

SPAWNING OF THE NORTHERN

# QUANTHOE

*MERCENARIA MERCENARIA* (LINNÉ), ACCORDING TO  
MICRO-HABITAT IN A TIDAL CREEK IN COASTAL GEORGIA

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# Spawning of the northern quahog, *Mercenaria mercenaria* (Linné), according to micro-habitat in a tidal creek in coastal Georgia

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## ABSTRACT

Gametogenesis and spawning in northern quahogs, *Mercenaria mercenaria*, from five micro-habitats were examined through biweekly histological analysis of quahog gonads from early March to mid-June 1993. Spring is the major spawning season for quahogs in the southeastern U.S. Quahogs were placed at five sites along a creek gradient from the creek mouth to its headwaters within House Creek, Little Tybee Island, Georgia. Since quahogs spawn according to changes in water temperature, it was hypothesized that quahogs would spawn according to water temperature fluctuations at low tide at each micro-habitat. Female quahogs spawned continuously at all sites from March to June with no major differences in spawning patterns observed among sites. Male quahogs, unlike females, underwent rapid gonadal redevelopment during late March and early April prior to spawning from mid-April to June. Male quahogs at Site 3 underwent a greater degree of gonadal redevelopment and commenced

spawning two weeks later than quahogs at other sites. Overall, we conclude that variations in water temperature among micro-habitats had little effect upon quahog gametogenesis.

Northern quahog, *Mercenaria mercenaria* (Linné, 1789), distribution is unique in coastal Georgia as compared to its habitat throughout the remainder of its natural range. In Georgia, most quahog beds occur in intertidal areas. Elsewhere, they are found in subtidal areas (Walker et al. 1980; Walker and Tenore 1984; Walker and Rawson 1985; Walker 1987). Furthermore, Georgia's quahogs inhabit the smaller creeks of the extensive salt-marsh system and are generally associated with shell-mixed substrates (Walker et al. 1980; Walker and Tenore 1984; Walker and Rawson 1985; Walker 1987). Within the tidal creeks, quahogs may occur in a variety of micro-habitats such as along mud creek banks, in pools of water dammed by oyster reefs at low tide, in shell bottoms, among intertidal oyster beds, or among the roots of marsh grass. Quahogs may also occur from the headwaters to the mouth of various salt-marsh tidal creeks.

Georgia has a 2.4 to 3.0 meter tidal amplitude which results in vast areas being exposed to open air conditions at low tide. Many areas of a typical marsh creek will completely drain at low tide, while in other areas shallow (< 0.3 m) pools of water form at low tide. Other pooled areas may have a meter of water covering the quahogs at low tide. Water temperatures in the shallow areas and the headwaters of creeks may rise rapidly during low tides. O'Beirn (1995) recorded an 8°C change in water temperature during a tidal cycle in a pool of water created by an oyster dam at low tide in a Georgia tidal creek. Since quahogs typically spawn according to water temperature changes, it is possible that quahog gametogenesis and spawning may be different within various micro-habitats within a tidal creek system. This study was carried out to determine if different patterns of gametogenesis and spawning occurred according to differences in water temperatures associated with various micro-habitats within a typical Georgia tidal creek.

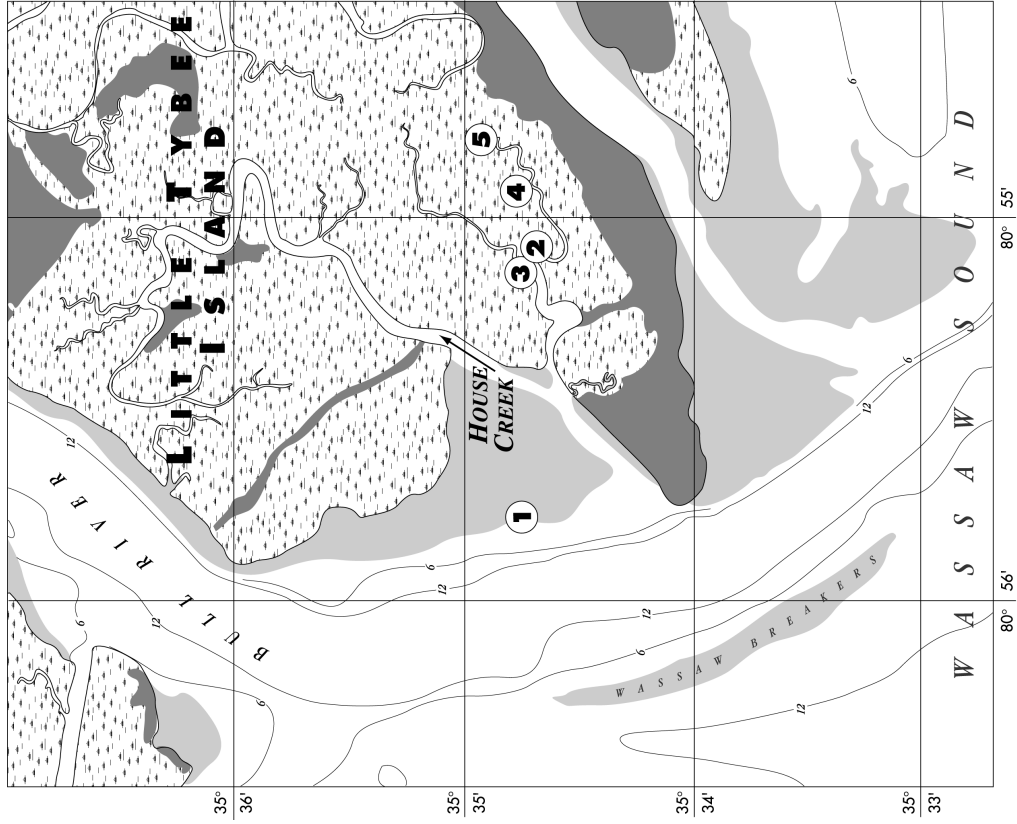
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## METHODS AND MATERIALS

Quahogs used in this study originated from a natural stock located in House Creek, Little Tybee Island, Georgia. Quahogs were gathered on October 29, 1992. Quahogs (N=400 per site) at a mean shell length of 53.4 mm (range 34.4 to 81.4 mm) were placed into five 0.6 X 0.6 X 0.1 m wooden boxes along with 12-mm grade Carolina bay gravel. Boxes were covered with 12-mm mesh vinyl-coated wire to exclude large predators. Boxes filled with quahogs and gravel were placed at their relative sites four months prior to sampling so that the quahogs could acclimate to their new environment. Boxes at each site were placed just below the mean low water mark. Biweekly sampling of quahog gonadal tissue occurred from early March through June, the major spawning period for quahogs in Georgia (Pline 1984; Heffernan et al. 1989; Walker and Heffernan 1994).

Boxes were placed in different micro-habitats within the right-hand branch of House Creek, Little Tybee

Island, Georgia (Fig. 1). Site 1 was an intertidal placement on a sandflat located at the junction of a creek mouth and the Bull River. A frame constructed of reinforcement rods was positioned so that the box containing quahogs was approximately 0.3 m off the sand bottom, but just below the mean low-water mark. No quahogs naturally occurred at this site; however, quahogs occurred at all other sites. Boxes were placed directly on the bottom at the remaining sites. Site 2 occurred in mud and shell substrate within a small pool of water (1 X 2 X 0.3 m depth) located between two oyster mounds and the creek bank. This site was approximately 0.6 m above mean-low water. Site 3 was adjacent to Site 2, but occurred much lower in the intertidal zone. Site 3 was located at the junction of the second major creek branch along the left-hand side of House Creek. This site occurred in a pool of water (2 X 5 X 0.3 m depth) that forms at mean-low water. The substrate was crushed oyster shells. Site 4



**Figure 1.** Location of field culture site of House Creek, Little Tybee Island, Georgia



occurred well back into the creek in a large pool of water approximately 0.6 m depth at mean-low water. The substrate was mud with some shell. A large oyster bed occurred adjacent to this site. Site 5 was established at the headwaters of the creek. Quahogs were placed in a pool of water approximately 0.3 m depth at mean-low water. Very little water was present in the surrounding area at mean-low water. The mud substrate was mixed with some shell. Only a trickle of water runs between Sites 4 and 5 at mean-low water, a distance of approximately 50 meters. Numerous large oyster reefs with mostly shell substrate occurred between Sites 4 and 5.

Quahogs (N=15) were collected biweekly from each site and returned to the laboratory. Then, a mid-lateral gonadal sample (ca. 1 cm<sup>2</sup>) was dissected from each quahog. Gonadal tissue was fixed in Davidson's solution, refrigerated for 48 hrs, washed with 50% ethanol (etoh), and held in 70% etoh until processing. Tissues were processed according to procedures outlined in Howard and Smith (1983).

Prepared gonadal slides were examined with a Zeiss Standard 20 microscope (20X), sexed, and assigned to a developmental stage as described by Ropes (1968), Kanti et al. (1993), and Spruck et al. (1994). A staging criteria of 0 to 5 was employed for Early Active (EA=3), Late Active (LA=4), Ripe (R=5), Partially Spawning (PS=2), Spent (SP=1), and Inactive (IA=0). Monthly gonadal index (G.I.) values were determined for each sex by averaging the number of specimens ascribed to each category score.

Sex ratios were tested against a 1:1 ratio with Chi-Square statistics (Elliott 1977). Statistical analysis of mean gonadal index values was performed by a Kruskal-Wallis test ( $\alpha=0.10$ ) using SAS for PC software (SAS Institute 1989).

Water temperatures were recorded daily at 0800 hr from February 1993 to July 1993 at the dock of the Marine Extension Service, Skidaway Island, Georgia. This site is approximately 4.5 nautical miles inland

from the various House Creek sites where the quahogs were field planted. Water temperature data from House Creek and the Skidaway River are comparable (Spruck et al. 1994). Within House Creek, continuous water temperature probes were placed subtidally at each site.

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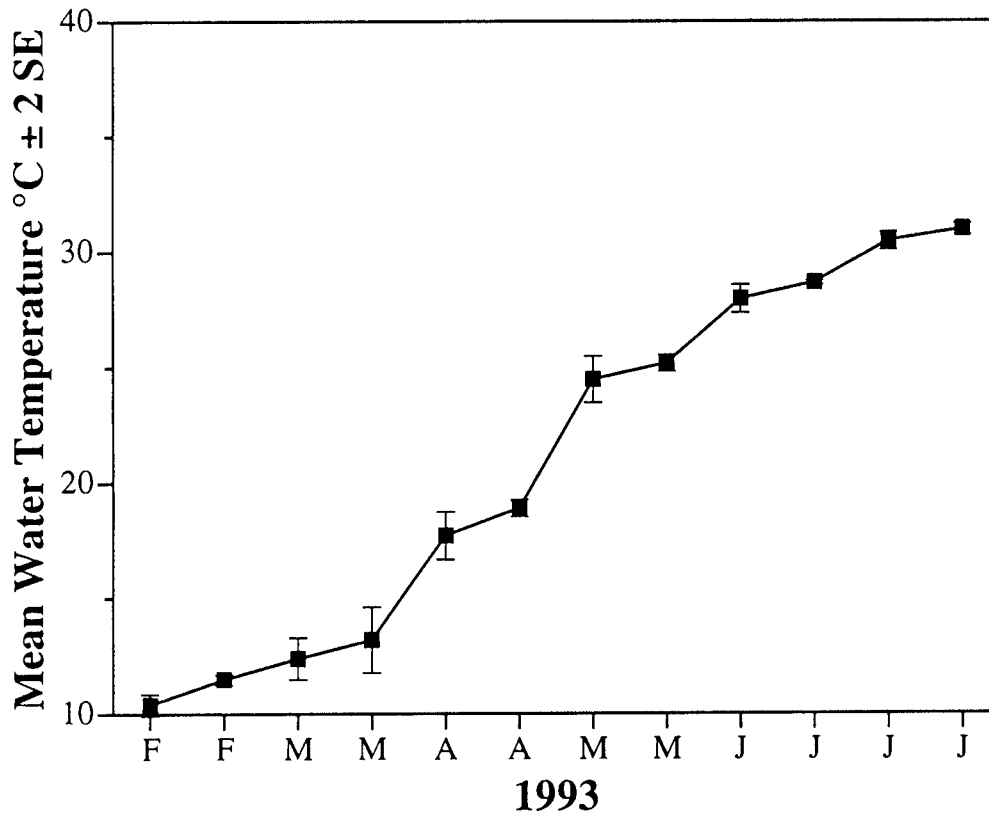
## RESULTS

Water temperatures in the Skidaway River increased from approximately 10.5°C in February to 29°C by July 1993 (Fig. 2). Water temperatures within House Creek followed a similar pattern (Fig. 3); however, different water temperatures occurred at individual sites. In general, water temperatures were similar at Sites 1, 3, and 5, but were slightly higher at Sites 2 and 4. Temperature recorders were lost at Site 1 in April to May, at Site 2 and 4 in June, and at Site 5 in mid-June.

Water temperatures at all five study sites followed a general warming trend similar to the Skidaway River data (Figs. 2 and 3). A decrease in water temperature occurred at each site in the first week of April which was more pronounced in the shallower habitats of Sites 2, 3, and 5. Water temperature variability was greatest at Site 2, the site highest in the intertidal zone. This site also has the smallest size pool of water at mean-low water. Water

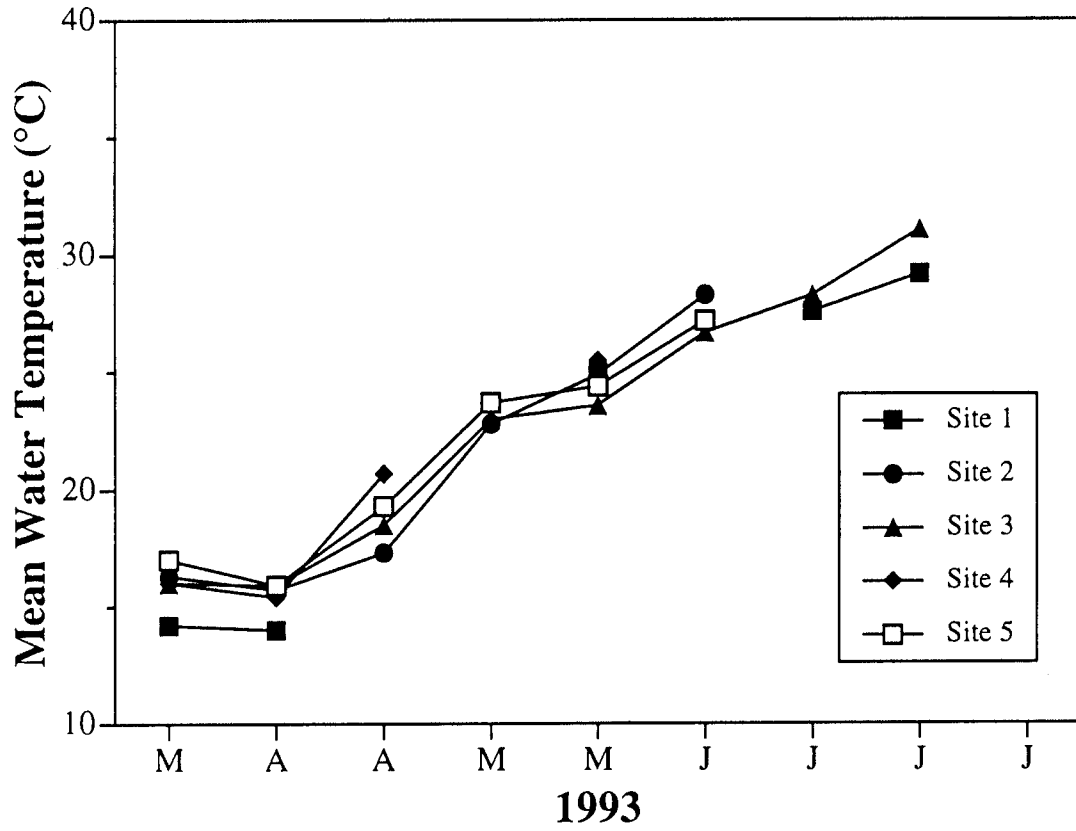
temperatures were lower in mid-April, but higher overall during May and June at Site 2 than at Sites 1, 3, 4, and 5.

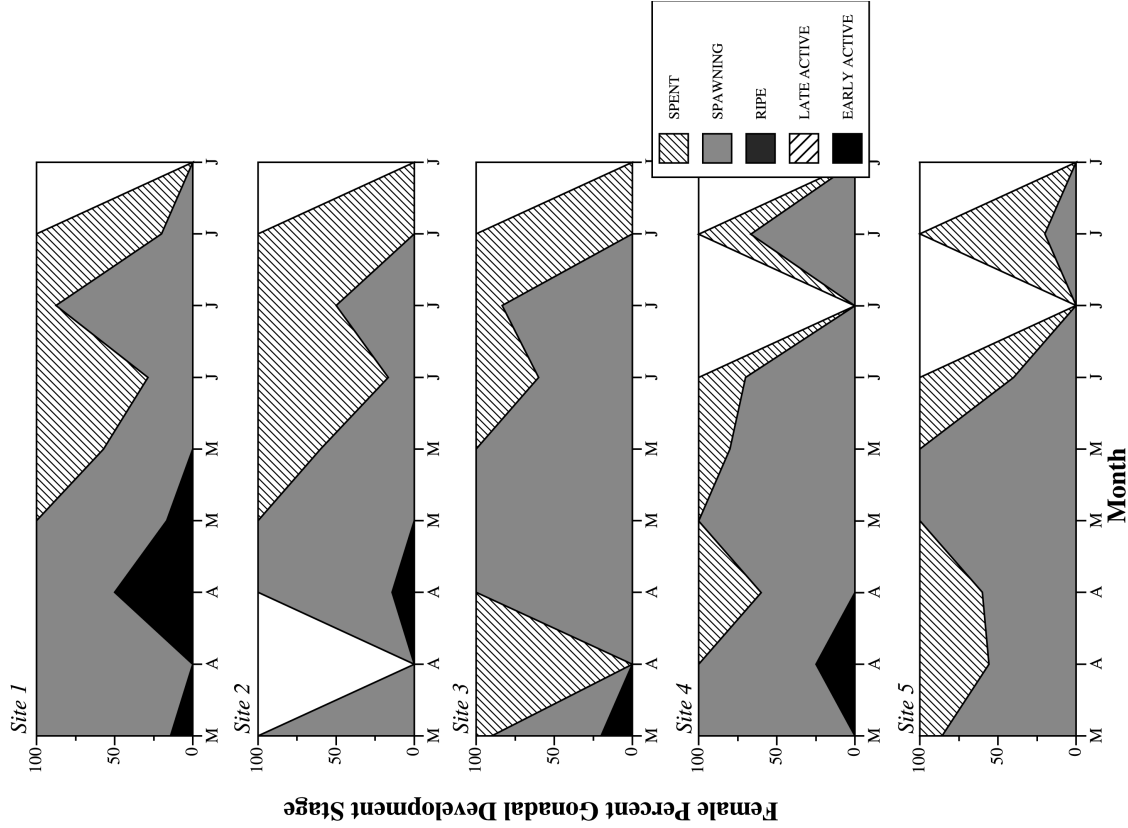
The spring reproductive cycle of female quahogs at each site is given in Fig. 4. Overall, few differences in gametogenesis occurred among the sites. Spawning-stage females dominated at all sites from March to mid-May, after which spent-stage females dominated. No females in late active or ripe stages were observed during this study. The results of the gonadal staging reveal the same gametogenic trend. Most of the G.I. values for females remained around 2 from March to June (Fig. 5). Krushal-Wallis revealed significant differences in G.I. values among sites only in mid-March ( $p=0.0380$ ) and in early April ( $p=0.0383$ ). In mid-March, the G.I. value from Site 3 (G.I. = 1.0) was significantly lower than that found at Site 4 (2.25); however, the Site 3 value was based upon a single female. Thus, the Site 3 value



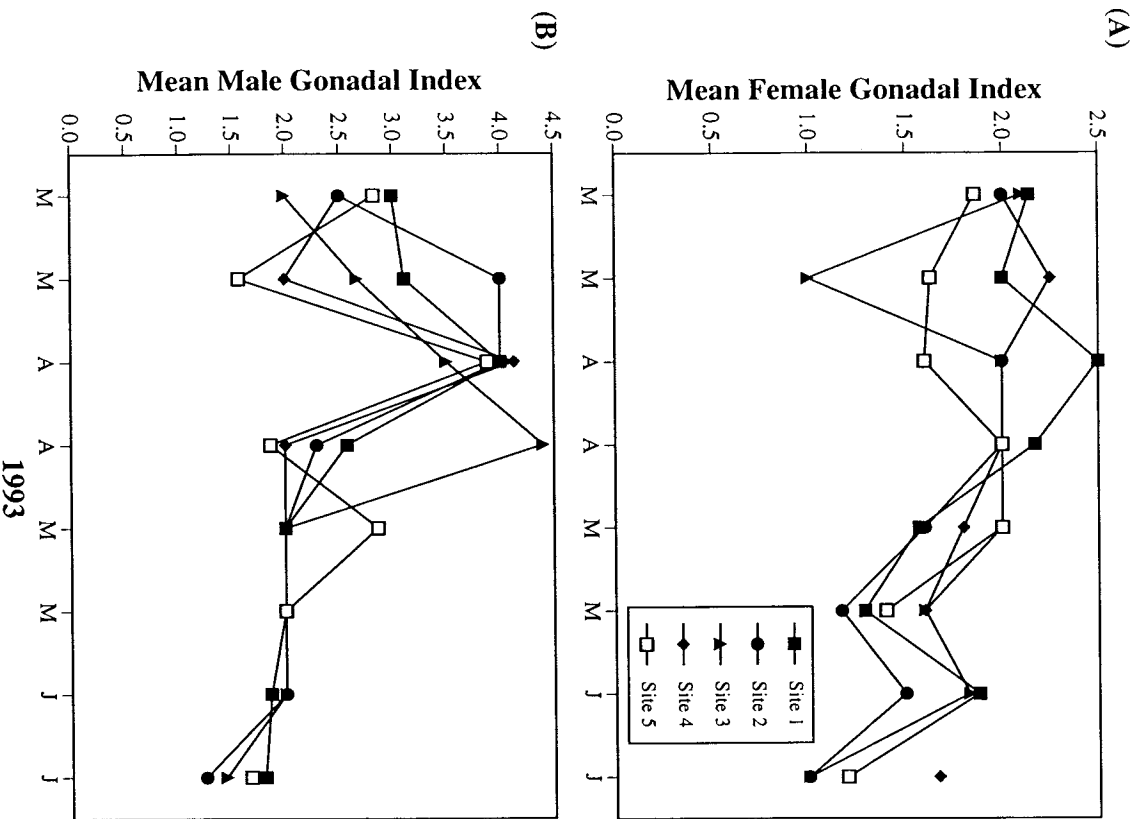
**Figure 2.** Biweekly mean ambient water temperature taken at the Marine Extension Service dock at the Skidaway Institute of Oceanography from October 1995 to July 1996

**Figure 3.** Biweekly means of water temperatures at the five experimental sites in House Creek, Little Tybee Island, Georgia





**Figure 4.** Percent gonadal development stage of female northern quahogs, *Mercenaria mercenaria*, from five micro-habitats within House Creek, Little Tybee Island, Georgia



**Figure 5.** Gonadal indices for female (A) and male (B) northern quahogs, *Mercenaria mercenaria*, from five micro-habitats within House Creek, Little Tye Island, Georgia

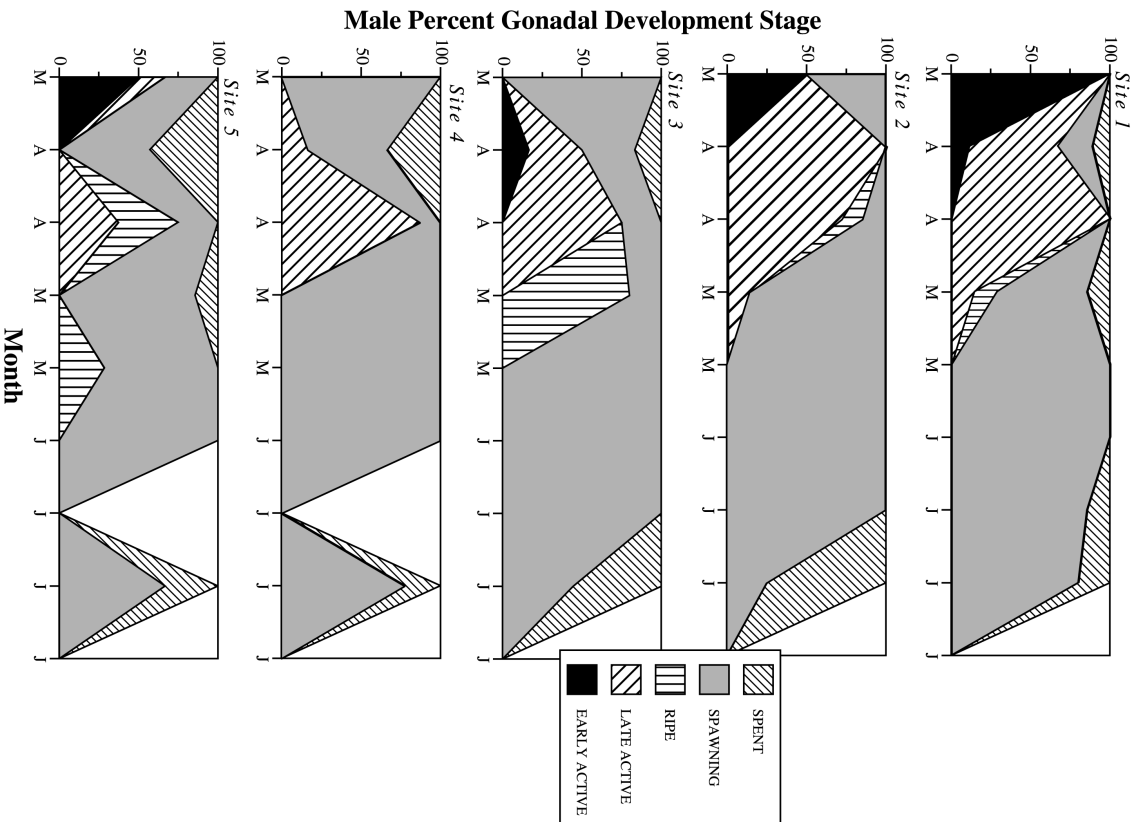
may not be representative of a true mean. In mid-April, the Site 1 G.I. value of 2.5 differed significantly only from the Site 5 value of 1.6. This difference was attributed to the fact that 50% of the quahogs at Site 1 were in an early active stage, while 40% of the quahogs at Site 5 were in the spent stage with no quahogs in the early active stage. Spawning-stage quahogs dominated at both sites at this time (50% at Site 1 and 60% at Site 5, Fig. 4).

The reproductive cycle of male quahogs showed more overall variability among sites and sample periods than that exhibited for females (Fig. 6). Spawning-stage males were observed at all sites, but not at all sample periods. Unlike females, spawning-stage males were only dominant at three sites (2, 3, and 4) in early March and at Site 5 in mid-March. During early April, spawning-stage males were either less dominant or absent. Early active-stage males dominated at three sites in early March. Late active-stage males dominated at Sites 1, 2, and 3 in mid-March and at all sites in early April. Ripe male

stages dominated only at Site 3 in mid-April. Few males (N=12) achieved a ripe stage during the study. Spawning stage dominated at four sites (excluding Site 3) in late April and was the dominant stage at all sites from late April to early June. By mid-June, spent males dominated at Sites 2 and 3 with spawning quahogs still dominant at the remaining sites.

The gonadal indices for male quahogs are presented in Figure 5b. Male G.I. peaked in early April for quahogs from Sites 1, 2, 4 and 5, and in mid-April for animals at Site 3. Spawning followed these peaks as reflected in the rapid drop in the G.I. Krushal-Wallis revealed significant differences in G.I. values among sites only in mid-March ( $p=0.0248$ ) and mid-April ( $p=0.0104$ ). In mid-March, the G.I. value for Site 2 (G.I. = 4.0) was significantly higher than the value obtained at Site 5 (G.I. = 1.6); however, the value for Site 2 was based upon a single male specimen. In mid-April, G.I. values for Site 4 (2.0) and Site 5 (1.6) were significantly lower than the





**Figure 6.** Percent gonadal development stage of male northern quahogs, *Mercenaria mercenaria*, from five micro-habitats within House Creek, Little Tybee Island, Georgia

value observed at Site 3 (4.0). In mid-April, quahogs at Site 3 were dominated by ripe individuals; whereas quahogs at the other sites were dominated by spawning individuals (Fig. 6).

An equal sex ratio occurred for quahogs at each site and for the overall population (Chi-square = 1.91). Of the 468 quahogs sexed, 249 were males and 219 females. An equal sex ratio also occurred at each time period with the exception of the early sample in April, where significantly more males occurred than females (Chi-square = 5.55).

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## DISCUSSION

Spring is the major spawning period for quahogs in the southeastern U.S. coastal area (Pline 1984; Manzi et al. 1985; Heffernan et al. 1989; Walker and Heffernan 1994). The results of this study concur showing that quahogs from the various micro-habitats in House Creek also spawned in spring 1993. For females, little variation in spawning occurred among micro-habitats or sampling periods. Spawning was continuous for females from March to mid-June. Male quahogs, however, exhibited a different reproductive pattern. Male spawning was dominant in three of the sites in early March, but males underwent rapid gonadal redevelopment as evidenced by the relatively high proportion of Early Active, Late Active and Ripe Stages during mid-March and early April sample times. Gametogenesis continued in quahogs at Site 3 in mid-April when ripe male quahogs dominated. Major male spawning occurred at all sites except Site 3 in mid-April and continued until the final

sampling in mid-June. Male spawning commenced at Site 3 two weeks later than at the other sites.

Little variation in spawning occurred for females among sites; however, differences in peak spawning of males did occur among sites. Male gonadal indices peaked in early April at Sites 1, 2, 4, and 5 and in late April at Site 3. Major male spawning occurred after peak G.I. values were achieved (Figs. 5b and 6). No apparent relationship exists between spawning and water temperature at the various micro-habitats. During early April, the lowest water temperature (14°C) occurred at Site 1, with little difference in water temperatures among the remaining sites (15.4°C at Site 4 to 15.9°C at Sites 3 and 5). In late April, the lowest water temperatures occurred at Site 2 (17.3°C) while the highest water temperatures occurred at Sites 4 (20.7°C) and 5 (19.3°C). Water temperatures at Site 3 were intermediate (18.5°C).

Among the House Creek sites, the reproductive pattern observed in quahogs at Site 3 probably best reflects the expected pattern (Pline 1984; Heffernan et al. 1989; Walker and Heffernan 1994). This is especially true for males, where many quahogs went from early active stage to dominant-ripe stage before spawning. It was originally expected that quahogs from Site 1 would exhibit the "normal" gametogenic cycle which could be used as a comparison to cycles observed at the other sites. This was based upon the assumption that quahogs at Site 1 were in the most stable habitat in terms of water temperature i.e., the largest body of water. However, quahogs at Site 1 were subjected to an added stress which probably interfered with their natural gametogenic cycle. On a number of occasions, strong storms displaced the box containing the quahogs. On one occasion, the box was dislodged from its platform and was found inverted on a sandflat. In this case, the animals were obviously stressed and unable to feed. Thus, quahogs at Site 3 occurred in the second largest body of water, which

should have exhibited less variability in water changes.

From May to June, the sites with the highest water temperatures were Sites 2 and 4. Site 2 was located in a small pool of water between two oyster mounds and the creek bank and at a tidal height of approximately 2 hrs above mean-low water, so it was not unexpected that it displayed the highest water temperatures (Fig. 3). Site 5, located at the headwaters of the creek, was expected to demonstrate higher water temperatures over those of Site 4; however, Site 4 had higher water temperatures (Fig. 3). An explanation for this is that Site 5 received runoff water from the marsh at low tide. Most of this water came from areas shaded by the marsh grass. The pool of water at Site 5 was also partially shaded by the surrounding marsh grass at low tide. Water at Site 4 occurred in a more open area and thus received more direct sunlight at mean-low water. Additionally, water draining from Site 5 at mean-low water flowed to Site 4 at a trickle across

50 meters of shell substrate. This would allow incoming water at low tide at Site 4 to warm while in transit from Site 5.

Although some differences in water temperatures and spawning patterns in male quahogs among micro-habitats were observed (primarily at Site 3), little overall differences in quahog spawning occurred between micro-habitats within the House Creek system. Female quahogs spawned synchronously at all sites throughout the experimental period. Thus, we conclude that variations in water temperature at different quahog micro-habitats had little effect upon the gametogenic cycle of quahogs at those sites.

- Elliott, J.M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association, Scientific Publication 25, 160 pp.
- Heffernan, P.B., R.L. Walker and J.L. Carr. 1989. Gametogenic cycle of three marine bivalves in Wassaw Sound, Georgia. I *Mercenaria mercenaria* (L.). Journal of Shellfish Research 8:51-60.
- Howard, D.W. and C.S. Smith. 1983. Histological techniques for marine bivalve mollusks. NOAA Technical Memorandum NMFS-F/NEC-25, 97 p.
- Kanti, A., P.B. Heffernan and R.L. Walker. 1993. Gametogenic cycle of the southern surf clam, *Spisula solidissima similis* (Say, 1822), from St. Catherines Sound, Georgia. Journal of Shellfish Research 12: 255-261.
- Manzi, J.J., M.Y. Bobo and V.G. Burrell, Jr. 1985. Gametogenesis in a population of hard clam, *Mercenaria mercenaria* (Linnaeus) in North Santee Bay, South Carolina. Veliger 28:186-194.
- O'Beirn, F.X. 1995. Reproduction and recruitment of the eastern oyster, *Crassostrea virginica* in coastal Georgia. Ph.D. Dissertation, Department of Zoology, University of Georgia, Athens.
- Pline, M.J. 1984. Reproductive cycle and low salinity stress in adult *Mercenaria mercenaria* L. of Wassaw Sound, Georgia. Masters Thesis, Georgia Institute of Technology, Atlanta, GA.
- Ropes, J. 1968. Reproductive cycle of the surf clam, *Spisula solidissima*, in offshore New Jersey. Biological Bulletin 135:349-365.

- SAS Institute, Inc. 1989. SAS User's Guide: Statistic, version 6. SAS Institute, Cary, North Carolina.
- Spruck, C., M. Sweeney, D. Hurley and R.L. Walker. 1994. Gametogenic cycle in the non-native Atlantic surfclam, *Spisula solidissima* (Dillwyn, 1817), cultured in the coastal waters of Georgia. Gulf Research Reports 9:131-137.
- Walker, R.L. 1987. Hard clam, *Mercenaria mercenaria* (L.), populations of coastal Georgia. Georgia Marine Science Center, Technical Report Series 87-1, Savannah, GA.
- Walker, R.L., M.A. Fleetwood and K.R. Tenore. 1980. The distribution of the hard clam, *Mercenaria mercenaria* (Linne), resources in coastal Georgia. Georgia Marine Science Center Technical Report Series, No. 80-8, 59 pp.
- Walker, R.L. and P.B. Heffernan. 1994. Temporal and spatial effects of tidal exposure on the gametogenic cycle of the northern quahog, *Mercenaria mercenaria* (Linnaeus, 1758), in coastal Georgia. Journal of Shellfish Research 13:479-486.
- Walker, R.L. and M.V. Rawson. 1985. Subtidal hard clam, *Mercenaria mercenaria* (Linne), resources in coastal Georgia. Georgia Marine Science Center Technical Report Series, No. 85-1, 164 pp.
- Walker, R.L. and K.R. Tenore. 1984. The distribution and production of the hard clam, *Mercenaria mercenaria*, in Wassaw Sound, Georgia. Estuaries 7: 19-27.