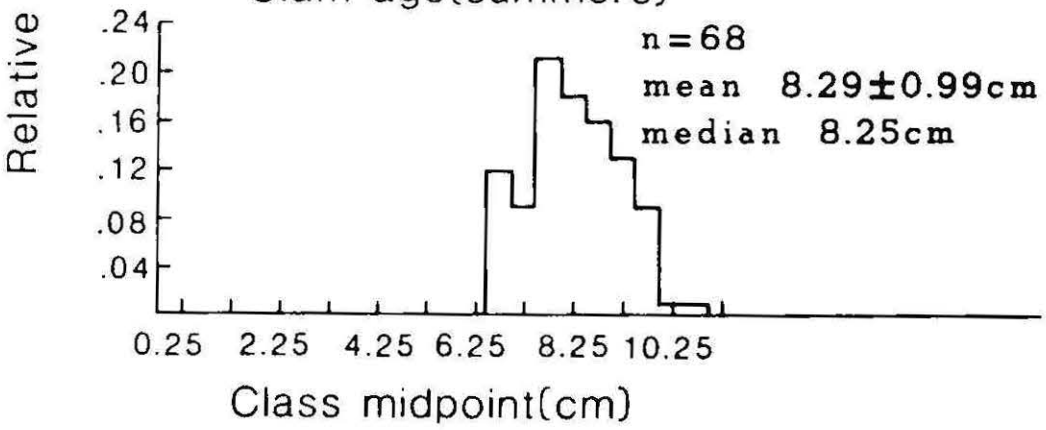
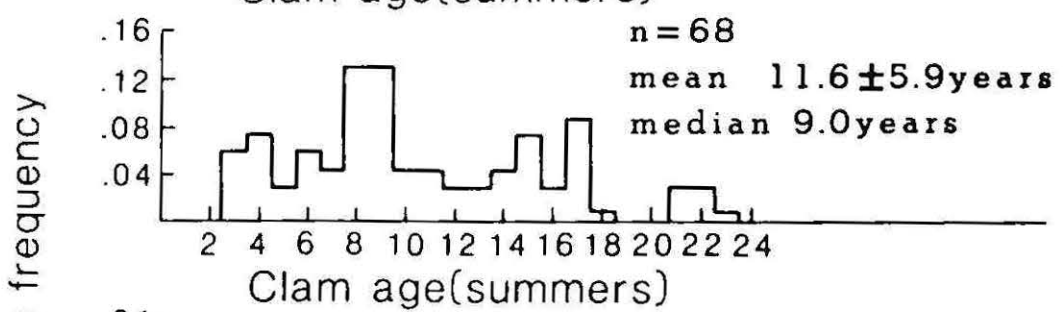
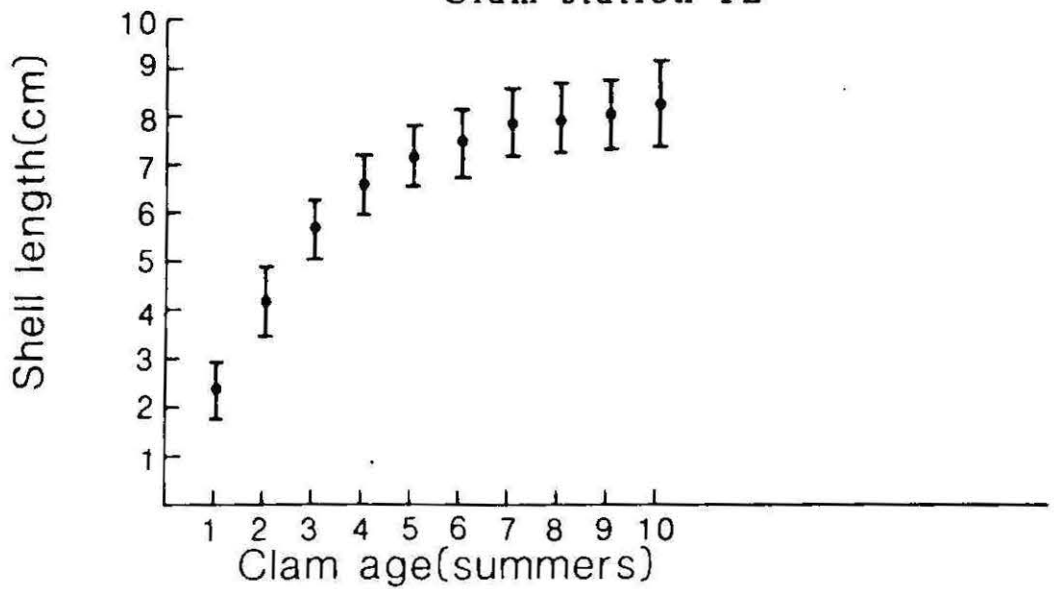
Wassaw Sound

Little Tybee Island

Clam station 11



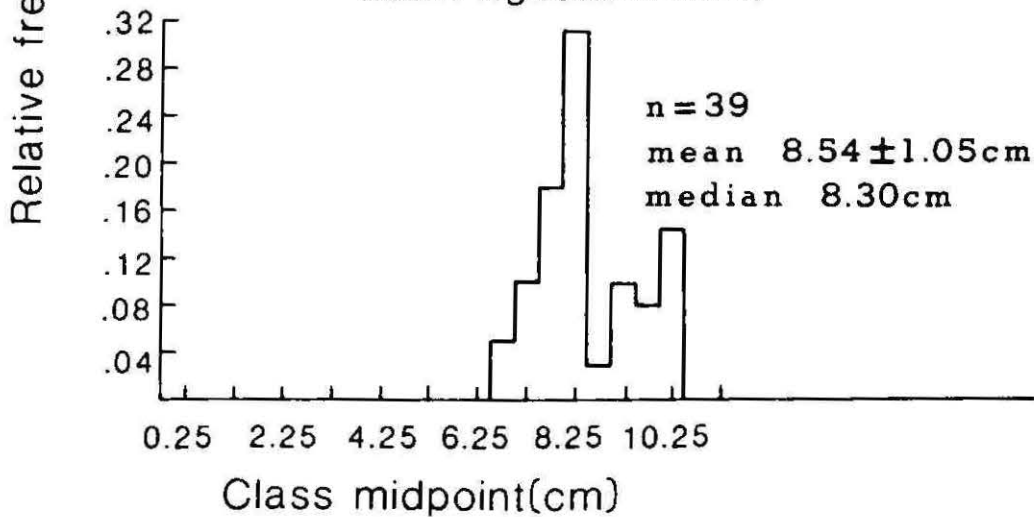
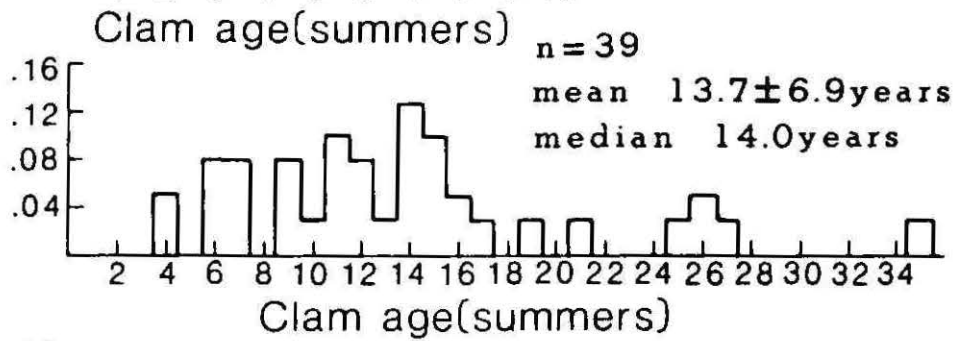
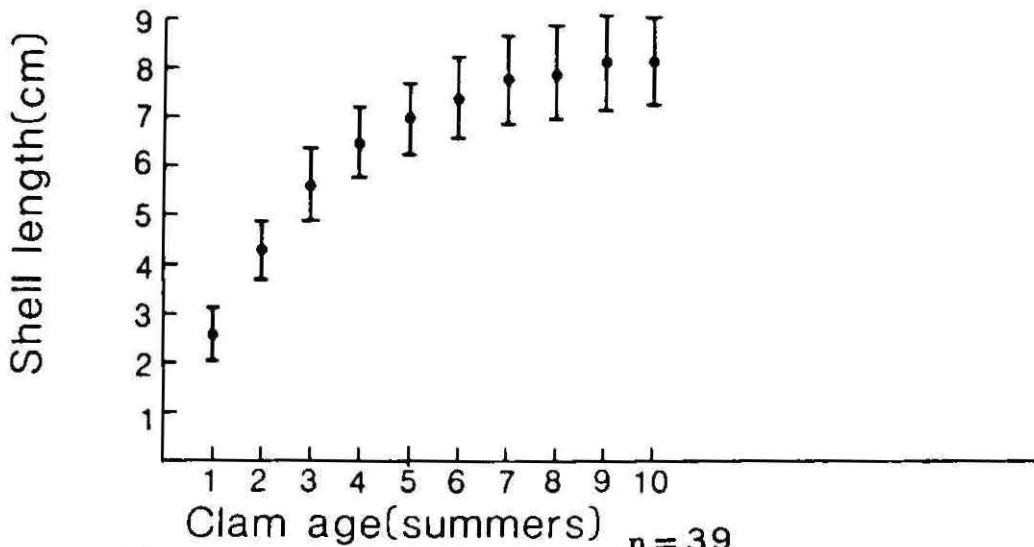
Wassaw Sound
Little Tybee Island
 Clam station 12



Wassaw Sound

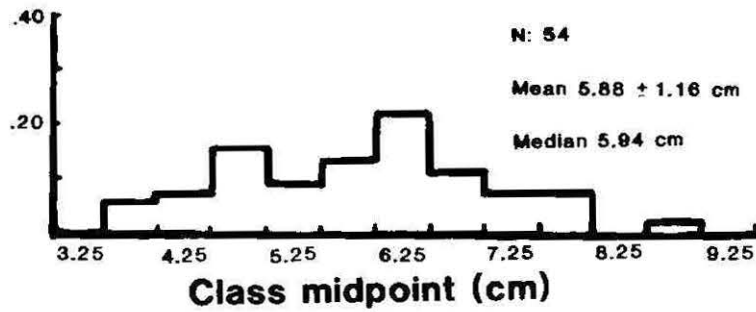
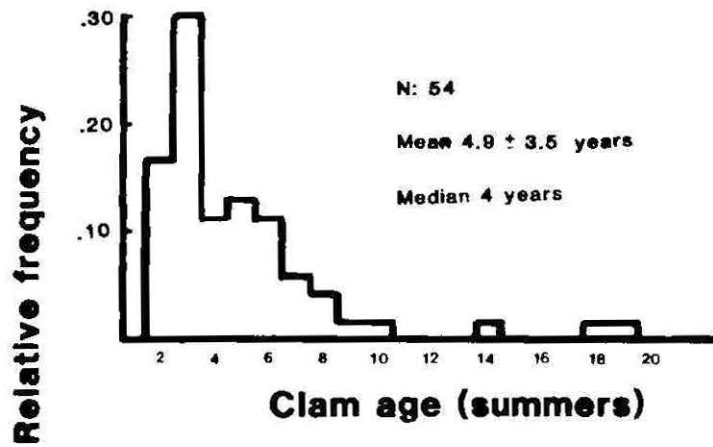
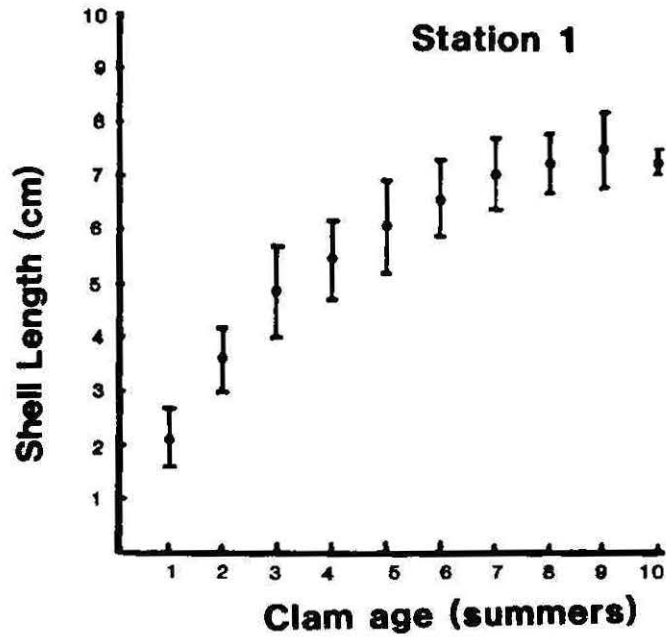
Little Tybee Island

Clam station 13



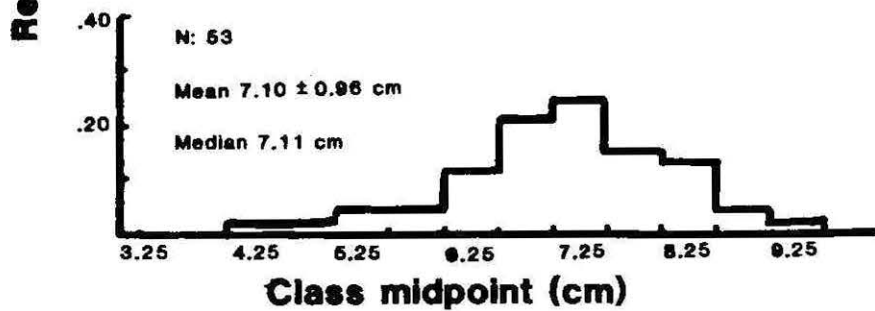
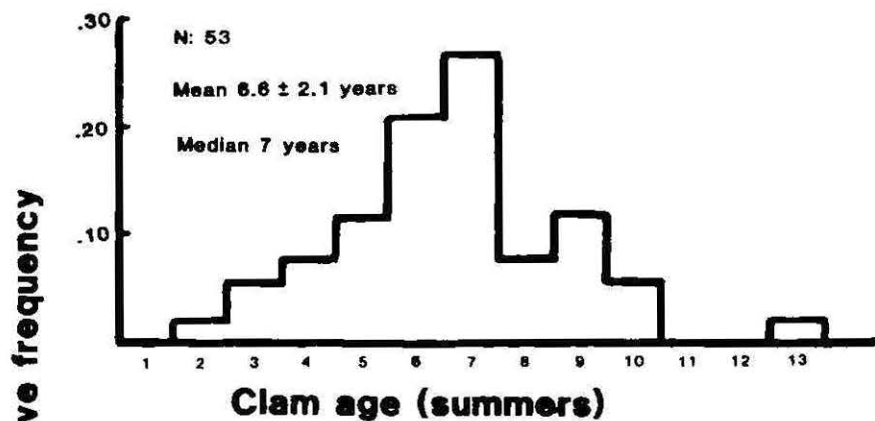
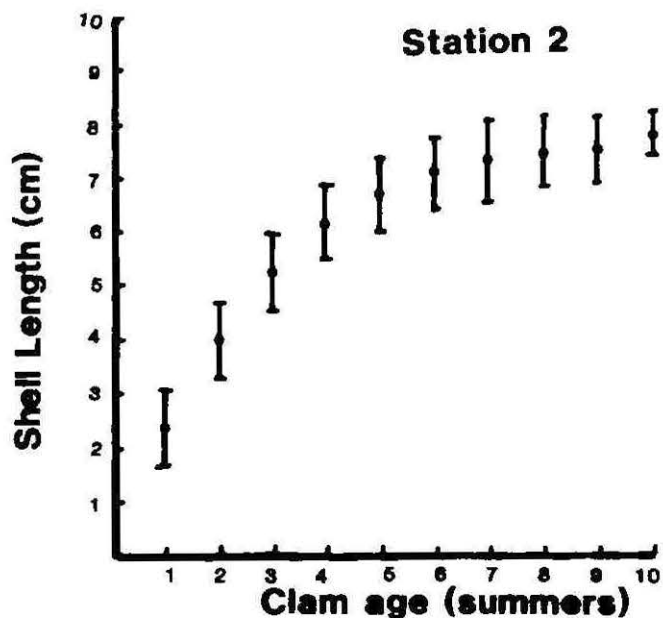
St. Catherines Sound

Station 1

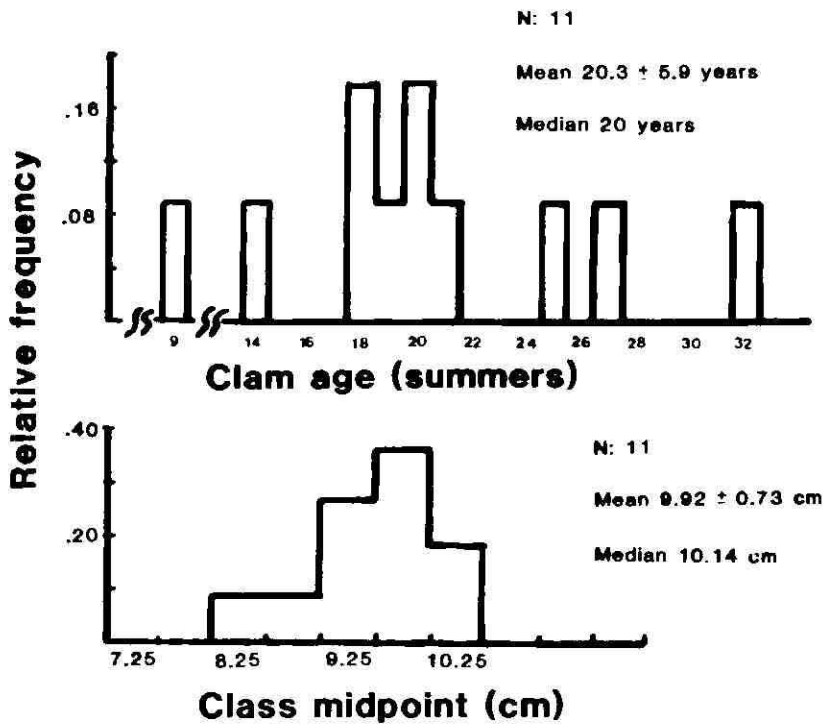
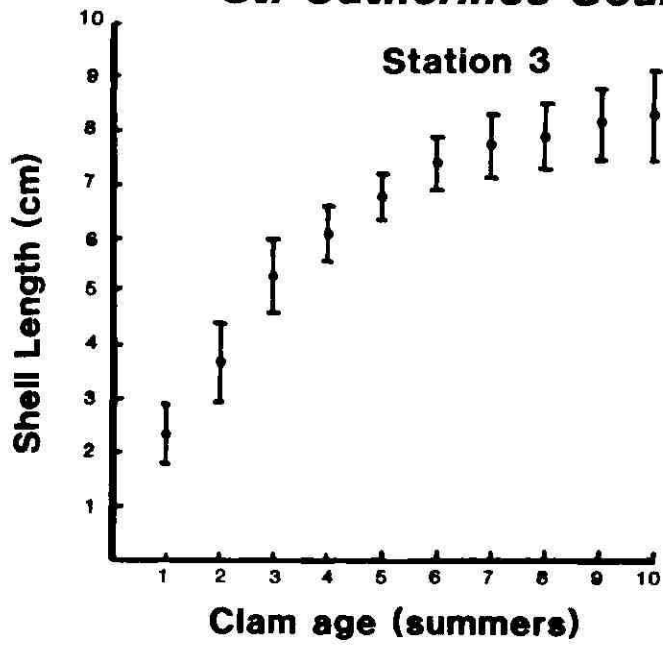


St. Catherines Sound

Station 2

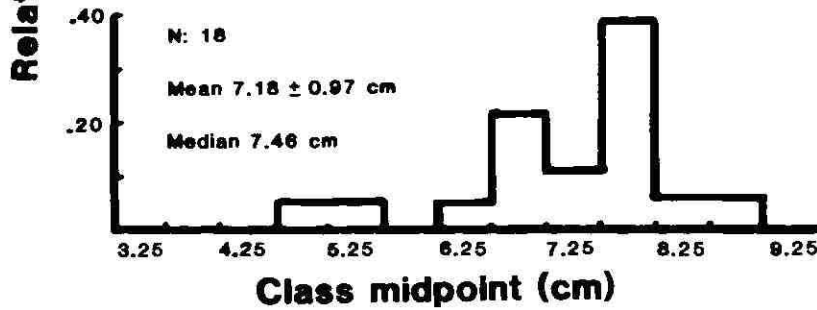
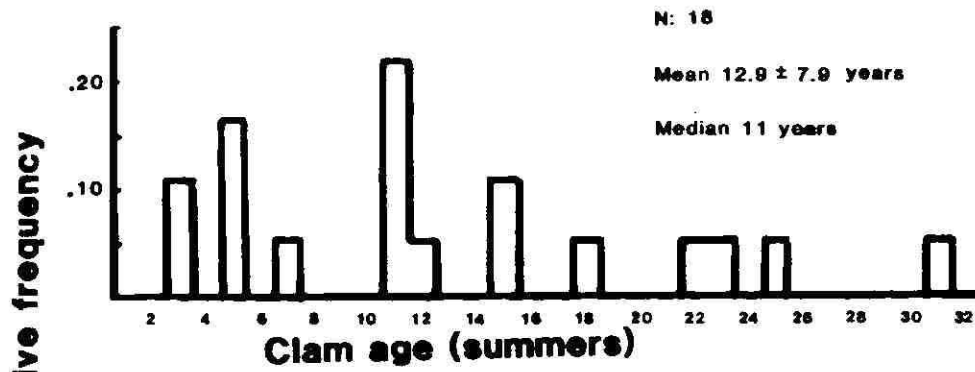
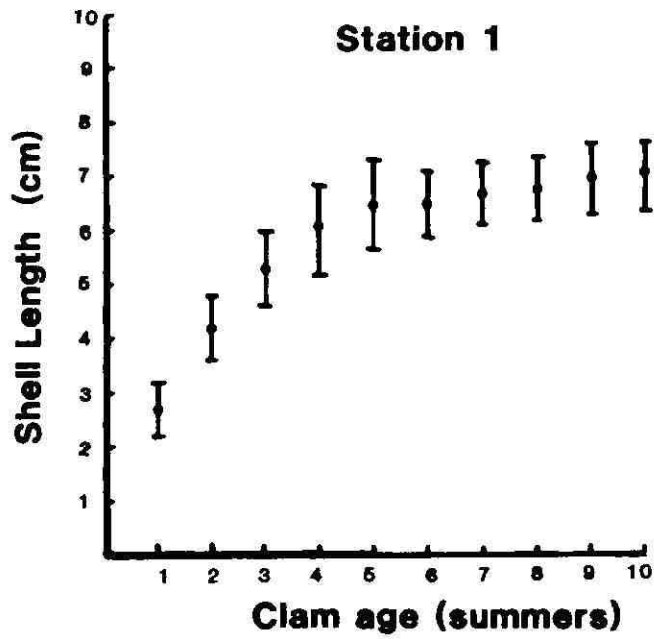


St. Catherines Sound



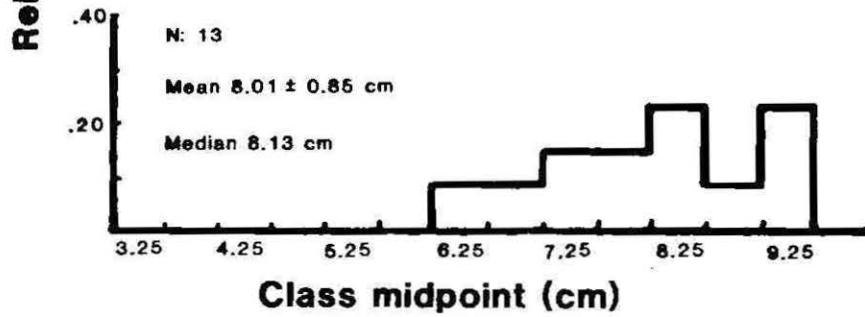
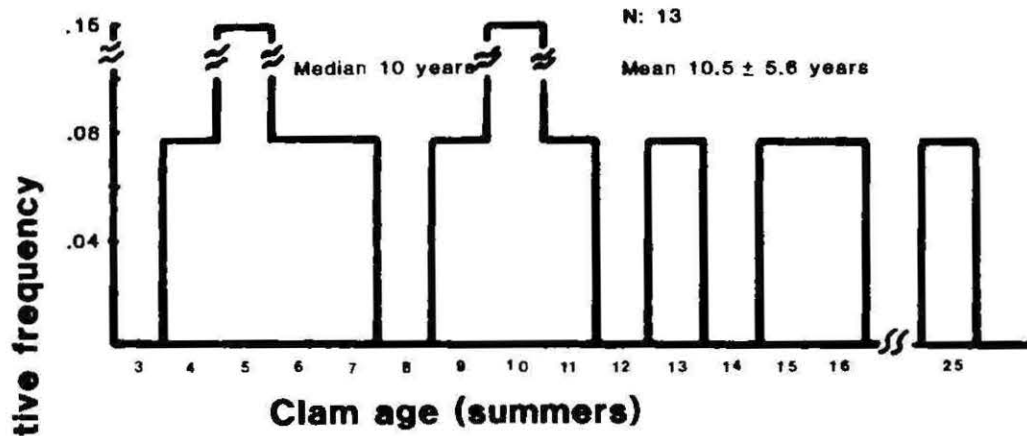
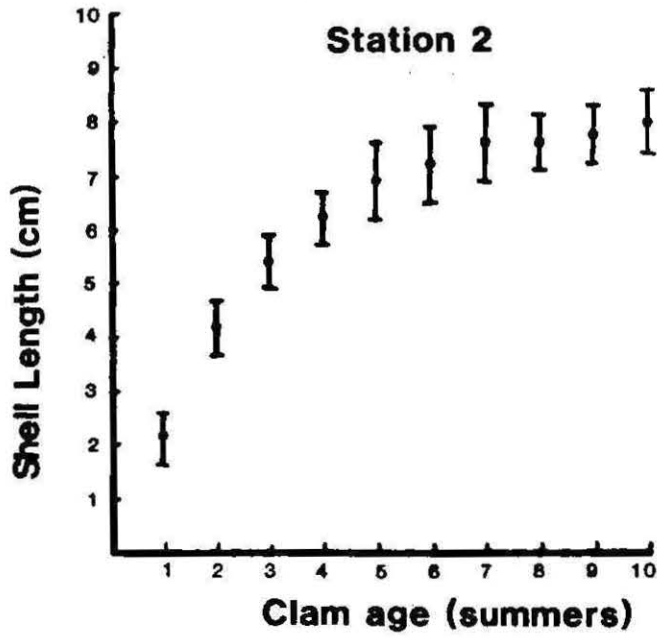
Sapelo Sound

Station 1



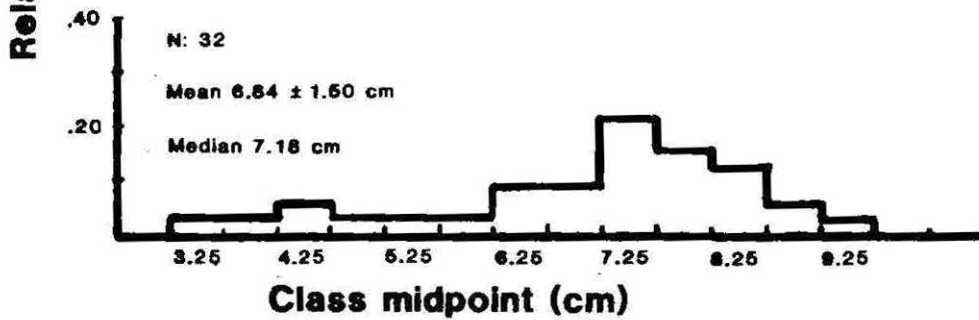
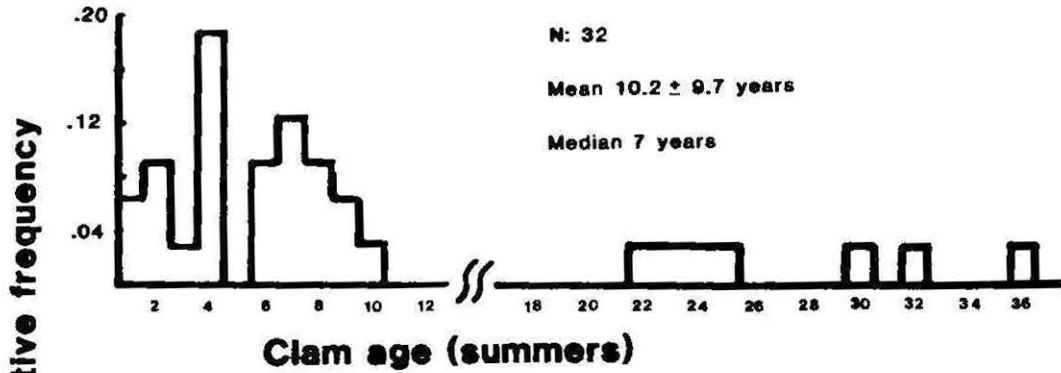
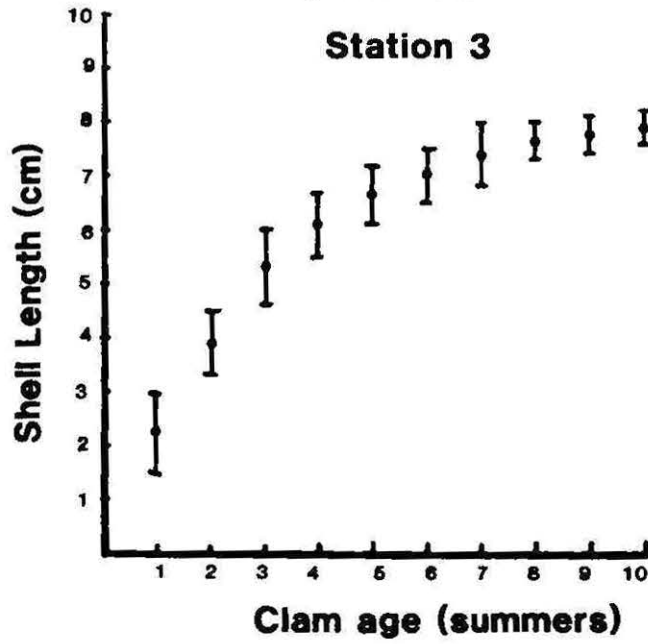
Sapelo Sound

Station 2



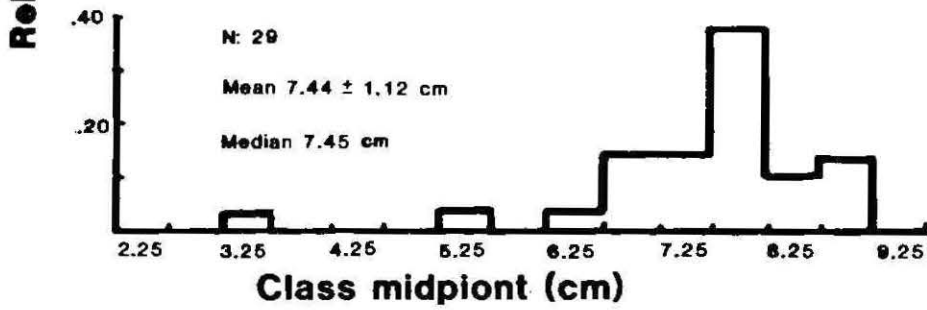
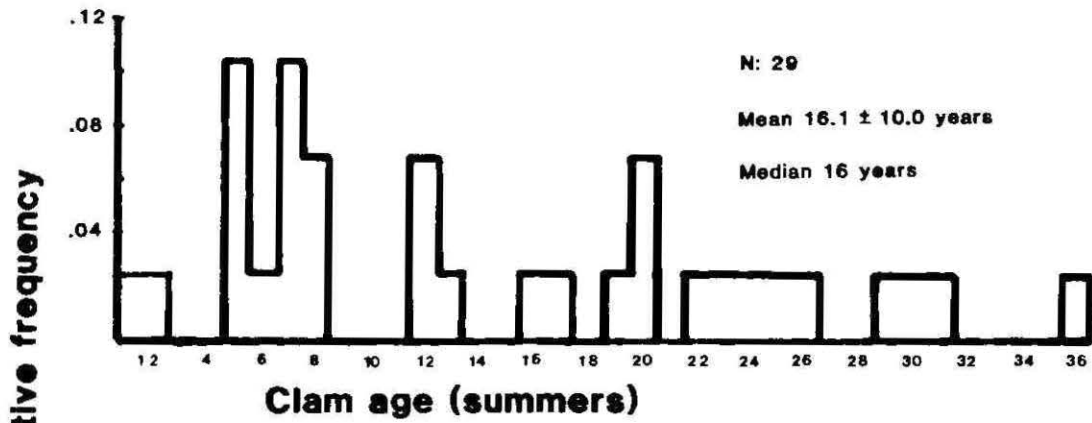
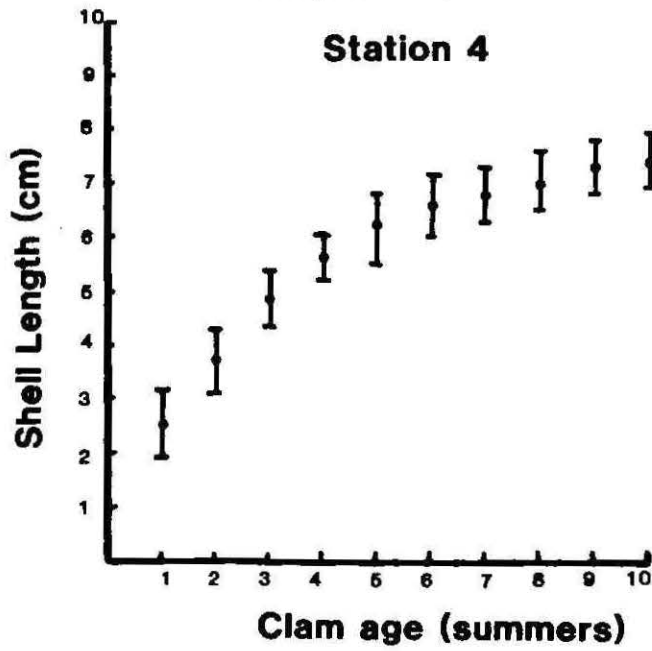
Sapelo Sound

Station 3



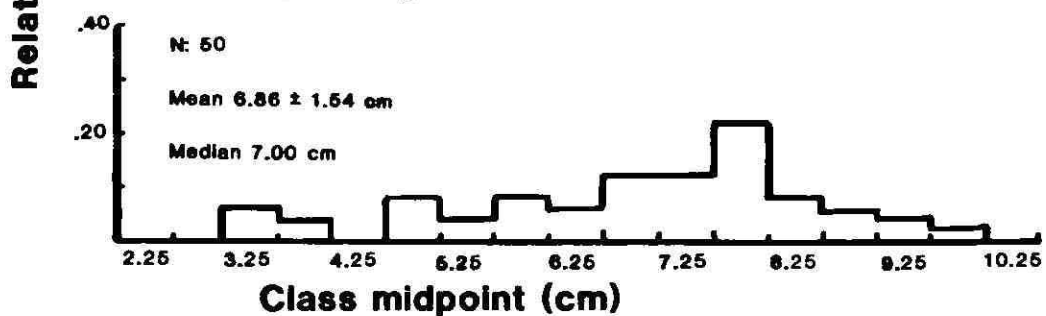
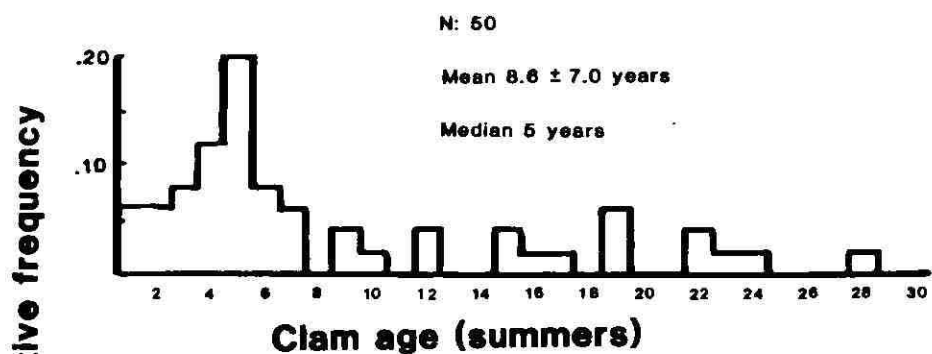
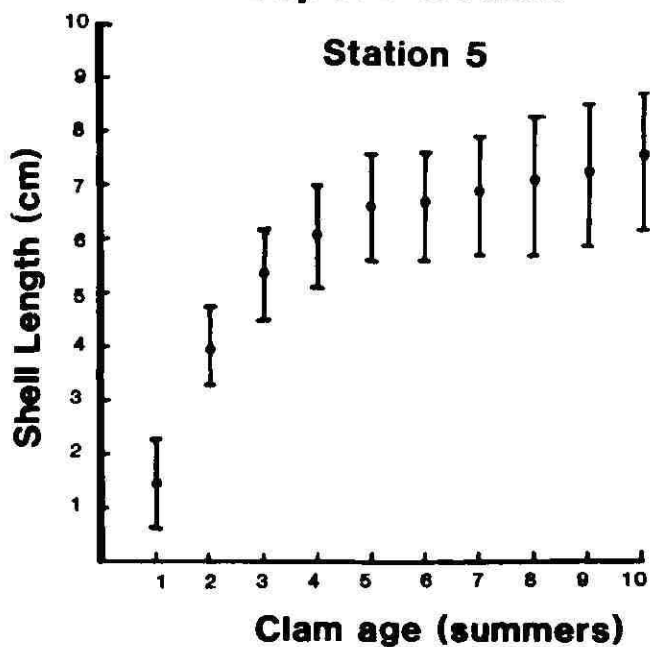
Sapelo Sound

Station 4



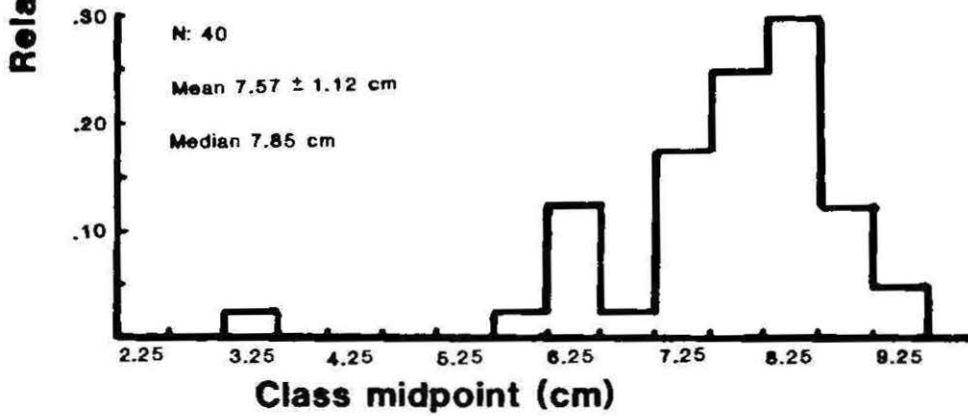
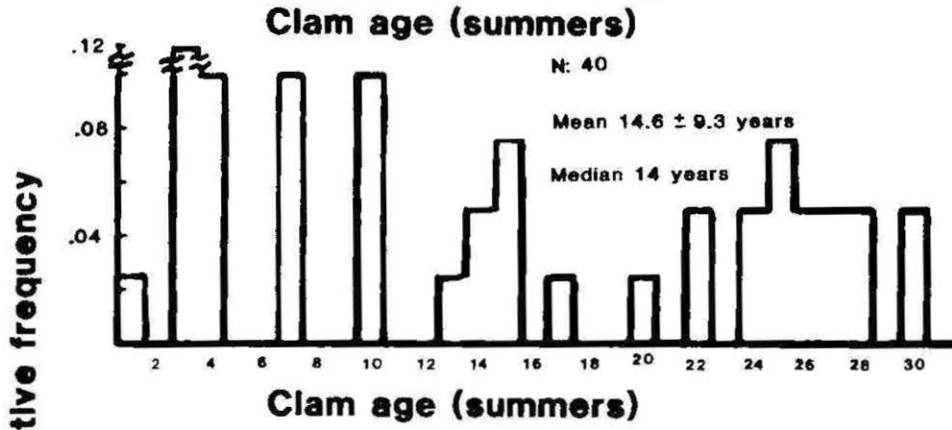
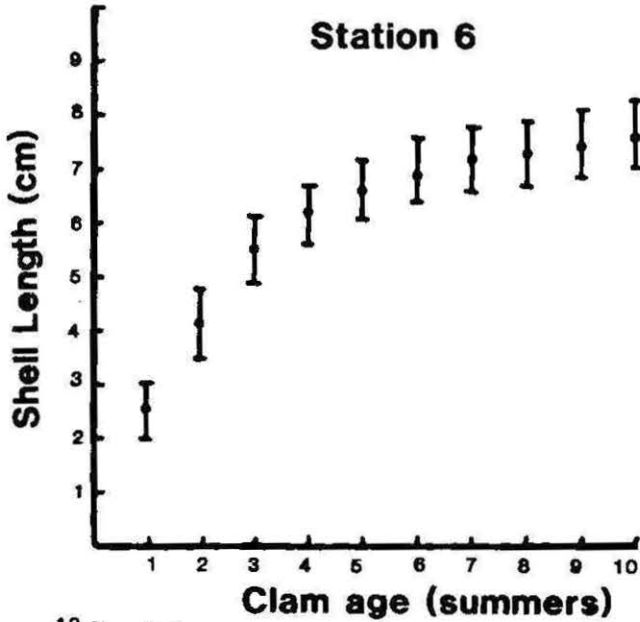
Sapelo Sound

Station 5



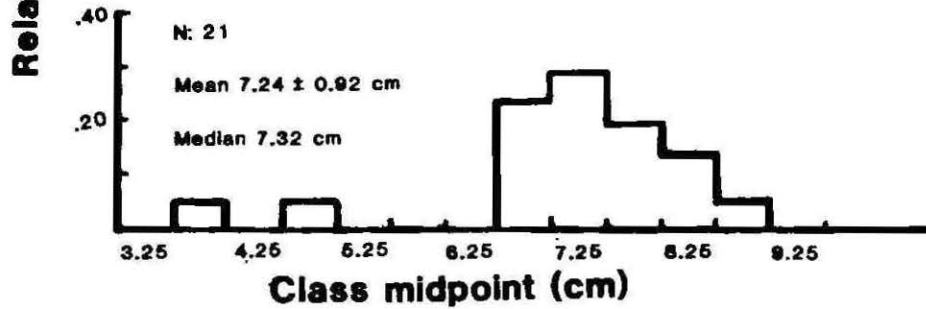
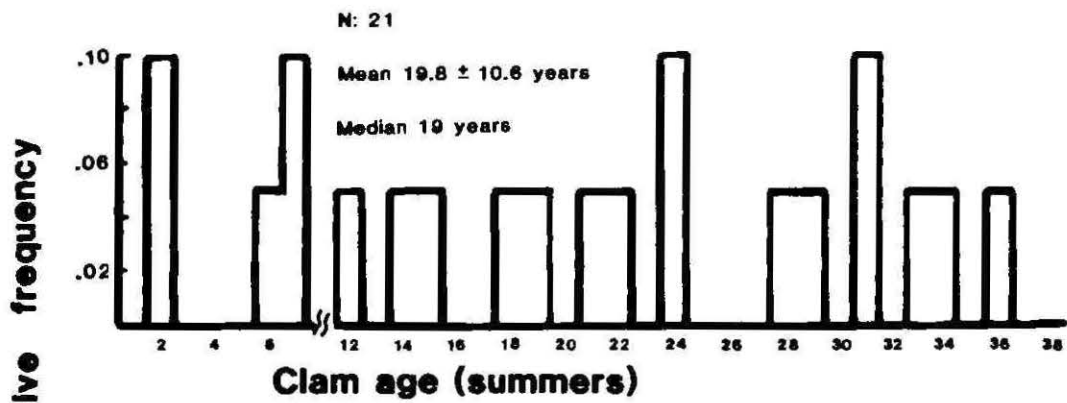
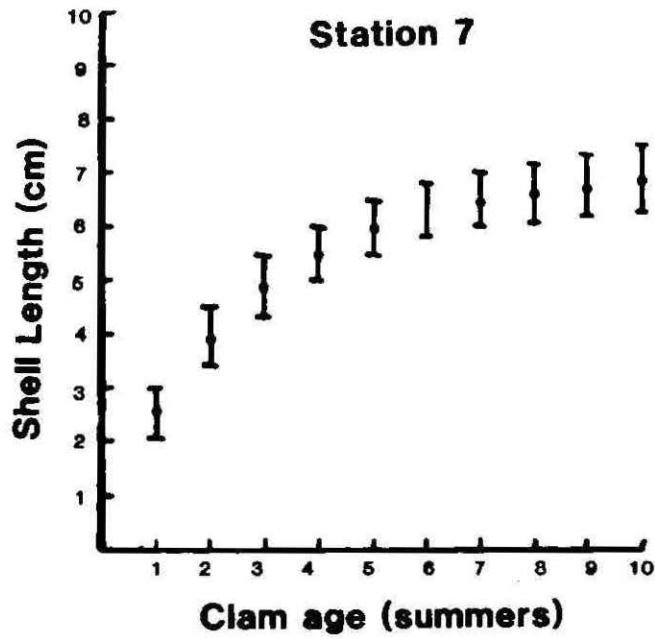
Sapelo Sound

Station 6



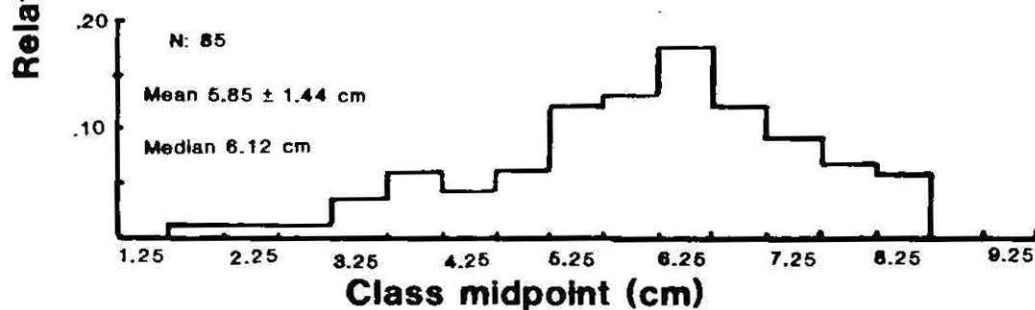
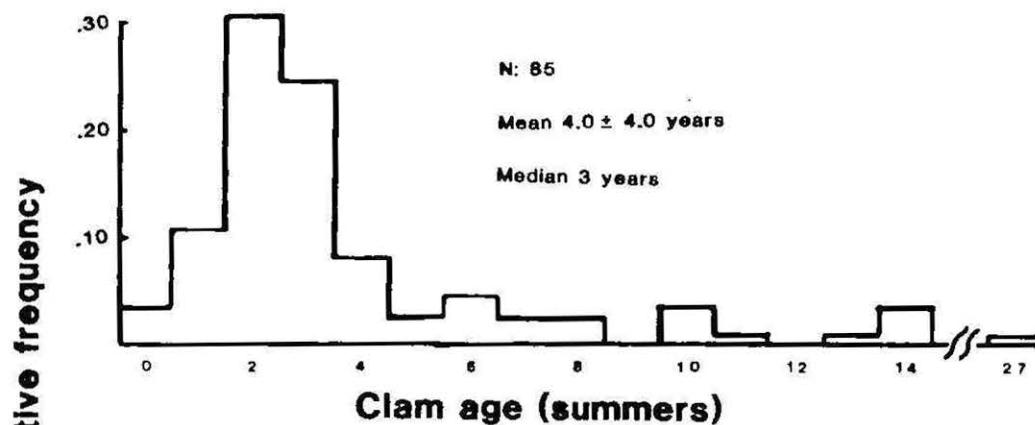
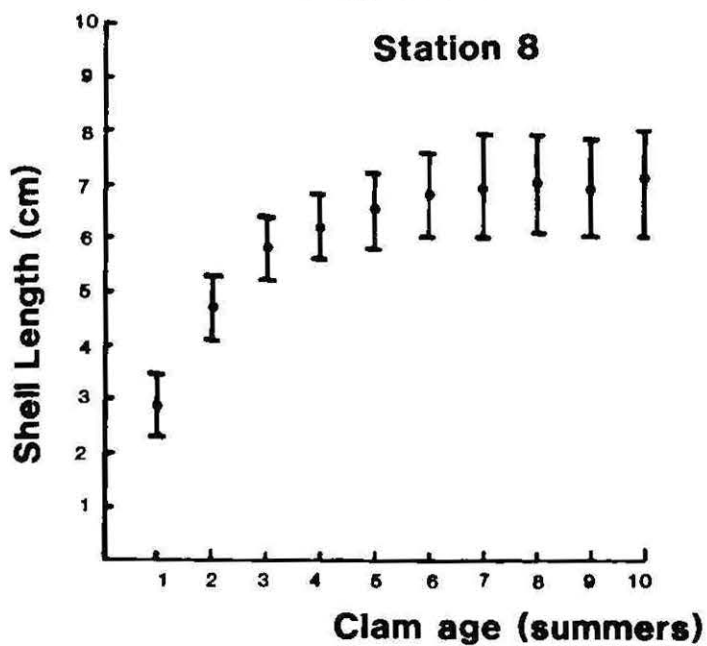
Sapelo Sound

Station 7



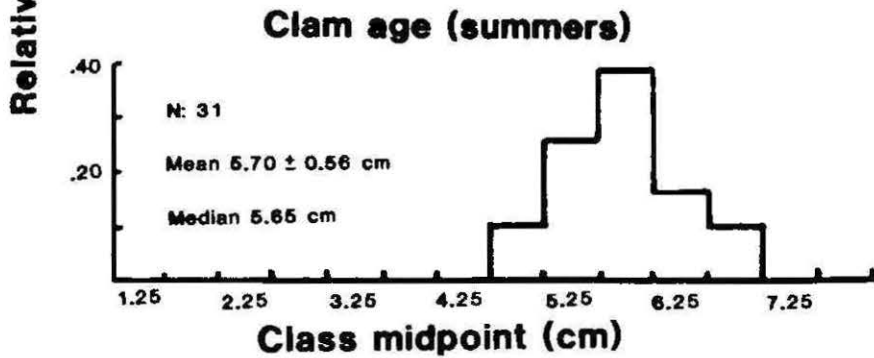
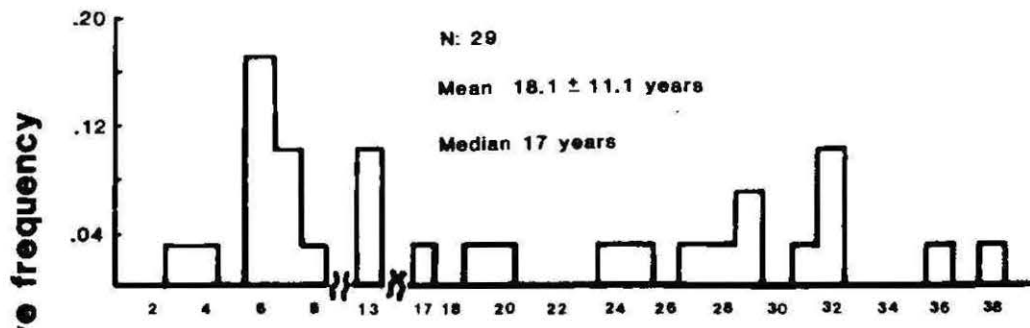
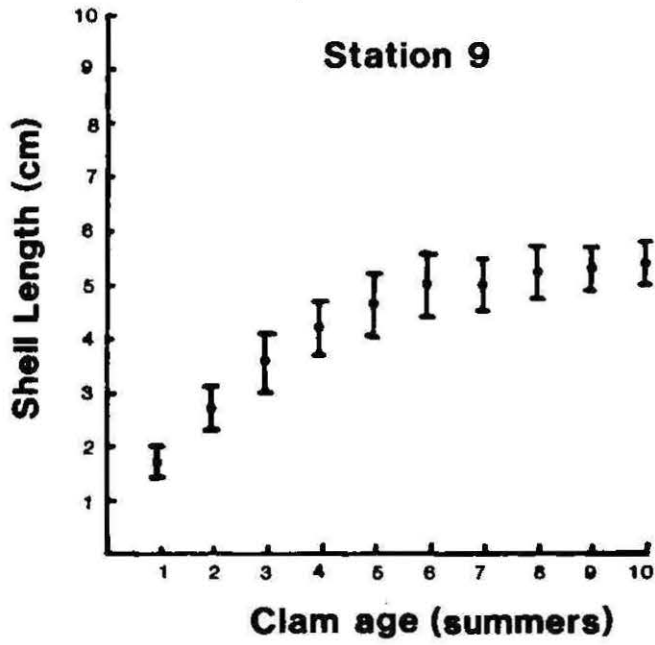
Sapelo Sound

Station 8

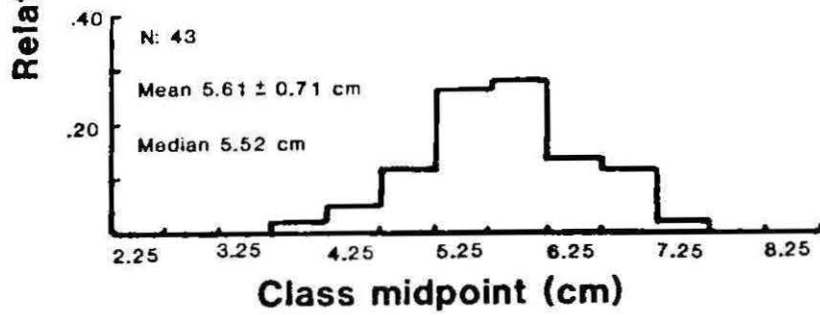
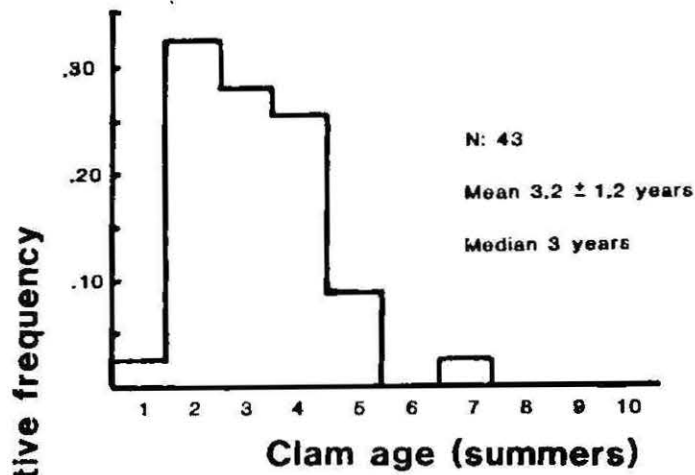
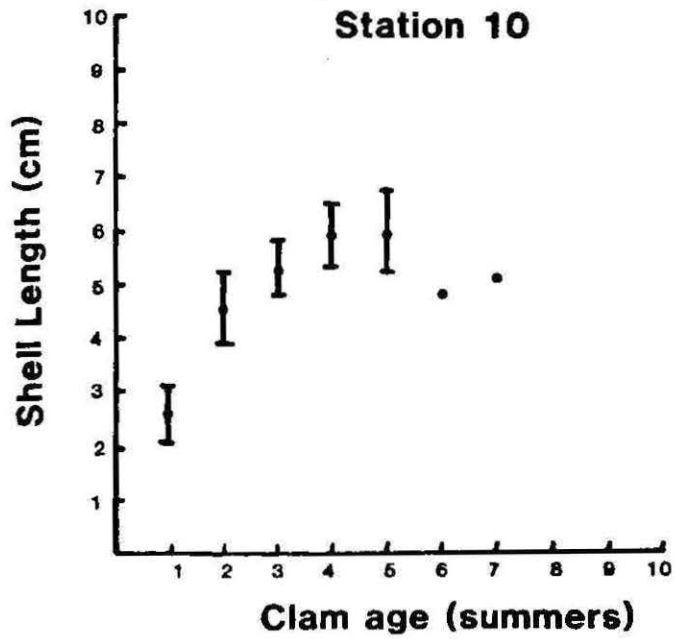


Sapelo Sound

Station 9

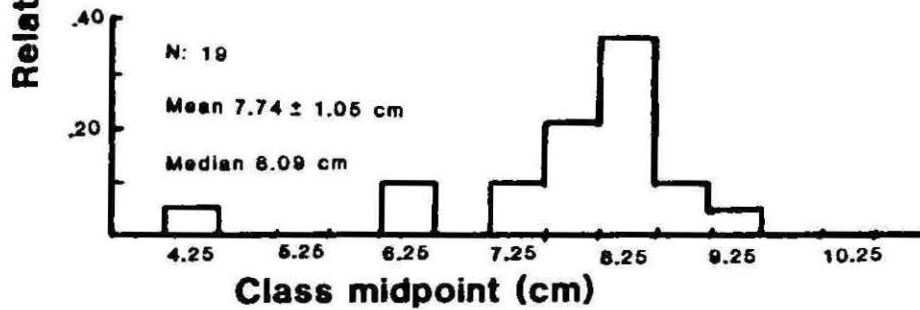
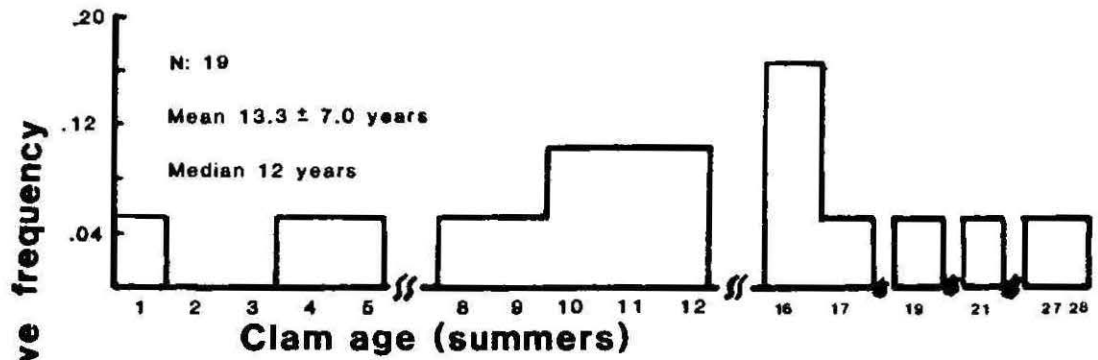
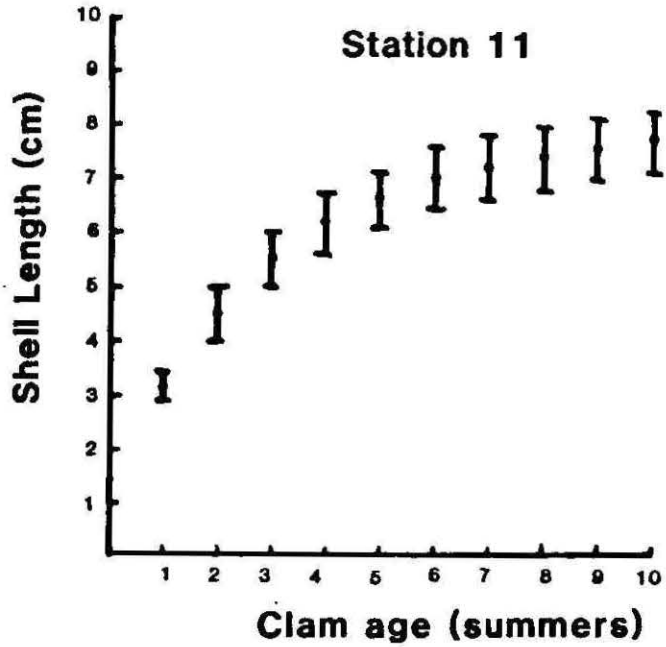


**Sapelo Sound
Station 10**



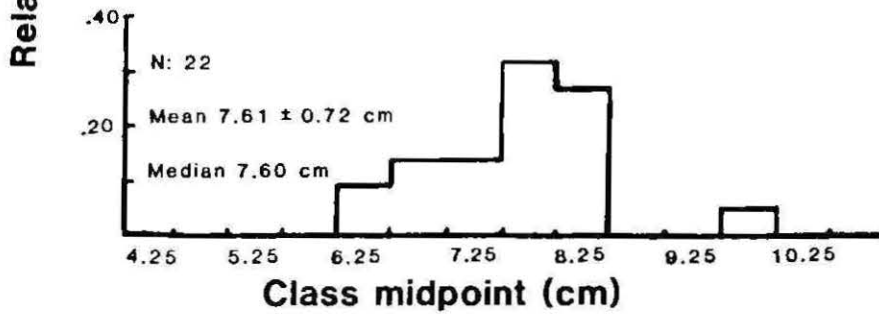
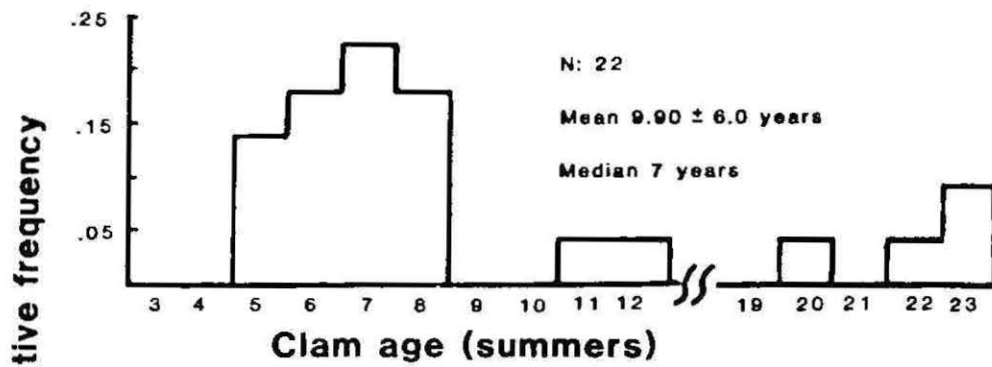
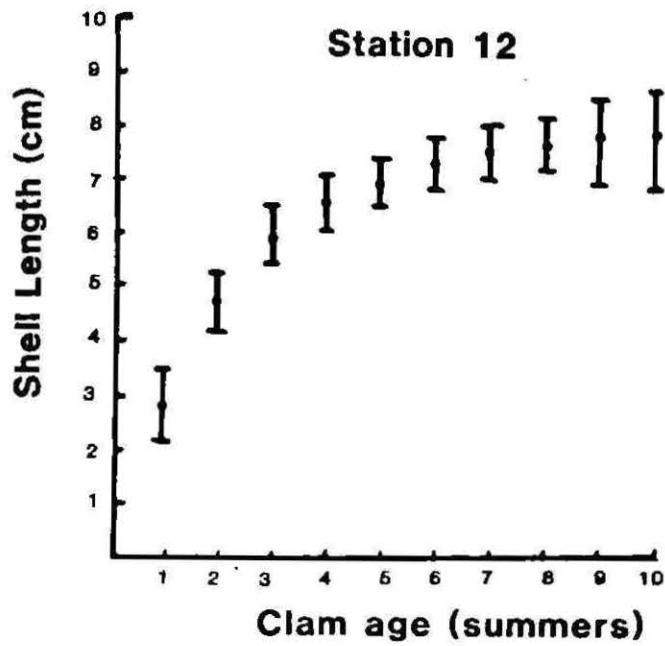
Sapelo Sound

Station 11

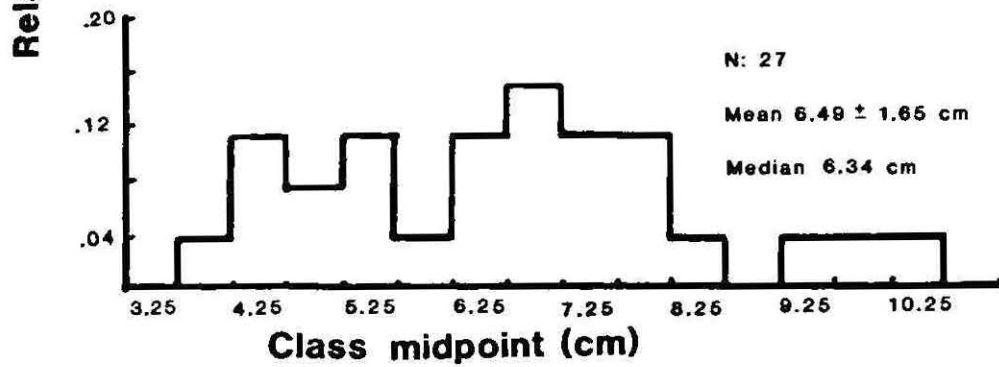
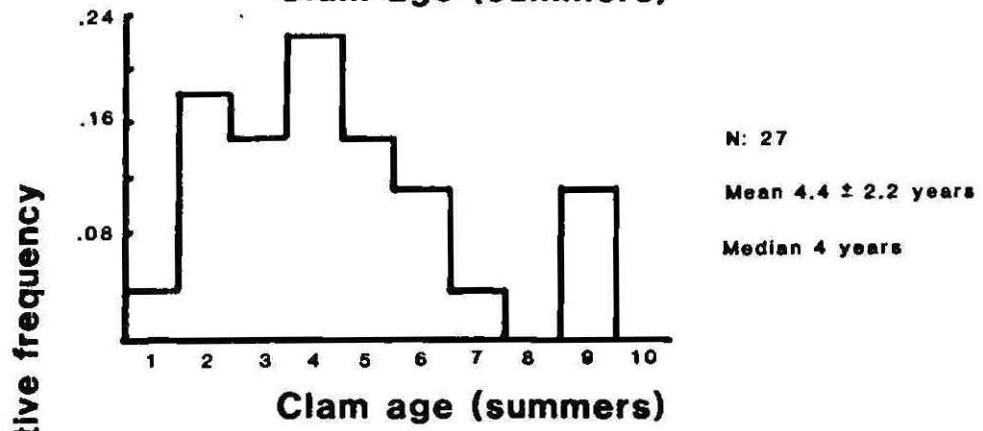
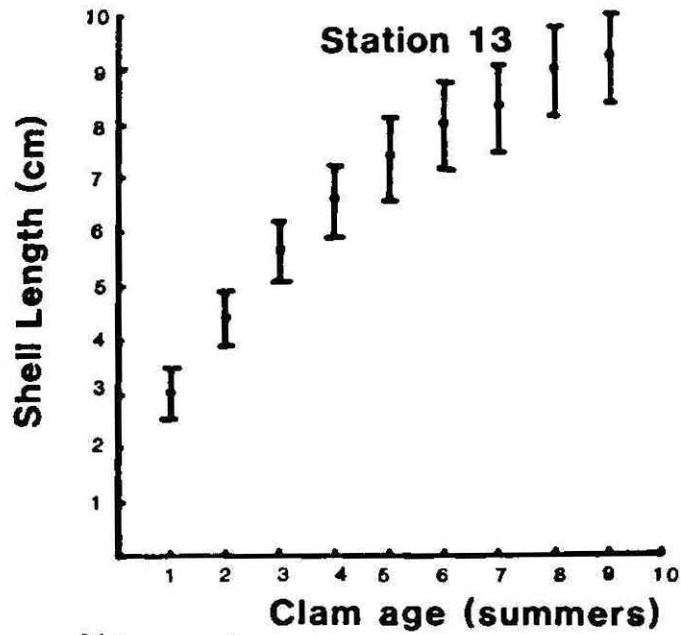


Sapelo Sound

Station 12

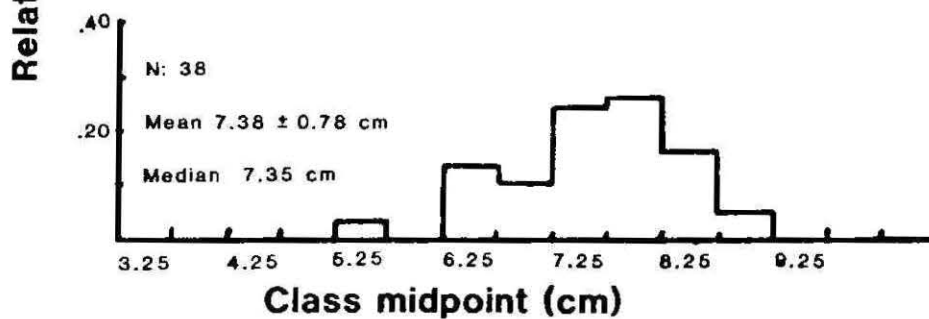
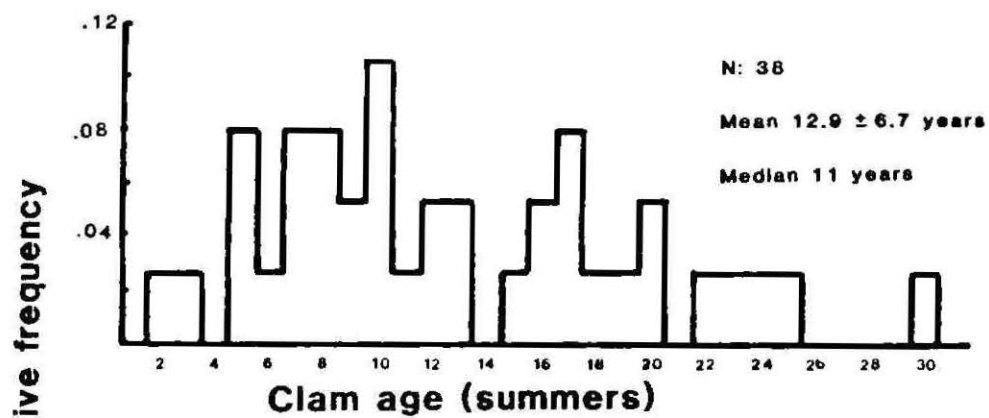
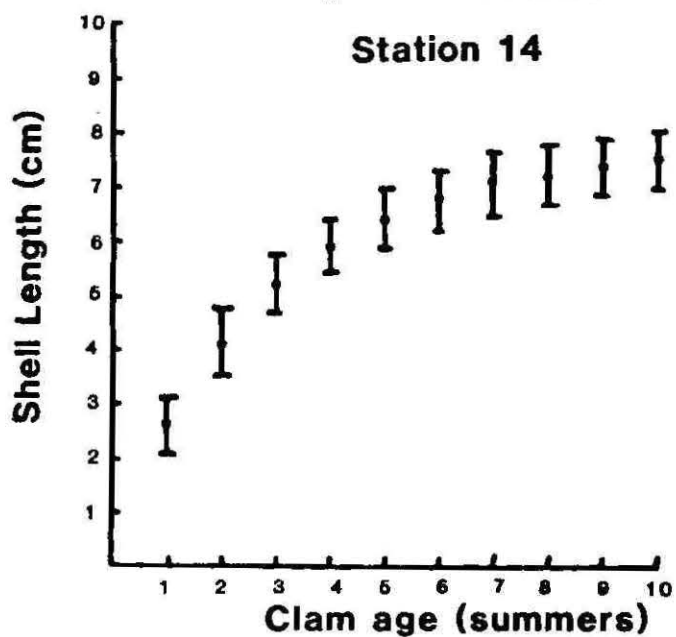


Sapelo Sound



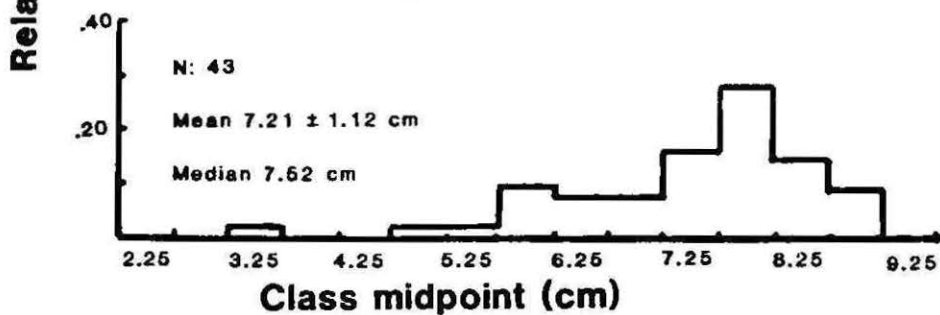
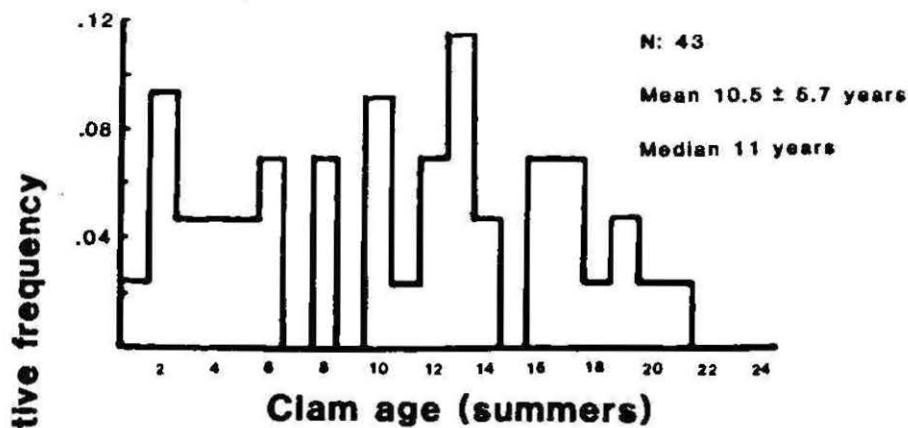
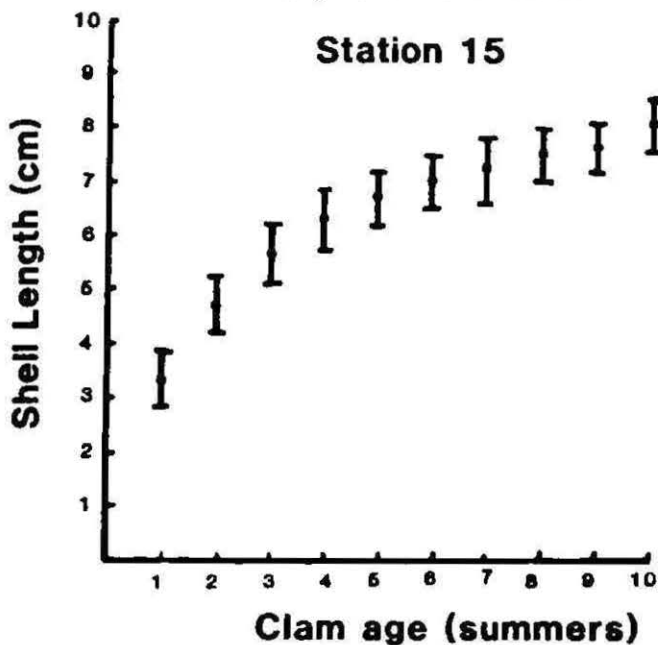
Sapelo Sound

Station 14

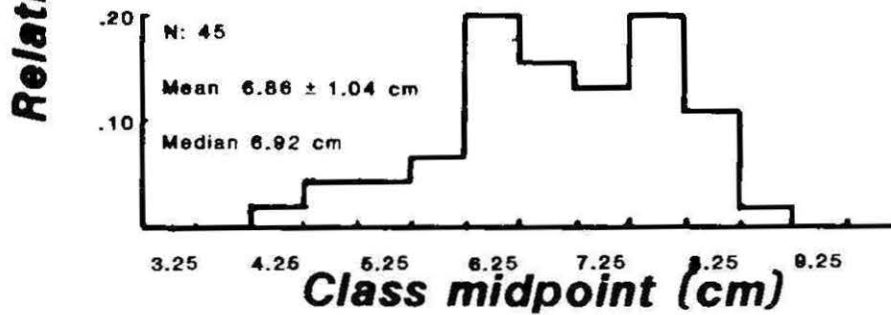
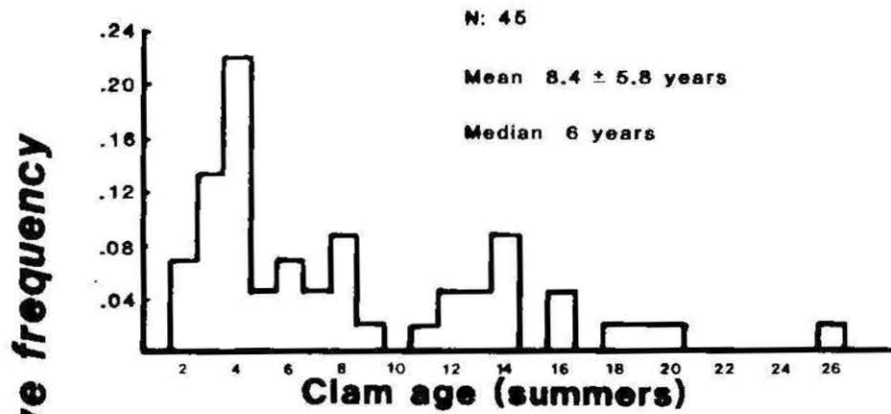
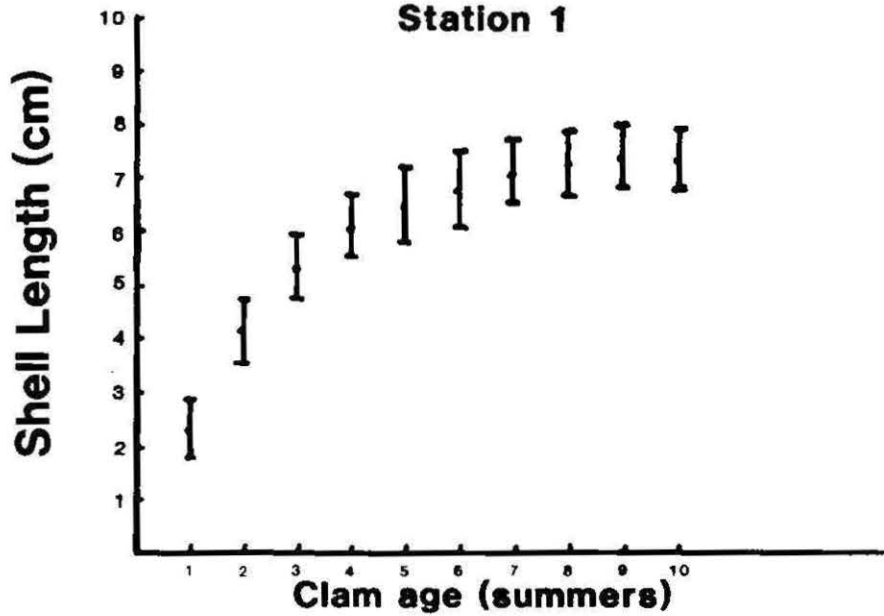


Sapelo Sound

Station 15

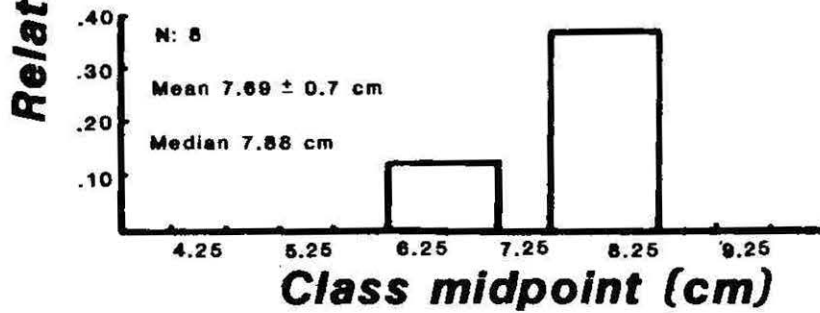
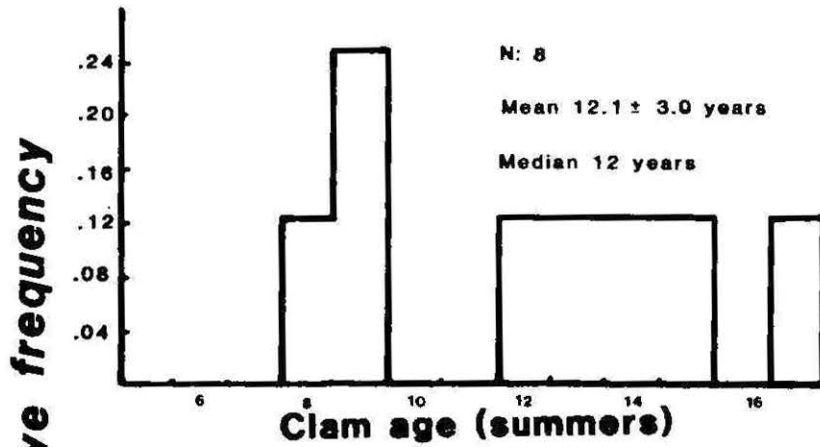
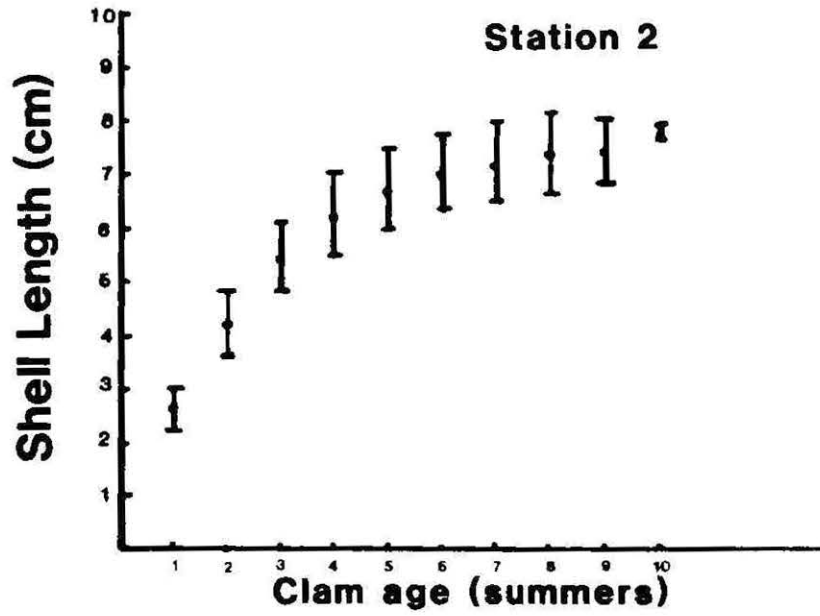


**Christmas Creek
Station 1**



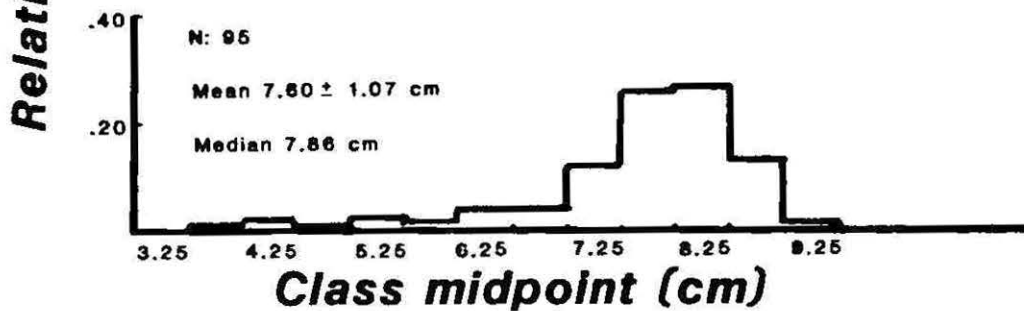
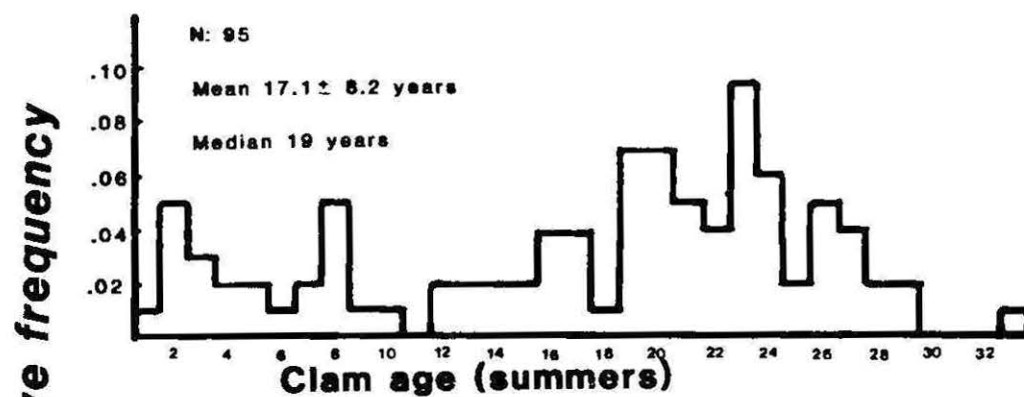
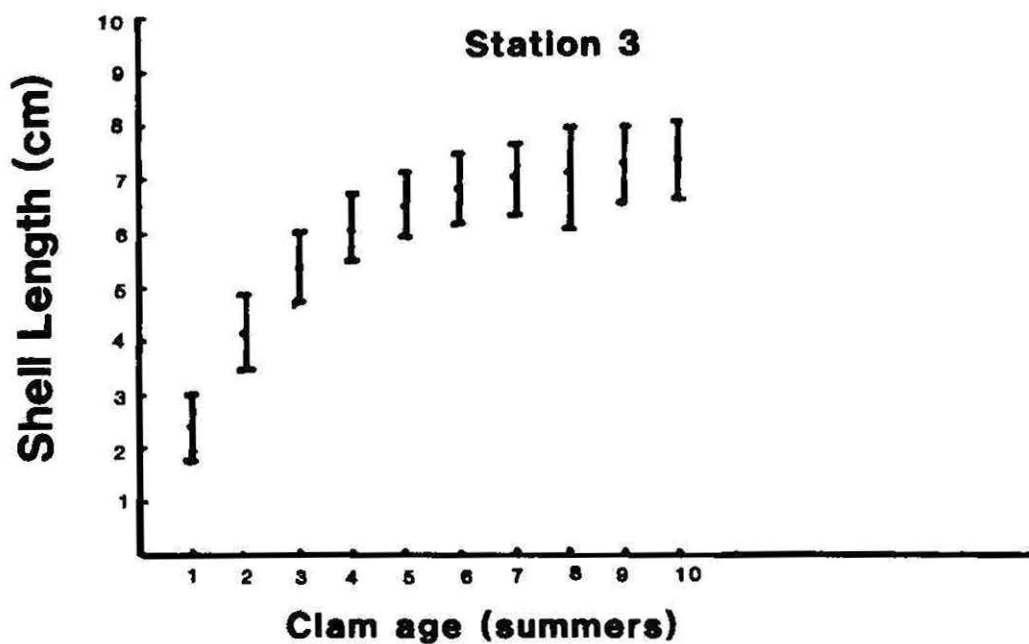
Christmas Creek

Station 2



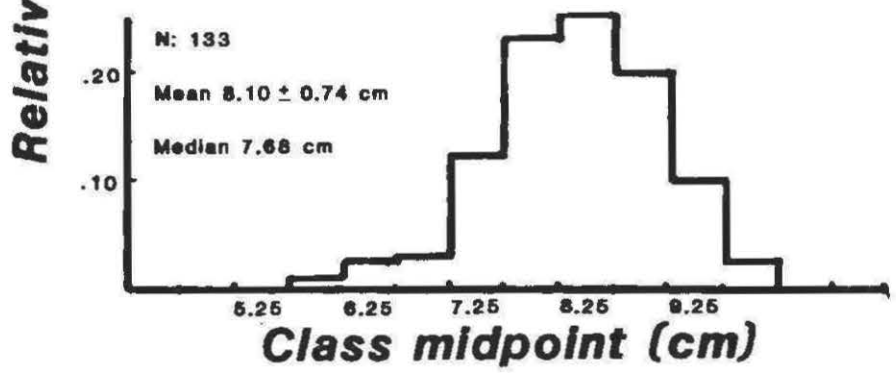
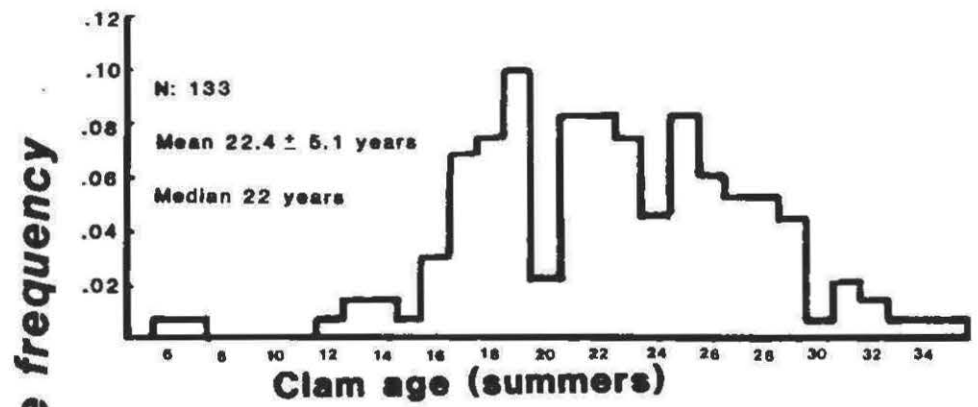
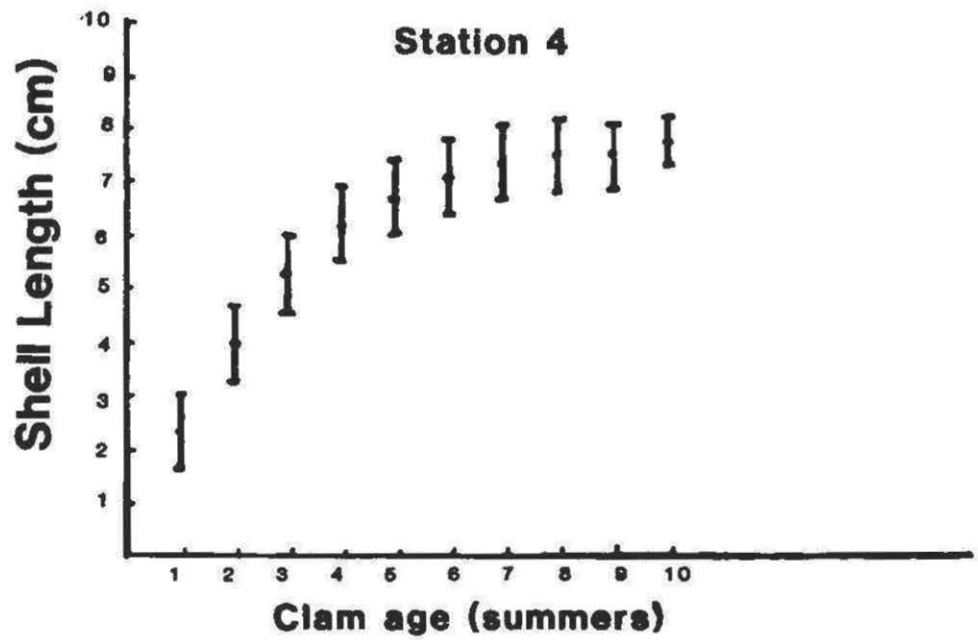
Christmas Creek

Station 3



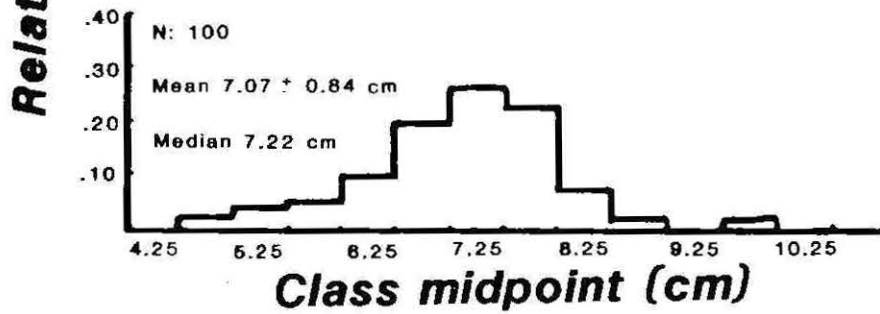
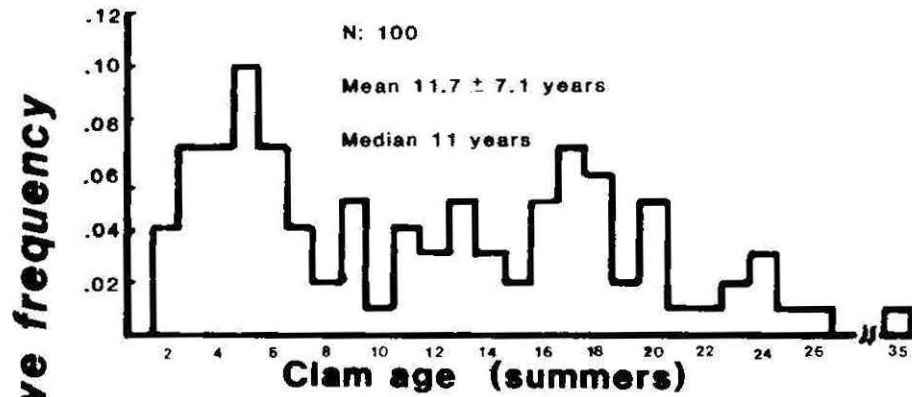
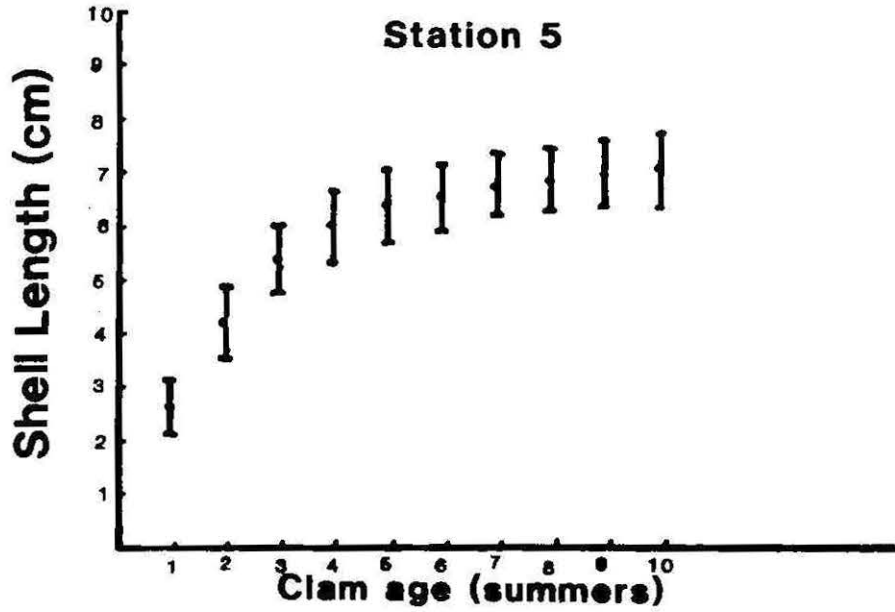
Christmas Creek

Station 4



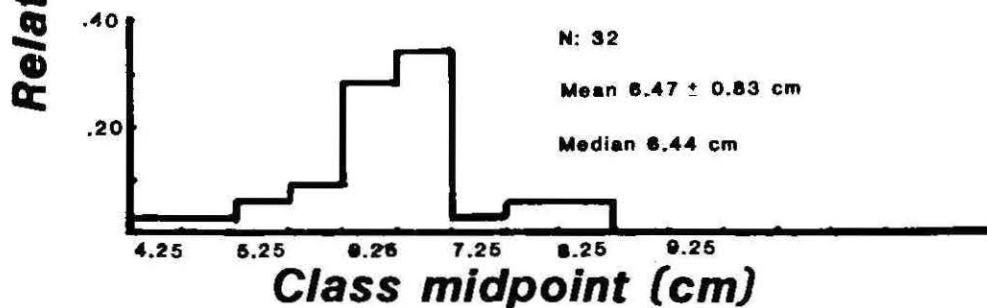
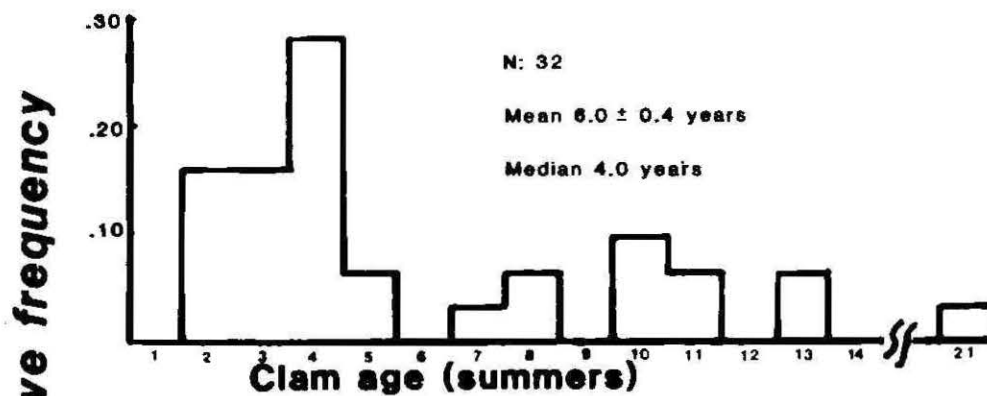
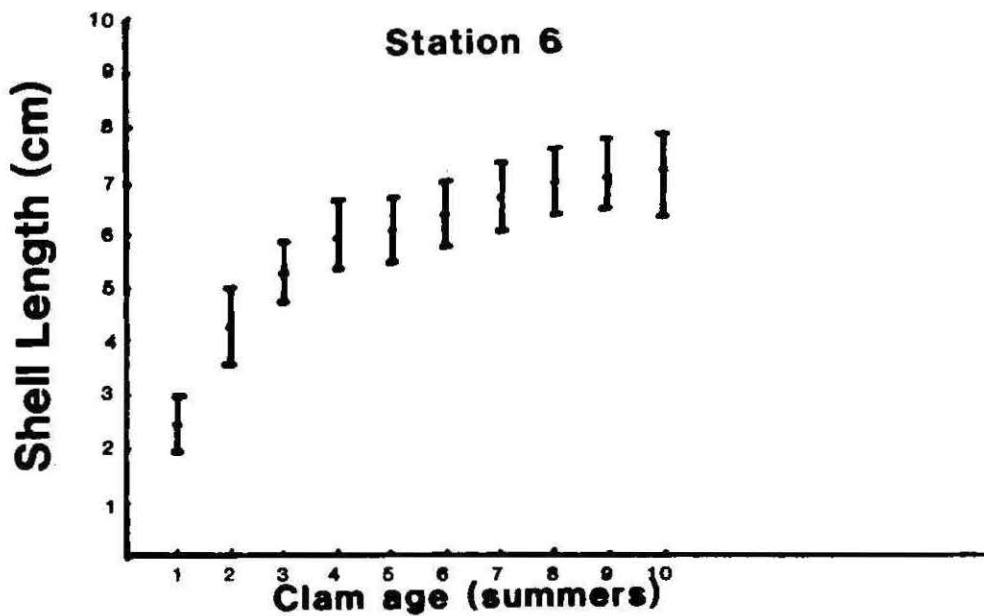
Christmas Creek

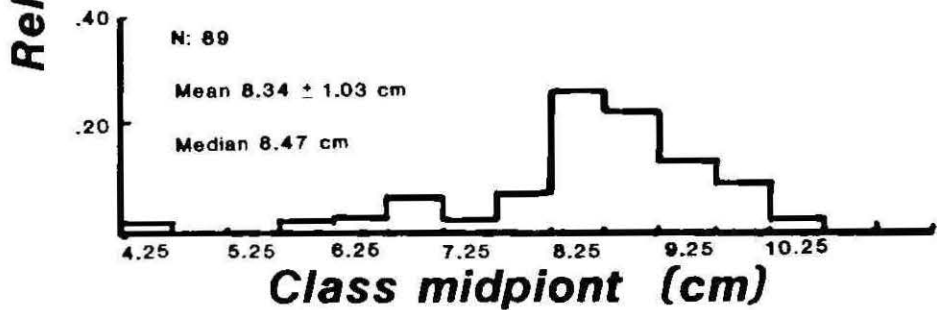
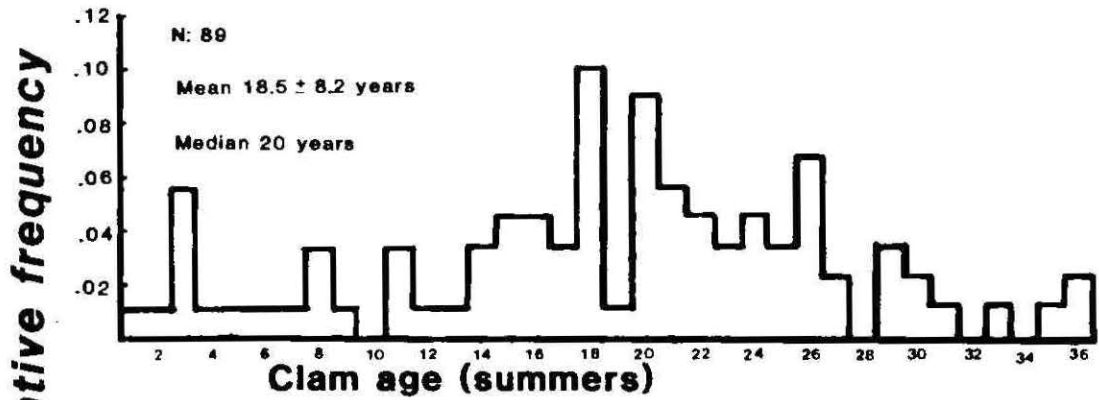
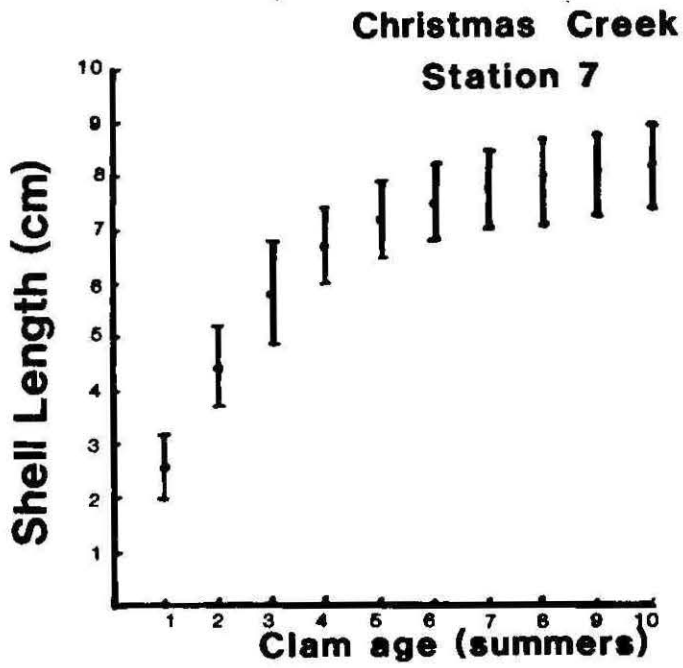
Station 5



Christmas Creek

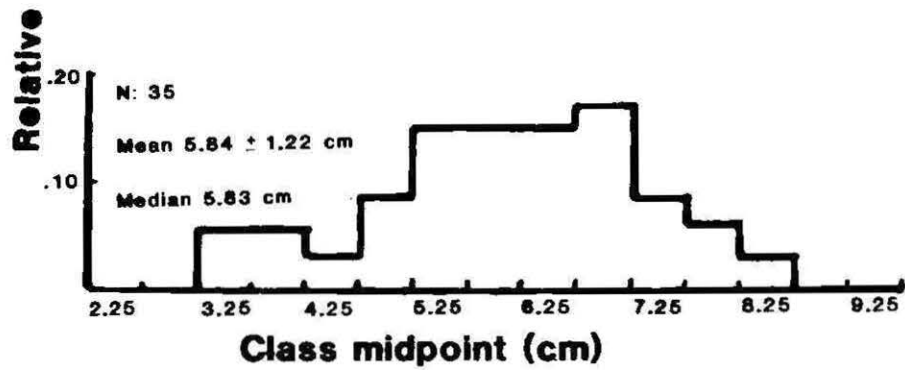
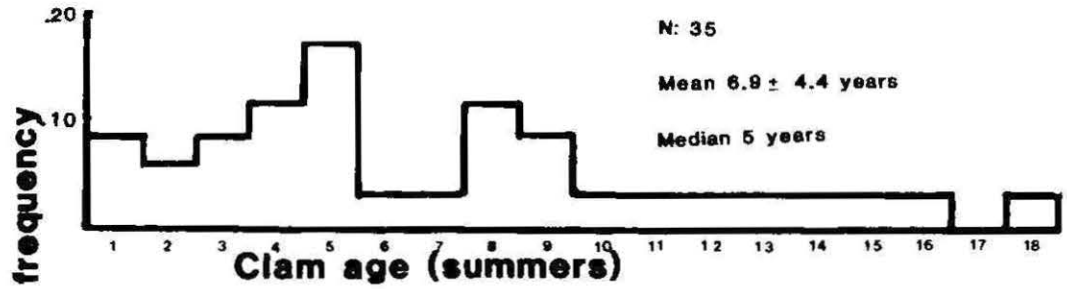
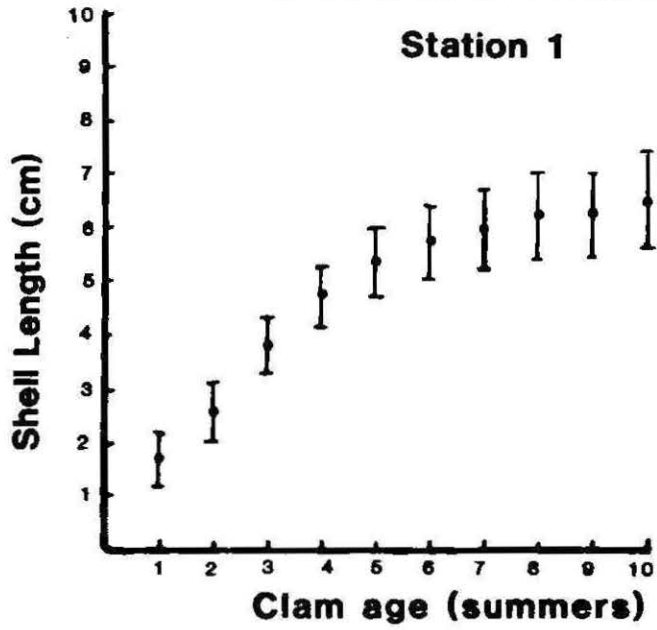
Station 6



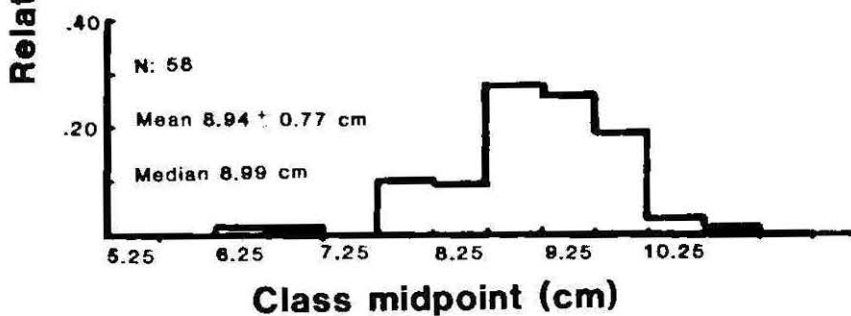
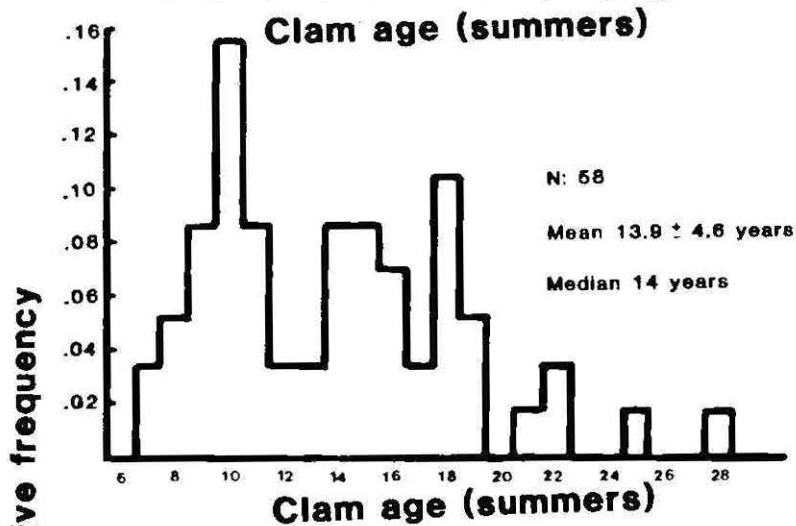
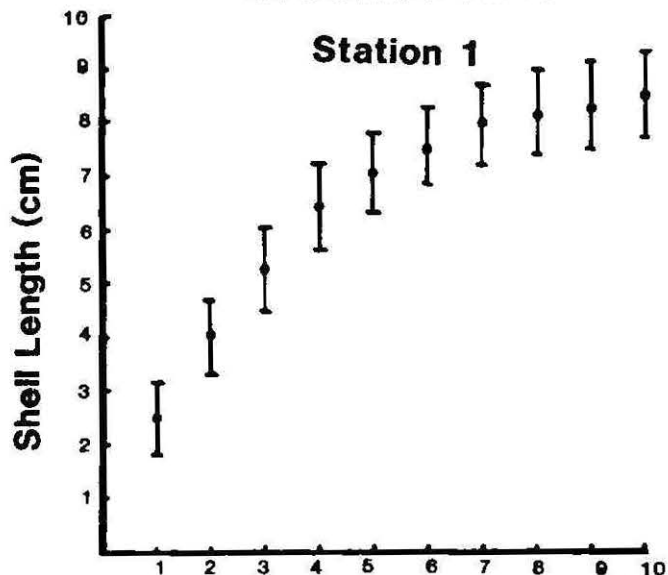


Cumberland Island

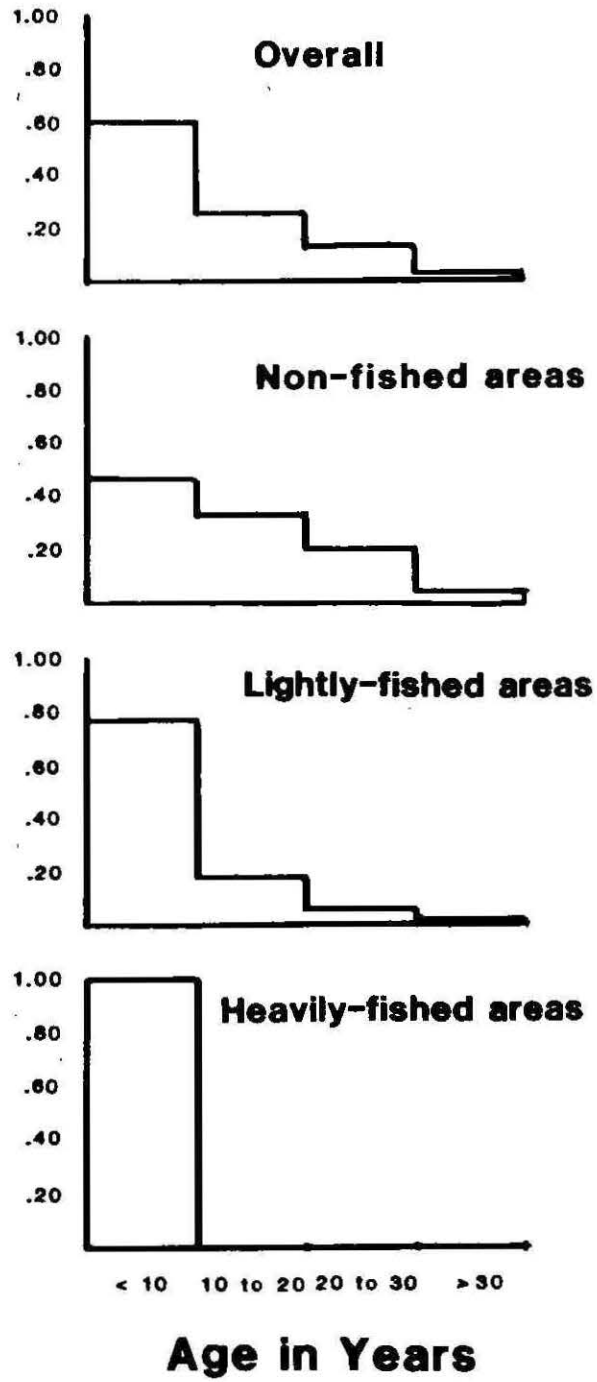
Station 1



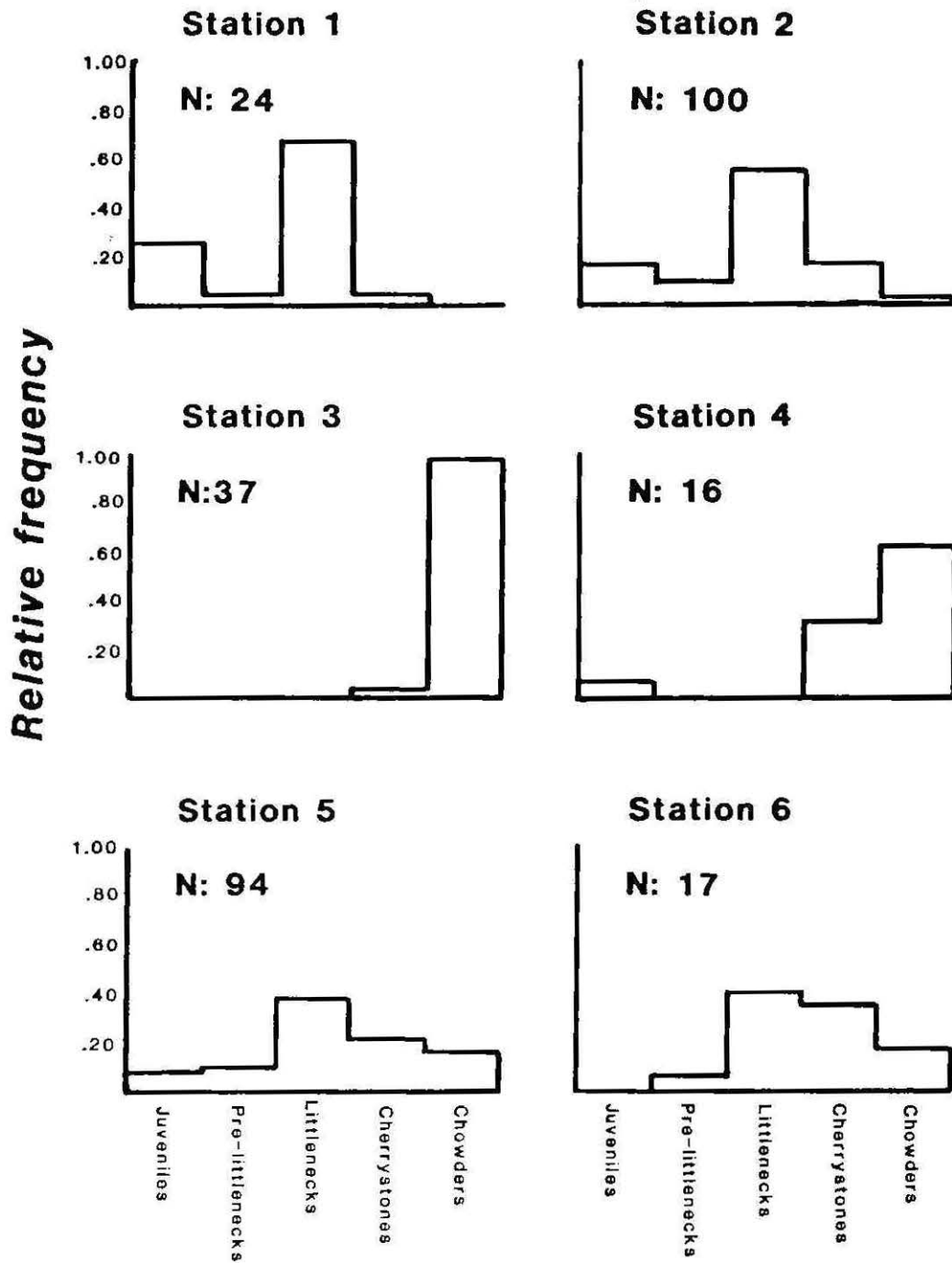
Crooked River



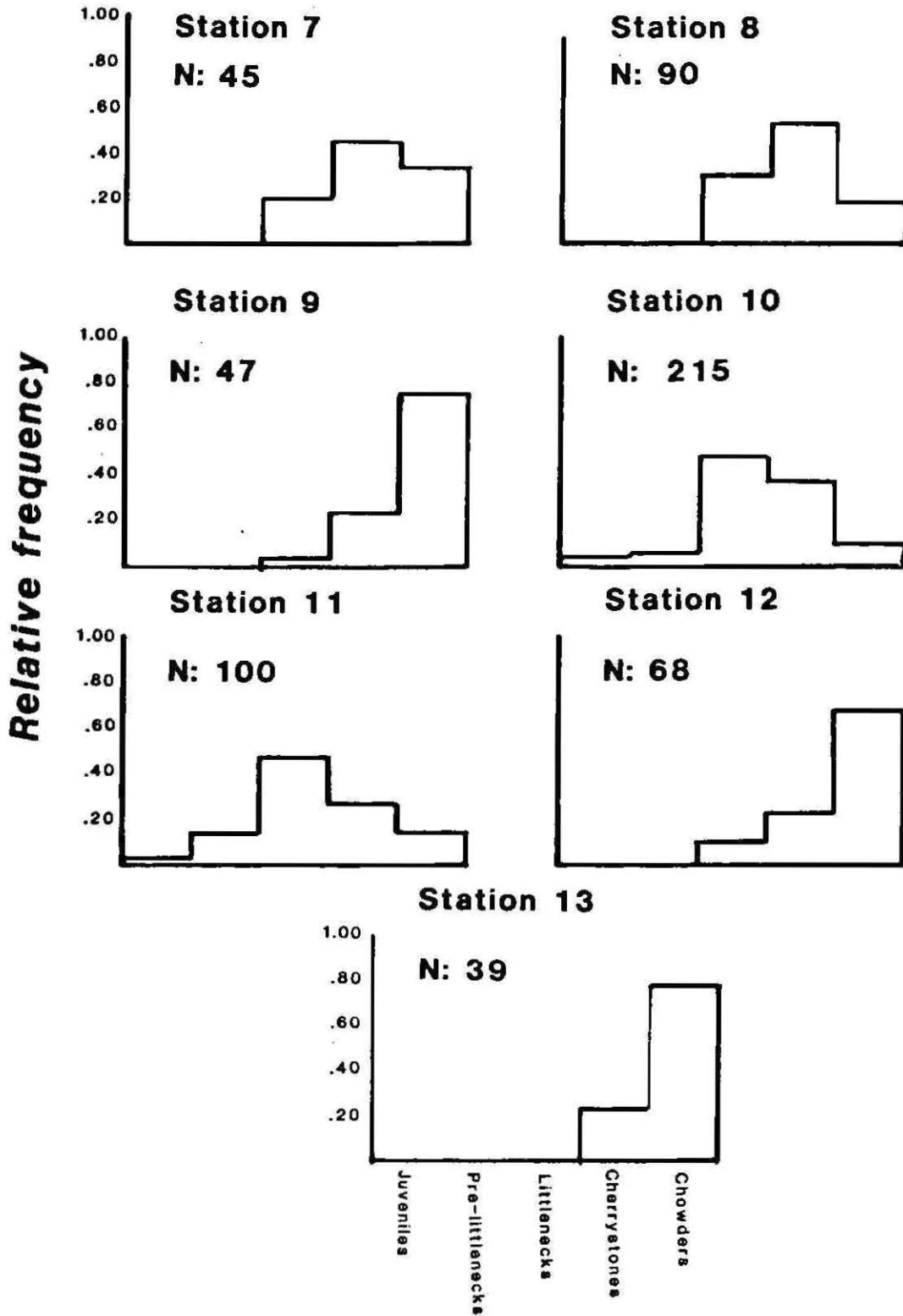
Relative frequency



Wassaw Sound

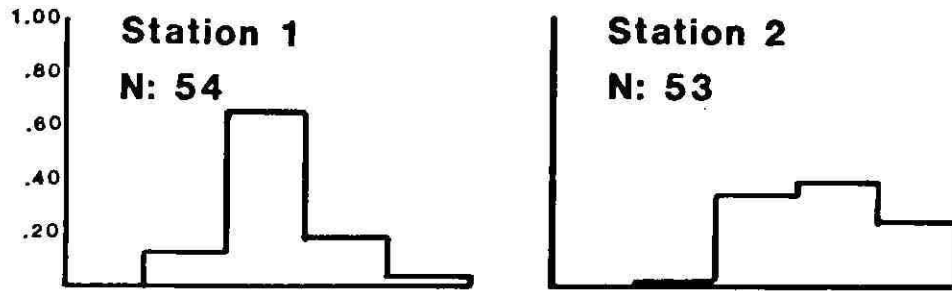


Wassaw Sound



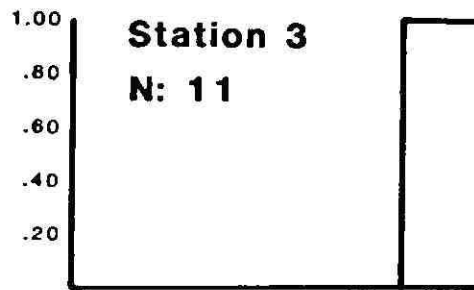
St. Catherines Sound

Beach Creek

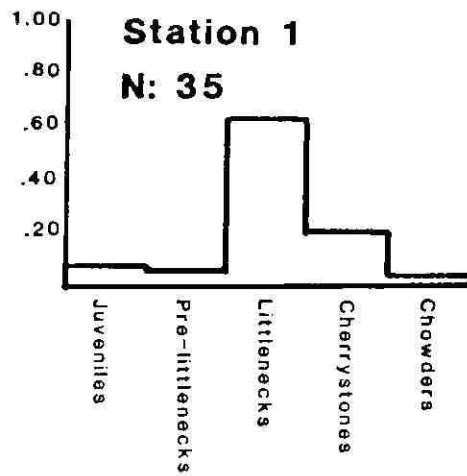


Relative frequency

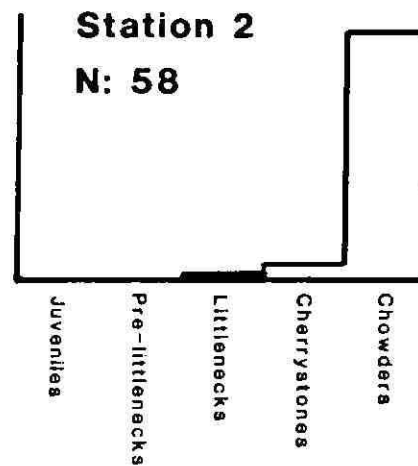
St. Catherines Sound



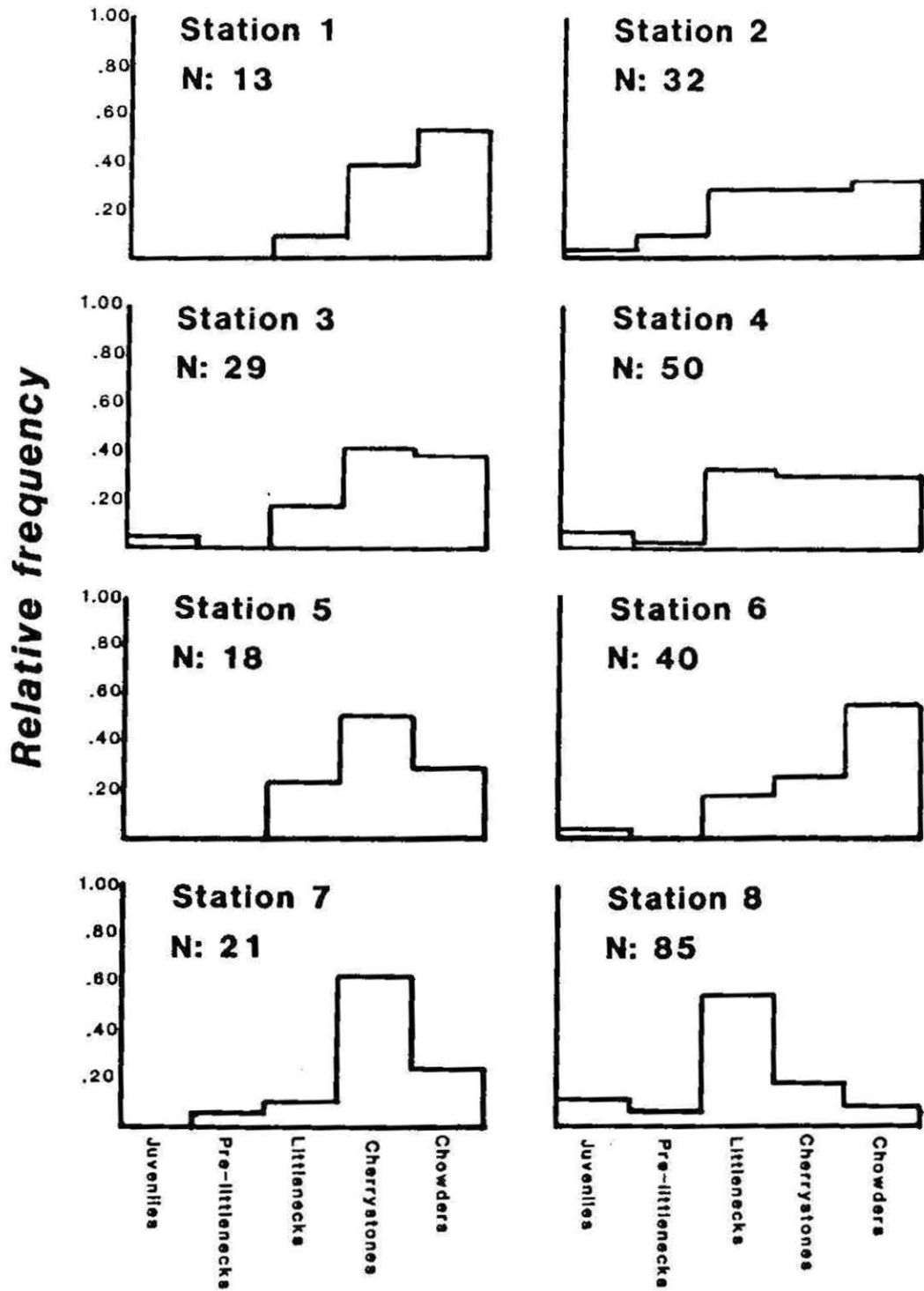
Cumberland Island



Crooked River

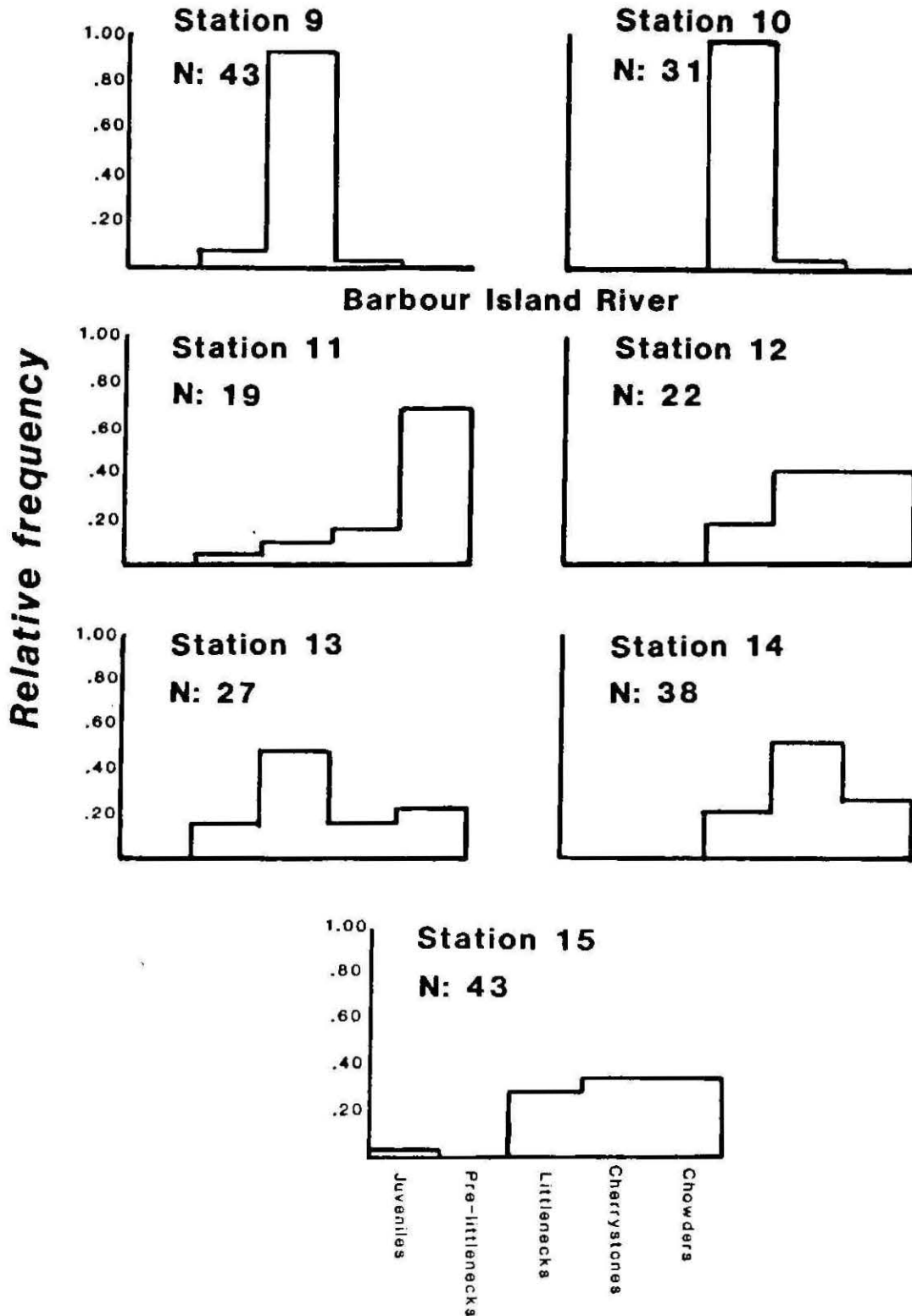


Sapelo Sound
Julienton River

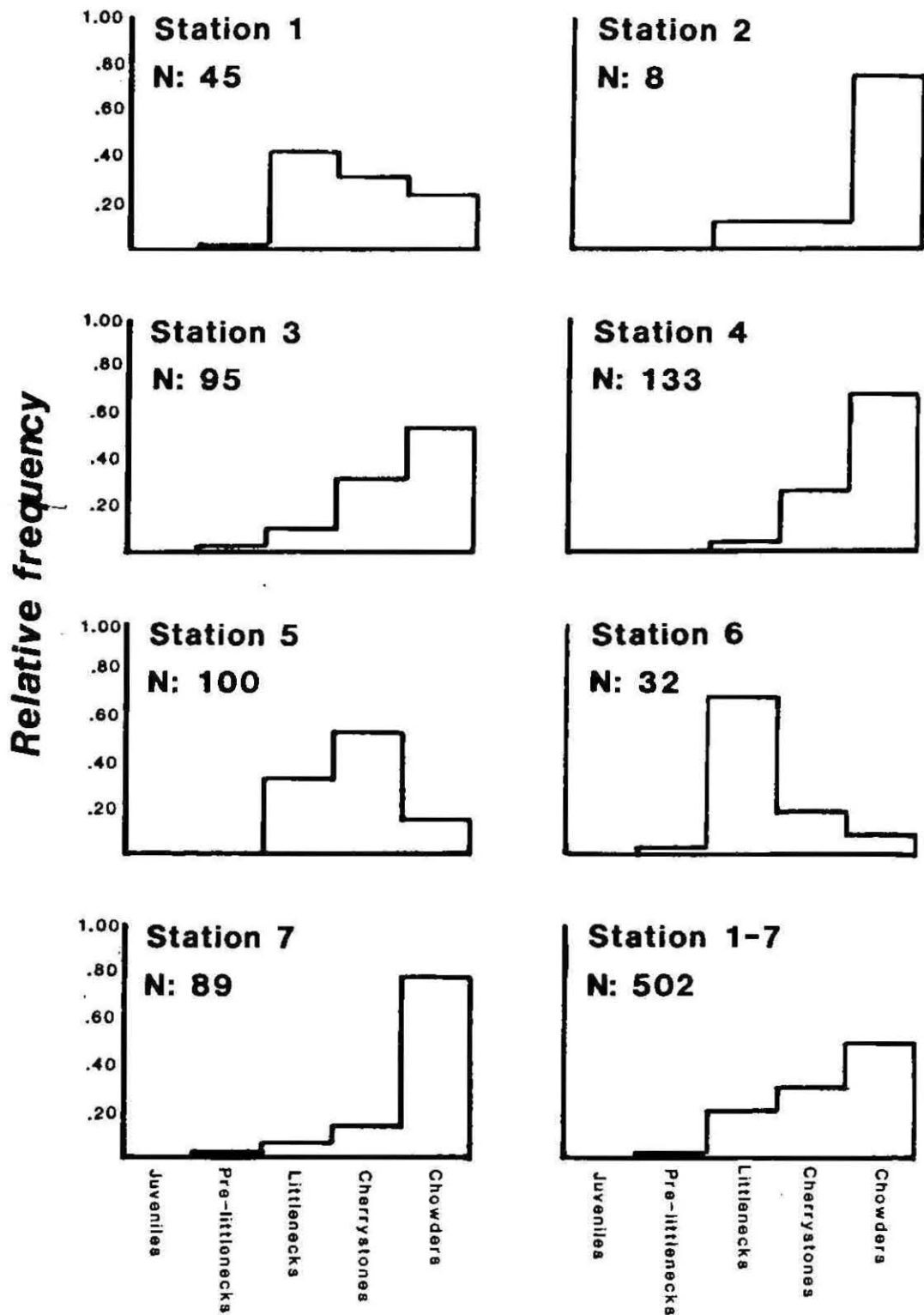


Sapelo Sound

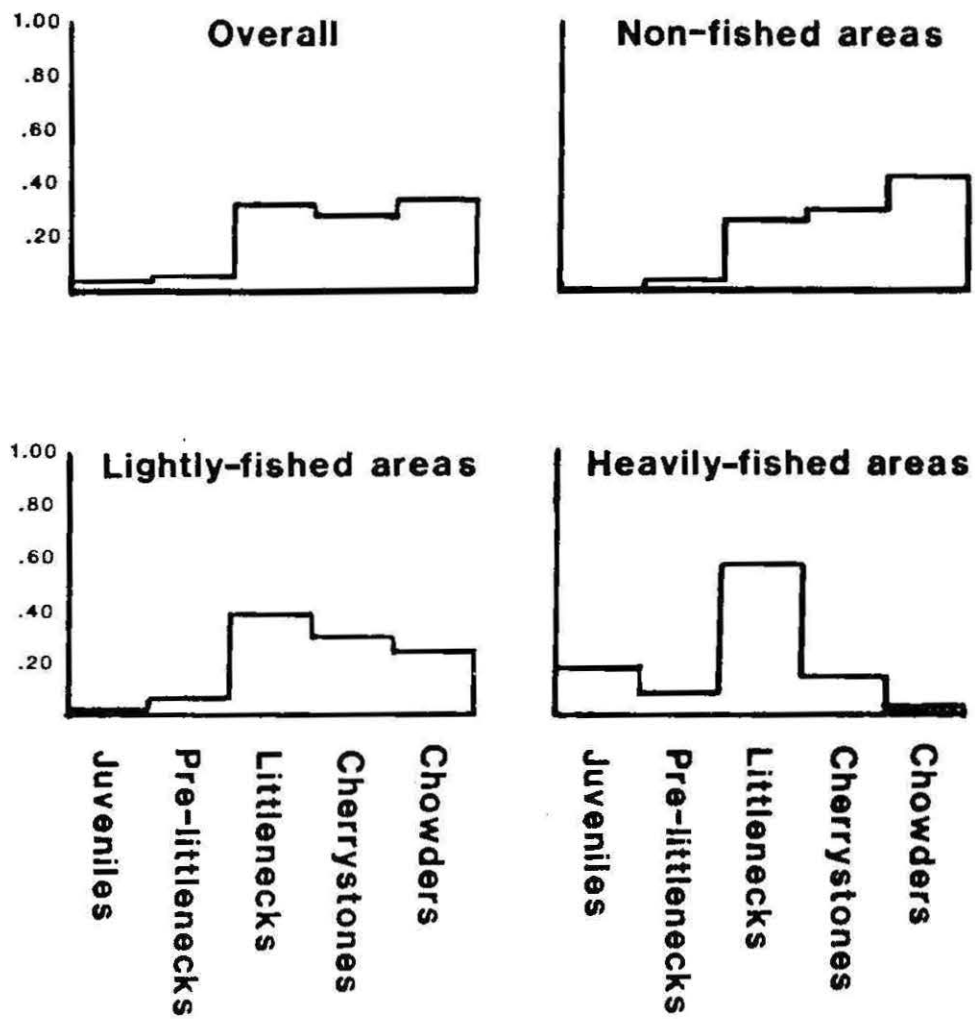
Sapelo Sound



Christmas Creek



Relative frequency



APPENDIX

Appendix I. Mean shell length in mm of the hard clam, *Mercenaria mercenaria*, per year band per area.

| | | Year Band | | | | | | | | | |
|-----------------------------|----|-----------|------|------|------|------|------|------|------|------|------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Wassaw Sound | | | | | | | | | | | |
| Population | 1 | 29.7 | 41.8 | 46.3 | 55.3 | 58.9 | 62.3 | 62.6 | 65.2 | | |
| | 2 | 22.0 | 38.2 | 50.4 | 58.8 | 64.8 | 70.5 | 75.2 | 75.9 | 70.5 | |
| | 3 | 25.0 | 42.5 | 57.3 | 67.1 | 72.7 | 76.9 | 80.7 | 83.8 | 85.7 | 88.2 |
| | 4 | 25.0 | 42.9 | 56.4 | 65.1 | 70.7 | 73.9 | 74.2 | 76.8 | 82.1 | 79.8 |
| | 5 | 22.8 | 41.1 | 53.9 | 62.0 | 65.6 | 68.2 | 71.6 | 74.1 | 74.3 | 75.6 |
| | 6 | 25.5 | 36.2 | 46.1 | 50.9 | 56.1 | 61.3 | 66.0 | 68.1 | 68.7 | 69.8 |
| | 7 | 23.4 | 39.4 | 49.6 | 57.1 | 61.2 | 64.4 | 67.2 | 73.3 | | |
| | 8 | 24.3 | 39.9 | 53.2 | 60.0 | 64.3 | 67.1 | 69.2 | 70.4 | 71.4 | 72.6 |
| | 9 | 23.9 | 42.0 | 57.2 | 65.7 | 70.5 | 74.0 | 76.3 | 77.2 | 79.0 | 79.9 |
| | 10 | 21.3 | 40.2 | 53.4 | 61.0 | 65.1 | 67.0 | 69.8 | 71.7 | 73.2 | 73.1 |
| | 11 | 21.5 | 41.3 | 55.3 | 64.0 | 69.9 | 73.7 | 76.8 | 79.7 | 83.6 | 85.9 |
| | 12 | 24.3 | 42.1 | 57.3 | 66.1 | 71.6 | 75.4 | 78.6 | 79.5 | 80.8 | 83.0 |
| | 13 | 25.8 | 43.2 | 56.5 | 64.8 | 70.1 | 73.9 | 78.3 | 79.1 | 81.7 | 8.16 |
| St. Catherines Sound | | | | | | | | | | | |
| | 1 | 21.2 | 36.1 | 48.7 | 54.7 | 61.1 | 65.6 | 70.5 | 72.6 | 75.4 | 73.0 |
| | 2 | 23.9 | 40.0 | 53.0 | 61.6 | 67.0 | 70.7 | 73.6 | 74.8 | 75.0 | 77.9 |
| | 3 | 23.0 | 36.9 | 52.5 | 60.8 | 67.5 | 73.4 | 77.1 | 78.7 | 81.6 | 83.8 |
| Sapelo Sound | | | | | | | | | | | |
| | 1 | 27.0 | 42.1 | 52.7 | 60.6 | 65.0 | 65.1 | 66.9 | 68.4 | 69.8 | 71.1 |
| | 2 | 21.1 | 41.7 | 53.8 | 62.0 | 69.0 | 72.1 | 75.7 | 76.0 | 78.3 | 80.4 |
| | 3 | 23.2 | 38.9 | 53.3 | 61.2 | 66.5 | 70.2 | 73.7 | 76.1 | 78.3 | 78.7 |
| | 4 | 25.5 | 37.2 | 48.6 | 56.8 | 62.5 | 66.2 | 68.1 | 70.8 | 72.9 | 74.3 |
| | 5 | 24.7 | 39.8 | 53.4 | 60.7 | 66.2 | 66.4 | 68.4 | 70.1 | 71.9 | 74.7 |
| | 6 | 25.6 | 41.6 | 54.9 | 61.8 | 66.4 | 69.4 | 72.3 | 73.1 | 74.8 | 76.0 |
| | 7 | 25.5 | 39.6 | 49.1 | 55.3 | 59.6 | 62.8 | 64.7 | 66.2 | 67.1 | 68.6 |
| | 8 | 29.0 | 46.9 | 57.8 | 61.7 | 65.0 | 68.4 | 69.1 | 70.0 | 69.3 | 70.6 |
| | 9 | 16.8 | 26.9 | 35.9 | 42.1 | 46.6 | 50.1 | 50.4 | 52.5 | 53.1 | 54.0 |
| | 10 | 26.2 | 44.9 | 53.0 | 59.1 | 59.1 | | | | | |
| | 11 | 31.6 | 45.6 | 54.8 | 61.5 | 66.4 | 69.6 | 72.1 | 73.6 | 75.8 | 76.8 |
| | 12 | 28.5 | 47.6 | 59.3 | 65.9 | 69.5 | 73.0 | 74.8 | 75.6 | 77.5 | 76.8 |
| | 13 | 30.5 | 44.3 | 56.7 | 65.6 | 73.9 | 80.7 | 83.4 | 89.9 | 92.5 | |
| | 14 | 25.9 | 41.4 | 52.3 | 59.3 | 64.1 | 67.7 | 70.9 | 72.2 | 73.7 | 74.9 |
| | 15 | 33.0 | 47.2 | 56.5 | 62.8 | 67.2 | 70.4 | 72.6 | 74.7 | 76.6 | 80.8 |
| Christmas Creek | | | | | | | | | | | |
| | 1 | 23.5 | 41.5 | 53.4 | 60.8 | 65.1 | 68.3 | 71.2 | 73.0 | 73.9 | 73.4 |
| | 2 | 26.5 | 42.2 | 54.5 | 62.3 | 67.0 | 69.6 | 71.7 | 73.5 | 74.2 | 76.4 |
| | 3 | 24.5 | 41.9 | 54.2 | 61.0 | 65.5 | 68.5 | 70.8 | 71.5 | 73.3 | 74.7 |
| | 4 | 27.1 | 44.1 | 55.3 | 62.8 | 67.3 | 70.9 | 73.2 | 75.0 | 76.2 | 76.9 |
| | 5 | 26.6 | 42.4 | 54.3 | 60.8 | 64.5 | 66.0 | 67.9 | 66.8 | 69.8 | 70.9 |
| | 6 | 24.7 | 42.9 | 53.3 | 59.6 | 60.7 | 64.0 | 67.1 | 69.5 | 71.4 | 72.2 |
| | 7 | 26.4 | 44.5 | 56.3 | 67.0 | 71.9 | 75.3 | 77.3 | 79.4 | 80.8 | 82.0 |
| Cumberland Island | | | | | | | | | | | |
| | 1 | 16.5 | 26.0 | 38.3 | 47.3 | 53.5 | 56.8 | 59.7 | 62.0 | 62.0 | 64.8 |
| Crooked River | | | | | | | | | | | |
| | 1 | 24.9 | 40.1 | 53.2 | 64.1 | 70.5 | 76.2 | 79.7 | 82.2 | 83.7 | 85.1 |

