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OBSERVATIONS ON EXTANT POPULATIONS OF THE SOFTSHELL CLAM, *MYA ARENARIA* LINNÉ, 1758 (BIVALVIA: MYIDAE), FROM GEORGIA (USA) ESTUARINE HABITATS

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ABSTRACT The softshell clam, *Mya arenaria* Linné, 1758, is reported from Georgia (USA) estuarine habitats based on studies conducted between 1969 and 1972. Observations on Georgia estuarine habitats where extant populations of softshell clams occurred are described. On several occasions, fresh shells with periostracum and tissue remnants were found in a brackish drainage system on Sapelo Island. These shells represent the first southern records of extant populations of softshell clams from such a specialized habitat type. Living specimens of *M. arenaria* from the benthos and specimens in the stomach contents of stingrays (*Dasyatis sabina*) were collected at four stations during 1969 in the North and South Newport Rivers, mesohaline tidal systems forming part of the southern and northern headwaters of St. Catherines and Sapelo Sounds. The stomach of a stingray collected near the mouth of Little Ogeeche River during another study also contained specimens of *M. arenaria*. Ephemeral, intertidal, winter populations of juvenile softshell clams are reported from exposed pleistocene beach faces along tidal rivers in Chatham, Georgia. The associated fauna collected with softshell clams and occurrence of other cold temperate and boreal species from Georgia estuaries are discussed. The distribution of *M. arenaria* appears to be mainly limited by a critical maximum temperature of 28°C. The relatively cooler summer temperatures observed at the Sapelo Island tidal ditch site may enable the species to survive in this restricted habitat. Data from the present study indicate that during winter and spring, softshell clams appear to be bionomically important components of the benthos and the diet of stingrays in some Georgia estuarine habitats. Whether or not reproducing populations of *M. arenaria* occur year-round in Georgia estuaries still remains an open question.

Introduction

Between 1967 and 1972, we made a series of collections and observations on two estuarine habitats, one associated with tidally influenced brackish water ditches on Sapelo Island, the other in the subtidal upper reaches of St. Catherines and Sapelo Sounds. These two habitats have been generally described in earlier publications dealing with other faunal studies (Sikora et al. 1972; Heard 1975; Rasmussen 1994).

At some of the study sites in these two areas, we were able to document the presence of extant populations of the softshell clam, *Mya arenaria* Linné, 1758, a commercially important bivalve (Hanks 1963; Pileggi and Thompson 1979) commonly known to northern temperate and boreal coastal habitats of Europe and North America (Theroux and Wigley 1983).

Historical

Mya arenaria has existed along the North American and European coasts since the Pliocene, but died out in Europe during the Ice Age at the beginning of the Pleistocene (Strauch 1972), after which it later became reestablished. Since the larvae could not have spread spontaneously to Europe from America, it was previously assumed that *M. arenaria* was reintroduced to Europe by man in the 16th century after the voyage of Columbus (Hessland 1946). Recent findings by Danish geologists, however, imply a reestablishment of the species in Europe much earlier, about 1200, probably by Viking voyagers. This is supported by carbon-dated analyses of shell material of *M. arenaria* from Holocene layers in the Kattegat region, Jutland (Petersen et al. 1992).

Extant populations of *Mya arenaria* are presently known or reported from most of western Europe, from the East Coast of the United States (Labrador to Charleston, South Carolina), from isolated populations in the Arctic, and from introduced populations established along the Pacific coast of North America (Foster 1946; La Rocque 1953; Ockelmann 1958; Tebble 1966; Laursen 1966; Abbott 1968, 1974; Emerson et al. 1976; Bernard 1979; Theroux and Wigley 1983; Abbott and Dance 1986). Because of its broad range in the northern hemisphere, various authors have placed the softshell clam in the following six zoogeographical faunal provinces: Virginian, Boreal, Celtic, Transatlantic, Aleutian Californian,

and Japonic (Coomans 1962; Gosner 1971; Dance 1974). None of these authors, however, mention the occurrence of *M. arenaria* in the Carolinian Province.

Records of softshell clams from the Carolinian Province are sparse and vague. According to Foster (1946), the North Carolina record (from Beaufort) is based on dead valves only. Abbott's (1968) South Carolina record is not documented or repeated in any of his later publications and may be an error. Regarding its North American, East Coast occurrence, Theroux and Wigley (1983: 48) state, "The normal distribution of the softshell clam is from Labrador to South Carolina, extending, locally, south to Florida.." The record from South Carolina is based on specimens from a population near Charleston; these specimens are housed in the Woods Hole Collections of the National Marine Fisheries Service. However, Theroux and Wigley (1983) cite no published or unpublished references to specimens or collection sites for the occurrence of softshell clams in Florida waters.

There are several nominal published records for *Mya arenaria* from Georgia estuarine waters. Two of these records are only mentioned in footnotes (Sikora et al. 1972:518; Howard et al. 1973:43). Howard and Frey (1975a) reproduced Heard and Heard's (1971) unpublished list of the common invertebrates of Sapelo and St. Catherines Sounds which included records of softshell clams from the mesohaline waters of the North Newport River system. Extant specimens of *M. arenaria* were listed from the Turtle River (St. Simmons Sound) and St. Marys River (Florida-Georgia border) by Howard and Frey (1975b) and from Doboy Sound by Mayou and Howard (1975). Frey et al. (1975:271) reported softshell clams from tidal river channels throughout the Georgia coast and considered this bivalve as one of several "best indicators of present-day estuarine environments in Georgia." Later, Howard et al. (1977:341) briefly mentioned the presence of *M. arenaria* in the diet of stingrays from Georgia estuaries.

MATERIALS AND METHODS

Sapelo Island Collection Sites

Sapelo Island is located off the coast of Georgia (Figure 1). The island study site was in a brackish-water drainage ditch under High Point Road (culvert then present). This ditch is part of the head waters of Barn Creek, which empties into the Duplin River, a northeastern arm of Doboy Sound, about 800 m NNW of the Sapelo Island air field (Figure 2). The general ecological characteristics of the tidal ditch habitats in this area have been described earlier by Rasmussen (1994). The collection site is located in an isolated area surrounded and shaded by a dense, mixed hardwood-pine forest. The water level was influenced by regular tides from the Duplin River. On the landward side of the ditch, the often strong currents through the culvert had created a pool, approximately one meter deep, with a relatively firm bottom where the shell material of *Mya arenaria* was collected.

The site was visually inspected weekly from early June 1971 to early February 1972. Any changes were noted and any visible shells were collected by hand or with a dipnet. Water temperature was measured with a mercury thermometer and salinity was measured with a T/C refractometer (American Optical Corporation). Both measurements were taken just below the surface. An attempt was initially made to obtain sediment samples, but it was impossible to dig in the hard substratum.

North Newport River Collection Sites (Figure 3)

Specimens of *Mya arenaria* from this area were collected in 1969 during a baseline study to monitor possible ecological effects of a paper mill on Riceburro Creek, a headwater tributary of St. Catherines and Sapelo Sounds. Faunal and water-quality data (dissolved oxygen (DO), pH, salinity, temperature, turbidity) were gathered during 43 monthly cruises using the University of Georgia Marine Institute research vessel, *R/V Kit Jones*. The faunal collections were made monthly at 14 stations in Sapelo Sound, St. Catherines Sound and their adjacent tidal river tributaries (Figure 3). Four of these stations (10, 11, 12, and 13), all located in the head waters of Sapelo and St. Catherines Sounds (North and South Newport River systems), are relevant to this study. Stations 10, 11, 12, and 13 were sampled along a 300 to 400 m track in or immediately adjacent to the river channel in depths ranging from 4 to 8 m. Stations 10, 12, and 13 had a mostly sand-silt substratum. Station 11 had a mosaic of bottom types ranging from coarse gravel with fossil lag deposits (sharks teeth, whale bone, etc.) to mixed sand-silt and hard mud substrata. The channel margins along some or all parts of these station tracks were composed of consolidated pleistocene sand deposits.

Fish and large epibenthic invertebrates were collected with a 25-foot otter trawl, infaunal macroinvertebrates with a bucket dredge. Samples of the latter comprised all fauna retained by a 1 mm screen. A series of fish specimens from each station were kept for stomach-content analyses. Apart from a few voucher specimens and the fish for stomach-

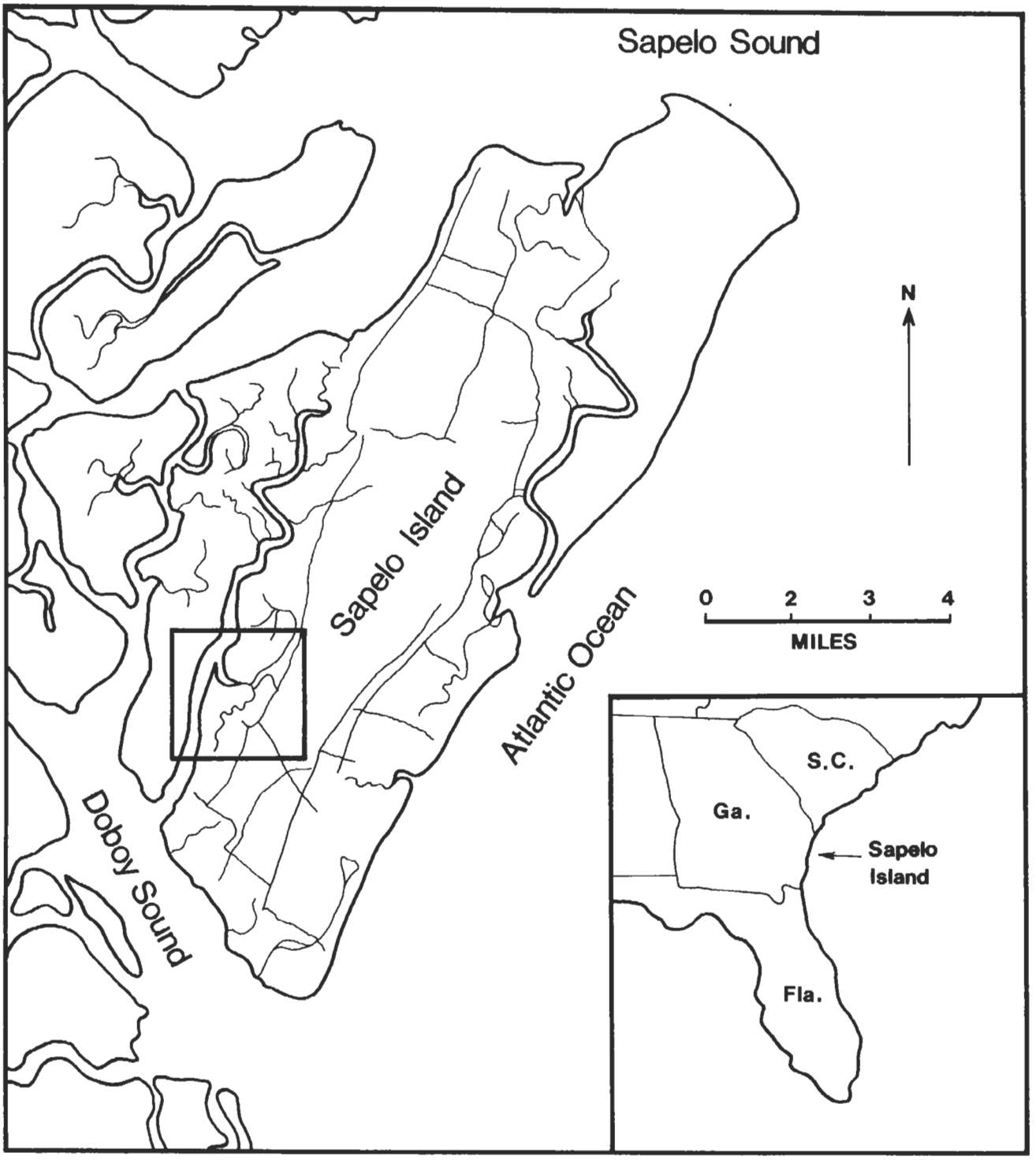

Figure 1. Map of Sapelo Island, Georgia, showing location on US East Coast (inset, lower right) and location of study area (framed, see Figure 2).

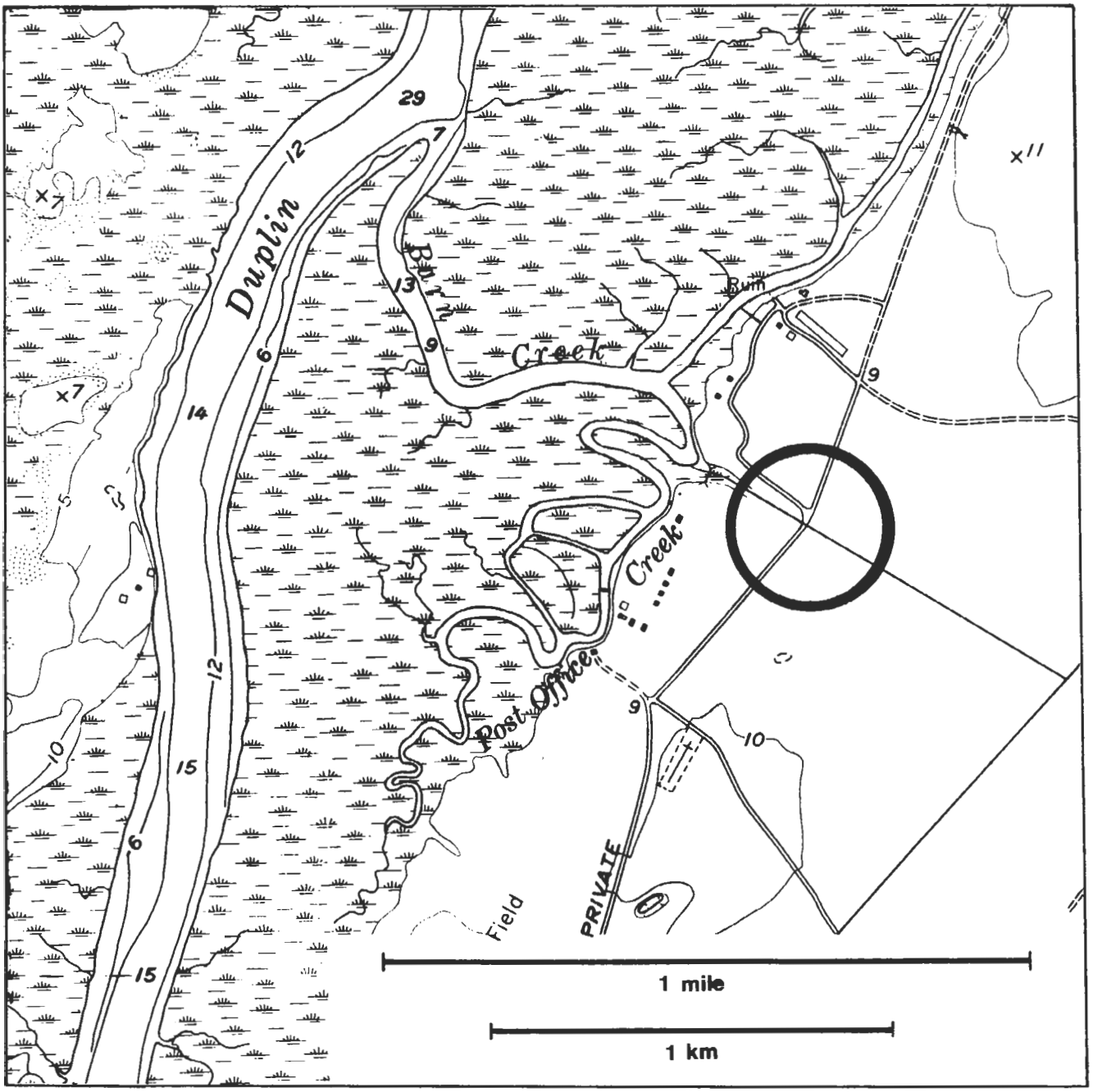

Figure 2. Enlarged map of study area on Sapelo Island, showing Duplin River, Barn Creek and Post Office Creek, leading to locality with *Mya arenaria* (circled). Depths in feet. Map from Doboy Sound, GA. N3122-W8115/7.5. US Department of Commerce Coast and Geodetic Survey, edited and published by the US Geological Survey, 1954.

content analyses, most fish and large macroinvertebrates were identified and counted while alive, then thrown overboard. All fish and sieve residues retained were fixed onboard in a 4% solution of formaldehyde in seawater, later washed in freshwater and transferred to 70% ethanol. Further analyses and taxonomic studies were done in the laboratory.

Representative specimens of *Mya arenaria* collected during this study with the bucket dredge are deposited in the National Museum of Natural History (USNM), the Zoological Museum, University of Copenhagen (ZMUC), and the Gulf Coast Research Laboratory Museum (GCRL). Common names for the mollusks, decapod crustaceans, and fishes used in this paper are from American Fisheries Society Special Publications 6, 16, and 17.

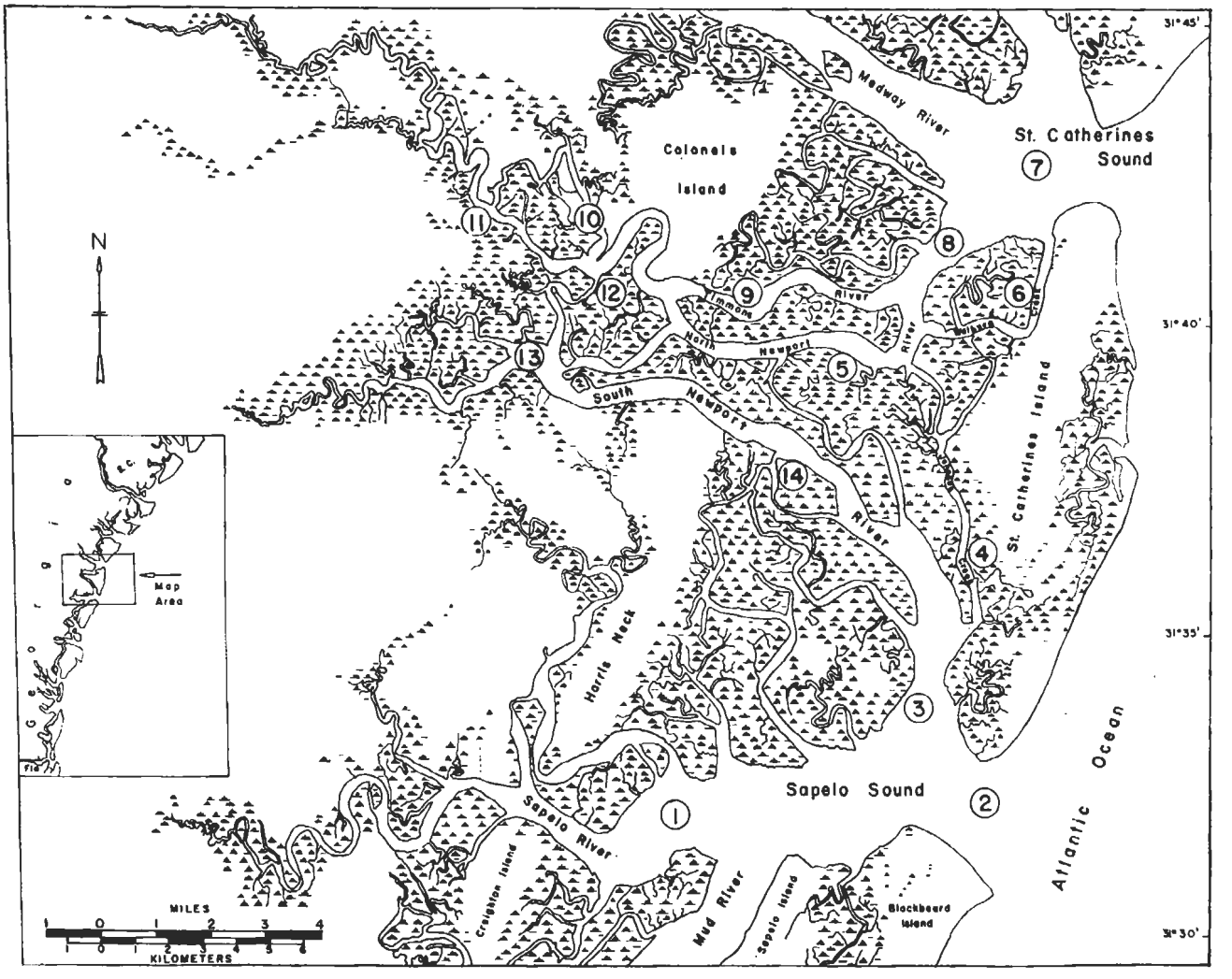

Figure 3. Map of Sapelo and St. Catherines Sounds indicating locations of 14 sites visited monthly during 1967 through 1970 for collections (bucket trawl and dredge) and water-quality data (from Sikora et al. 1972).

RESULTS AND OBSERVATIONS

Sapelo Island

A total of nine shell pairs and 25 single valves of *Mya arenaria* were found on seven occasions from July to December 1971 (Table 1) at the High Point River culvert site. All shells were thin and fragile. Although no living specimens were obtained, all shells had fresh periostracum. The attached tissue remnants on a few of the valves suggested that the living clams had been eaten by crabs, birds, or raccoons. The thin shells may be a result of life under less than optimal conditions for the species. All shells were found on the bottom of the pool on the landward side of the culvert and probably were washed in from the marsh by the strong currents at high tide. The largest number of shells was found on 6 December, shortly after a strong storm on 2-3 December which raised the normal sea level over a meter. Water temperatures at the time of sampling ranged from high averages of 26.0-27.4°C in summer to low averages of 13.4-16.4°C in winter. Salinity ranged from 20-26‰ in June and December to occasional lows of 3-5‰ in August and in January-February which were associated with heavy local rainfall.

Despite careful and regular searches during the senior author's stay on Sapelo Island, no living specimens of *Mya arenaria* were found along the more open mud bars, beaches and sandy shallows of the island. Only a single valve of a dead and worn specimen, perhaps a fossil, 66 mm long, was found washed ashore on the open Atlantic beach.

TABLE 1

***Mya arenaria* from Sapelo Island, Georgia. Shells and attached shell pairs found in 1971. Shell length expressed as average (minimum-maximum); for averages, each shell pair counted as one unit.**

Date in 1971	Shell Pairs	Single Shells	Shell Length (mm)
9 July	2	--	29 (23-35)
8 September	1	--	48
9 November	1	3	36.5 (34-39)
22 November	--	2	37 (36-38)
6 December	4	9 left, 5 right	40.7 (26-55)
20 December	--	2 right	35.5 (29-42)
27 December	1	3 left, 1 right	37.4 (30-47)

Of the many ditch and creek habitats of the island examined in 1971, only the above locality contained material of *Mya arenaria* in the form of fresh shells, some with tissue remnants. An attempt was also made to sample the *Spartina* marsh downstream from the drainage culvert, but the dense tangle of blades and rhizomes combined with the very soft mud made it nearly impossible to dig there. No living clams or recent shells were found. Since the possible uniqueness of this drainage ditch habitat was not known to us at the time, no further efforts were made to find living specimens.

We did not have an opportunity to collect in the channel bottoms of the adjacent tidal creeks (Post Office and Barn Creeks) on Sapelo Island where sand-silt substrata are present some sections of their runs. In future studies, such creek-bottom habitats should be sampled seasonally with cores, yabby pumps (hand-held suction devices), or small water-jet pumps to determine if softshell clams are present.

North Newport River

Our observations on North Newport River populations of *Mya arenaria* represent an expansion of the data presented in an unpublished final report by Heard and Heard (1971). In that study, which dealt with an ecological evaluation of the invertebrate communities in St. Catherines and Sapelo Sounds and their respective tidal river tributaries, *M. arenaria* was reported in bucket-dredge samples taken at three stations on eight different occasions. Softshell clams were reported at stations 10 and 11 from the middle, mesohaline reaches of the North Newport River during winter and spring (February to June) of 1969 (Table 2).

With the exception of salinity-temperature-DO measurements, neither Heard and Heard (1971) nor another unpublished companion report by Dalhberg (1971) presented exact information about depth and bottom conditions or the size and quantity of animals, whose occurrence was simply designated as "present," "common," or "abundant".

We are now able to present additional information on the populations of *Mya arenaria* collected from the North Newport and South Newport River systems during the 1967-1971 paper mill environmental impact study, but not included in Heard and Heard (1971). This information includes additional environmental data on the stations where softshell clams occurred, records from Station 12 (Table 2), and data on *M. arenaria* from the stomach contents rays and hakes.

During the five-month period in which *Mya arenaria* was present in the samples (10 February-2 June), temperatures at stations 10, 11, and 12 were lowest on 6 March (10.8°C at 10 and 11, 10.7°C at 12) and highest on 2 June (29.4°C, 28.1°C, and 28.3°C at 10, 11, and 12, respectively). Salinities for stations 10, 11, and 12 were lowest on 1 April (15.7‰, 12.4‰, and 15.3‰) and highest on 10 February (23.4‰, 23.6‰, and 25.4‰, respectively).

During the winter and spring of 1969, specimens of *Mya arenaria* were taken twice at station 10 ("present" in March and May) and five times at station 11 ("common" in February and April, "present" the other three months), and once at station 12 (station 12 not included in Heard and Heard 1971).

Regrettably, most of the specimens of *Mya arenaria* reported in Heard and Heard (1971) are now unavailable for study. However, voucher specimens for four of these eight North Newport River collections are extant. Stations, collection dates, and measurements for these voucher specimens are presented in Table 2.

TABLE 2

Occurrence of *Mya arenaria* collected with a bucket dredge from the North Newport River at stations 10 and 11 during March, April, May, and June 1969 (from Heard and Heard 1971), plus data from station 12 and from voucher specimens. Length measurements in mm for available voucher specimens.

Station (Cruise)	Date (1969)	No. of Clams	Shell Length mm*
10 (33)	1 April	present	unknown
10 (35)	2 June	present	unknown
11 (31)	10 February	(6) common	16.7 (14.2-20.6)
11 (32)	6 March	(8) present	17.7 (11-23.2)
11 (33)	1 April	(4) present	16.9 (14.2-20.6)
11 (34)	1 May	present	unknown
11 (35)	2 June	present	unknown
12 (32)	6 March	(2)	15.1 (8.1-22.1)

*Based on range and average of voucher specimens (number of voucher specimens in parentheses).

The voucher specimens from the February, March, and April collections appear to be juveniles and subadults. Based on notes and sketches of the second author, the specimens taken with the bucket dredge at Station 11 during June 1969 were distinctly larger than those collected in February and April (R. Heard, unpublished observations). These tentative observations are supported by the similar size (40+ mm) of softshell clam specimens taken from the stomachs of Atlantic stingrays collected at this station during the same period.

Fauna Associated with North Newport River *Mya arenaria* Populations

A fairly diverse benthic assemblage of macro-invertebrates was associated with spring populations of *Mya arenaria* in the North Newport River (Heard and Heard 1971). At stations 10, 11, and 12 in depths ranging from 4 to 8 meters, dense populations of the ascidian *Mogula manhattensis* (DeKay) with associated hydroids, bryozoans (*Anguinella palmata* van Beneden and *Amathia distans* Busk) and gammarid amphipods (*Gammarus mucronatus* Say and *Melita nitida* Smith) were attached to the consolidated pleistocene deposits along the edges of channels. Other species commonly associated with the pleistocene deposit community were the nereidid polychaete *Neanthes succinea* (Frey and Leuckart); the hooked mussel *Ischadium recurvum* (Rafinesque); the false angelwing *Petricola pholadiformis* Lamark; the common grass shrimp *Palaemonetes vulgarus* (Say); and the xanthid crab *Rhithropanopeus harrisii* (Gould).

In or on the sand-silt bottom deposits where *M. arenaria* occurred, three other mollusks were common: the Atlantic paper mussel, *Amygdalum papyrium* (Conrad), the dwarf surf clam, *Mulinia lateralis* (Say), and the brown banded wentletrap, *Epitonium rupicola* (Kurtz). Populations of the amphipod *Ampelisca abdita* Mills, the isopods *Cyathura polita* Stimpson and *Cleantoides planicauda* (Benedict), and the polychaetes *Diopatra cuprea* Bosc and *Sabellaria vugaris* Verrill also occurred in or on the same substratum with softshell clams.

Georgia Intertidal Populations of *Mya arenaria*

Additional observations on extant populations in Georgia waters were made by one of us (RWH) between 1962 and 1994. Ephemeral, intertidal, winter populations of juvenile *Mya arenaria* occurred intermittently on exposed pleistocene beach faces along Moon River, a mesohaline tidal river in Chatham, Georgia. In the lower intertidal zone along these shore faces, juvenile softshell clams (6-12 mm in length) were observed in small silt-filled depressions that pocked the consolidated sand-clay shore face. During some winters,

densities often exceeded 250 individuals per m^2. It is likely that such ephemeral juvenile "accessory" populations occur at other similar intertidal habits in Georgia estuaries during the winter and early spring.

Such juvenile clam populations may be bionomically important in the diets of shore birds. On several occasions during the late winter at the Chatham county site, flocks of small unidentified "sand pipers" were often seen feeding along the lower shore in areas where juvenile soft shell clams were common.

Possible Factors Determining the Occurrence of *Mya arenaria* in Georgia Estuaries

Based on our limited observations, Georgia populations of *Mya arenaria* appear to have restricted habitats, be most common during the winter and spring months, and have shell sizes that do not approach those found in northern softshell clam populations. Ecological factors, including salinity, food supply, substratum and temperature (Swan 1952a) determine the occurrence, distribution, and size of softshell clams in Georgia estuaries.

Salinity. Over the period of this study, salinity at the *Mya arenaria* collection site on Sapelo Island varied from highs of 20-26‰ in June and December to occasional lows of 3-5‰ in August and in January-February. Since *M. arenaria* is known to tolerate sudden and considerable changes in salinity (Matthiessen 1960), it is unlikely that the infrequent salinity fluctuations at the Sapelo Island site and those observed in the North and South Newport River systems would be a decisive factor in softshell clam survival.

Substratum. Theroux and Wigley (1983) found softshell clams to be most common in sand-silt bottoms. Swan (1952b) reported that these clams grow faster in sandy bottoms than in compact mud substrata. The substratum surrounding the ditch collection site was soft mud or mud permeated with rhizomes of associated marsh grasses. Based on the observations of Swan (1952a), softshell clam growth in this type of habitat may be retarded. This might be one reason why the largest shells examined from the extant population on Sapelo Island (Table 1) were only 4.8 cm long.

The largest specimens of *Mya arenaria* observed from the North and South Newport River systems were taken from stingray stomachs at station 11 during June 1969. Like clams from the Sapelo Island site, these clams had maximum valve lengths under 5 cm, even though the bottom sediments in the vicinity of this station were predominantly sand-silt and appeared to be more suitable for growth of softshell clams than the mud bottom at the Sapelo Island site.

Food supply. In Georgia habitats, food supply should not be limiting in view of the high primary production throughout the surrounding marsh and estuarine waters (Odum 1961). Odum and de la Cruz (1967), working on Sapelo Island, found the amount of organic detritus (2-20 mg ash-free dry organic matter per liter), mainly from *Spartina*, to be much greater than that reported for the open sea. The nutrient-rich waters of Georgia estuaries support a rich planktonic and benthic diatom flora (Pomeroy et al. 1981) which could be utilized as a food source by local populations of *Mya arenaria*.

Temperature. *Mya arenaria* is essentially a boreal-cold temperate species with its main distribution in more northern latitudes. Its restricted occurrence in the warm-temperate, estuarine waters of Georgia would be an interesting subject for studies on physiological adaptation. A comparison between the lower temperature conditions at the Sapelo Island drainage site that supported a population of *M. arenaria* during 1971 and the higher temperature conditions of adjacent marine habitats lacking clam populations may explain this special occurrence. Published hydrographic data from comparable habitats in Georgia coastal waters are mostly limited to hydrographic and ecological studies conducted in the sounds and oceanic waters adjacent to Sapelo Island. For comparison with the data from the brackish-water ditch habitats, we utilized physical data collected between 1967 and 1970 from surface waters at station 2 (Figure 3), located in Sapelo Sound off the northern tip of Sapelo Island (Dalhberg 1971). During that study, temperatures ranged from high averages of 28.7-29.2°C in summer to low averages of 8.8-11.8°C in winter. In spite of the fragmentary and incomplete data from both localities, these data suggest that overall lower temperatures exist at the drainage ditch site (13.4-16.4°C winter lows to 26.0-27.4°C summer highs) as compared to the open water (i.e., Sapelo Sound site), especially during the summer months. The subtle temperature differences in such specialized habitats that support lower temperatures during the summer months may help support a niche in which softshell clam populations can survive at lower latitudes where they normally would not be expected to survive.

High temperatures are reported to be an important limiting factor for softshell clams in southern estuarine habitats (Laursen 1966). Accordingly, well established populations of *Mya arenaria* normally occur in estuarine and marine habitats where water temperatures are consistently less than 28°C (Kennedy and Mihursky 1971). In Chesapeake Bay, large-scale mortalities of softshell clams took place when summer temperatures exceeded 28°C (Pfitzenmeyer 1972).

Temperature may also control the size of southern softshell clam populations. The observed small size of *Mya arenaria* specimens from Georgia estuaries may be an adaptive or ecophenotypic response to the overall higher temperatures found in southern parts of its range. As in southern populations of the Atlantic surf clam, *Spisula solidissima* (Dillwyn, 1817), Georgia estuarine softshell clam populations may mature at a smaller size and never approach the size of the northern "cold water" forms. It would be very interesting to culture transplanted juvenile specimens of *M. arenaria* from Georgia populations in a suitable New England habitat in order to determine if regional size differences are due more to environmental than to genetic factors.

In the cold temperate coastal habitats of New England where softshell clams are harvested commercially for food, shells are reported to commonly reach lengths of up to 7.6-15.4 cm (Abbott 1986). The largest known shell for *Mya arenaria*, collected at Barnstable Harbor, Massachusetts, has a length of 16.6 cm (Clench 1961). There also remains the possibility that adult clams of "typical" size (8+ cm) occur in Georgia waters, but have not been detected because of the limited and inadequate sampling methods employed thus far.

Softshell Clams in the Diet of Georgia Estuarine Fishes

Softshell clams occurred in the stomach contents of fishes collected in monthly trawls taken in the North and South Newport River during 1969 as part of a paper mill monitoring study (Dahlberg 1971). There is also an additional record of *Mya arenaria* from the stomach of an Atlantic stingray collected in June 1972 by trawl in a mesohaline area near the mouth of the Little Ogeeche River, Chatham Co., Georgia (R.W. Heard, unpublished data).

As part of a study on the feeding habits of the Atlantic stingray, *Dasyatis sabina* (Lesueur), collections were made during 1969 in the North and South Newport River systems when softshell clams occurred in benthic samples. It was found that *Mya arenaria* was an important part of the spring diet of the stingrays occurring in this area.

Between 1967 and 1972, the stomach contents of 321 Atlantic stingrays from a variety of Georgia coastal habitats were examined (R. Heard, unpublished data). Of these rays, 14 (5%) of the 293 rays with recognizable food in their stomachs had been feeding on *Mya arenaria* (Table 3). Of these 293 rays, 46 were collected from stations 10, 11, 12, and 13 in the North and South Newport River systems where known or suspected populations of softshell clam occurred during 1969. Of the rays examined from these stations on a year-round basis, 13 (28%) had been feeding on softshell clams. Based on examination of 26 rays collected during the spring from these stations, 50% contained from 2 to 17 softshell clams, which in terms of biomass comprised the major part of their diet. The majority of rays found feeding on *M. arenaria* occurred at station 11 during May and June 1969, where 11 of 13 (85%) of the stomachs examined contained clams. During the June collections, many of the softshell clam remains from the ray stomachs appeared to have valve lengths in the 30 mm to 40+ mm range. The remaining 20 rays examined from Stations 10-13 were collected during the fall months. They had been feeding predominantly on the commercial white shrimp, *Penaeus setiferus* (Linné), and had no softshell clams in their stomach contents.

Two small softshell clams were taken from the stomach of a juvenile spotted hake, *Urophycis regius* (Walbaum), collected during the spring of 1969 from the North Newport River above station 11 (Station C of Heard 1975). These two clams were in poor condition and are no longer available for study (Sikora, unpublished data; Sikora et al. 1972, footnote p. 518).

In another study (Heard 1975) which deals with the feeding habits of white catfish, *Ictalurus catus* (Linné), collected from the North Newport River and its tributaries, no *Mya arenaria* were observed in the stomach contents of 174 fish examined. Many of these catfish were collected at stations C and B (= station 11) during periods when softshell clams were known to be present.

Other Cold Temperate-Boreal Species in Georgia Estuaries

During the spring and winter months, the Baltic macoma, *Macoma balthica* (Linné, 1758), and the Atlantic rock crab, *Cancer irroratus* Say, 1817 occur in Georgia estuaries. Like *Mya arenaria*, both are common to cold-temperate and boreal Atlantic regions. *Macoma balthica* has been reported in Georgia waters (Abbott 1974; Theroux and Wigley 1983; Mayou and Howard 1975; Frey et al. 1975). Juveniles of the crab *Cancer irroratus* are not uncommon in the sounds near Sapelo Island (Heard and Heard 1971). *Macoma balthica* appears to be an important component of winter brackish water benthos of Doboy and Altamaha Sounds, which are part of the greater Altamaha River delta system just south of Sapelo Island (Mayou and Howard 1975; R.W. Heard, unpublished observations). The juveniles of *C. irroratus* are common winter residents of the lower, high salinity reaches of Georgia sounds. Adult populations south of North Carolina are confined to colder deep-water habitats (Williams 1984). Juveniles of *C. irroratus* have been reported in the diet of hakes collected in Sapelo and St. Catherines Sounds (Sikora et al. 1972). Juvenile hakes, like *C. irroratus*, occur in Georgia estuaries during the cooler periods of the year, and leave the estuaries during the spring to migrate back into deep offshore waters where the adult populations occur.

TABLE 3

Occurrence of *Mya arenaria* in 14 stomachs of the Atlantic stingray, *Dasyatis sabina*, collected from Georgia estuaries during 1967-1970 (North and South Newport River system) and 1972 (Little Ogeeche River).

Collection Date	Station	Disk Width (cm)	Sex	No. of *Mya* in Stomach
	North Newport River			
5/69	11	24	Female	5
	11	24	Female	5
	11	25	Female	3
	11	26	Female	17
	11	32	Female	14
6/69	11	21	Female	2
	11	26	Female	2
	11	29	Female	5
	11	30	Female	10
	11	30	Female	12
	11	33	Female	16
	South Newport River			
5/69	13	33	Female	4
	13	33	Female	15
	Little Ogeeche River			
6/72	17	23	Male	12

CONCLUSIONS

Based on our limited data, we believe that there is a good possibility that year-round, reproducing populations of the softshell clam, *Mya arenaria*, exist in Georgia waters. During the colder months, juvenile populations are often recruited into areas such as intertidal sand banks. During warmer months, however, biotic and abiotic factors such as predation and temperature may make these areas uninhabitable for the clams and thus limit their distribution.

The restricted cooler habitats associated with tidal ditches on Sapelo Island and the mesohaline tidal river channels with sand-silt bottom substrata like those associated with the middle reaches of the North and South Newport Rivers may serve as year-round refuges for local breeding populations of *Mya arenaria*. However, since Theroux and Wigley (1983) have documented that softshell clams occur at depths of over 150 m off New England, it is possible that permanent, offshore populations may be present on the continental shelves of the Carolinas, Georgia, and

northeastern Florida. Hypothetically, if such a situation exists, then the softshell clams from Georgia estuaries could simply be ephemeral, non-breeding accessory populations representing a seasonal larval recruitment from offshore populations. To our knowledge, however, no populations of *M. arenaria* are documented or known from the continental shelf off Georgia or immediately adjacent states.

Notwithstanding, softshell clams appear to be a bionomically important component of some Georgia estuarine habitats during winter and spring months. Further studies are needed to establish with certainty whether or not year round breeding populations of *Mya arenaria* exist in Georgia estuarine waters.

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