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Randal L. Walker
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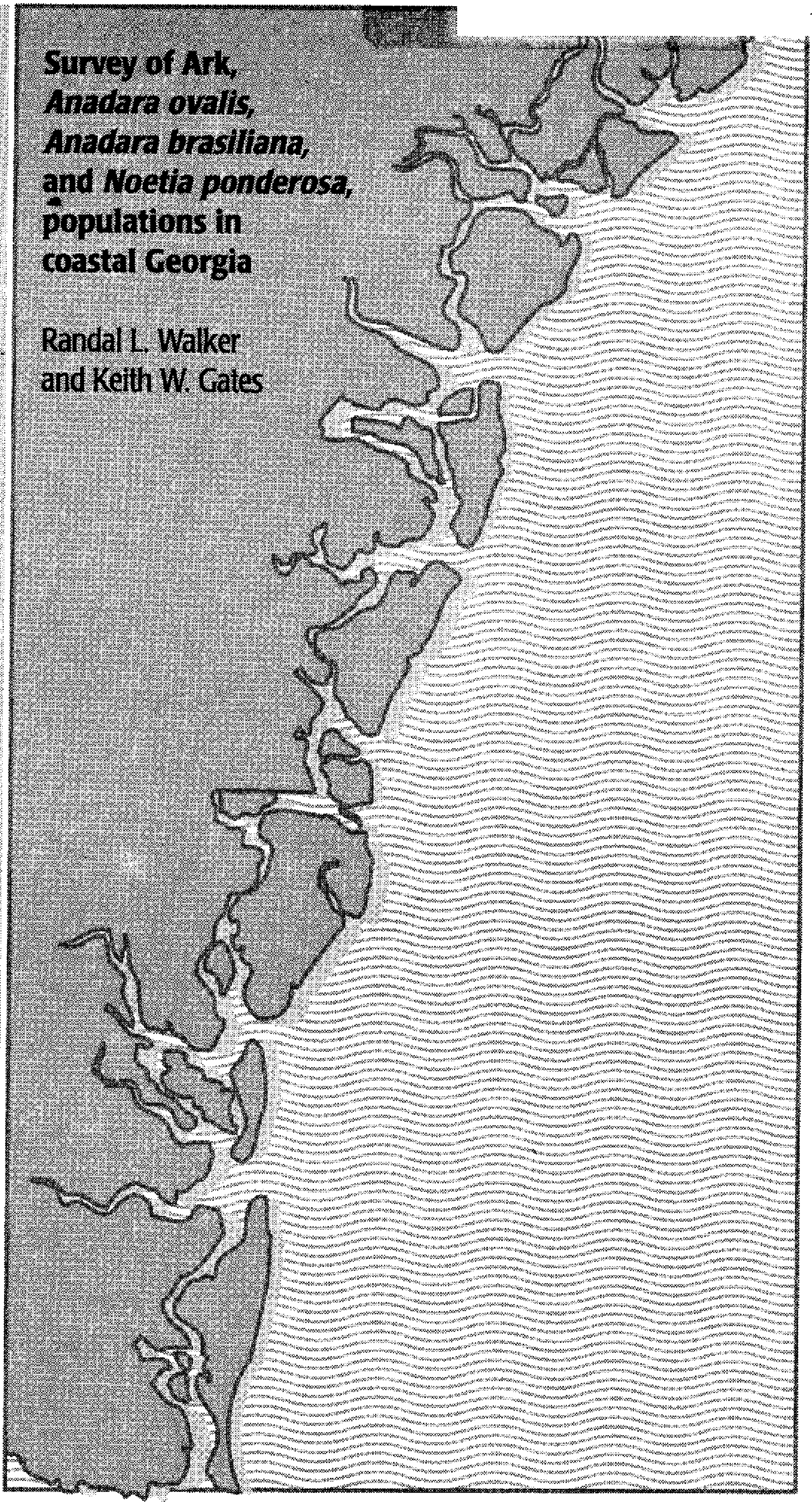

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Abstract

The potential for developing a fishery for wild stock arks in coastal Georgia is limited; however, development of an aquaculture industry based upon the blood ark, *Anadara ovalis*, and possibly the incongruous ark, *Anadara brasiliana*, is very promising. Most natural ark beds occur in closed waters that have not been monitored and certified by the State of Georgia for the harvest of shellfish. The ark beds are limited in size and could easily be overharvested. The 10-foot scallop try net or larger gear of similar design offer the only commercially practical and effective means for Georgia shrimp boats to harvest ark clams as a supplemental fishery. Growth rates calculated for both blood and incongruous arks indicate they grow rapidly and could achieve a marketable size in a year to a year-and-a-half of cultured growth. The ponderous ark, *Noetia ponderosa*, grows much more slowly, requiring three to four years to reach a 50-mm size. Based on the rapid growth rate of *Anadara brasiliana* and *Anadara ovalis*, the possibility of successfully developing these species for an aquaculture industry is high. However, the mortalities in the wild ark populations found by our study must be explained before large-scale aquaculture operations could begin.

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INTRODUCTION

Arks

Arks (Family Arcidae) represent an important worldwide bivalve molluscan fishery (Broom 1985; Manzi and Castagna, 1989). Species of *Anadara* are harvested in Korea, Malaysia, Thailand, Japan, Fiji, India, Indonesia, the Philippines, Columbia, Mexico, and West Africa (Broom, 1985). Arks of the genus *Scapharca* are also harvested in Japan (Umezawa, 1992). China (Nie, 1990), Thailand (Broom, 1985), and Japan (Broom, 1985; Umezawa, 1992) culture arks. The 1993 worldwide harvest of arks was 264,174 metric tons, a 13% increase over 1992 landings (FAO 1995).

In the United States, ark resources have been ignored by the fishing industry until recently. A survey of ark populations in South Carolina, undertaken in 1987, showed that arks could support a commercial fishery, but a marketing survey failed to produce viable markets (Anderson et al., 1984; Anderson and Eversole, 1985). Since then a small fishery for arks, primarily the blood ark, *Anadara ovalis*, and the ponderosa ark, *Noetia ponderosa*, has developed in Virginia. Arks are sold primarily as an ethnic food in Chicago, New York, Los Angeles, and Washington, D.C. or exported to Mexico (McGraw and Castagna, 1994), where an ark fishery has existed for many years (Baquiero et al., 1982; Baquiero, 1989). The demand for arks has outpaced the numbers that can be supplied by the Virginia fishery. Other areas of the east coast of the United States support ark populations. Georgia and Florida could develop an ark fishery in conjunction with two seasonal or intermittent fisheries, scallop and whelk harvesting. A dedicated or supplemental ark fishery would bring some bycatch of the scallop and whelk fisheries, discarded arks, into commerce. Successful marketing of arks would not only support an ark fishery, but could lead to a new aquaculture industry in the southeastern United States.

The cut-ribbed ark, *Anadara floridana*, is the largest of the U.S. east coast arks, attaining a shell length up to 5 inches as compared with the ponderosa and blood arks that reach lengths of 2.5 and 2.3 inches, respectively (Abbott, 1974). *Anadara floridana* ranges from North Carolina to Texas. In the U.S., the larger ponderosa ark sells better in west coast markets than the smaller blood ark. Both sell well in the New England Markets (Wec Terry, Terry Brothers, Inc., Willis Wharf, VA, personal communication). California dealers prefer to purchase the clams by the pound, while east coast sellers market individual clams. It usually takes two to three of the larger ponderosa arks to make a pound of clams. A pound of the smaller blood arks will contain many more clams. In Virginia, fishermen sold arks to dealers for $ 0.06 each. Virginia dealers then sold the arks on the west coast for $0.52 a pound, bringing a sizable profit to the dealers (Wec Terry, Terry Brothers, Inc., Willis Wharf, VA, personal communication). Larger arks are preferred in the more lucrative west coast markets. The major hindrance to the development of an ark fishery in Virginia is the lack of supply and the possibility those ark populations have already been overfished (Wec Terry, Terry Brothers, Inc., Willis Wharf, VA, personal communication).

Conversations with the shrimp and whelk fishermen in Georgia indicate that there are many areas offshore from Georgia that at least occasionally support large ark populations. Shrimpers and whelk fishermen avoid certain offshore areas because so many arks are caught that it makes it difficult to bring the nets back aboard. A great deal of time is spent sorting the arks from the shrimp or whelks. This study examined the distribution and basic biological parameters of the various ark populations in coastal Georgia to determine if sufficient stocks exist to warrant the development of an ark fishery for Georgia fishermen.

Scallop Fishery

In 1994, Mr. Robert Cummins, retired from the National Marine Fisheries Service, brought samples of juvenile cut-ribbed arks to the Shellfish Aquaculture Laboratory in Savannah, GA for identification. The scallop industry reported to him that millions of the clams were attached both to calico scallops, *Argopecten gibbus*, and to dead shells collected from the scallop beds off Cape Canaveral, Florida. The Industry was concerned that the animals could pose a threat to the fishery since they were so numerous and were attached to scallops by byssal threads. He informed the industry that the arks would not kill the scallops, but they were potential competitors for diatoms and other species of phytoplankton used by the scallops for food. Environmental conditions in 1994 enabled the massive recruitment of arks within the calico scallop beds off Cape Canaveral, Florida.

The Calico Scallop, *Argopecten gibbus*, supports a large southeastern U.S. commercial fishery. Calico scallops are harvested from three major offshore areas: (1) Cape Lookout, North Carolina, (2) Cape Canaveral on the east coast of Florida, and (3) Cape San Blas, Florida in the Gulf of Mexico (Cummins 1971). In 1994 the calico scallop fishery landed seven million pounds of meat from Florida waters valued at $ 6.9 million (O'Bannon, 1995).

Shrimp boats pulling modified shrimp nets harvest scallops. The nets efficiently gather other epibenthic organisms that dwell on the scallop grounds. A long list of invertebrate species live in association with the calico scallop and many are harvested in scallop trawls. Most of the bycatch is shoveled overboard or brought to shore for disposal in scallop shell dumps located near the meat processing plants. Wells et al. (1964) recorded more than 100 macroscopic invertebrate species living on or in scallop shells. Schwartz and Porter (1977) reported that 112 species of fish lived in association with calico scallops in beds off North Carolina. They also identified 60 species of macromolluscs, 25 crustaceans, 12 echinoderms, four coelenterates, and one annelid living in the complex. Of the 24 bivalve mollusk species collected, *Andadara floridana*, *Macrocallista maculata*, *Chione latilirata*, and *Chione intapurpurea* were collected in fair numbers during each sampling period. The ponderosa ark, *Noetia ponderosa,* was collected during one sample period (Schwartz and Porter 1977). One animal commonly found within scallop dumps in Florida and Georgia is the cut-ribbed ark, *Anadara floridana* (personal observation by Walker). Arks appear to form an important component of bycatch discarded from typical scallop harvesting operations.

Calico scallops are harvested whenever sufficient numbers can be found to support commercial operations. No season exists for the calico scallop fishery in Florida (William Arnold, Florida Department of Natural Resources, personal communication). If scallops are present, the fishery could operate year-round twenty-four hours a day and seven days a week. Since commercial concentrations of scallops occur at irregular intervals, long periods may elapse between commercial fishing efforts. Poor scallop recruitment may close the industry for a year or more. One factor that may lead to poor recruitment is the practice of transporting the scallop and its shell along with other molluscan shellfish to landfills for disposal. The fishery would be better served by returning the empty shells to the main harvest areas to promote future recruitment of individuals. Recent parasite infestation by an ascetosporan disease crippled the calico fishery off Cape Canaveral, Florida (Moyer et al., 1993). Fishing for arks during the off-season for scallops could provide an alternative resource that would enable fishermen to keep working. Harvested arks also could supplement scallop landings during a poor season. In good seasons, the discarded ark bycatch could be sold at a profit and not disposed of in scallop refuse piles.

A fishery for the offshore ark, *Anadara floridana,* could offer an alternative or supplementary fishery to the present calico scallop fishery. *Anadara floridana* is known to occur within the same offshore habitat as the calico scallop (Schwartz and Porter 1977). By using different gear such as hydraulic dredges, modified scallop dredges, tumbler dredges, oyster dredges, or scallop try nets to dig into the sand bottom, it should be possible to fish for arks with the same boats used for scalloping. Several other ark species could be exploited such as *Acra zebra, Noetia ponderosa, Anadara ovalis, Anadara brasiliana, Anadara notabilis*, each of which reaches a shell length of approximately 2.5 inches. The smaller 1.5 inch, *Anadara transversa*, is not a possible resource. All of the arks occur in inshore, nearshore, or offshore waters throughout the southeastern U.S. (Abbott, 1974).

Whelk Fishery

Georgia enjoys a successful whelk fishery that harvested 672,600 pounds of product valued at $377,300 in 1995. Whelk harvesting developed as a supplementary fishery to the shrimp fishery. The fishery supports local crab plant processing operations during the winter months when crabs are too scarce or too expensive to process. Whelk fishermen have reported harvesting arks while dragging for various species of whelks, but most catches have been associated with the knobbed whelk, *Busycon carica*, found in near to offshore waters. Whelks are known predators of various ark species. The fishermen shovel the arks overboard, making it uncertain which species of arks were harvested as bycatch. However, populations of *Anadara ovalis* and *Anadara brasiliana* are the two dominate ark species found in the nearshore areas. Sometimes arks were harvested in sufficient numbers to suggest commercial concentrations though the large webbing size on whelk nets would allow many arks to escape. As with the scallop fishery, arks could compliment a small seasonal fishery that many believe is in decline because of decreased landings while making use of animals normally discarded as bycatch.

Several species of arks are found in Georgia's inshore and nearshore waters. *Anadara ovalis*, *Anadara brasiliana*, and *Noetia ponderosa* are common. *Anadara transversa*, *Anadara notabilis*, and *Arca zebra* are found less frequently than the previous species (personal observations by Walker and evidence from the shell collection of Shellfish Aquaculture Laboratory). *Arca zebra* attains a shell size of three inches and occurs from North Carolina to Brazil (Abbott 1974). This ark has only been found rarely in offshore Georgia waters. *Noetia ponderosa* reaches a shell length of 2.5 inches, ranges from Virginia to Texas, and generally inhabits Georgia's inshore waters. *Anadara notabilis* reaches 3.5 inches and occurs from North Carolina to Brazil. *Anadara brasiliana* is distributed from

North Carolina to Brazil (Abbott 1974) and attains a shell length of 2.5 inches. Large numbers may be found washed upon the beaches of coastal Georgia after storms. *Anadara ovalis* and *Anadara transversa* both occur from Cape Cod, Massachusetts to Texas. *Anadara ovalis* reaches 2.3 inches, while *Anadara transversa*, the smallest ark, attains only 1.5 inches in shell length (Abbott 1974). *Anadara transversa* is uncommon in Georgia. *Anadara ovalis* with a shell length of 2.3 inches and *Anadara brasiliana* at 2.5 inches are both within the size range of the ponderosa and blood arks that are successfully marketed from Virginia. The rapid growth rate of *Anadara ovalis*, common to Georgia's inshore waters, has prompted the Marine Extension Service to investigate its potential for aquaculture (Walker 1999).

In many conversations, Georgia shrimp and whelk fishermen indicated that numerous offshore areas apparently support large ark populations at certain times. Shrimpers and whelk fishermen avoid these offshore areas because so many arks are caught that it makes it difficult to bring the nets back aboard their boats. Too much time is spent sorting the arks from the shrimp or whelks in some trawl areas. This study examines the distribution and basic biological parameters of the various ark populations in coastal Georgia to determine if sufficient stocks exist to warrant the development of a commercial ark fishery for Georgia.

PROJECT BACKGROUND

We investigated ark populations found in commercial calico scallop and whelk fishing grounds. The crew of the R/V GEORGIA BULLDOG employed several commercially available dredging devices and shrimping gear to assess ark populations and the relative harvesting effectiveness of: (1) a 10-foot scallop try net (3 inch stretched mesh, #94 twine bag with ½ inch chain- cutting cable), (2) a 2-foot rock dredge (a 3 inch stretched mesh, #94 twine bag), and (3) 4 6 inch homemade dredge (6 inch teeth, 3 inch stretched mesh, #94 twine bag, and 2 inch ring chaffer). This project assessed the potential commercial use of ark species found in the bycatch of the calico scallop fishery (*Anadara floridana)* and the whelk fishery (*Anadara brasiliana* and *Anadara ovalis*) of the southeastern U.S. Commercial scallop and whelk fishermen were consulted to select the most promising locations for our preliminary sampling efforts along the Georgia and Florida coasts from Savannah to Cape Canaveral. More efficient dredging gear than commercial nets used to capture scallops and whelks were employed to statistically sample and estimate potential commercial concentrations of the three ark species believed to be associated with the two established fisheries. We documented the distribution and abundance of other smaller ark species within Georgia's nearshore and offshore waters. Representative animal samples were collected to measure shell length, shell width, shell height, total weight, and meat weight. The population studies quantified the potential commercial viability of ark fisheries associated with both scallop and whelk harvesting operations.

The study's second part investigated the nutritional content and meat yields of *Anadara floridana*, *Anadara ovalis*, *Anadara brasiliana*. Nutritional analyses will include percent protein, percent moisture, and percent ash.

The third component of the study, to assess the marketing potential for the species through a cooperative program with a local coastal Georgia seafood dealer and experienced ark dealers located in Willis Wharf, Virginia and Philadelphia, Pennsylvania, was not completed because so few arks were harvested during the study. Contacts were made with a large specialty market in Atlanta that promotes ethnic products including exotic seafood, but arks were not harvested in sufficient quantities for even limited retail trials.

Ark Aquaculture Potential

Little life history information exists for ark populations in the United States. Virtually no information other than broad distribution data from taxonomical guides is available for ark species including the cut-ribbed ark, *Anadara floridana* (Conrad, 1869). Loosanoff and Davis (1963) and Chanley and Andrews (1971) described the spawning and larval development of the transverse ark, *Anadara transversa* (Say, 1822). Loosanoff et al. (1966) described the various larval dimensions of *Anadara transversa*. Larvae found in the water column showed that the spawning of *Anadara transversa* in Virginia waters occurs from May to September. The ponderosa ark, *Noetia ponderosa* (Say, 1822), was reported to spawn from June to December (Chanley and Andrews, 1971). Larval development of *Noetia ponderosa* was investigated in Virginia (Chanley 1966; Chanley and Andrews, 1971). Growth rates and ages of *Noetia ponderosa* and *Anadara ovalis* were calculated for animals from Virginia waters. *Anadara ovalis* is considered a possible aquacultural species because of its rapid growth rate (McGraw and Castagna 1994). A reproductive study to learn the gametogenic cycle of inshore ark species is underway in Virginia. Little is known about the population biology of arks in the coastal waters of the southeastern U.S.. If the demand for arks is great enough, the supplemental ark fishery could help drive future aquaculture programs aimed at the commercial production of the clams.

METHODS

Arks were collected by trawling in the nearshore and offshore areas of coastal Georgia. A 20-foot conch net was pulled by the R/V GEORGIA BULLDOG or the R/V SEA DAWG for 7 to 30 minutes. Captured arks and articulated shells were sorted according to species and returned to the laboratory for processing. In the laboratory, each ark was measured for shell length, shell height, and shell width to the nearest 0.5 mm with Vernier calipers. Live animals and articulated ark shells were weighed on a balance after air drying. Notes were taken on associated epifauna attached to shells for 586 *Noetia ponderosa*. Little epifauna occurred on *Anadara brasiliana* or *Anadara ovalis* specimens. Shell or live weights (meat plus shell) were determined only for specimens with no epifauna or after removing the epifauna and then weighing. Some small blood arks were collected from surfclam, *Spisula solidissima solidissima*, grow-out cages partially buried on a sandy-mud flat at the mouth of House Creek, Little Tybee Island, and Wassaw Sound, Georgia. Arks had attached to cages and were gathered when the cages of surf clams were harvested. Growth rates were determined by measuring the shell length with vernier calipers at each annual band present on the outer shell of the specimens.

In July-August, bottom dragging in the offshore areas harvested thousands of ponderous arks that had recently died. Articulated shells, often containing residual meat, were collected. Out of several thousand arks, only one or two were alive. Live arks caught throughout the summer and returned to the laboratory generally died. Dead and dying arks from offshore areas were of the same approximate size class. The cause of death, natural mortality or an environmental disturbance, was not apparent. Death of live animals collected and returned to the laboratory in Brunswick was probably caused by stress. Animals were obviously exposed to whatever conditions were killing the arks in offshore areas, stressed during capture, and then stressed additionally by changes in water salinity.

The animals were captured in high salinity water, returned to Brunswick, and placed in flow-through tanks receiving seawater from lower salinity inshore water. In later trawls, arks were trucked directly to Savannah and placed in Shellfish Certified Growing Grounds at the mouth of House Creek, Little Tybee Island, Georgia.

RESULTS

Ark Harvests

The three sets of gear tested to harvest ark clams recovered the following numbers of live specimens: (1) a 10-foot scallop try net (1,142 clams), (2) a 2-foot rock dredge (331 clams), and (3) a 46-foot homemade dredge (362 clams). Given the constraints of a secondary fishery adapting to a primary shrimp harvest fishery and current Georgia harvest gear limitations, it appears that the 10-foot scallop try net or larger gear of similar design offers the only commercially effective means to harvest ark clams from Georgia's waters.

Samples of the ponderous ark, *Noetia ponderosa,* were collected approximately 5 miles offshore from the mouth of St. Simons Sound, Georgia by the R/V GEORGIA BULLDOG in March and July-August 1997. Animals collected in March were placed in shrimp baskets and held onboard in the shade. Mortalities reached 50%, following one week of shipboard storage. Additional arks were placed in a shrimp basket and placed into a cooler maintained at 4°C. These animals survived for a month before 50% mortality occurred.

In July-August, thousands of recently dead ponderous arks were harvested by bottom-dragging in the offshore area. Articulated shells, often containing residual meat, were collected. Out of several thousand arks, only one or two were alive. Live arks caught throughout the summer and returned to the laboratory generally died. Dead and dying arks from offshore areas were of the same approximate size class. The cause of death, natural mortality or an environmental disturbance, was not apparent. Death of live animals collected and returned to the laboratory in Brunswick was probably caused by stress. Animals were obviously exposed to whatever conditions were killing the arks in offshore areas, stressed during capture, and then stressed additionally by changes in water salinity. Because of high mortality rates in *Noetia ponderosa* arks, we decided to delay further bed surveys until fall, after the water had cooled and hopefully the die-off ceased.

The animals were captured in high salinity water, returned to Brunswick, and placed in flow-through tanks that receive seawater from lower salinity inshore water. In later trawls, arks were trucked directly to Savannah and placed in Shellfish Certified Growing Grounds at the mouth of House Creek, Little Tybee Island, Georgia.

Allometric measurements were completed for 350 *Noetia ponderosa* collected from offshore St. Simons Island, Georgia. Shell length, width, height and wet weight of animals plus shells were obtained. Shell lengths ranged from 22.8 mm to 70.4 mm. Animal weights ranged 3.6 g to 148.1 g, excluding the individuals with live coral attached to outer shell (10% of arks). It requires five to nine, four to five, and three arks of 5 cm, 6 cm, and 7-cm shell length, respectively, to obtain a pound of ark.

Only 21 ponderous arks, *Noetia ponderosa*, were collected at three locations off the coast of Georgia by the R/V GEORGIA BULLDOG on March 24, 25, and 26, 1998. The Bulldog completed 17 tows offshore from Jekyll Island, nine tows off Cumberland Island and the Fernandina Beach Jetty, and 17 tows between the Brunswick Channel and Jekyll Beach using a 12-foot scallop net and a 40-foot shrimp net. We decided to postpone additional sampling until the fall months. It appears that any commercial ark fishery will be limited to the late fall and early winter, which corresponds to the whelk fishery season in Georgia.

We collected several hundred juvenile arks in September 1998. They were transferred to our grow-out area on Skidaway Island, GA. We requested a six-month no-cost project extension through May 1999 so specialists could monitor their growth over the winter and spring. Survey work was scheduled for October when the waters have cooled down. Many juvenile arks were attached to whelks. This finding increases the probability of a successful joint whelk/ark fishery.

The R/V GEORGIA BULLDOG spent seventeen boat-days trawling for commercial quantities of ark clams. We hired a commercial vessel for one boat-day to search for ark clams. A total of 197 tows was completed during the test period using both a 12-foot scallop tri-net and a four-foot modified oyster dredge aboard the BULLDOG and four 30-foot commercial conch nets aboard the cooperating commercial vessel. Eighteen boat-days of trawling produced only 1,456 live arks collected in a search area ranging from the St. Marys Entrance Channel in the south to the Savannah River Entrance Channel in the north. Average daily ark production was approximately 81 animals per day. Even at $ 0.30 each, daily production worth $24.30 will not support a viable fishery. We were unable to produce arks in sufficient quantities to initiate planned marketing studies in Atlanta and Virginia. Commercial contacts working in the scallop fishery off Cape Canaveral, FL informed us that no significant quantities of arks were encountered during scalloping operations.

We began the research because commercial scallop and conch fishermen operating in coastal Georgia, South Carolina, and northern Florida reported large numbers of ark clams harvested as bycatch. Our first survey attempts at the start of sampling efforts in the late spring and early summer of 1997 produced large numbers of dead and dying ark clams. We initially attributed the mortalities to rising seasonal water temperatures. It now appears that ark populations in coastal Georgia experienced a catastrophic collapse caused by either natural population fluctuations or some unknown environmental or biological factors. We ceased trawl operations until the next fall when coastal water temperatures decrease.

Ark Distribution

In Georgia, the incongruous ark, *Anadara brasiliana,* occurs from the low tide mark off the coastal beaches to approximately one-to-two miles offshore. Highest concentrations are found adjacent to the coastal beaches, where the arks live in a sandy substrate. Ponderous arks, *Noetia ponderosa,* generally occur in the offshore areas. Ponderous arks inhabit muddy bottoms that feature a mixture of shell or rubble. Blood arks, *Anadara ovalis,* are found inshore and in the mouth of associated channels to the sounds. The blood ark generally occurred in muddy-sandy bottoms. Survey data and ark locations are given in Table 1 of the appendix.

Anadara brasiliana

Of the 184 incongruous arks collected, only two were live specimens. The remainder were articulated shells. Incongruous arks ranged in shell length (Fig. 1) from 22.9 mm to 67.3 mm with a mean and median size of 46.6 mm and 46.3 mm, respectively. Shell width of the animals (Fig. 2) ranged from 16.9 mm to 55.7 mm with a mean and median size of 38.3 mm and 38.3 mm, respectively. Shell heights (Fig. 3) ranged from 12.5 mm to 54.4 mm with a mean and median size of 32.5mm and 32.5 mm, respectively. Linear regression analyses for each parameter are given in Table 1 and Figures 4, 5, and 6. Shells weights ranged from 1.0 g to 50.7 g (Fig. 4) with a mean and median weight of 14.2 grams and 12.1 g, respectively. Only two live incongruous arks were captured. Incongruous arks ranged in age from zero to nine years with a mean and median ages of 2.8 and 2 years, respectively (Fig. 8). Incongruous arks grow fast (Table 3 and Fig. 9) obtaining a mean size of 25 mm at age one and 42.3 mm at age two. Incongruous arks reach a marketable size of 40 mm by their second year.

Anadara ovalis

Of the 1,062 blood arks collected, 853 were alive at the time of capture, and 177 were articulated shells. The bimodal distribution is a result of collecting the smaller animals from cages, while the larger animals were collected with trawls. Shell length of the blood arks (Fig. 10) ranged from 29.4 mm to 84.3 mm with a mean and median size of 55.6 mm and 57.6 mm, respectively. Shell width of the animals (Fig. 11) ranged from 23.7 mm to 64.1 mm with a mean and median size of 45.4 mm and 48.1 mm, respectively. They ranged in shell height (Fig. 12) from 18.0 mm to 52.4 mm with a mean and median size of 34.8 mm and 35. 3 mm, respectively. The results from Linear Regression Analyses of each parameter are given in Table 1 and Figures 13, 14, and 15.

The live weight of arks with shell and meat is given in Figure 16. Shell weights are given in Figure 17. Live weights (N=853) ranged from 9.2 g to 135.7 g with a mean and median weight of 49.9 g and 51.9 g, respectively. Shell weights (N= 177) ranged from 9.9 g to 130.0 g with a mean and median weight of 70.4 g and 71.4 g, respectively. The shell weight of a ponderous ark is heavier per standard size than the other two ark species. The relationships between live wet weight and shell weight of ponderous arks according to shell length are given in Table 1.

Table 1. Shell morphometrics of the Incongruous ark, *Anadara brasiliana*, the Blood Ark, *Anadara ovalis*, and the Ponderous Ark, *Noetia ponderosa*.

	No.	a	b	r^2
Linear regression models: $Y = a + bX$				
Anadara brasiliana				
Length to height	184	8.69	1.165	0.960
Length to width	184	1.09	1.187	0.965
Height to width	184	-5.78	1.000	0.967
Anadara ovalis				
Length to height	1062	3.55	1.496	0.916
Length to width	1062	1.53	1.190	0.896
Height to width	1062	2.52	0.710	0.779
Noetia ponderosa				
Length to height	1048	8.11	1.103	0.805
Length to width	1048	9.91	1.065	0.786
Height to width	1048	5.50	0.883	0.817
Power curve models: $Y = aX^b$				
Anadara ovalis				
Live weight	853	$1.51X10^{-3}$	2.59	0.970
Shell weight	176	$3.35X10^{-5}$	3.44	0.807
Anadara brasiliana				
Live weight	Insufficient numbers of live arks collected			
Shell weight	183	$6.97X10^{-5}$	3.14	0.963
Noetia ponderosa				
Live weight	817	$4.44X10^{-4}$	3.01	0.890
Shell weight	112	$5.04X10^{-2}$	1.78	0.549

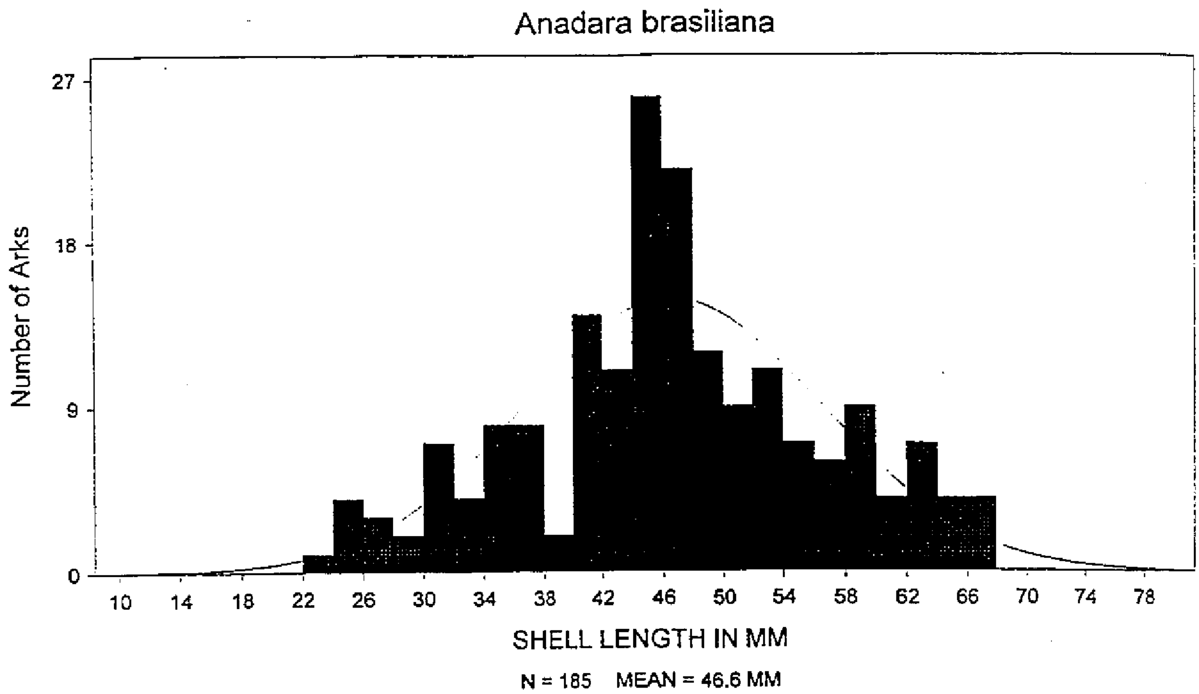

Figure 1. The shell length distribution of *Anadara brasiliana* collected from Georgia's coastal waters.

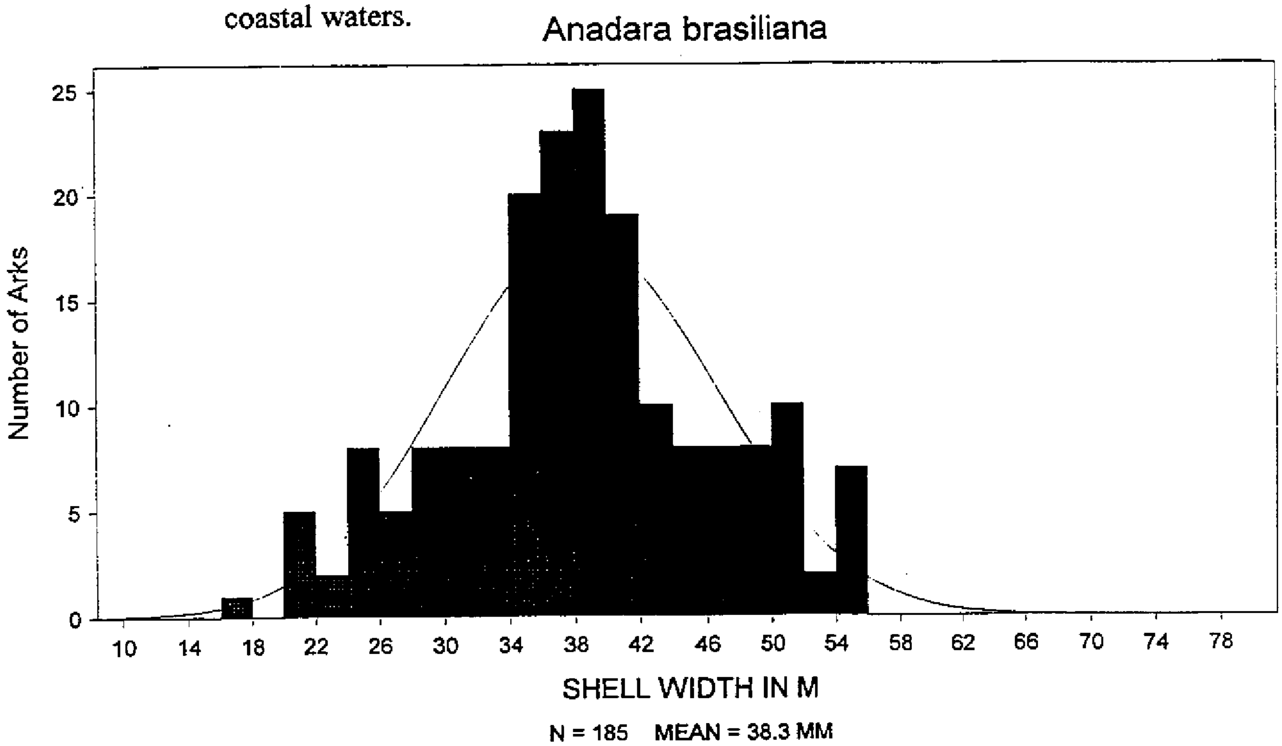

Figure 2. The shell width distribution of *Anadara brasiliana* collected from Georgia's coastal waters.

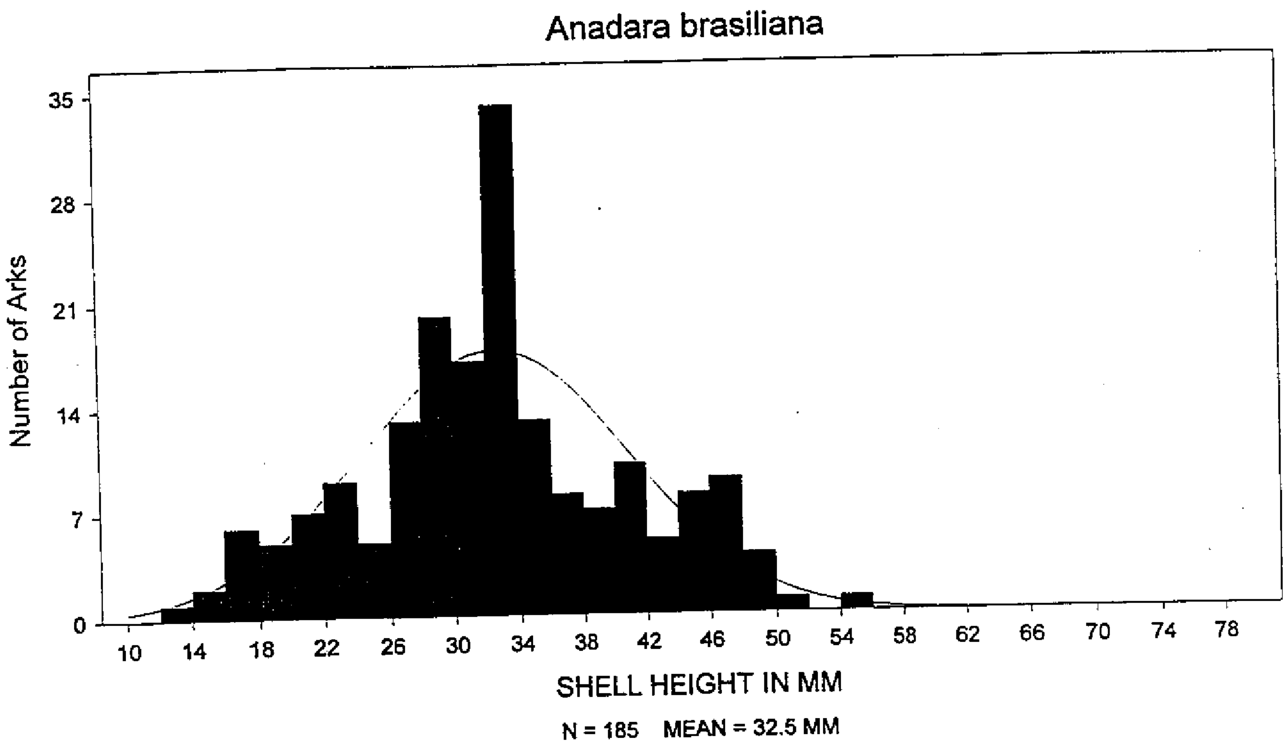

Figure 3. The shell height distribution of *Anadara brasiliana* collected from Georgia's coastal waters.

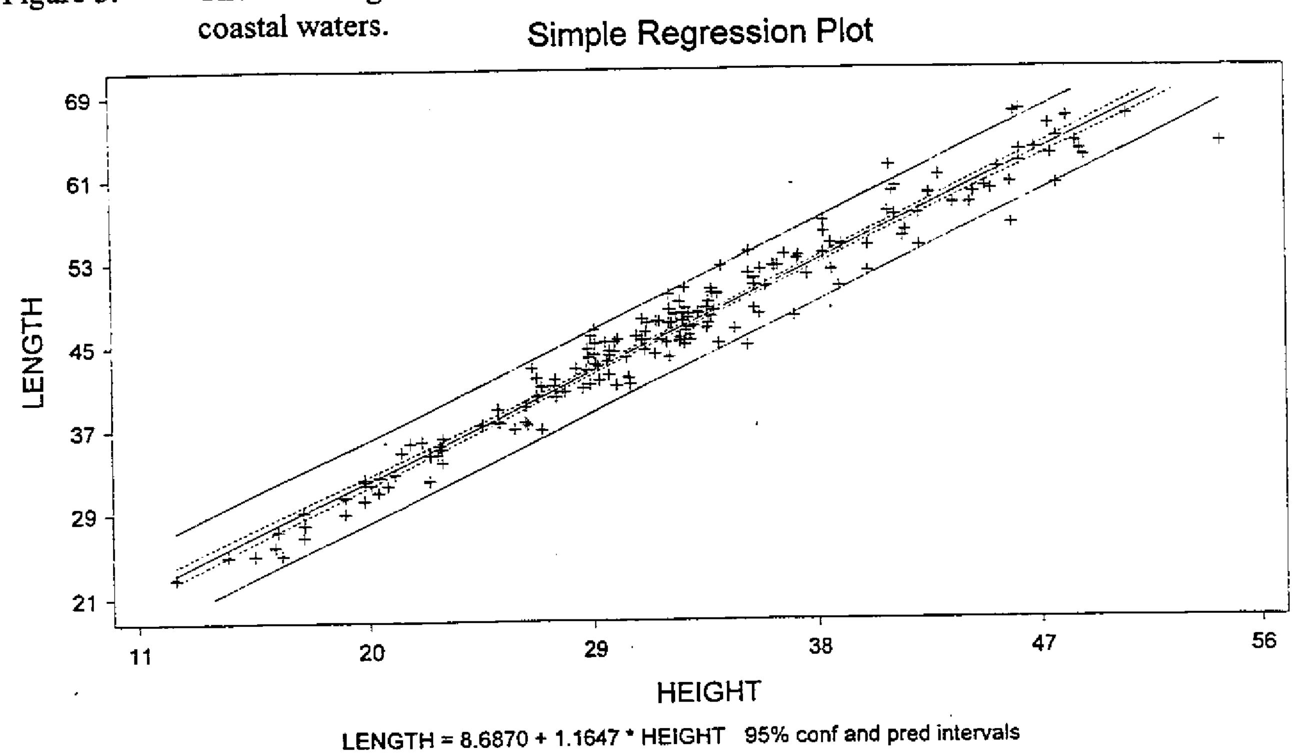

Figure 4. The relationship between shell length and shell height for *Anadara brasiliana*.

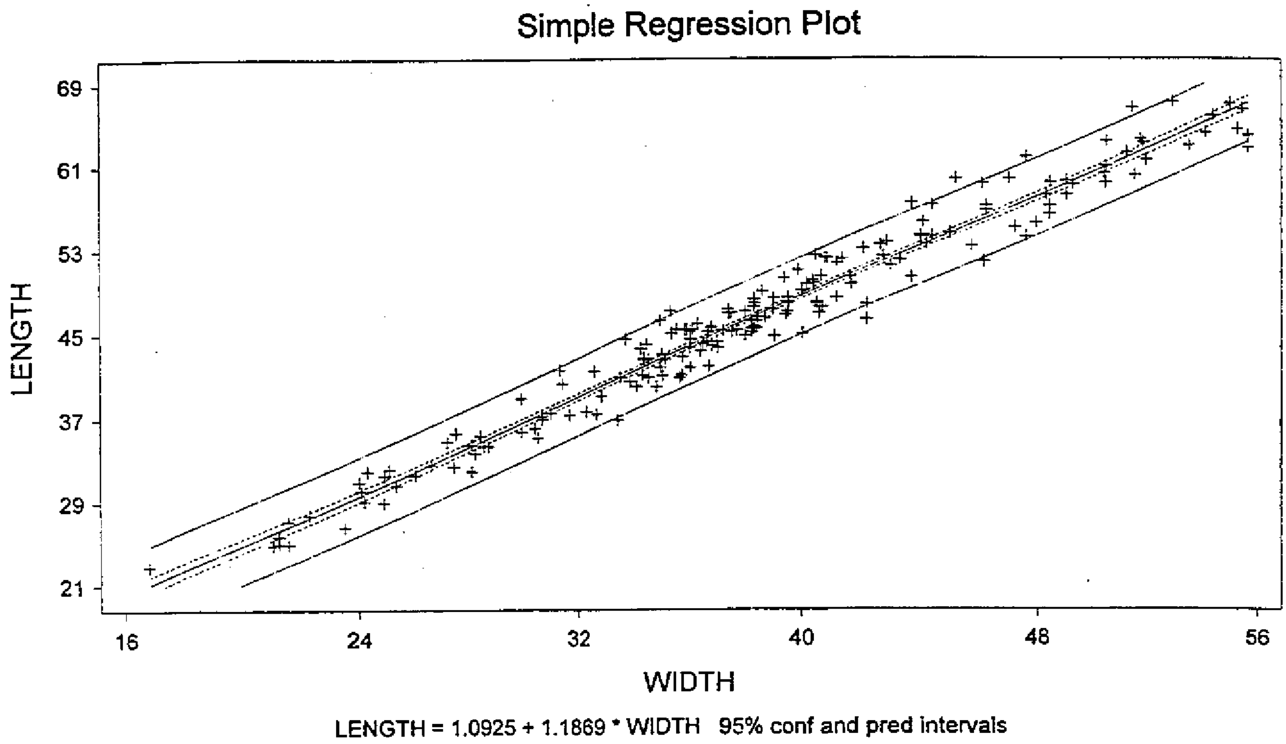

Figure 5. The relationship between shell length and shell width for *Anadara brasiliana*.

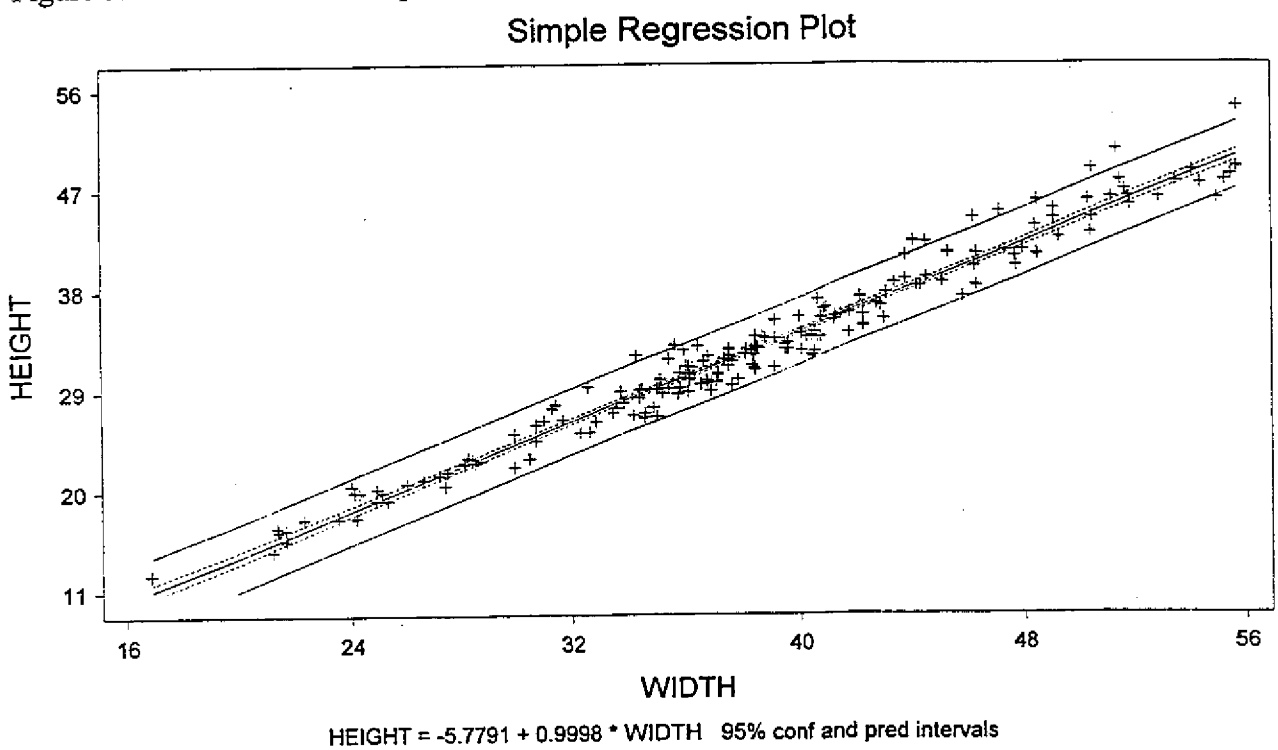

Figure 6. The relationship between shell height and shell width for *Anadara brasiliana*.

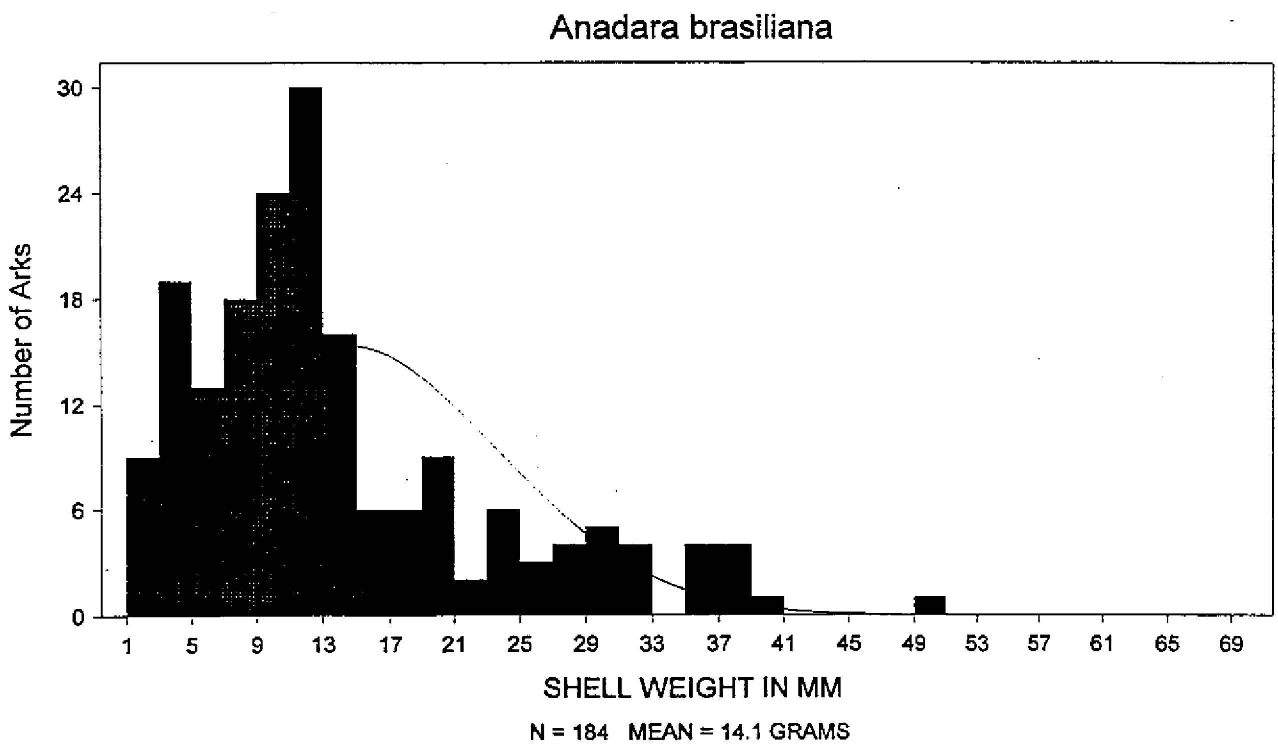

Figure 7. The shell weight in grams distribution of *Anadara brasiliana* collected from the coastal waters of Georgia.

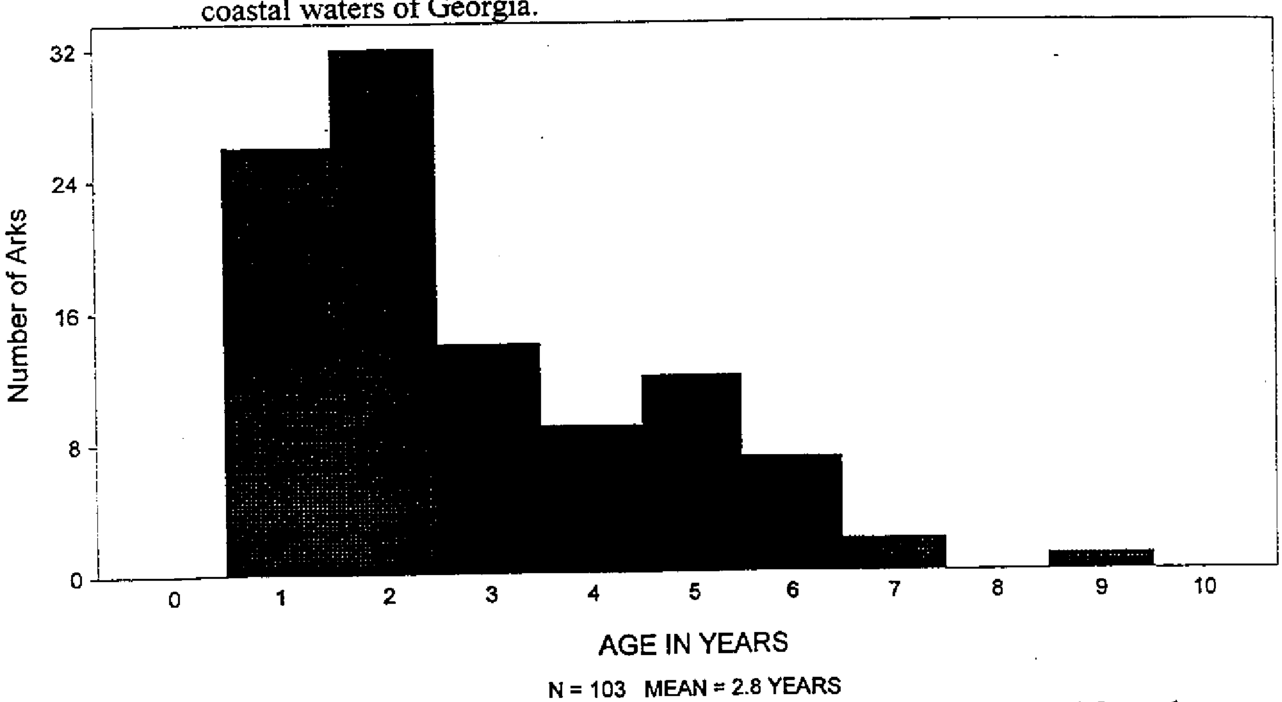

Figure 8. The age-class structure distribution of *Anadara brasiliana* collected from the coastal waters of Georgia.

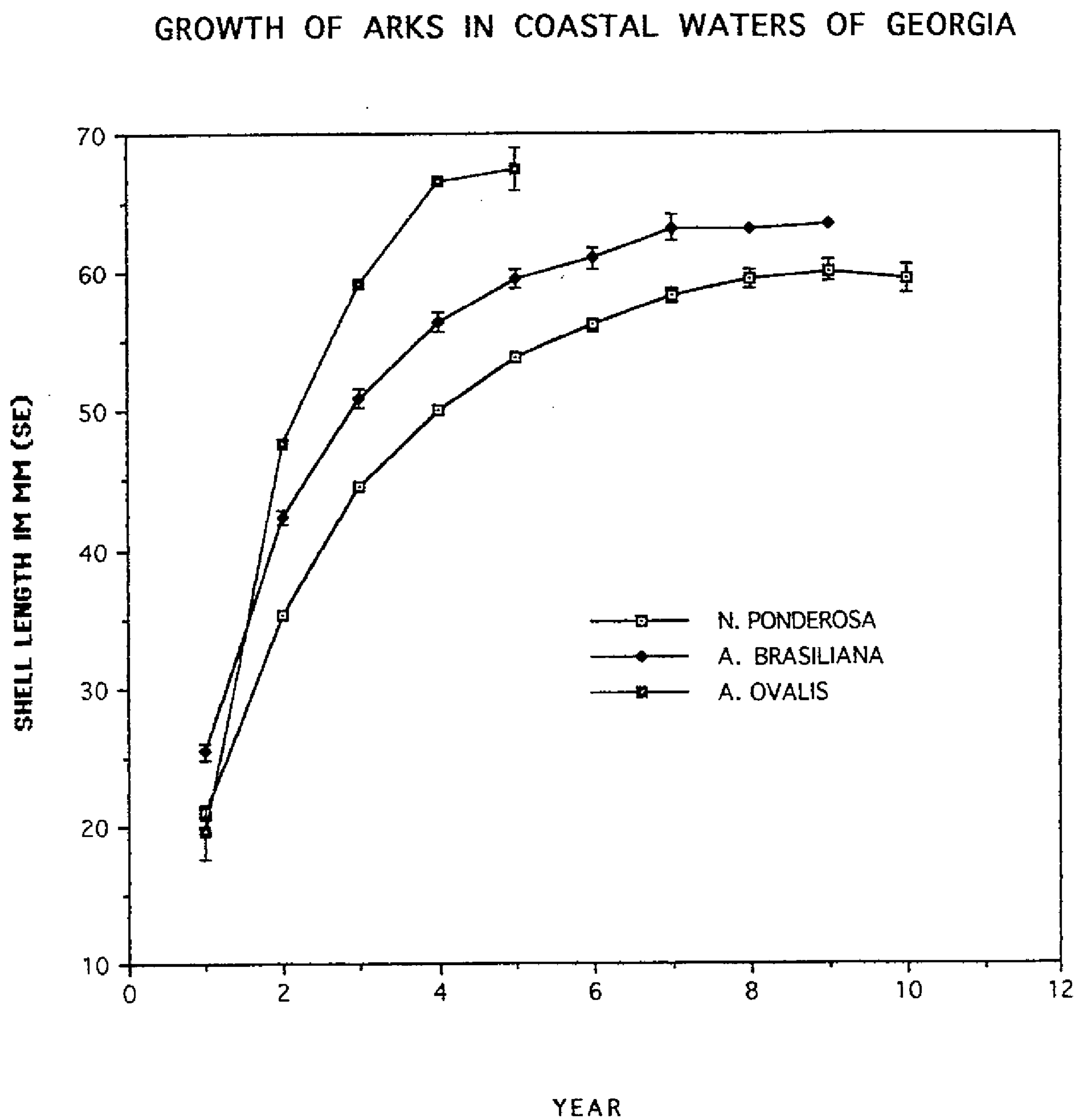

Figure 9. Mean shell length at each annual band for *Anadara brasiliana, Anadara ovalis*, and *Noetia ponderosa* collected from coastal waters of Georgia.

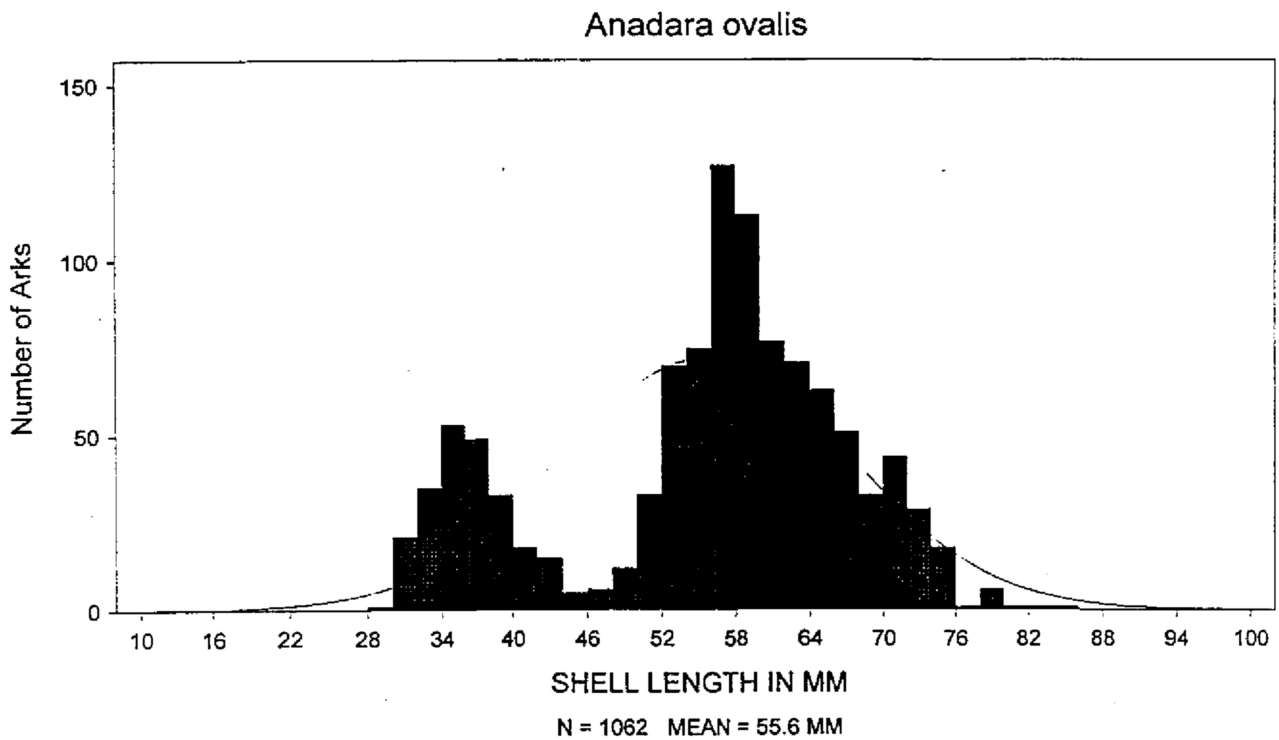

Figure 10. The shell length distribution of *Anadara ovalis* collected from the coastal waters of Georgia.

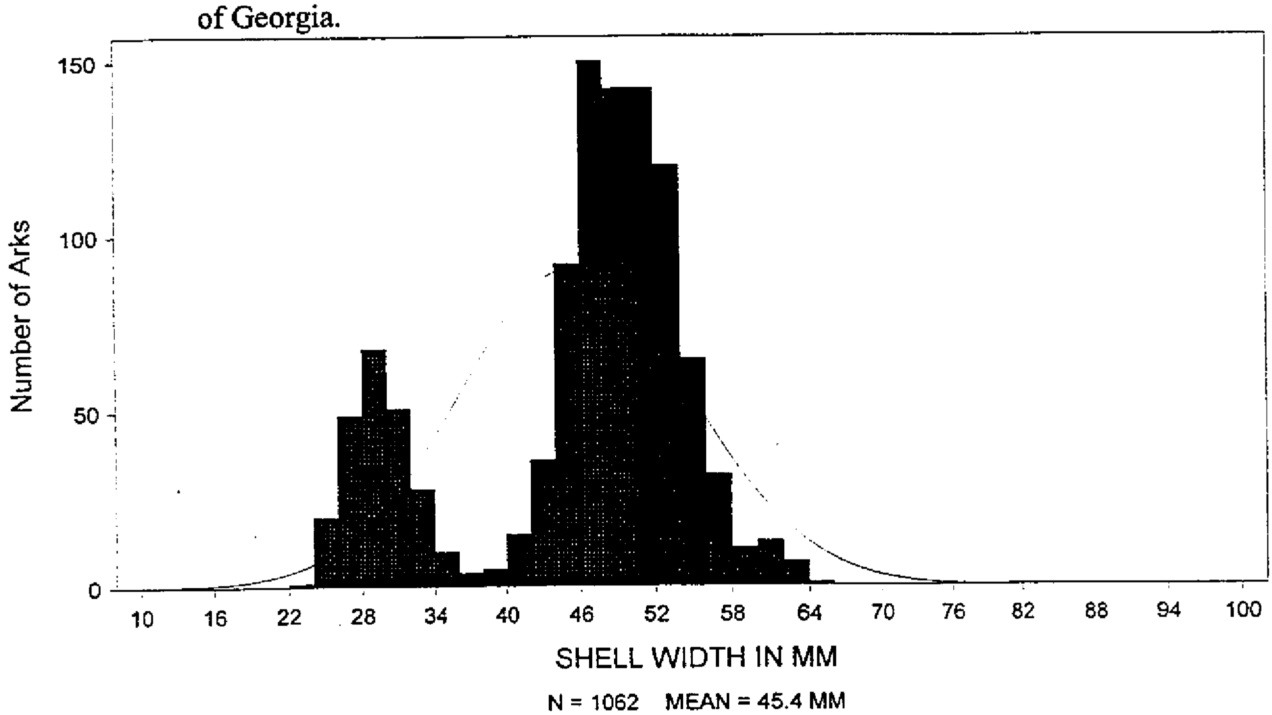

Figure 11. The shell width distribution of *Anadara ovalis* collected from the coastal waters of Georgia.

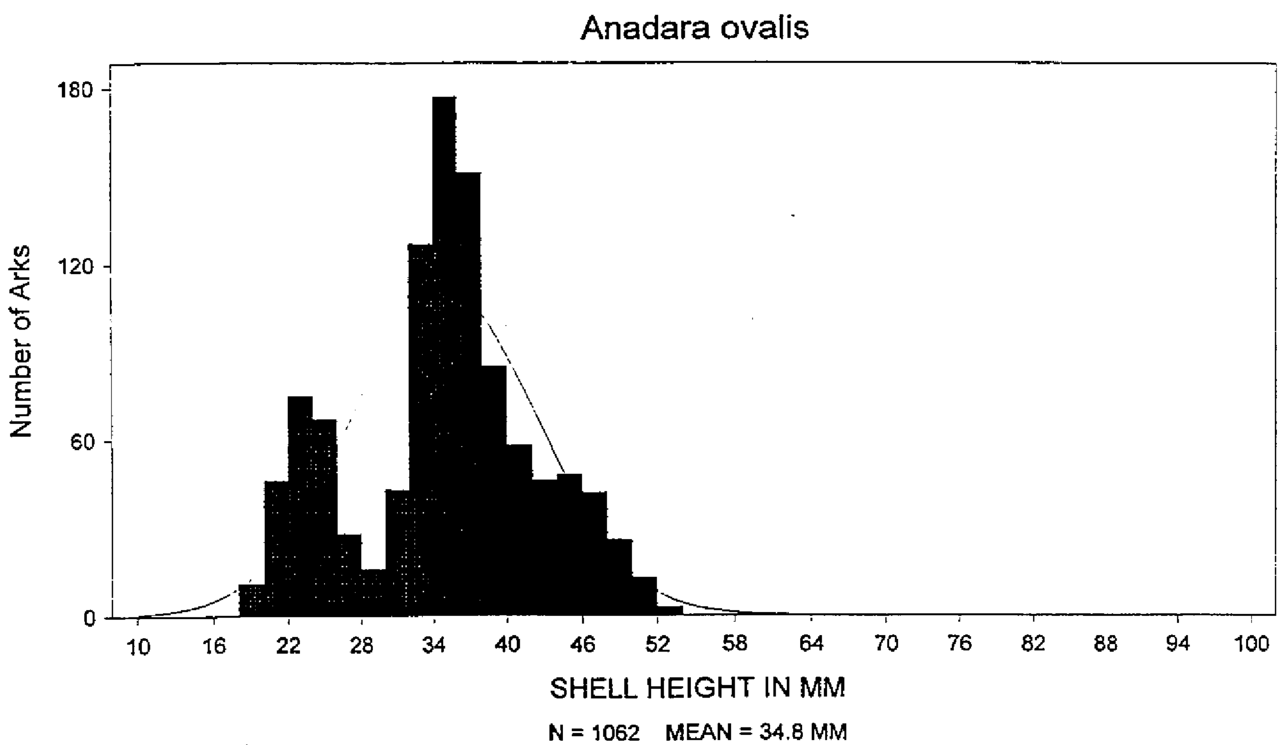

Figure 12. The shell height distribution of *Anadara ovalis* collected from the coastal waters of Georgia.

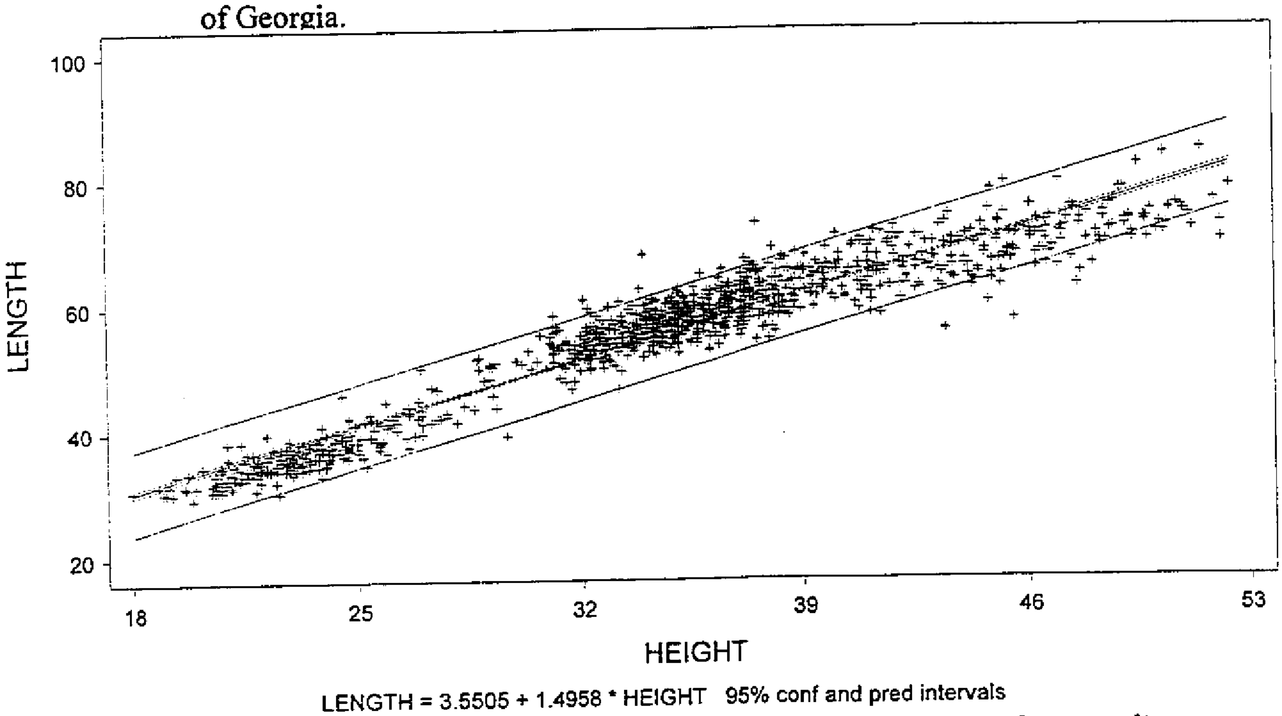

Figure 13. The relationship between shell length and shell height for *Anadara ovalis*.

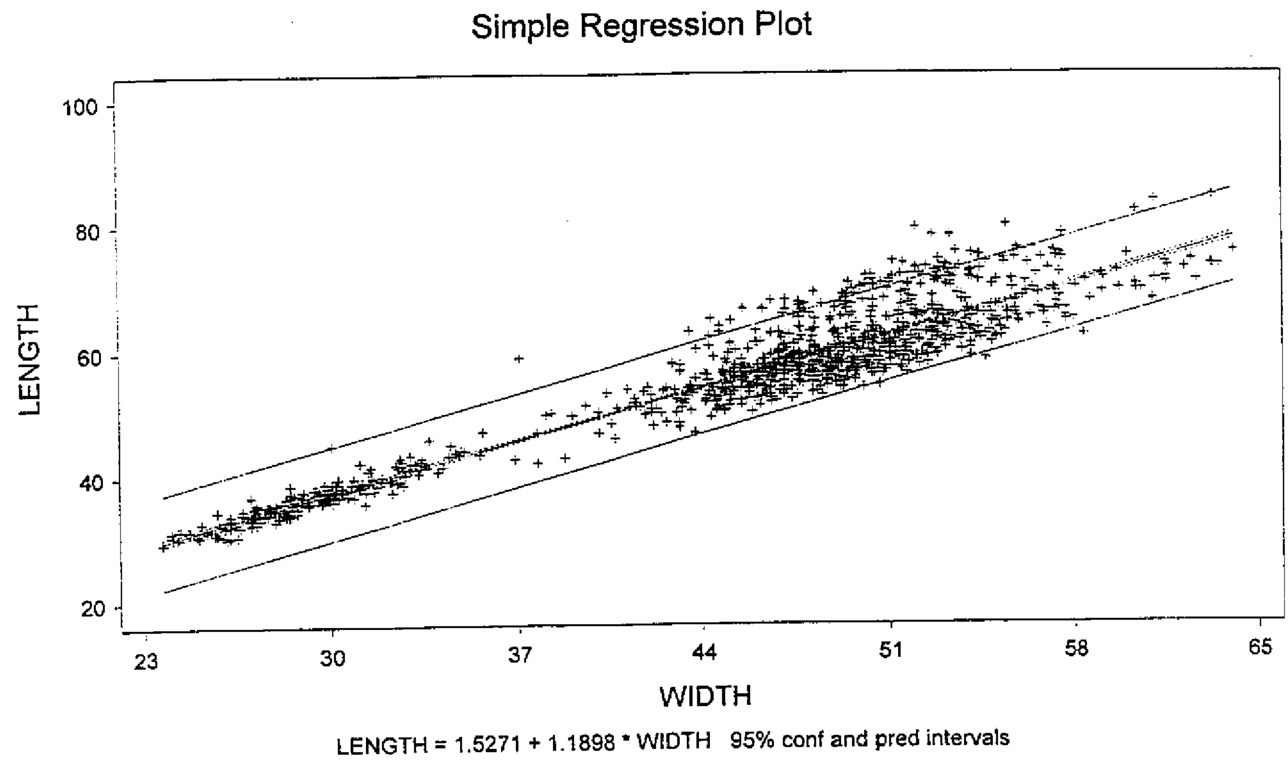

Figure 14. The relationship between shell length and shell width for *Anadara ovalis*.

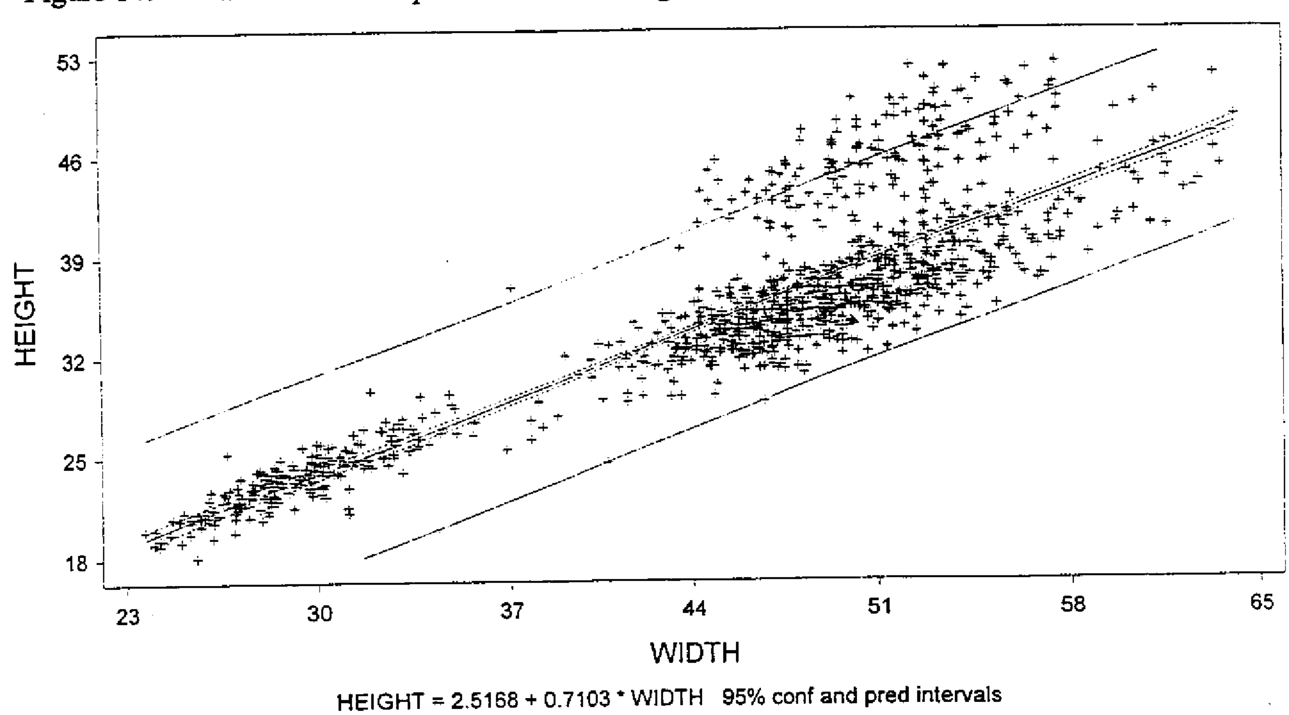

Figure 15. The relationship between shell height and shell width for *Anadara ovalis*.

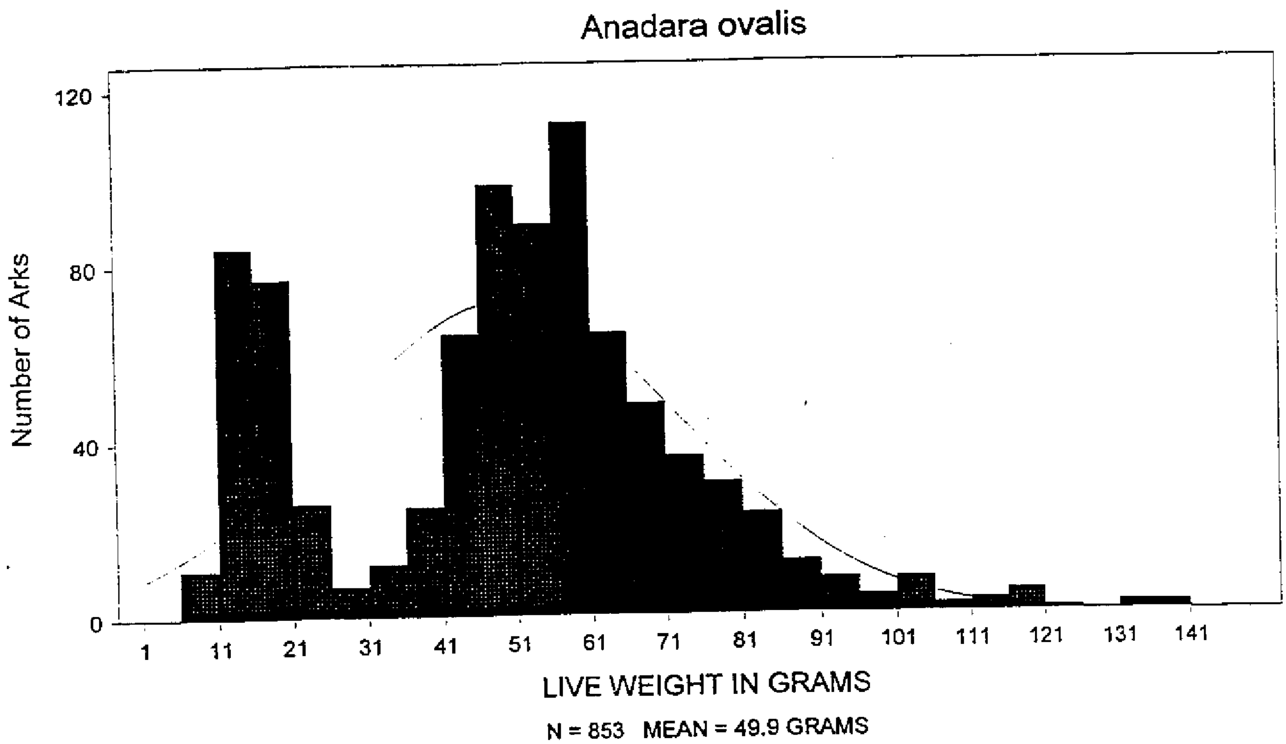

Figure 16. The live wet weight distribution of *Anadara ovalis* collected from Georgia's coastal waters.

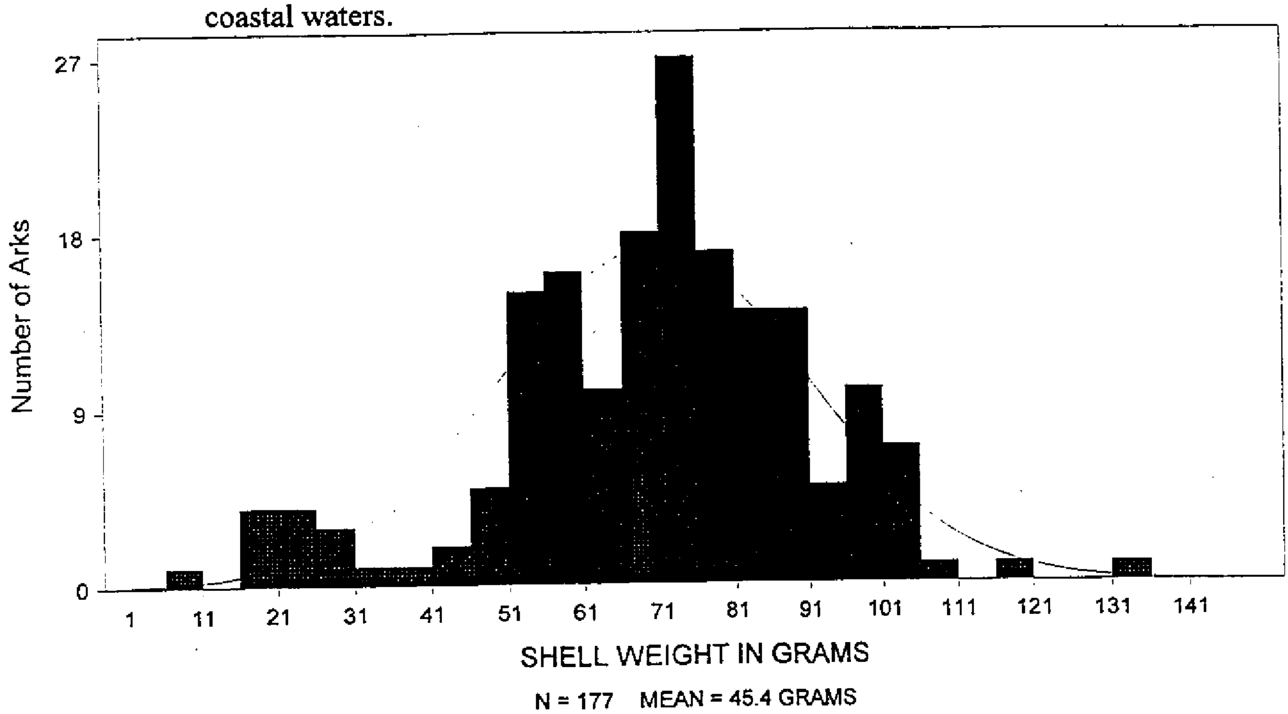

Figure 17. The shell weight distribution of *Anadara ovalis* collected from Georgia's coastal waters.

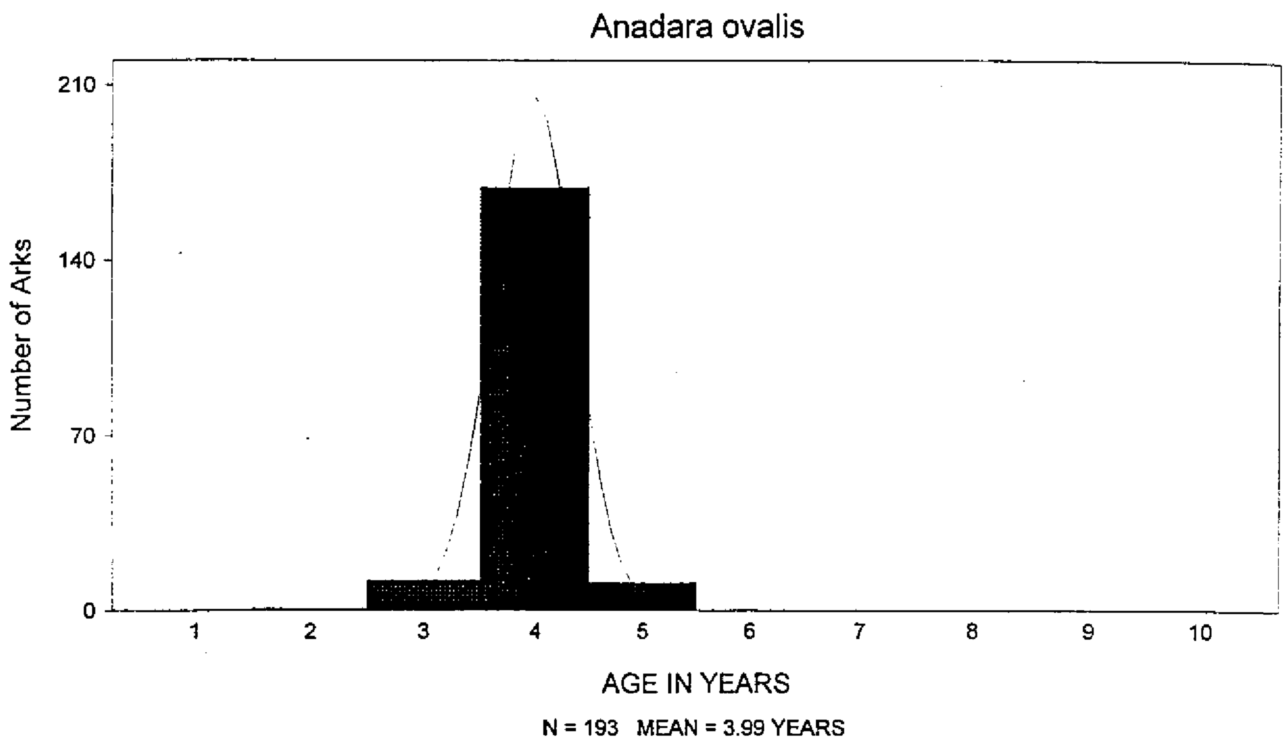

Figure 18. The age-class structure distribution of *Anadara ovalis* collected from Georgia's coastal waters.

Blood arks ranged in age from zero to five years with a mean and median ages of 4.0 and 4.0 years, respectively (Fig. 18). Blood arks grow faster than the other ark species (Table 2 and Figure 9) obtaining a mean size of 20 mm at age one and 47.7 mm at age two. Blood arks grow to a marketable size of 40 mm well prior to their second year of life.

<u>*Noetia ponderosa*</u>

Of the 1,048 ponderous arks collected, 821 were collected alive, while 114 were articulated shells. Ponderous arks ranged in shell length (Fig. 19) from 17.7 mm to 70.4 mm with a mean and median size of 59.8 mm and 60.7 mm, respectively. Shell width (Fig 20.) ranged from 11.2 mm to 55.9 mm with a mean and median size of 46.9 mm and 47.7 mm, respectively. They ranged in shell height (Fig. 21) from 14.8 mm to 56.3 mm with a mean and median size of 46.9 mm and 47.7 mm, respectively. Linear regressions calculated for each parameter are given in Table 1 and Figures 22, 23, and 24.

Ark clam live weights for both shell and meats are presented in Figure 25. Shell weights are presented in Figure 26. Live weights (N=821) ranged from 1.7 g to 156.2 g with a mean and median weight of 102.8 g and 106.4 g, respectively. Shell weights (N= 14) ranged from 53.1 g to 105.8 g with a mean and median weight of 70.4 g and 71.4 g, respectively. The shell weight of a ponderous ark is heavier per standard size than the shell weights of the other two ark species. The relationships between live wet weight and shell weight of ponderous arks according to shell length are given in Table 1. Ponderous arks grow more slowly than the other ark species (Table 3 and Figure 9), obtaining a mean size of 21 mm at age one, 35.3 mm at age two, and 44.6 mm at age three. The slow-growing ponderous reaches a marketable size of 40 mm by its third year in Georgia.

Of 586 ponderous arks examined for associated epifauna, 15.2% had one to five species of organisms attached to their outer shells (Table 2). The coral *Astrangia danae* was attached to 11% of the arks either singularly (8.2%) or in conjunction with other organisms. Likewise, *Cliona* infested 5.1% of the shells. Other organisms included the shell boring clam *Diplothyra smithii* (1.5%), the oyster *Ostreola equestris* (0.68%), and unidentified snail eggs (0.3%).

<u>Proximate Analysis</u>

Mean proximate analyses for the blood ark, *Anadara ovalis*, and the ponderous ark, *Noetia ponderosa,* were as follows:

Ark Clam Species	% Moisture	% Protein	% Ash
Anadara ovalis	87.25	10.88	2.05
Noetia ponderosa	83.11	8.67	3.09
Mixed Clam (USDA)	81.82	12.77	1.87

Table 2. Mean shell length at each annual band for *Anadara brasiliana, Anadara ovalis*, and *Noetia ponderosa* collected from Georgia's coastal waters

	Noetia ponderosa		*Anadara brasiliana*		*Anadara ovalis*	
Annual Band	Number of arks	Shell Length mm ± SE	Number of arks	Shell Length mm ± SE	Number of arks	Shell Length mm± SE
1	87	21.0 ± 0.45	100	25.4 ± 0.54	16	19.6 ± 1.97
2	87	35.3 ± 0.40	78	42.3 ± 0.58	189	47.7 ± 0.33
3	85	44.6 ± 0.37	43	50.9 ± 0.62	188	59.1 ± 0.29
4	85	50.1 ± 0.35	33	56.4 ± 0.65	174	66.5 ± 0.36
5	74	53.8 ± 0.38	21	59.5 ± 0.67	10	67.4 ± 1.58
6	53	56.2 ± 0.46	10	61.0 ± 0.78		
7	36	58.3 ± 0.59	3	63.2 ± 1.00		
8	22	59.5 ± 0.70	1	63.1		
9	18	60.1 ± 0.80	1	63.4		
10	12	59.5 ± 1.00				

Table 3. Associated epifauna found attached to shells of 586 Ponderous Arks, *Noetia ponderosa*, harvested from approximately 5 miles offshore of St Simons Sound, GA.

Epifauna	Number of ark fouled	Percentage fouled
Astrangia danae	49	8.36
Cliona celata	15	2.56
Diplothyra smithii	6	1.02
Ostreola equestris	1	0.17
Unidentified snail eggs	2	0.34
Diplothyra and *Astrangia*	1	0.17
Cliona and *Astrangia*	8	0.51
Astrangia and *Ostreola*	1	0.17
Cliona and *Diplothyra*	2	0.34
Cliona, Astrangia, and *Ostreola*	2	0.34
Cliona, Astrangia, and Diplothyra	3	0.51

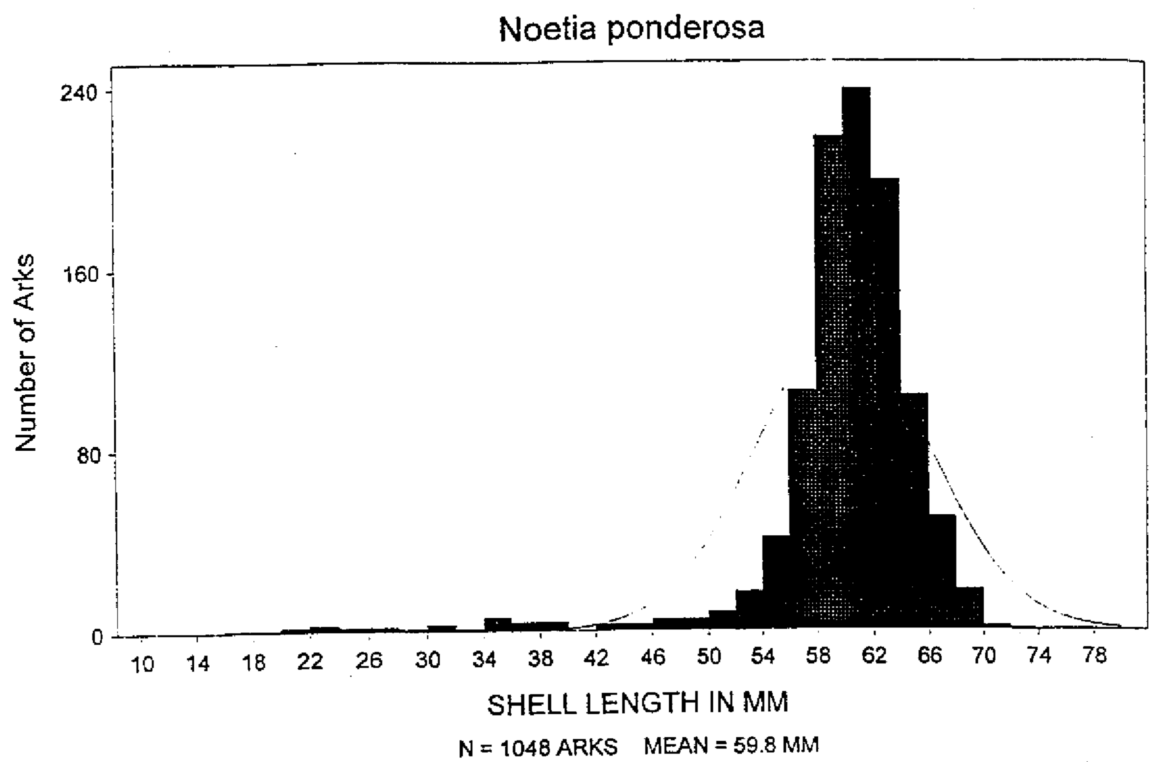

Figure 19. The shell length distribution of *Noetia ponderosa* collected from Georgia's coastal waters.

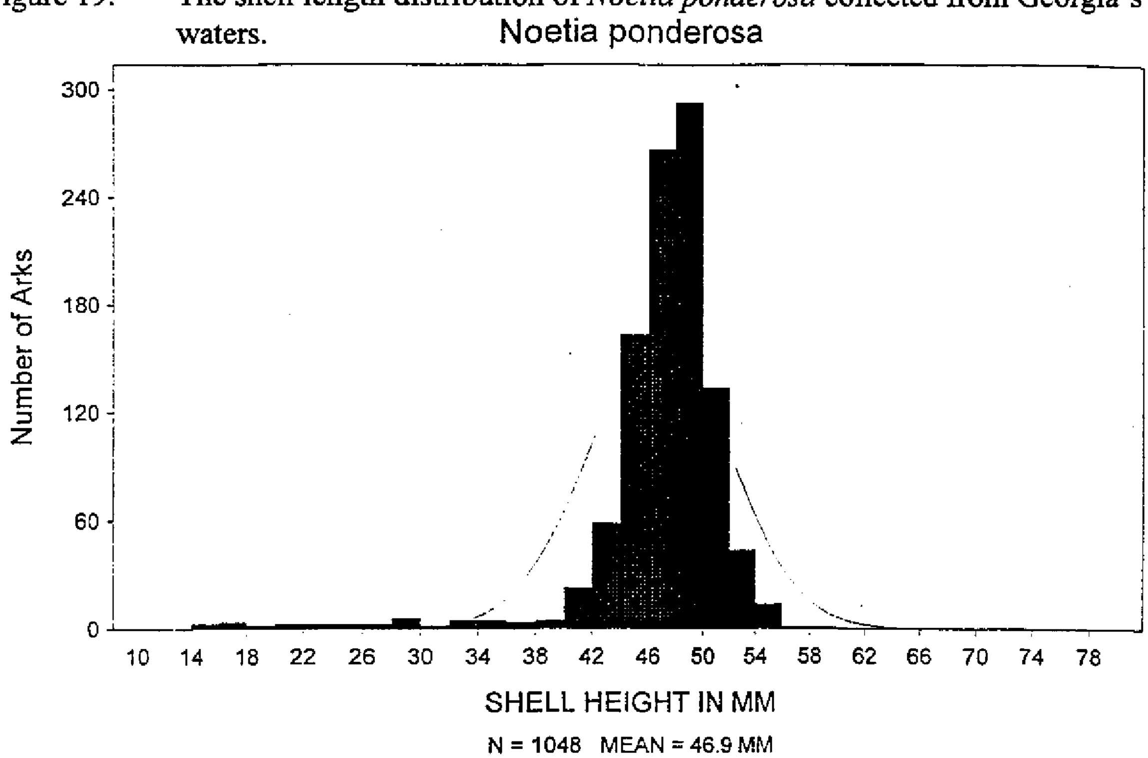

Figure 20. The shell height distribution of *Noetia ponderosa* collected from Georgia's coastal waters.

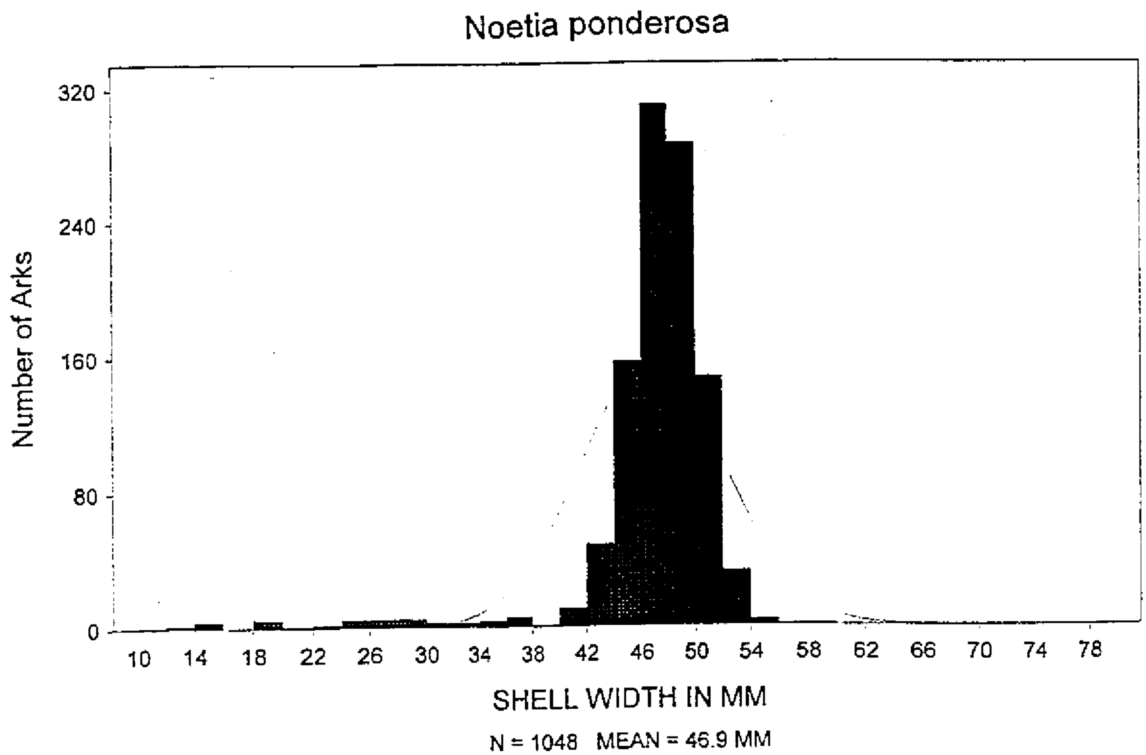

Figure 21. The shell width distribution of *Noetia ponderosa* collected from Georgia's coastal waters.

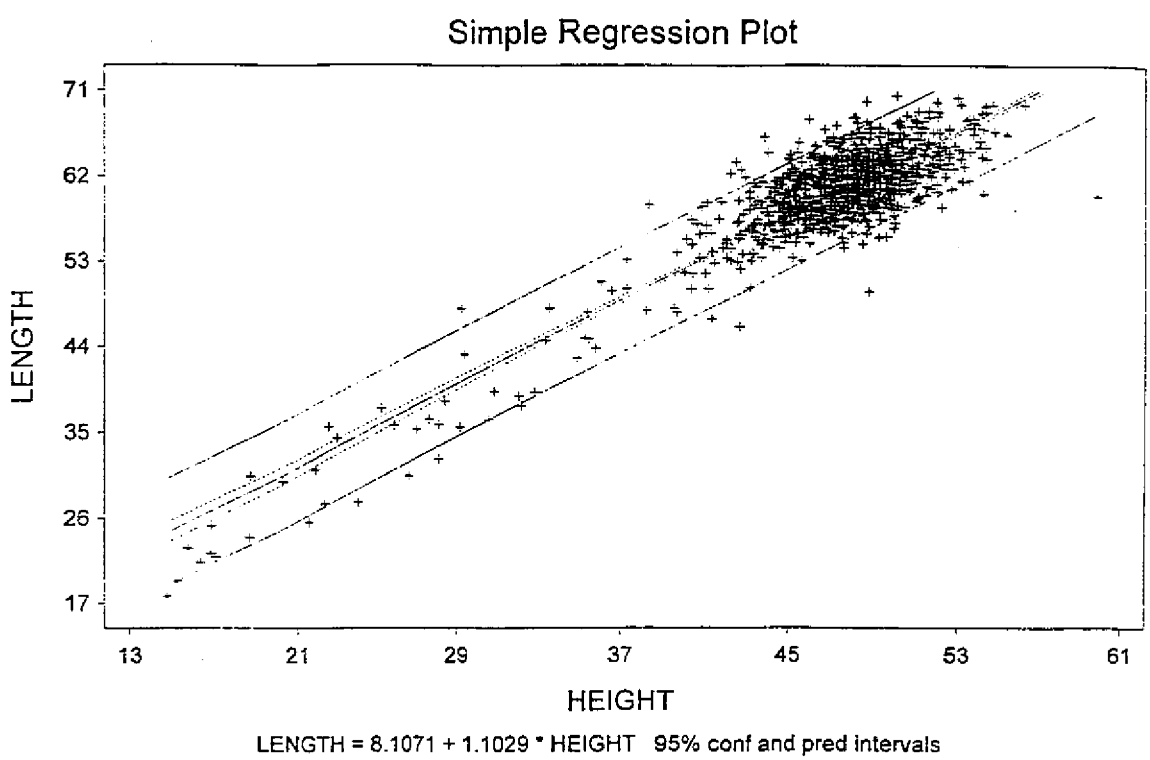

Figure 22. The relationship between shell length and shell height for *Noetia ponderosa*.

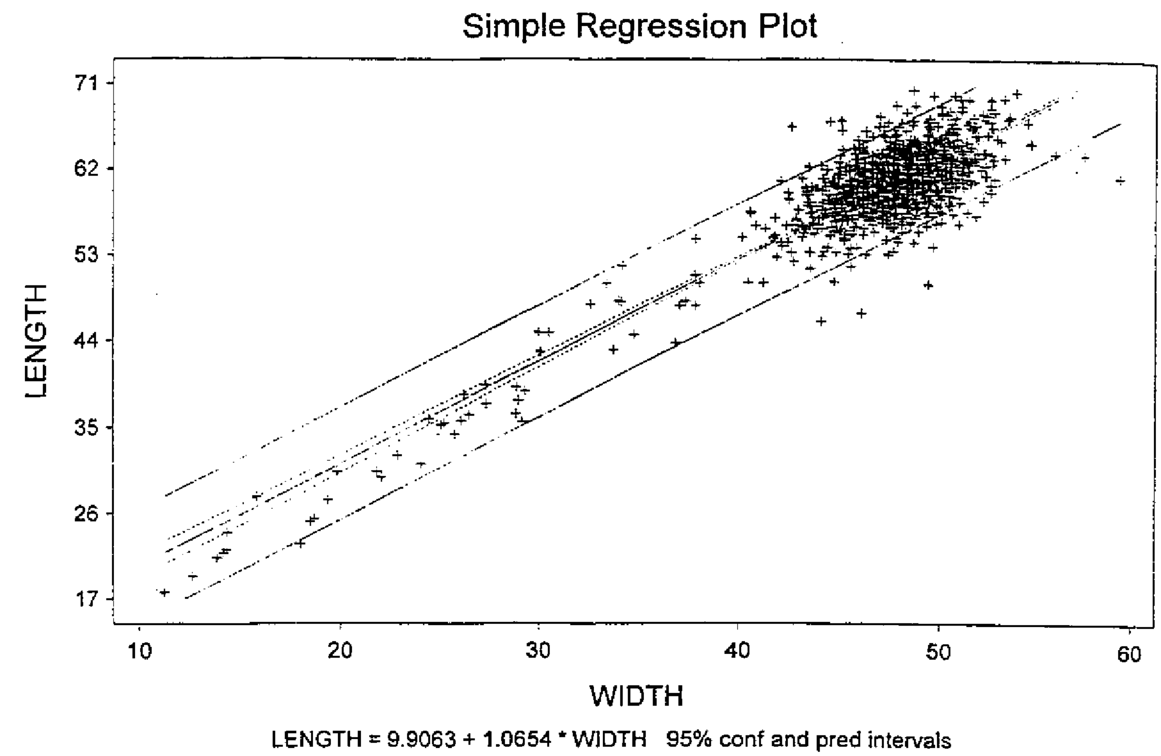

Figure 23. The relationship between shell length and shell width for *Noetia ponderosa.*

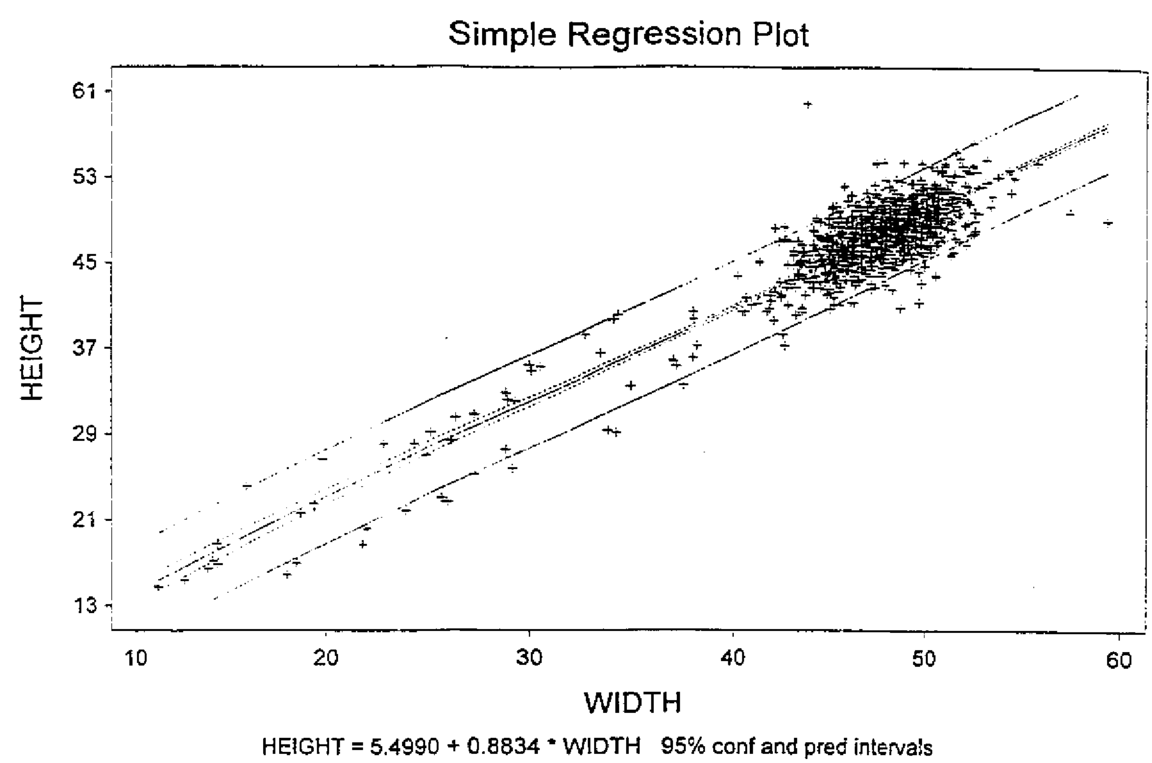

Figure 24. The relationship between shell height and shell width for *Noetia ponderosa.*

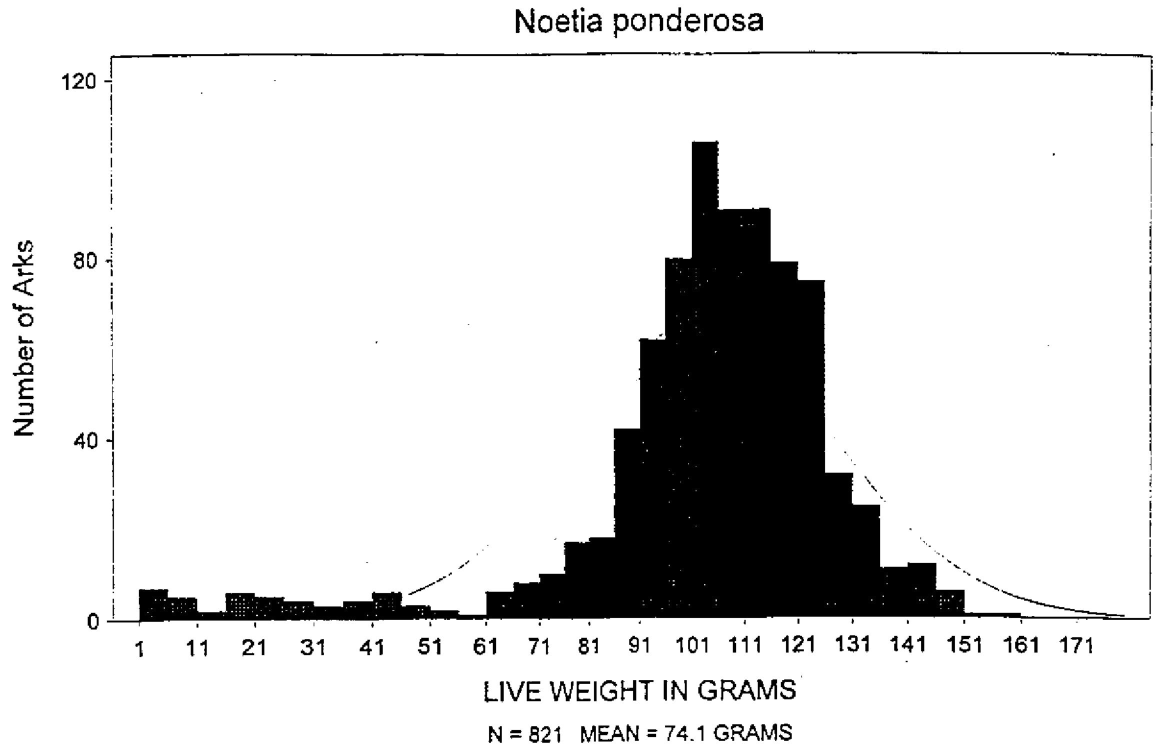

Figure 25. The live wet weight distribution of *Noetia ponderosa* collected from Georgia's coastal waters.

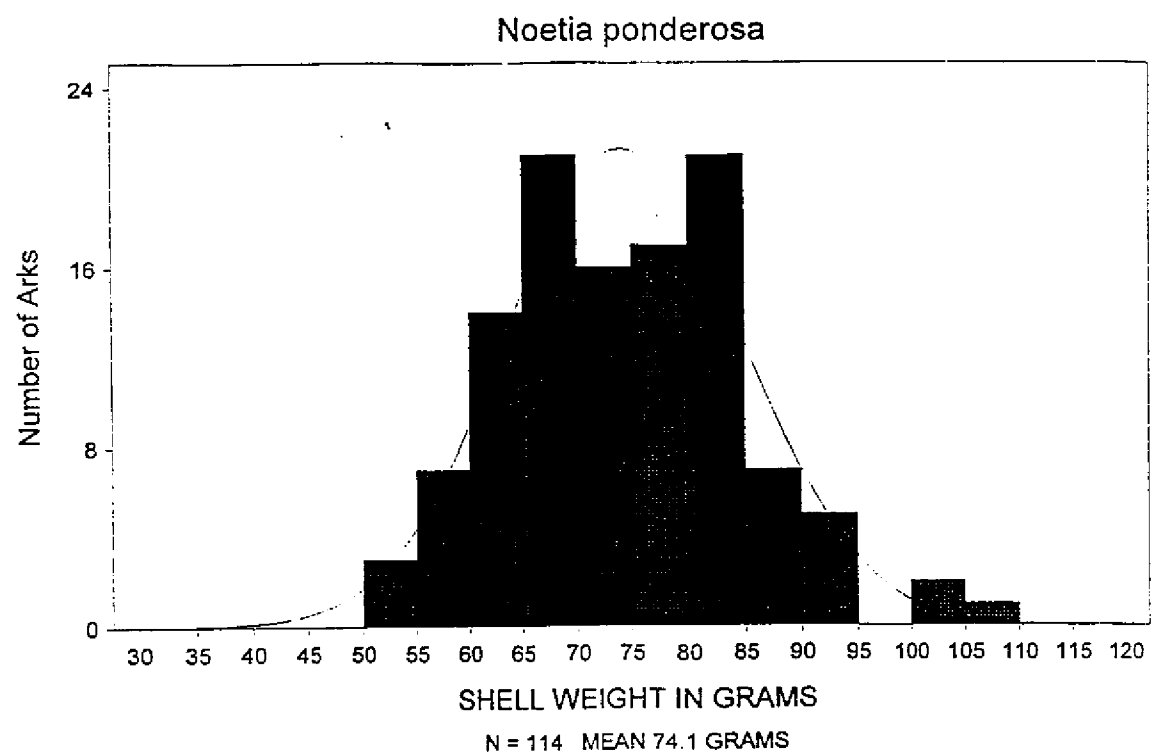

Figure 26. The shell weight distribution of *Noetia ponderosa* collected from Georgia's coastal waters.

The moisture content of the blood ark was greater than the moisture found in the ponderous ark. Moisture levels were higher for both arks than that of a mixed species of clams used as a nutritional reference by the U.S. Department of Agriculture (USDA Web Site, www.nal.usda.gov/fnic/cgi-bin/list_nut.pl). The ponderous ark had less available protein than the blood ark and both contained less protein than the standard USDA clam mixture used as reference.

Marketing

Attempts to market arks from Georgia by Sapelo Seafarms and DeWitt Seafood proved unsuccessful. Efforts to sell the arks through Virginia dealers were at first met with enthusiasm, but the buyers were only interested in consistent supply. Georgia marketers had a limited ark supply and could not provide consistent quantities of arks for a long-term sales commitment. The demand for the product was there, but Georgia suppliers were not able to supply the arks in sufficient numbers to attract state and regional marketers.

DISCUSSION

The results of this ark survey in Georgia were similar to findings in South Carolina (Anderson et al., 1984). Incongruous arks occur along the coastal beaches, primarily in a sandy substrate, to approximately two miles offshore. Blood arks are found in muddy-sandy substrates within the sounds and rivers to just offshore of the mouths of the sounds. The ponderous ark occurs primarily in offshore areas in bottoms containing shell debris. Few live incongruous arks were collected during this survey, but this is probably a result of the type of net used to perform the survey. The conch net used does not perform well in hard sand bottoms. Incongruous arks dwell in sand bottoms close to the beaches. Commercial quantities of both the blood and ponderous arks were found; however, the likelihood of developing a commercial fishery for arks in Georgia is low.

The number of arks found in Georgia was fewer than the number found during a South Carolina survey (Anderson et al., 1984). South Carolina's survey used an escalator harvester to sample for arks. Escalator harvesters are very efficient mechanisms for harvesting marine bivalves. The conch nets used primarily in this study do not efficiently harvest burrowing bivalves. It is extremely unlikely that Georgia Department of Natural Resources would allow the use of escalator harvesters in Georgia waters. The only commercial option for Georgia fishermen is the use of conch nets. The nets worked well for blood arks found in muddy substrates and in the offshore area where ponderous arks were located. Conch nets will not work in areas where the incongruous arks dwell, i.e., sand substrates.

There are several reasons why a commercial ark fishery in Georgia is unlikely. Most ark beds located during this survey were small in overall area. The authors believe that these areas would be easily overfished. As happened in Virginia, Georgia fishermen would rapidly deplete the standing stocks of arks if a commercial fishery was developed. The incongruous ark is found adjacent to the barrier island beaches in a sandy substrate. Conch nets are not designed to work efficiently in a sandy bottom. Many of the larger shrimp boats will be unable to operate in the shallow waters adjacent to the beaches.

An additional problem with developing an ark fishery in Georgia is the location of most ark beds in uncertified state shellfish growing waters. Through state budget cuts in recent years, the Georgia Department of Natural Resources has curtailed its water quality sampling in large portions of our state's historically available shellfish growing areas. Vast areas which were certified as safe for the harvesting of shellfish have been closed. Most of these areas are still safe and productive shellfish areas, but without the proper water quality sampling, they will remain closed to shellfish harvesting.

A large ponderous ark bed was located approximately 5 miles offshore in the Brunswick Channel. Fishermen informed us of this bed, and initial trawls produced large quantities of ponderous arks. In May 1998, when we returned to this bed to gather arks for marketing trials, we found few living arks, but tremendous numbers of dying and recently dead arks. Ark shells were still articulated and decaying meat was still present in many shells. Most arks were of large size, but a wide range of apparent age-classes was present among the dying arks. Collected live arks transported to estuaries for relaying in certified shellfish growing areas soon died as well. The cause of the ark mortality is unknown.

Little life-history information exists for ark populations in the United States. Virtually no information other than broad distribution data from taxonomical guides is available for ark species, including the ponderous ark, *N. ponderosa*. Ponderous arks occur from Virginia to Florida and to Texas (Abbott, 1974). Loosanoff and Davis (1963) and Chanley and Andrews (1971) described the spawning and larval development of the transverse ark, *Anadara transversa* (Say, 1822). Loosanoff et al. (1966) described the various larval size dimensions of *A. transversa*. Larvae found in the water column showed *A. transversa* spawned from May to September. The ponderous ark, *N. ponderosa*, was reported to spawn from June to December (Chanley and Andrews, 1971). Larval development of *N. ponderosa* was investigated in Virginia (Chanley, 1966; Chanley and Andrews, 1971). Growth rates and ages were calculated for *N. ponderosa* and *A. ovalis* from Virginia waters. *A. ovalis* is considered a possible aquacultural species because of its greater growth rate compared to *N. ponderosa* (McGraw and Castagna, 1994). In Virginia, blood arks were suspended from rafts in October at a mean size of 14.5 mm and grew 2.7 mm by the following June (McGraw and Castagna, 1994). Little is known about the life history traits of ark populations in southeastern U.S. coastal waters.

Blood arks from wild stocks in Georgia were aged to five years. The mean age of the arks collected during this survey was four years with only 10 (5.2%) individuals being five years of age. In Virginia only five (3.2%) recovered individuals were aged five years. Our findings concerning the age structure of blood arks in Georgia agree with those from Virginia (McGraw et al. 1996). Blood arks have a maximum life span of five years.

Growth of arks in Georgia was determined from the analysis of growth checks or annual bands on the outer shells of animals. Growth bands were fairly obvious on all three species of arks. However, they became hard to read in older *Noetia* individuals, which precluded our reporting of their age structure. The growth bands of *A. ovalis* are known to be annual bands laid down during periods of slow growth in winter (Walker 1999). These winter bands were verified by following the growth of juvenile wild-caught arks held in nets over a three-year period. The bands in *N. ponderosa* and *A. brasiliana* have not been verified as actual annual bands, but the authors believe they represent annual bands.

Ponderous arks in Georgia appear to be longer lived than other ark species. A few shells were aged to 10 years, but bands beyond ten years became very difficult to read. It appeared by visual inspection of the outer shell's growth checks that most of the *N. ponderosa* collected in Georgia were older than 10 years. Bands beyond ten years occur very close together and the periostracum prevents clear recognition of the bands. Shell sectioning techniques and acetate peels are required to generate accurate estimates of age for this clam. In Virginia, McGraw et al. (1996) were able to age this ark to 14 years by using acetate peels.

In Georgia, The Shellfish Aquaculture Laboratory has investigated the growth and life history of the blood ark, *A. ovalis*, in an attempt to determine the potential of developing an aquacultural fishery for this species. Our work shows that inshore blood arks live approximately two and one-half years. The arks grow rapidly from set in August though September to a size of 40 mm within one year when cultured in pearl nets (Walker 1999). In Georgia, arks suspended in pearl nets in October grew from 14.2 mm to 17.5 mm by January. The arks grow to 30 mm by June and to 38.5 mm by September (Walker 1998).The rapid growth in Georgia is contrasted with the same amount of growth in Virginia arks after eight months (McGraw and Castagna, 1994). Preliminary reproductive analysis shows that the blood ark can attain sexual maturity within three months of setting. We are presently documenting the reproductive cycle of this animal from the coastal waters of Georgia (Walker, unpublished data). Arks grow more rapidly in Georgia (Walker 1999) than in Virginia, where growth studies led researchers to believe that the blood ark showed good potential as a cultured species (McGraw and Castagna, 1994).

Growth of *A. ovalis* and *N. ponderosa* in Georgia is more rapid than observed for arks from Virginia's wild stocks. *N. ponderosa* attains a mean size of 44.6 mm in shell length by year three in Georgia. Virginia arks require an additional year to attain a mean size of 45.1 mm in shell length (McGraw et al. 1996). Similarly, Georgia *A. ovalis* individuals attain a mean size of 47.7, 59.1, and 66.5 mm in shell length in years 2, 3, and 4, respectively, compared to 40, 46.2, ad 47.5 mm in shell length for arks in Virginia.

REFERENCES

Abbott, R.T. 1974. American Seashells, second edition. Van Nostrand Reinhold Co., New York 663 pp.

Anderson, W.D., W.H. Lacey, III and A.G. Eversole. 1984. An investigation concerning the feasibility of harvesting and marketing underutilized *Anadara* off the coasts of South Carolina and Georgia. Report prepared for the Gulf and South Atlantic Fisheries Development Foundation under Grant Contact No. CASAFDI 22-18-17320

Anderson, W.D. and A.G. Eversole. 1985. Arks - is there a resource and a market? Journal of Shellfish Research 5: 31 (Abstract).

Baqueiro, E.C. 1989. Clam culture in Mexico: Past, present and future. In Manzi, J.J. and M.A. Castagna (Eds.), pp. 383-394, Clam Mariculture in North America, Elsevier, New York.

Baqueiro, E.C., M.D. Mucino and R.M. Merino. 1982. Analisis una poblacion de Pata de Mula *Anadara tuberculosa* sujeta a explotacion intensiva en la Bahia de la Paz, Baja California Sur, Mexico. Ciencia Pesquera Instito Nacional de la Pesca, Mexico 3: 75-82.

Broom, M.J. 1985. The biology and culture of marine bivalve mollusc of the genus *Anadara*. ICLARM, International Center for Living Aquatic Resources Management, Manila, Philippines. ICLARM Studies and Reviews 12, Contribution No. 263, 37 pp.

Chanley, P. 1966. Larval development of the large blood ark, *Noetia ponderosa* (Say). Proceedings of the National Shellfisheries Association 56: 53-58.

Chanley, P. and J.D. Andrews. 1971. Aids for identification of bivalve larvae of Virginia. Malacologia 1: 45-119.

Cummins, R. 1971. Calico scallops of the southeastern United States, 1959-69. U.S. Department of Commerce, N.O.A.A., National Marine Fisheries Service, Special Scientific Report-Fisheries No. 627. 22 pp.

FAO, 1995. Fishery statistic catches and landings. Vol 76. Food Agriculture Organization of the United Nations. Rome 1995.

Loosanoff, V.L. and H.C. Davis. 1963. Rearing of bivalve mollusks. Advances in Marine Biology 1: 1-136.

Loosanoff, V.L, H.C. Davis and P. Chanley. 1966. Dimensions and shapes of larvae of some marine bivalve mollusks. Malacologia 4: 351-435.

Manzi, J.J. and M.A. Castagna. 1989. Clam Mariculture in North America. Elsevier, New York 461 pp.

McGraw, K. and M.A. Castagna. 1994. Some observations on arkshell clams, *Noetia ponderosa* and *Anadara ovalis*, and implications for fisheries Management. Virginia Sea Grant College Program, Technical Report VSG-94-11.

Moyer, M.A., N.J. Blake and W.S. Arnold. 1993. An ascetosporan disease causing mass mortality in the Atlantic calico scallop *Argopecten gibbus* (Linnaeus, 1758). Journal of Shellfish Research 12: 305-310.

Nie, Z.-Q. 1990. The culture of marine bivalve mollusks in China. In: Menzel, R.W. (ed.), pp. 261-276, Estuarine and Marine Bivalve Culture. CRC Press, Inc., Boston

O'Bannon, B.K. 1995. Fisheries of the United States, 1994. Current Fishery statistics No. 9400. U.S. Department of Commerce, National Marine Fisheries Service, Washington, D.C.

Schwartz, F.J. and H.J. Porter. 1977. Fishes, macroinvertebrates, and their ecological interrelationships with a calico scallop bed off North Carolina. Fishery Bulletin 75: 427-446.

Umezawa, S. 1992. Experimentation to improve recruitment of blood ark shell, *Scapharca broughtonii*, in the Seto Inland Sea. NOAA Technical Report NMFS 106:105-114.

Walker, R.L. 1999. Growth and survival of the blood ark, *Anadara ovalis* (Bruguiére, 1789), in coastal Georgia. Georgia Journal of Science 56: 181-200.

Wells, H.W., M.J. Wells and I.E. Gray. 1964. The calico scallop community in North Carolina. Bulletin of Marine Science of the Gulf and Caribbean. 14: 561-593.

APPENDIX

Sampling station locations, depth of water in feet, tow time in minutes and species harvested with a 12 foot conch try net in the coastal waters of Georgia. Ark species are identified as: Ab = *Anadara brasiliana*, Ao = *Anadara ovalis* and Np = *Noetia ponderosa*.

Date	Location	Depth	Time	Arks	Notes on other species
R/V SEA DAWG					
1/20	31 25'41"X81 13'59"	12	30	0	
1/20	Offshore Sapelo Isl	12	30	0	
1/20		12	30	0	
1/20		8	30	0	many juvenile knobbed whelks
1/20		14	30	1 Ab	many dead *A. brasiliana*
1/20		12	30	0	blue crabs
1/20		10	30	0	
1/20		9	30	0	many sea cucumbers
1/20		6	30	0	blue crabs, channeled whelks
1/20		10	30	1 Ab	knobbed whelks, blue crabs
11/10	Offshore Wassaw Isl	8	30	1 Ab	many dead Ab, recent storm
11/10	along beach	13	30	0	
11/10		14	30	0	
11/10		11	30	0	many dead Ab
11/10		9	30	0	
11/10		15	30	0	
11/10		7	30	0	
11/10		13	30	0	
11/10		15	30	0	1 cockle
11/10	south channel	26	30	8 Ao	
11/10		21	30	1 Ao	shelly bottom mostly oyster shell
11/10	sand bar	8	30	0	
12/10	SE Ossabaw	25	30	0	
12/10	Island	27	30	10 Ao	15 knobbed whelks
12/10		10	30	0	Several surfclams
12/10	Marker 27	27	30	6 Ao	all juveniles attached to shell
12/10		17	30	0	18 knobbed whelks
12/10		13	30	0	
12/10	Beakers	6	30	0	
12/10	inside beakers	16	30	10 Ao	several dead shell Ao, whelks
12/10	Middle grounds	28	30	5 Ao	
12/10	Walburg Creek	17	30	0	2 surfclams
12/10	Walburg Creek	8	30	0	
12/10	South channel	23	30	0	

R/V GEORGIA BULLDOG

3/24	31 05'67"X81 20'04"	17	10	2 dead Np	
3/24	31 01'75"X81 19'65"	20	15	0	2 knobbed whelk
3/24	31 00'94"X81 21'76"	15	15	0	20 knobbed whelks
3/24	31 01'02"X81 23'20"	13	15	0	2 channeled whelks
3/24	31 00'72"X81 25'31"	13	15	0	2 channeled, 70 knobbed whelks
3/24	31 00'98"X81 22'04"	15	15	0	
3/24	30 59'21"X81 19'73"	12	13	0	3 knobbed whelks
3/24	30 57'43"X81 19'41"	17	20	0	
3/24	30 53'77"X81 19'70"	13	16	0	
3/24	30 53'36"X81 21'25"	8	30	0	
3/24	30 53'02"X81 23'46"	7	15	0	1 loggerhead turtle
3/24	30 53'23"X81 24'29"	5	30	0	
3/24	30 52'08"X81 23'66"	10	12	0	2 channeled whelk
3/24	30 50'57"X81 21'79"	23	30	0	
3/24	30 47'99"X81 25'19"	17	18	0	
3/24	30 47'18"X81 26'72"	16	13	0	many whelks, mostly knobbed
3/24	30 46'15"X81 26'76"	18	20	0	
3/24	30 44'69"X81 26'21"	23	20	2 dead Ao	many knobbed whelks
3/25	30 43'29"X81 23'98"	36	10	0	6 whelks, 6 blue crabs
3/25	30 43'76"X81 25'21"	24	10	1 dead Np	
3/25	30 44'02"X81 26'74"	12	10	0	6 whelks
3/25	30 44'18"X81 26'15"	20	10	8 dead Np	6 knobbed, 2 channel whelks
3/25	30 43'89"X81 25'49"	22	10	24 dead Np	6 whelks
3/25	30 44'21"X80 26'12"	19	25	0	
3/25	30 44'23"X80 25'99"	19	10	0	3 whelks, 2 blue crabs
3/25	30 44'24"X81 24'94"	25	13	0	8 whelks
3/25	30 44'30"X81 23'68"	27	16	0	48 whelks
3/26	31 06'88"X81 24'21"	8 ft	15	16 Ao	½ bushel whelks
3/26	31 06'55"X81 23'82	7	10	0	17 whelks
3/26	31 06'61"X81 23'46"	8	12	0	16 whelks
3/26	31 06'08"X81 23'11"	7	12	1 A. ovalis	15 whelks
3/26	31 06'53"X81 23'36"	8	10	1 A. ovalis	12 whelks
3/26	31 06'48"X81 23'34"	6	12	1 Ao	15 whelks
3/26	31 06'14"X81 23'06"	7	20	15 dead Ao	15 whelks
3/26	31 06'08"X81 22'92"		45	0	
3/26	31 05'48"X81 21'88"	6	15	0	2 whelks
3/26	31 05'62"X81 21'43"	7	12	0	
3/26	31 06'54"X81 21'52"	12	20	0	1 blue crab
3/26	31 05'95"X81 19'81"	23	7	0	1 cockle
3/26	31 05'77"X81 19'48"	14	14	0	11 dead Ab
3/26	31 05'72"X81 19'78"	11	10	0	4 blue crabs
3/26	31 05'35"X81 19'34"	13	15	0	

5/26	31 06'42"X81 17'27"	27	20	52 Np	
5/26	31 06'48"X81 17'34"	27	10	35 Np	
5/26	31 06'77"X81 17'43"	29	11	2 Np	
5/26	31 06'66"X81 17'35"	29	15	44 Np	
5/26	31 06'23"X81 17'30"	27	15	24 Np	100's Np dead
5/26	31 06'46"X81 17'05"	20	16	66 Np	lots Np dead
5/26	31 06'60"X81 17'14"	26	19	6 Np	lots Np dead
5/26	31 06'53"X81 17'90"	22	21	28 Np	1 octopus, lots Np dead
5/26	31 06'50"X82 17'18"	25	14	19 Np	lots Np dead
5/26	31 06'77"X81 17'37"	22	20	75 Np	lots Np dead
5/26	31 06'48"X81 17'34"	27	10	35 Np	lots dead
5/26	31 06'68"X81 17'44"	22	20	20 Np	lots Np dead, 2 stone crabs
5/26	31 06'45"X81 17'41"	28	19	53 Np	lots Np dead
5/26	31 06'67"X81 17'53"	26	21	67 Np	lots Np dead
5/26	31 04'43"X81 17'66"	20	18	0	
5/26	31 04'85"X81 18'02"	17	22	0	5 whelks
11/30	31 09'97"X81 14'42"	27		0	2 dead cockles,
11/30	31 24'60"X81 09'67"	17	17	0	
11/30	31 26'24"X81 12'39"	9	20	0	8 channeled whelks
11/30	31 27'40"X81 12'73"	5	11	0	3 whelks
11/30	31 26'11"X81 09'58"	11	10	0	
11/30	31 35'09"X81 08'87"	10	20	0	20 whelks
11/30	31 33'67"X81 09'83"	14	12	0	12 whelks
11/30	31 35'26"X81 08'83"	10	25	0	
12/1	31 43'66"X81 02'75"	19	10	0	8 whelks, 1 live cockle
12/1	31 44'29"X81 06'16"	8	11	0	50 whelks
12/1	31 43'57"X81 07'14"	13	10	0	30 whelks
12/1	31 43'90"X81 05'51"	8	10	0	23 whelks, 1 cockle
12/1	31 42'97"X81 03'19"	14	10	0	3 conchs
12/1	31 41'03"X81 00'41"	28	10	0	
12/1	31 43'78"X80 57'78"	32	10	0	1 spiny oyster
12/1	31 44'70"X80 58'99"	21	10	0	
12/1	31 45'46"X81 01'31"	11	10	0	
12/1	31 45'83"X80 57'10"	26	11	0	100 *Luldia*
12/1	31 47'82"X80 56'55"	19	15	0	
12/1	31 48'44"X80 56'95"	14	15	0	1 whelk
12/1	31 47'65"X80 57'56"	15	15	0	
12/1	31 47'79"X80 56'62"	18	21	2 dead Np	
12/1	31 48'94"X80 56'61"	18	15	0	
12/1	31 48'81"X80 56'97"	15	20	0	2 whelks
12/1	31 50'76"X80 57'37"	13	15	0	3 whelks
12/1	31 51'97"X80 51'96"	6	11	0	3 cockles, 4 whelks
12/1	31 48'94"X80 56'71"	27	20	2 dead Np	

12/1	31 49'40"X80 56'17"	28	10	0	2 dead Np
12/1	31 50'53"X80 54'60"	29	10	0	1 whelk, 3 whelks
12/2	31 54'73"X80 53'34"	13	10	6 dead Np	
12/2	31 55'80"X80 53'84"	9	10	0	1 whelk
12/2	31 55'15"X80 52'23"	19	10	2 dead Np	2 dead cockles
12/2	31 55'75"X80 50'92"	17	15	0	
12/2	31 56'85"X80 50'15"	12	10	1 dead Np	1 whelk
12/2	31 58'92"X80 47'20"	15	10	0	1 whelk
12/2	32 00'31"X80 47'96"	15	10	4 dead Ao	many dead cockles, blood arks
12/2	32 02'42"X80 50'21"		10	0	Thousands of *Ostrea equestris*
12/2	32 02'05"X80 48'94"	17	10	0	
12/2	31 59'67"X80 45'73"	18	10	0	
12/2	31 58'88"X80 45'34"	37	10	0	Dead shells, many dead cockles
12/2	31 53'45"X80 51'33"	22	10	1 Ao	3 dead Ao, 6 dead cockles
12/2	31 53'53"X80 54'09"	13	10	0	1 whelk
12/2	31 54'04"X80 53'92"	28	13	4 Np, 2 Ao	
12/2	31 54'59"X80 55'12"	25	10	0	cockles, whelks
12/2	31 54'77"X80 56'03"	16	10	0	
12/2	31 49'30"X80 56'03"		12	0	3 whelks
12/3	31 48'99"X80 56'55"	28	10	3 dead Ao	3 whelks
12/3	31 49'66"X80 56'48"	27	13	0	
12/3	31 49'34"X80 56'82"	17	11	0	
12/3	31 49'97"X80 56'44"	14	11	0	
12/3	31 49'71"X80 55'33"	29	30	1 dead Ao	
12/3	31 48'78"X80 56'43"	13	33	24 dead Ao	
12/3	31 38'61"X81 02'29"	23	11	0	
12/3	31 34'71"X81 04'16"	15	10	0	
12/3	31 31'55"X81 04'42"	16	10	0	
12/3	31 28'10"X81 04'69"	18	10	0	
12/3	Rocks	24	20	25 Np	11/2 bushel dead shell
12/3	Rocks	20	19	0	Bag ripped open
12/3	Rocks	20	18	31 Np	2 bushels dead shell
12/4	31 06'06"X81 23'99"	7	13	0	2 bushels whelks
12/4	31 06'97"X81 24'27"		10	0	few dead A. ovalis, lots shell
12/4	31 06'54"X81 23'42"		10	10 Ao	whelks
12/4	31 06'08"X81 23'16"		11	3 Ao	1/4 bushel whelks