Annotated Bibliography II of the Hard Clam

*Mercenaria mercenaria*

J. L. McHugh
Marjorie W. Sumner
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50. Preparation of acetate peels of valves from the ocean quahog, Arctica islandica, for age determinations, by John W. Ropes. March 1987, 5 p.


64. Illustrated key to peneiculid shrimp of commerce in the Americas, by Isabel Pérez Fafante. April 1988, 32 p.


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Introduction

In this era of proliferating scientific information it is difficult to keep up with the literature, even in one's own field. Review articles are helpful in summarizing the status of knowledge. In oyster biology, several such published reviews have been of great help to working scientists. The outstanding contributions that come to mind are those by Baughman (1948), Korringa (1952), Joyce (1972), Breisch and Kennedy (1980), and Kennedy and Breisch (1981). If done well, such compilations serve as checkpoints, eliminating or vastly reducing the need to consult the literature in detail.

On Long Island, New York, where the hard clam Mercenaria mercenaria is the major commercial resource, we have felt the need for some time for a compendium of knowledge on this important mollusk. Several years ago my secretary, students, and I began to gather materials for an annotated bibliography. We have already published a collection of 2233 titles (McHugh et al. 1982), nearly all accompanied by abstracts, and in this publication we have added another 460.

The experience has been rewarding. We have been surprised at the extent of the literature, much of it only remotely related to the shellfish industry itself, but nevertheless throwing light on the biology, physiology, and many other aspects of the scientific knowledge of hard clams.

The following bibliography is divided into three parts. Part 1 comprises the bulk of the bibliography, while Parts 2 and 3 contain additional titles that we decided to include during editing, submission, and approval of the manuscript for publication. All three parts are indexed together, however.

We also reexamined those titles in the previous bibliography (McHugh et al. 1982) which did not include abstracts. These are included in Parts 2 and 3 of this bibliography. Most of these contained no specific reference to Mercenaria mercenaria. A few searches were terminated for various reasons.

Acknowledgments

This work was sponsored by the New York Sea Grant Institute under a grant from the Office of Sea Grant, National Oceanographic and Atmospheric Administration, U.S. Department of Commerce. The junior author carried most of the load of searching the literature, and her familiarity with the main library of the State University of New York at Stony Brook and its various branches and their staffs was of inestimable value. Thanks also to the staffs of these libraries for helping to locate elusive papers, including many through interlibrary loan. Preparation of the final copy was done by Carol Case, assisted by John Ellsworth.

Citations

Baughman, J.L.
1948. An annotated bibliography of oysters, with pertinent material on mussels and other shellfish and an appendix on pollution. Texas A&M Research Found., College Station, TX 77843, 749 p.

Breisch, L.L., and V.S. Kennedy.

Joyce, E.A., Jr.

Kennedy, V.S. and L.L. Breisch.

Korringa, P.

McHugh, J.L., Marjorie W. Sumner, P.J. Flagg, D.W. Lipton, and W.J. Behrens.

Freezing tolerance in intertidal invertebrates is restricted to species in the supralittoral zone of temperate and Arctic regions. Cold resistance of animals appears to be based on tolerance to tissue ice formation. Invertebrates found naturally in seawater of high salinity are more cold-tolerant than those in brackish waters. Improved freezing resistance can be obtained by acclimating animals to low temperature in conjunction with high salinity. Differences in lethal temperatures among bivalves appear to be caused by differences in the freezeable fraction of tissue water. The intertidal mussel *Mytilus edulis* possesses less freezable water than the subtidal quahog *Venus mercenaria*.


Clams of known genotype, from a wild population of known composition, were individually induced to spawn. All gametes were mixed at one time to produce a randomly bred cohort from each. After one year the sample of 1080 was measured and their enzyme phenotypes determined by a starch gel electrophoresis for Pgd, Lap, Pgi, Pgm-2 and Pgm-3. The genotype frequencies differed significantly from Hardy-Weinberg expectations for all genes except Pgd, but only for Lap was the deviation associated with heterozygosity, for which there was a striking deficiency. The explanation must be differential survival.


Clams were spawned individually and mated to produce two sibships. Progeny showed complete conformity with Mendelian expectations in segregation and assortment of ratios for five allozyme loci: Lap, Pgi, Pgm-2, Pgm-3 and 6Pgd.


Hard clams (*Mercenaria mercenaria*) were spawned individually and mated to produce two sibships. Progeny showed complete conformity with Mendelian expectations in segregation and assortment of ratios for five allozyme loci: Lap, Pgi, Pgm-2 and Pgm-3. The genotype frequencies differed significantly from Hardy-Weinberg expectations for all genes except Pgd, but only for Lap was the deviation associated with heterozygosity, for which there was a striking deficiency. The explanation must be differential survival.


Clams (*Mercenaria mercenaria*) of known genotype, from a wild population of known composition, were individually induced to spawn. All gametes were mixed at one time to produce a randomly bred cohort of clams. After one year the sample of 1080 was measured and their enzyme phenotypes determined by starch gel electrophoresis for the enzymes Pgd, Lap, Pgi, Pgm-2, and Pgm-3. The genotype frequencies differed from Hardy-Weinberg expectations for all genes except Pgd and Pgm-2, but only for Lap was the deviation associated with heterozygosity, for which there was a striking deficiency. Since the cohort was randomly bred, the Wahlund effect cannot explain this observation but differential survival can. Two genes, Lap and Pgm-3, showed highly significant associations of genotype with shell size.


Florida has only recently become a significant producer of hard clams (*Mercenaria mercenaria*). In 1984 the dockside value of hard clam landings represented 43% of total dockside value of all species of clam landed in the U.S. Landings in Florida were 1.8 million pounds of meat with a dockside value of $6.6 million in 1984. Most production in Florida comes from the Indian River Lagoon system. The growth of the hard clam fishery is obviously of importance to the local economy. Tables give total U.S. clam landings, reported Florida landings and value 1970-84, landings of the most important species of fish and shellfish in Florida, hard clam landings and value by county in Florida, and hard clam landings and value for Brevard County 1975-84.


Cites work of several authors abstracted elsewhere in this bibliography. Bivalves can distinguish between favorable and unfavorable environmental conditions and make appropriate behavioral responses. Many utilize valve closure as a protective mechanism. Sensory receptors on the marginal lobes of mantle and siphons can detect changes in the medium even when valves are apparently closed. Valve closure allows the organism to overcome short-term changes in environmental conditions. It has no survival value when changes are long-term.


Juvenile clams, *Mercenaria mercenaria* were fed one of three diets consisting of the flagellate *Isochrysis galbana*, the torulopsis yeast *Candida utilis*, or a 50% dry weight mixture of each. Increases in most growth parameters were higher for clams fed algae or the mixture than yeast alone. Clams fed yeast grew at approximately half the maximum rate, while oysters fed yeast showed zero or negative growth. Nutritive quality appears to be important, although amino acid composition among the three diets was similar. Growth of clams was directly related to the amount of protein, lipid, and ash. Growth of oysters was related only to the amount of lipid. Respiration rates appeared normal for all groups, yet respiration frequency accounted for a large percentage of assimilated calories. Growth efficiency for clams fed yeast was very low. The quantity and quality of the ingested yeast ration probably are suboptimal, and differences in diet quantity and quality are reflected by differential partitioning of energy within the energy budget of the animal. It is likely that yeast lacks a vital micro nutrient or fatty acid is required.


Of bacterial exudates (*Lactobacillus sp.*), 61.7% were consumed by *Venus verrucosa*, but only 19.9% of algal (*Pavlova lutheri*) exudates. The clam seems to assimilate bacterial products more easily.


Utilization of a viable bacterial suspension (*Lactobacillus sp.*) by the clam *Venus verrucosa* was investigated as a function of time. Data on the functioning of the different sources suggest an important recycling of the metabolic products of the bivalves by bacteria of the suspension, demonstrating the role of bacteria as food for bivalves. *Mercenaria mercenaria* is not mentioned.


The technique of weighing in water has been tried with hard clams, *Mercenaria mercenaria*, without much success. Calculation is apparently much slower than in oysters. Hard clams held in trays without substratum become infested with *Polydora wohlersi* and are incapable of covering the resulting mud blisters satisfactorily.


Dr. Louis Leibovitz is a shellfish doctor, formerly involved with bird diseases. He is now a shellfish doctor helps N.Y. hatcheries combat diseases in clams and oysters. He points out that raising clams and oysters is similar to raising birds and raising shellfish. He is an expert in the field of shellfish.
Each clam (Mercenaria mercenaria) was marked with paint and returned to one of 30 one-meter plots. Half were covered in Cuban shoal grass, the others stripped of their grass and clams left bare, sandy bottoms: Hard clams with cover of sea grass fared well but clams left in sandy bottom lost 32% to wheeless after 6 months. Repeating the experiment in warm weather for 4 months he found that 70% of clams in sandy areas had been destroyed by wheeless. Conclusion: grass beds densified by raking and clam kicking increase predation by wheeless. (J.L.M.)


Traditionally, most clammers have used rakes or tongs to unearth hard clams from the bottom. Most hand claming is done in the warmer months. One method is called "swimming for clams" which is done on hands and knees in shallow water. Others clam "by the sign" which involves looking for the small hole made in the sand when they are feeding. Kicking, by which clams are brought out of the bottom by the propeller wash, and dredging, are winter fisheries, limited by the NC Division of Marine Fisheries. In 1981, 1,458,000 pounds of clams were harvested in the State, 30% by kicking, 64% by hand methods, and 4% by dredging. Pollution and overharvesting are the greatest threats. Researchers are looking at harvesting methods and contamination, hoping to manage wisely. (J.L.M.)


Describes the operation of a hatchery in North Carolina Clams are held until January or February before planting, and are protected from predation by nets. They showed good growth and little predation. Others hold them until May. Clam hatcheries face a lot of unknowns, but may produce more clams. (J.L.M.)


There has never been a commercial hard clam fishery for M. mercenaria in Texas, yet clams are abundant and Indian shell mounds are loaded with clam shells. Researchers are investigating the possibility of establishing a clam fishery. (J.L.M.)


Aging clams still active in bed. Univ. NC Sea Grant Coll. Prog., Raleigh, NC 27695.

Coastwatch Nov/Dec 1985:5.

Despite rumors, big, old clams (Mercenaria mercenaria) are not sexually inactive. In fact, they produce many more eggs per clam than smaller clams. (J.L.M.)


The major nutritional constituents of hard clams (Mercenaria mercenaria) are listed. Some shellfish related illnesses are described, and the NY State Dept. of Health has issued an advisory against consumption of all raw shellfish. (J.L.M.)


In 1977 a clammer from New Jersey began shipping Florida clams to the Fulton Market in New York. He also opened Florida's first depuration plant to increase the supply of clams. In 1982 an unusually heavy set of clams (Mercenaria mercenaria) occurred in the Indian River, FL. Local clammers soon were outnumbered by migrants from the northeast, with high powered boats and sophisticated rakes and tongs. Clams became the second most important fishery in Florida (next to shrimp), valued at some $15 million per year. Cries of "Yankee go home!" and rumors of vandalism alarmed officials. The fabulous set of 1982 was quickly decimated over the next few years and only remnants remain. The price of clams has escalated steeply. It is believed that a dependable, long-term supply depends on culture. The most serious constraint is the supply of seed, and an experimental hatchery started in 1983 is presently the only hatchery in Florida. The current goal is production of at least 10 million seed in 1986 and more later. (J.L.M.)

20 Ansell, A. D. 1960.


Approximately 15% of the population of Venus striata was bored by Nasico alderi in the first year of life, 5% in the second, and 1-2% in the third. The holes were near the ventral margins of the shell. The observed distribution of holes over the shell appears to be the result of a stereotyped behavior pattern involving recognition of the prey and adoption of a particular attitude while boring. The possibility that the appearance of Nasico alderi in Kamas Bay was connected with the great increase in density of Venus striata from a high spillet in 1955 is discussed. (J.L.M.)


Hard clams were more vulnerable to predation by crabs in the laboratory in soft sediments (sand, sand/mud) than in crushed oyster shell or granite gravel aggregates. When crabs were given a choice of clam sizes, small crabs (<75 mm carapace width - CW) consumed 3.5 and 10 mm size-class clams. Medium crabs (75-125 mm CW) preferentially consumed 10 mm size class clams. Large crabs (>125 mm CW) consumed 10 and 25 mm size-class clams equally. All blue crab size-classes showed a preference for soft substrates rather than aggregates. The following sediment types are ranked in increasing order of their potential to protect clams from blue crab predation: bare substrate (<sand/mud>crushed oyster shell=fine gravel. Shell and fine gravel provide a refuge from blue crab predation for all sizes of clams. (Modified author's abstract - J.L.M.)


In the laboratory blue crabs of all size classes exhibited a preference for sand, mud, and sand/mud rather than crushed oyster shell or granite gravel. Crabs were more vulnerable to predation by crabs in sand and sand/mud than in crushed oyster shell or granite gravel. Small crabs (<75 mm carapace width - CW) consumed clams of 5 and 10 mm shell length. Medium crabs (75-125 mm CW) preferentially consumed 10 mm clams. Large crabs (>125 mm CW) consumed 10 and 25 mm clams equally. Blue crabs did not eat clams >40 mm. (J.L.M.)

23 Austin, H.M. 1981.


Salinity intrusions upstream have produced favorable conditions for hard clam (Mercenaria mercenaria) larval survival. The hard clam needs a salinity of at least 18‰ for successful reproduction and larval survival. Migration of the 18‰ isohaline north into Pocomoke and Tangier Sounds and the York River may result in the first good clam strike there in many years. (J.L.M.)


Mitochondria with high respiratory control ratios (RCR) have been isolated from the ventricile of the marine clam Mercenaria mercenaria. Proline is the preferred substrate of the mitochondia of the ventricile based on state 3 rates. Pyruvate, ornithine, and succinate are oxidized at rates 3/4 that of proline. α-Glycerophosphate was oxidized at rates one-half that of proline. The pH optimum for proline oxidation lies between 6.5 and 7.5 based on state-3. KCl concentrations between 250 and 450 mM gave optimum values for the oxidation of proline based on RCR and state-3 rates. KCl concentration had little effect on ADP/O between 100 and 850 mM. (Modified authors' abstract - J.L.M.)


Compared with the isosmotic state, the rate of oxidation at any concentration of proline by intact mitochondria is greater in the hypoosmotic state and lower in the hyperosmotic state. It is suggested that volume changes in mitochondria during the early stages of osmotic stress may be responsible for adjustments in intracellular con-
centrations of certain amino acids observed during volume regulation in marine bivalves. (Modified authors' abstract - J.L.M.)


The Lagoon produced 80% of Florida's clam harvest. Clammers from New York, Rhode Island, and North Carolina have introduced basket racks, and sophisticated depuration plants and relay techniques purify clams from polluted waters. Today the Indian River is home to a population of about 600,000 people and it is still growing. (J.L.M.)


The purpose was to determine if these small algae and indirectly nitrogenous wastes from Long Island duck farms are responsible for poor growth of Mercenaria mercenaria in New York. Preliminary experiments showed that hard clams were capable of clearing "small form" cells from suspension. In a 6-week growth experiment, clams fed Nannochloris atomus, a common "small form" species, showed growth, while clams fed on algal species Pseudosidoglossys parasoda, known to support growth in bivalves, grew well. In subsequent experiments, absorption efficiencies of "small forms" by clams ranged from 17.6% to 31.1% compared with 80.3% and 86.5% for algae normally used in clam culture. (Modified author's abstract - J.L.M.)


Nurseries are designed for the convenience of the operator, not the stock. The obvious variables such as salinity, turbidity, food type, and concentration have been attended to but losses continue to occur. Frequently mortality occurs apparently due to decay products and associated organisms. To overcome this problem the stock has to be evacuated before mortality sets in. Theoretically decay processes could be kept apart from the healthy animals but this is impossible to do in practice. There is also the possibility of an epizootic. Presently no cures from molluscan diseases have been developed, and in the event of an outbreak, one must assume that it would spread rapidly through the entire stock causing heavy losses. The necessity of pond and stock hygiene should be emphasized. When washing the bivalve stock the washings should not run back into the culture pond, which is a routine practice in many nurseries. (J.L.M.)


Gelora ceylonica and Anadara granosa experience hypoxic conditions and can regulate their oxygen consumption at reduced oxygen tension in water of full salinity. These two species and Mytilus edulis can also regulate oxygen consumption at reduced oxygen tension in diluted seawater. Their capacity to regulate is reduced under these conditions, although only in Anadara is this reduction very marked. At reduced-salinity oxygen consumption Mytilus is inhibited at first, but recovers within 48 hours. The ability to regulate oxygen uptake at reduced oxygen tension is not lost during the acclimation period. At 23.5°C salinity perfusion index increases with reduced PO2, but at 16.3°C perfusion index does not change as PO2 is reduced to 60 mm Hg. Mercenaria mercenaria is not mentioned. (J.L.M.)


Snapping shrimp Alpheus heterochaelis and A. normanni in laboratory tanks used their major chelae to crush and consume juvenile hard clams Mercenaria mercenaria. Shrimp of 19.1-39.4 mm total body length ate clams in the largest size-class 15.1-20.0 mm shell length. But they preferred smaller clams when offered equal numbers in this large size-class and in each of three smaller size classes. Female shrimp had a higher predation rate than males. Major chelae of female A. heterochaelis >32 mm total length were smaller than those of males of equal size. A. heterochaelis 19.1-27.2 mm total length had larger major chelae for a given body length than did specimens of A. normanni but predation rates were not significantly different. The number of clams crushed was related to size of major chelae and total body length for A. normanni but not for A. heterochaelis Alpheus spp. inflict two types of shell damage which are identical with those of blue crabs. The results imply that previous studies may have overestimated the importance of crab predation and underestimated or ignored the importance of predation by snapping shrimp. (Modified author's abstract - J.L.M.)


Predation on Mercenaria mercenaria by snapping predators occurred only at unvegetated sand flats and accounted for 87.6% of all clams recovered at one site. This high mortality rate was unique among all sites and predation rate was significantly lower at other sites. Mercenaria mercenaria unvegetated sand sites do not reach an escape size in size range of snapping predators. Hard clams in muddy areas appear to reach a safe refuge from predation by crushing or chipping predators and a spatial refuge from snapping predators, which are less effective in more fluid substrates. Field tests provide little support for the hypothesis that sea grasses provide hard clams the structural habitat heterogeneity as a refuge from predation. Natural shell bottom, on the other hand, served to reduce efficiency of large epibenthic digging or burrowing predators. This is supported by three observations: 1) natural hard clam densities were higher at a shell site than at any other unvegetated site, and higher than natural densities at two nearby sea-grass meadows; 2) survivorship of experimental clams was independent of initial clam size; and 3) recruitment was highest at a shell site. Growth of small clams (<29.9 mm long) was probably exponential, but growth rates differed little between sites perhaps because few small clams survived the full year. Small clams (<29.9 mm long) in the high-density treatment were found to have higher survival rates than their low-density counterparts. It was hypothesized that the dense assemblage of neighboring large clams in the 8x density treatment provided a structural barrier which protects smaller clams from predation. Growth rates were affected positively by increasing intraspecific density as two of the nine sites, suggesting, over the range of densities tested, that no food limitation on growth existed. However, at four sites growth rate of shell length relative to shell width was faster in the high-density treatment, implying that competition for space may have occurred. There was no relationship between recruitment rate and adult density at any site, which suggests that adult larval interactions were relatively unimportant within the range of densities tested in regulating hard clam populations. Hard clams from Back Sound were transplanted to sites in the North River, Bogue Sound, and Core Sound. At these transplant sites the natural growth rate of naturally occurring clams was comparable to Back Sound-derived clams. Results suggest that environmental factors operate over and above any possible genetic differences. These experiments can be used by shellfish managers to incorporate basic but essential biological parameters into existing regulatory measures and also into fishery yield models. These will help determine whether the abundance of hard clams is self-sustaining given the current rate of commercial exploitation. A management scheme based in spreading of shell or stone aggregate in unprotected areas is considered. (J.L.M.)


In 1982 the NY State Dept. of Health (DOH) investigated over 275 incidents of enteric illness associated with eating of raw or partially cooked hard clams and oysters. As a result DOH issued health advisories warning against consumption of raw clams or oysters. This disease outbreak was one of the largest of recent times. Altogether more than 400 people became ill from eating shellfish, mostly hard clams (Mercenaria mercenaria), showing symptoms associated with gastrointestinal illness, including nausea, vomiting, diarrhea, chills, weakness, low fever, and headache. Ten also contracted infectious hepatitis, a communicable disease of the liver. Later over 250 incidents of enteric illness, including between 5 and 10 cases of infectious hepatitis, associated with raw clam or oyster consumption were investigated, followed by another DOH health advisory. Principal sources of shellfish implicated in the first outbreak were out-of-state. The later outbreaks were caused by contamination of out-of-state and local Long Island clams. These outbreaks clearly demonstrate the need for improved resource management by industry and government cooperatively. These will
entail costs to the industry and to the state, and these costs must be weighed against the high cost of maintaining the status quo. (J.L.M.)


Simultaneous analyses of changes in dry body weight, heavy metal concentrations, and total body burden of heavy metals in *Mercenaria mercenaria* show that temporal variations in metal levels are associated with biological processes of the organism. Changes in Ni, Pb, and Cu levels are related to the spawning cycle, but Cd, Cr, and Zn levels are not. Interpretation of fluctuations in metal concentrations may be misleading unless considered with respect to seasonal variations in body weight. (Modified authors’ abstract - J.L.M.)


An area in Great South Bay, NY, which has been closed to shellfishing from domestic pollution, was also shown to have elevated levels of heavy metals in hard clams and in sediments. Clams from this area were transplanted to the central portion of the Bay which is open to shellfishing. Behavior of heavy metals in transplanted clams was primarily affected by long-term trends based on seasonal fluctuations. The clams were depurated of bacteria, but no depuration of any heavy metal analyzed (Cd, Cr, Cu, Ni, Pb, and Zn) was noted during the 50-day period of the study. In fact, significant increases in total body content of Cd, Ni, and Pb occurred. Cd and Pb levels were not elevated above natural levels found in the transplantation area, but Ni was approximately 56% higher. (Modified authors’ abstract - J.L.M.)

The large edible clam *Codakia orbicularis* lives in sulfide-rich environments in subtropical regions. Gill tissues contain intracellular procaryotic cells and yield enzyme activities associated with sulfide oxidation, carbon fixation, and nitrogen reduction. This suggests chemosynthetotrophic capabilities similar to those of deep-sea hydrothermal vent animals. Reproduction, growth rates, and chemical composition of *C. orbicularis* are similar to other commercially exploited clams like *Mercenaria mercenaria*. The potential for mariculture using industrial sulfur waste products is evident, but needs to be demonstrated. (Modified authors’ abstract - J.L.M.)

37 Berrigan, Mark. 1986.

A conservative estimate of the landings and values in 1984 is about 166 million clams of various sizes worth over $7 million. This compares with weights of about 125,000 pounds of meat and $0.4 million in the preceding two years. Harvesting, transport, and relocation are closely monitored and supervised by law enforcement officers and the Fla. Department of Natural Resources. Depuration is accomplished in tanks using recirculated UV-treated water. (J.L.M.)


Shell strength of *Mercenaria mercenaria* was within or below the range of maximum force generated by blue crabs of the sizes tested. All *Mercenaria* could be crushed by blue crabs, yet they persist in nature. Survival must be associated with reproductive behavior and/or their restricted availability to blue crabs and other predators in refuges of time or space. (J.L.M.)


No mention of *Mercenaria mercenaria*. Ecological studies of predator-prey interactions have frequently concluded that surviving prey live in refuges from their predators. The effectiveness of various refuges in protecting *Mya arenaria* from predation by *Callinectes sapidus* was tested. (J.L.M.)

40 Bodoly, Alain. 1983.
The population of *Venus gallina* consists of several cohorts of varying importance. There are generally two recruitments per year, and the life span in the Gulf of Marseille is about 2 years. Growth in weight occurs in spring when nutritional conditions are good. Spawning occurs in summer. *Mercenaria mercenaria* is not mentioned. (J.L.M. and M.W.S.)

41 Bolton, Ellis T., and Noel D. Dey. 1979.
Describes a new method to mark large numbers of molluscs permanently. They are placed in a tank containing media, food, and tetracycline at a concentration of 0.5/200 mg. Bivalves so treated daily for 1 to 14 days, or longer as desired, will be permanently marked. The mark is normally weakly visible, but fluoresces a vivid yellow-orange when exposed to ultraviolet light. (Modified authors’ abstract - J.L.M.)

42 Botton, Mark L. 1983.
There was a preference for *Mulinia lateralis* over hard-shell clams *Mercenaria mercenaria* of equal size. Shell length and shell thickness appear to influence the preference of horseshoe crabs for bivalve prey. (Modified author’s abstract - J.L.M.)


*Mercenaria mercenaria* is not mentioned, but the vulnerability of burrowing bivalves to shell-breaking predation by crabs is influenced strongly by shell features: size, shell thickness, degree of inflation, and the presence or absence of a gape. Thick-shelled clams resisted a greater number of force pulses than did thin-shelled clams of the same body weight. This suggests that the reason for increased resistance to crabs is prolongation of the shell-breaking time. A thick-shelled, tightly-closing clam may eventually be opened, but it probably would be rejected in favor of prey with shorter handling times. (J.L.M.)

Field experiments involving recovery of marked clams (*Protothaca staminea*) showed that even adult native littleneck clams could suffer high mortality to cancrid crabs. Mortality rates increased with clam density, suggesting that these crabs preferentially forage in areas of higher prey density. Acoustic telemetry showed that at least one of the crabs, *Cancer productus*, is sufficiently mobile to search large areas while foraging. (J.L.M.)

45 Bricelj, Vera Monica. 1984.
The study showed that clams can sort sediments from algae and selectively reject organic-coated and organic-free sediment particles in pseudofaeces. Clams also appear to selectively reject larger/heavier mineral particles from a sediment suspension containing particles <44 µm in diameter. Phaeophorbide a is the predominant phaeophycean pigment in clam faeces, making up 92-99% of total pigments. Algal ingestion rate declines with increasing sediment load, caused by a reduction in clearance rate. Within the concentration range tested, clams lose a limited amount of the algae cleared (up to 18%) as pseudofaeces. Silt additions to a diet of *Pseudoisochrysis paradisa* or *Nannochloris atomus* do not enhance algal absorption efficiency through a so-called “grinding” effect. Clams maintain a constant absorption rate of organic materials up to a concentration of 20 mg silt/liter. They are thus able to compensate for the dilution of algae by utilizing a considerable fraction (21%) of sedimentary organic materials. Growth rate of juvenile clams is not affected by silt concentrations up to 25 mg/liter, but it is significantly reduced at 44 mg/liter. Thus, growth enhancement by addition of silt, reported for mussels, surf clams, and oysters, was not found in *Mercenaria mercenaria*. It is suggested that these three species are better suited than hard clams for culturing efforts in turbid waters above muddy bottoms. (Modified author’s abstract - J.L.M.)

Suspended sediments, a major component of seston in estuaries, exert a profound effect on food availability and feeding activities of filter-feeding bivalves. Negative and positive effects of silt on growth have been reported. Clams (M. mercenaria) were able to sort sediment from algae, and selectively reject organic-coated and organic-free particles as pseudofaeces. They also selectively rejected the larger/heavier mineral particles from a sediment suspension containing a wide range of particle sizes (up to 44 μm in diameter). Amounts of algae ingested declined with increasing sediment concentration. This decline resulted primarily from a reduction in clearance rate. Clams lost a maximum of about 22% of the algae cleared as pseudofaeces. Presence of silt produced no enhancement in utilization of algae ingested through a so-called "mechanical effect." However, clams appeared to be able to compensate for the dilution of algae by utilizing a small fraction of the organic material in the sediment. (Modified author's abstract - J.L.M.)


Hard clams were repeatedly induced to spawn in the laboratory. Unfertilized spawned ova ranged from 50 to 97 μm and were characterized by a bimodal size-frequency distribution. In spite of high variability in egg production, correlation between size (length) and egg production was significant. Fifteen to 25% of variation in spawn, but had extremely low fecundities. Great ova ranged from 150 cells/mL to 97 μm.

Correlation between length and egg production of clams was significant: 1:;-25% of variation in total egg production in the Bay. There is no evidence to support a decline in egg fecundity, with increasing age. Large cherrystones or chowders are worth using for parent stock. The current New York minimum size may be ineffective in protecting breeding beds of larger clams. (J.L.M.)


An optimum gamete ratio of approximately 1.8 x 10^6 sperm/100 eggs was determined. Unfertilized spawned ova ranged from 50 to 97 μm and had a bimodal size frequency. Correlation between length and egg production of clams was significant: 15-25% of the variation in fecundity was attributable to difference in size of clams. Maximum egg production for a single female over the spawning season was 16.8 million eggs. No significant differences in fecundity, size of eggs, or larval survival were detected between clams from two diverse Bay habitats. It was suggested that laboratory spawning tends to underestimate natural fecundities. Sexes were about equal in abundance. Smallest clam to spawn was a sublegal female 33.1 mm long. Seed clams were capable of producing viable spawns, but had extremely low fecundities. Great South Bay populations are dominated by littlenecks under 4 yr of age. Clams are removed in most areas soon after they reach legal size, and intensive harvesting has caused a sharp downward shift in size-frequency distributions. A continuing shift to smaller sizes could reduce total egg production in the Bay. There is no evidence to support a decline in egg production with increasing age. Large cherrystones or chowders are worth using for parent stock. The current New York minimum size may be ineffective in protecting breeding stocks in the Bay. Maximum egg production of a large cherrystone is about eight times that of a seed clam. The State's minimum legal size should be reexamined, or regulatory efforts be directed at preserving beds of larger clams. (J.L.M.)


Feeding experiments were conducted to determine response of hard clam Mercenaria mercenaria (32 mm shell length) to increasing sediment concentrations. Clams were fed mixed suspensions of Pseudosimochysis paradoxa (50 and 150 cells/μL) and bottom sediments (0 to 44 mg/L). Algal ingestion rate declined with increasing sediment loads. The reduction was of similar magnitude for juvenile (13 mm) clams. Loss of algae in pseudofaeces increased with increasing sediment loads, but even at highest silt and algal concentrations, clams lost a maximum of only 18% of the algae cleared from suspension. Thus, pseudofaeces production is not expected to cause significant loss of algal food at sediment concentrations normally encountered in the natural environment (≤40 mg silt/L). Integration of physiological rate measurements suggests that at moderate to high algal concentrations (≤300 μg C/L), growth improvement by addition of silt, documented in mussels, surf clams, and oysters, is unlikely to occur in M. mercenaria. It is suggested that a suspension-feeding bivalve's success in maximizing energy gain in a turbid environment depends on a combination of two features: a high selection efficiency and a high rate of pseudofaeces production. It is proposed that species which regulate ingestion primarily by producing pseudofaeces are better adapted to cope with high suspended sediment loads than species like M. mercenaria, which control ingestion mainly by reducing clearance rate. (Modified authors' abstract - J.L.M.)


Mercenaria mercenaria was pulse-fed labeled microalgae. Clams absorbed approximately 14% of the 14C ingested. When clams were fed Pseudosimochysis paradoxa, a "good" food source, the gut residence time of 14C was greater than that of 13C. Thus, analysis of a single fecal subsample can cause significant error in calculated absorption efficiency. Therefore, pulse-chasing, or recovery of faeces over a fairly extended period of time, is strongly recommended. Examination of the time course of 14C egestion revealed that the gut passage time of P. paradoxa, which was absorbed with 82% efficiency, was significantly greater than that of two chlorophytes (Nannochloris atomus and Stichococcus sp.) and two cyanobacteria of the genus Synechococcus, which are inefficiently utilized by M. mercenaria. Clams are able to sort different algal species as they pass through the gut. Control of gut clearance rates, through more rapid elimination of those algal species which are also poorly utilized, may contribute to the species adaptive strategy. (Modified authors' abstract - J.L.M.)


Growth rates of clams Mercenaria mercenaria were not significantly affected by sediment concentrations up to 25 mg/mL. Significant reduction in growth and condition of clams occurred at 44 mg silt/L. Growth enhancement by addition of silt to an algal diet, reported in mussels, surf clams and oysters, was not found in Mercenaria mercenaria. It is suggested that these species are better suited than hard clams for culturing efforts in inshore turbid waters above uncompacted, muddy bottoms. (Modified authors' abstract - J.L.M.)


Two bacterial strains of Vibrio were implicated in a recent outbreak of disease in larvae of Crassostrea virginica at a Long Island shellfish hatchery. Juvenile clams (presumably hard clam) held at the hatchery were affected by the disease that occurred during the summer of 1979. (J.L.M.)


Prices at Fulton fish market for three sizes of hard clams (Mercenaria mercenaria) were examined for the period Jan. 1973 to Dec. 1982. Prices for littlenecks were about equal in abundance. Smallest clam to spawn was a sublegal female 33.1 mm long. Seed clams were capable of producing viable spawns, but had extremely low fecundities. (J.L.M.)


From Sept. 1980 to Dec. 1981, a total of 19,733,000 seed clams were imported into the nursery. Of these, 13,008,000 remained in the nursery at the end of the year; 3,337,700 were planted in the field; 14,700 were returned to the nursery. Apparent mortality was 3,337,700 clams during the 15 months. This 16.9% mortality is misleading because the number of clams in the nursery was rapidly increasing over the period. With a correction for mortality, a detailed budget analysis was given and linear programming was employed to determine optimal importation strategies. (Modified authors' abstract - J.L.M.)

55 Brown, John W., John J. Manzi, Harry Q. M. Clawson, and Fred S. Stevens. 1983. Moving out the learning curve: An analysis of hard clam, Mercenaria mercenaria,

Trident Seafoods Company has a cooperative venture with the South Carolina Wildlife and Marine Resources Department in which Trident Seafoods provides total capital funding while the Marine Resources Research Institute of the South Carolina Wildlife and Marine Resources Department provides technical direction and scientific expertise. The South Carolina Sea Grant Consortium provides funding for scientific research and staff time for some of the analytical work. Seed stock is purchased from commercial shellfish hatcheries which provide set averaging 1 mm in size. These small animals are placed in trays or upflow silos where estuarine water is continuously pumped over them. No supplemental feeding is used. When they reach a size of 8.10 mm they are placed in vinyl-coated wire trays for field growout, and placed in the intertidal zone of a saltmarsh creek. They grow to a size of about 25 mm. At this stage the trays are opened and clams are sorted and replanted at about one-quarter the density in less well protected trays. These trays are placed in the intertidal zone again and the clams are allowed to grow to marketable size of about 50 mm. The report analyzes the economics of the nursery during the first 18 months of operation. It is concluded that the nursery system works as it was designed. (J.L.M.)


A high prevalence of several types of lesion was found: neoplasia in Mya, and hemosiderosis, hyperplasia, and lipofuscinosis in both species. The results are preliminary. The field survey indicates that the environment at Quonset/Davisonville may be polluted to the extent of having a detrimental effect on the health of clam populations. It was recommended that fishing of Mya and Mercenaria not be allowed until the populations have been analyzed for hazardous organic chemicals. (J.L.M.)


A survey of the available mollusc literature shows that reproductive effort is higher in semelparous species (29.9%) than in iteroparous species (18.21%) to which Venus (Mercenaria) belongs, and that in iteroparous species reproductive effort increases with successive breeding seasons. Oviparous species like Mercenaria were found to divert considerably more into reproduction than viviparous species (24.24% vs 5.25%, respectively). (J.L.M.)

58 Buckner, Stuart C. 1981.


Seed clams (Mercenaria mercenaria) of mean shell length 3.6-6.9 mm were planted in various culture systems during a 2 yr period. All systems were located in a saltwater basin where clams were held in protected enclosures. Best growth and survival were obtained at the larger sizes of clams. Estimated cost per clam was similar in stacked trays and on prepared bottom. Stacked trays were most productive per area because greater quantities of clams could be grown. Bottom plots have one advantage, however, because their low visibility reduces the possibility of vandalism. To increase cost-effectiveness, the entire process—from protected grow-out of seed to transplantation to test plots and grow-out grounds—should be concentrated as quickly as possible. The applicability of hard clam culture as a resource management tool needs to be thoroughly evaluated. The appropriate scale at which seeding can make a contribution to the resource should be established. Each agency must then determine the extent of the contribution required to meet its needs in light of the goals of its shellfish management effort. (J.L.M.)

59 Buckner, Stuart C. 1983.


In the 1960s and 1970s production of hard clams Mercenaria mercenaria increased appreciably in Great South Bay, the most important hard clam producing area in the world. It reached its peak in 1976. This increase in production has been attributed to a shift in fishing effort following collapse of the Bay's oyster fishery, a series of excellent sets in the 1960s, and steadily increasing clam prices. Signs of stress on the resource appeared in the mid-1970s as greater numbers of baymen entered the fishery at a time when the rate of increased production was slowing down. In 1974 the Town of Islip began a Shellfish Management Program aimed at maintaining production. This included stock assessment programs to develop information on abundance and distribution, growth rates, mortality rates, and recruitment. The harvestable population in certified areas has declined from an average of 65 bushels/acre in 1976 to less than 35 bushels/acre in 1980. From 1974 to 1980 the average daily catch per man declined from about 3.05 to 1.75 bushels, and the greatest reduction in catch was in the littleneck size category. The program also included stock-enhancement programs by transplants, spawning relays, and mariculture. These programs were successful only in localized areas and for short periods of time because harvesting pressure was so intense. Their effects were compounded by inadequate law enforcement. Alternative management strategies need to be developed if production is to be increased. A most important aspect of the plan is to limit access to particular areas of the fishery on a rotating basis, to rebuild stocks to productive levels. More funding will be required to explore the full potential of these programs. (J.L.M.)

60 Buckner, Stuart C. 1983.


Overwhelming agreement was reached on the following points: 1) A multidisciplinary approach is the most effective method to develop viable solutions; 2) local government must continue its management efforts; 3) more stringent management controls must be imposed; 4) more enforcement officers and tougher enforcement procedures are needed; 5) tighter public health regulations and better inspection procedures are necessary; and 6) substantial increases in funding will be required. (J.L.M.)


Abundance, distribution, growth, mortality, and recruitment rates of populations of hard clams (Mercenaria mercenaria) were studied in a portion of Great South Bay, NY. Surveys were done in two successive years, and population characteristics were examined separately in certified, uncertified, and leased shellfishing areas to determine the effects of different forms of exploitation on the population. Significant differences in mean density were found in both years among harvestable populations in all areas. Substantial reductions in abundance of harvestable stock occurred throughout the study area. Harvest mortality was the major factor. Predicted levels of recruitment were sufficient to maintain existing population levels only if harvesting were greatly reduced. Such reductions were not expected, and it was predicted that abundance and catch would continue to decline. The intensity of fishing in conjunction with reductions in abundance and catch, as well as the presence of characteristic symptoms associated with the size and age composition of an overharvested population gave strong evidence that the resource has been overfished. It was concluded that management measures are needed to control the rate at which the resource is being exploited. A management strategy is described. (J.L.M.)

62 Buckner, Stuart C., and Barry D. Andres. 1978.


A method for quantitative survey of the hard clam population was adapted for use, and applied in a 20,000-acre area managed by the Town of Islip. The clamshell bucket was most suitable. The size of the sample was more closely controlled; an intact section of bottom was removed with all included organisms; and the natural appearance and position of organisms in the bottom could be observed. Also it was found that this method permitted satisfactory sampling to depths at which hard clams were found under all substrate conditions, except in extremely rocky areas. (J.L.M.)

63 Burnett, Jay. 1981.


Harry Clawson of Trident Seafoods Co. in Charleston, South Carolina, is playing a major role in developing an emerging industry in commercial clam production. Working with South Carolina Sea Grant, his company is studying the feasibility of intensive hard clam (Mercenaria mercenaria) culture. The raceway system allows them to purchase seed clams too small for field planting and grow them to field size. The program also included a Shellfish Management Program aimed at maintaining production. This included stock assessment programs to develop information on abundance and distribution, growth rates, mortality rates, and recruitment. The harvestable population in certified areas has declined from an average of 65 bushels/acre in 1976

64 Busby, Derek S. 1986.

Estuaries are among the most productive ecosystems on earth. One species which has recently experienced a rapid growth in production and value is the hard clam, *Mercenaria mercenaria*. The east coast of Florida is the southernmost extent of the range of the northern quahog, which extends as far north as Nova Scotia and the Gulf of St. Lawrence. They have also been introduced to Florida’s west coast near St. Petersburg and a small fishery now exists there. Southern quahogs, *Mercenaria campechiensis*, occur from Chesapeake Bay to as far south as St. Lucie Inlet and are also found in the Gulf of Mexico, Yucatan, and Cuba. The calm, shallow flats of the Indian River Lagoon are ideal for this clam which may be found from just below the surface to depths as great as 50 ft. Growth rates in Florida may be three times that of clams living in northern waters. In Tampa Bay they have reached a size of 2½-3 inches by the end of the second year. Changing climatic conditions in the past few years have contributed to significant increases in clam production. In 1984, 1.7 million pounds of meats worth $6.1 million were landed. Part of this increase has been caused by improvement in depuration technology. The economic success of the clamming industry in the Lagoon has brought clammers from as far away as Massachusetts. This has placed burdens on the enforcement branch of the Florida Department of Natural Resources. The health of the industry is tied to the health of the Lagoon itself. Mariculture is being considered. (J.L.M.)


For clammers who wish to start trial plantings with aggregates VIMS offers the following suggestions: 1) select aggregates that are cheap and plentiful in your area; 2) before buying in bulk to test to see if particles are heavy enough to sink and remain on bottom, and are small enough to pack well; 3) spread over planting area to a thickness of at least 1 to 3 inches; 4) scatter seed clams evenly over the aggregate at a rate of about 25-50/ft²; 5) aggregate can be put on bottom any time of year, clams should be planted at 48°F or higher when they are still active, plant at slack tide to avoid excessive clumping or scattering. (J.L.M.)

A number of diets formulated from inexpensive agricultural or fishery products were tested for promotion of growth in postset hard clams (M. mercenaria). Meal-type diets were mixed in a weak brine solution and pumped into the test containers at preset rates. Increases in shell height and dry weight were used as indicators of growth. Significantly higher growth rates were observed in clams fed certain diets. These diets are being refined and will undergo further testing. (Modified authors’ abstract - J.L.M.)

80 Chanley, P. 1967.


Larvae of 23 species, including Mercenaria mercenaria were identified and described. Identification aids include: 1) comparative photomicrographs of typical larvae arranged by sizes; 2) graphs of length-height relationships for interspecific comparison of larvae throughout development; 3) tables of dimensions and umbonal shapes; 4) keys to straight-hinge and umbonate larvae; 5) indirect aids (spawning seasons and geographic distribution); and 6) brief descriptions of each species. Combined use of all aids is recommended for identification of larvae. Large larvae are easier to identify than smaller ones, so workers should begin with umbonate larvae and progress to smaller individuals. (Modified author’s abstract - J.L.M.)

83 Clark, George R., II. 1980.


Acetate peels have largely replaced thin sections in recent research on shell structure and growth lines. They provide much less information than thin sections, but can be prepared in a fraction of the time. The introduction of low-speed diamond saws now makes it possible to prepare high-quality thin sections nearly as easily as acetate peels, and this may reverse the trend. Preparation of thin sections is described. (J.L.M.)

84 Clark, George R., II. 1980.


Complex crossed lamellar structure, and prominent growth lines in Mercenaria mercenaria formed by concentration of organic matter are illustrated by scanning electron micrographs. (J.L.M.)


Shells from New Jersey, North Carolina, and Georgia exhibited reasonably regular patterns, with reasonably consistent relationships to the time of year. Shells from Maine, near the northern limit of the range, exhibited irregular and nearly continuous patterns of stress beyond the juvenile stage. Differences in timing of events was greatest between North Carolina and New Jersey, where features characteristic of winter in one locality could occur in summer in the other. Mercenaria shells have great potential for seasonality studies, but interpretations should be restricted to shells with regular seasonal patterns and should be based upon studies of local living populations. (J.L.M.)

86 Clark, Robert Hugh. 1953.


The most rapid rate of growth and the greatest increment of growth occurs in young specimens in length classes 40-70 mm long with 1-4 "annual rings". Growth rings were much more difficult to determine in older clams with 8 or more "annual rings". Two types of rings were observed: 1) thin "disturbance rings" which were more numerous than "annual rings" probably caused by sudden and short changes in the environment; and 2) thick "annual rings" probably caused by seasonal changes in the environment. Shell weights of specimens from Pocomoke and Tangier Sounds were significantly greater than shell weights of clams from Sinepuxent Bay, MD, and Avon, NC. As length increased, the number of "annual rings" increased also. (J.L.M.)

87 Claus, Christine. 1981.


In Dennis, MA, Mercenaria mercenaria is grown on pure algal strains cultured in large outdoor tanks. Mortality in a controlled onshore nursery installation is expected to be 20-60% for Mercenaria mercenaria. Thirty-day values for the instantaneous growth rate of 3-mm spat is optimal at a temperature of 20°C. From an economic viewpoint the artificial heating of large volumes of seawater needed for commercial mollusc production is theoretically prohibitively expensive, but waste heat from a power plant may be a solution. Some advocate use of marine cooling water as a culturing medium, but indirect use of thermal effluents of all kinds might be interesting. A suitable water current is required to stimulate feeding and carry away feces. There is a significant correlation between flow rate and filtration rate. The regulation of filtration rate is influenced by cell density and by algal size. Optimum cell concentration of a medium-size algal species of 100 μm (± 6 μm) diameter is ~25 cells/μL for M. mercenaria. Presently it is impossible to draw firm conclusions with regard to the future of mollusc nurseries. All systems presented in this paper have proven to be technologically feasible but the economics should be evaluated. The margin of profit in a nursery operation is very narrow. This is a review paper and only specific references to M. mercenaria have been recorded. The entire paper should be read for details. (J.L.M.)
The entire publication is worth reading, although some papers do not mention Mercenaria mercenaria specifically. In addition, the roundtable discussions (p. 319-368) contain useful material. Papers that mention Mercenaria mercenaria are abstracted elsewhere in this bibliography. (J.L.M.)

89 Claus, Christine, Henk Maeckelberghe, and Niels De Pauw. 1983.  
Mercenaria mercenaria is not mentioned. Species examined were Ostrea edulis, Crassostrea gigas, and Venerupis semidecussata. Even very eutrophic water does not provide enough microalgae to sustain growth in winter, whether the water is heated or not. Cultured live algae must be added. Although nursery rearing of burrowing bivalves such as clams appears to be feasible, attention must be paid to shell deformations of clams in the nursery. (J.L.M.)

This paper reports on the first results obtained in Belgium at culturing postlarvae of a few millimeters to a few centimeters in size at densities as high as possible in an indoor experimental nursery with spat of Ostrea edulis, Crassostrea gigas, and Venerupis semidecussata. Mercenaria mercenaria is mentioned from a paper by Mann and Ryther (1977) abstracted elsewhere in this bibliography. (J.L.M.)

Although myosins from various muscles such as white adductor muscle and transverse adductor muscle of Mercenaria mercenaria form similar aggregates in vitro, they may form quite different structures in nature. As an example of a specialized myosin assembly, we analyzed the thick filaments of molluscan muscle. In this case the myosin assembly is directed by the underlying core of paramyosin. A possible biological role of the special design of this thick filament may be the regulation of tension maintenance. Study of the in vitro aggregates of the purified proteins provides a powerful way to comprehend the organization of the native systems. The structure and interactions of the fibrous muscle proteins are revealed by their polymorphic forms. (J.L.M.)

Preplanting surveys showed that the mean number of wild clams on the primary site was 4.3 (per square foot). No clams were found on the secondary plot. These natural densities would not support commercial operations. Clams were planted in Sept. 1977 at a density of 270 clams per square foot. They ranged in size from 2 to 4 mm. Eight live tagged clams and 1 unbroken tagged valve were found in Nov. 1977. Thus, at least some clams survived. (J.L.M.)

93 Colvin, Gordon C. 1986.  
Describes a new law which increases criminal penalties for violation of fishery laws. Also describes public hearings soon to be held on major proposed revision of shellfish tagging and record-keeping requirements. (J.L.M.)

Juvenile clams collected from natural beds were placed in plastic trays suspended from plastic flotation collars in the intake canal of a nuclear power plant. Clams ranged in size from 2 mm to 15 mm long and were maintained according to a size-frequency distribution similar to a natural population under study. Mortality over a 5-month period was less than 10%. Juveniles on natural beds had a mortality rate of nearly 90%. Maximum growth rate in trays was 0.4 mm per week in September 1979. Influence on growth rate of 10-mm clams by fouling organisms attaching to trays was examined for screens made of galvanized hardware cloth and two commercially available plastic meshes. Mortality was 5% or less in trays which held sediments in the range of 0.5-1.0 grain size and which were covered by galvanized-wire mesh. (J.L.M.)

Great South Bay has produced most of the hard clams landed in the State of New York. Within the past 5 yrs, however, landings have dropped from a peak of 700,465 bu in 1976 to 338,839 bu in 1980. The number of commercial permits issued also has declined, but the yield per permit has also gone down, from 146.4 bu in 1970 to 79.3 bu in 1980. Little necks are the most valuable. Baymen would benefit if a larger number of little necks were allowed to grow to cherrystone or chowder sizes. Sustaintable net revenues of $26 to $54 million could be generated from adherence to an optimal harvest policy. The current uncontrolled fishery has an opportunity cost in the form of foregone net revenues. The gross revenue in 1980 as reported was only $18.8 million. Institution and enforcement of the necessary quotas will not be popular among baymen. But proper controls, though requiring sacrifices today, could lead to a more profitable fishery tomorrow. (J.L.M.)

96 Conrad, Jon M. 1983.  
Landings of clams per official permit have been declining since at least 1970, from over 146 bushels per permit per year in 1970 to about 64 bushels per permit per year in 1982. Overfishing brought about by open access to the fishery is probably reinforced by the high price of little necks. The hard clam resource in Great South Bay exhibits all the classic symptoms of overfishing caused by open access to the resource. A management program which includes a system of transferable harvest quotas, a system of certified collection centers, a records system, public auctions, and a modest landings tax per bushel, is proposed. Great South Bay could have produced gross revenues of between $35 and $70 million in 1980, and net revenues between $25 and $55 million, compared with the $18.8 million reported. No one can predict with certainty what a well managed fishery might be worth. But it seems worthwhile to consider new alternatives for management. If that gamble is not taken, the true potential of the fishery may never be known. (J.L.M.)

97 Cook, Dick. (no date, probably 1982).  
A brief account of the life history of Mercenaria mercenaria with uses of clams, fishing areas, recent landings, harvest methods, and instructions on holding and buying. Concludes with recipes. (J.L.M.)

The amount of acreage available to oyster and clam harvest is severely limited by lack of an adequate Shellfish Sanitation Program and private ownership of most oyster and clam bottoms. Despite this, many out-of-state oyster and clam producers have recently expressed interest in Georgia's shellfish resources (including Mercenaria mercenaria). The summary includes attempts to remedy past causes of the decline of the industry and the current program of the State to encourage shellfisheries development. (Modified author's abstract - J.L.M.)

99 Crenshaw, Miles A. 1980.  
Zonation in the shell of Mercenaria mercenaria is shown in fig. 2. The soluble matrix from the shell of M. mercenaria contains about 20% carbohydrates. The B-carboxyl group of aspartic acid appears to be amidated rather than being a free acidic group in the soluble matrix. When alkali-induced B-elimination of the carbohydrate was tried, to detect the presence of the O-glycosidic linkage to serine, no evidence of this linkage was found in the soluble matrix of M. mercenaria. The soluble matrix from M. mercenaria specifically binds calcium. It was suggested that the pores in the nacreous interlamellar membranes of several mollusks are filled with a soluble matrix
similar to that isolated from *M. mercenaria*. Some bivalves dissolve previously precipitated shell when they become anaerobic. In *M. mercenaria* shell dissolution is caused by an anaerobically produced acid with a pK similar to that of lactic acid. It was later shown that this was succinic acid, and that only 2% of the total acid was lactic acid. Analysis of body fluids and soft tissues showed that there is a stoichiometric relationship between the increase in succinic acid and calcium concentrations. Analysis of extrapallial fluid showed that succinic acid accounted for only 80% of the calcium change in this compartment. This may be accounted for by the carbonate and bicarbonate derived from the shell and by ionic exchange with the mantle epithelium. Dissolution of the shell during anaerobiosis appears to occur primarily inside the pallial line. The chalky appearance of the inner shell surface that characteristically develops with this dissolution is not found outside the pallial line even after extended periods out of water. Scanning electron micrographs show that crystals inside the pallial line have irregular edges and are poorly organized with large voids on the inner surface. Outside the pallial line the crystals have sharp edges, are well organized, and fill available space. (J.L.M.)

100 Cresswell, LeRoy. 1986.

Preliminary results show that hatchery production of hard clams in the Indian River area is feasible. Several million clam seeds were cultured at the Harbor Branch Foundation facility in 1984. This program can expand production of clam seed should the demand for cultured hard clams for mariculture increase. (J.L.M.)


This dredge was used successfully during clam surveys along the northeast coast of the United States in water depths up to 50 fathoms. Advantages of the system compared with conventional surface-supplied hydraulic dredges are ease of handling, consistency of operation, and efficiency in power transmission. The dredge and various controls are described in detail. (J.L.M. and M.W.S).


Young quahogs of the northern and southern species (*Mercenaria mercenaria* and *M. campechiensis*) and both reciprocal hybrids were collected as approximately monthly intervals from Alligator Harbor, Fla. Gonadal sections were examined histologically from Nov. 1974 to Nov. 1975 to determine reproductive cycles. *Mercenaria mercenaria* had three minor spawning peaks (late Jan., late Apr., and mid-Sept.). *M. campechiensis* had a single spawning period with peak activity in early February. *M. campechiensis* × *M. mercenaria* (the female parent is listed first in all hybrids) had a major spawning period (Dec.-March) and a minor spawning (May-Aug.). Data for the reciprocal hybrid were incomplete but seemed to indicate two spawnings (Dec.-Feb. and June-Aug.). Growth among the 4 groups followed the same general trends, but *M. mercenaria* had the best growth. (Modified author’s abstract - J.L.M.)

Seasonal gonadal development of young laboratory-spawned southern (*Mercenaria campechiensis*) and northern (*Mercenaria mercenaria*) quahogs and their reciprocal hybrids in northwest Florida. J. Shellfish Res. 3(1):11-17.

All young clams were males and one or more stages of gametogenic activity were seen each month of the year. Winter spawning was considered abnormal and resulted from the unusually warm winter of 1974-75. Gonadal development of hybrid female *M. campechiensis* × male *M. mercenaria* was similar to its southern parent; the reciprocal hybrid was similar to its northern parent. This may indicate maternal influence. Little or no spawning by *M. campechiensis* in the warmer months was unlike that of the other three pedigrees. Temperature was the overall controlling factor in gonadal development and spawning, but genetic differences existed between the two species. (Modified authors’ abstract - J.L.M.)

104 Dauvin, Jean-Claude. 1985.

The dynamics of a *Venus ovata* population from a muddy fine sand community at station Pierre Noire from the Bay of Morlaix has been studied with a view to estimating its production. *Mercenaria mercenaria* is mentioned only in relation to a publication abstracted elsewhere in this bibliography. (J.L.M.)

105 Davis, Harry C., and Anthony Calabrese. 1964.

Rate of growth of larvae at different temperatures was critically affected by the type of food organisms available. Clam and oyster larvae were able to utilize naked algae such as the chrysophytes Monochrysis lutheri, Isochrysis galbana and Dicrateria sp. and show significant growth at lower temperatures than those at which chlorophytes such as Chlorella sp. which have cell walls could be utilized. This implies that the enzyme systems required to digest naked flagellates are active at lower temperatures than are the enzyme systems required to digest cell walls. The cells of *I. galbana* and *M. lutheri* are destroyed by temperatures at 27.5-30.0°C, and growth of larvae receiving these foods at such temperatures was reduced. *Chlorella* sp. continued to increase with each 2.5°C increase in temperature up to 33.0°C. Salinity also affects the temperature tolerance of clam and oyster larvae. At near-optimum salinities the larvae survive and grow over a significantly wider range of temperatures than at salinities near the lower limits of their tolerance. We observed the temperature tolerances of clam and oyster larvae at a series of decreased salinities. (Modified authors’ abstract - J.L.M.)


Mortality among 3-mm seed clams (*Mercenaria mercenaria*) is about 95%. Blue crab is a major predator, but mud crabs, stone crabs, shrimp, snapping shrimps, bottom-feeding fishes, moon snails, and whelks also take their toll. Growth rate of clams affects rate of predation. The faster the growth, the less time is available for predation, and big clams are less vulnerable than small clams. Seed planted in winter will grow in North Carolina, so that by spring they are less vulnerable. Caging also is helpful, but it may not be cost effective. Seed clams might be held in crab shedding tanks during the off-season, growing until they reach sizes sufficient for planting. (J.L.M.)


Nearly all commercial enterprises involved in nursery rearing of bivalve molluscs in Europe use natural phytoplankton as food. In contrast, small-scale and large-scale experiments carried out in many countries have shown the potential and reliability of cultivating microalgae species for nursery bivalves, in analogy to the well established algal culture for hatchery molluscs. Some hatcheries continue to feed spats with the same species of microalgae used to rear larvae. The increasing quantities of algae needed soon becomes a limiting technological and economical factor. Scaling up of sophisticated systems used to produce monospecific algae species seems to be prohibitive. Two trends are evident. The first relies on completely controlled production of specific algal species. The second is based on induction of natural phytoplankton blooms in outdoor systems. This arrives at a certain control of species composition by manipulating different internal and ambient conditions, such as nutrients, pH, detention time, and mixing. The biotechnological aspects of large-scale production of algae are discussed, and the present needs and possibilities of a more controlled way to produce food for nursery bivalves are examined. The original paper should be examined for details. (Modified author’s abstract - J.L.M.)

108 Dey, N. Dean. 1978.

Clams (*Mercenaria mercenaria*) were planted at a density of 270/ft² over the 100-ft² plots. If they were evenly distributed and all had survived, a total of 48 live clams should have been collected. The pooled samples contained eight live tetracycline-tagged *Mercenaria* for a return of 16.67%. In addition, 11 unbroken tagged valves were found, accounting for another 23% of the planted clams. Finding of marked fragments of shells indicates that predation was occurring. Growth was apparent in only one of the live clams. The results, along with return of tagged material, provided preliminary data on evaluation and success of clam planting. (J.L.M.)

Hatchery-spawned hard clams, *Mercenaria mercenaria*, were planted at two sites in Rehobeth Bay in Sept. 1977. They were marked with tetracycline. The average size at planting was 2.70 mm. On recovery in June 1978 the average size at the deepwater station was 8.3 mm, and at the shallow-water station was 12.5 mm. Apparent survival was only 0.37% with a range of 0.19-0.49%. No obvious evidence of severe predation was seen. The low survival rate apparently was caused by several factors. Fifty percent appeared to have been killed by other means than predation, probably by the effects of the very cold winter of 1977-78. The very small clams may have been killed by polychaete predation. In spring and summer some predation was caused by *Polinices*, crabs, *Busycon*, and possibly sea stars. Use of tetracycline was important in that it allowed positive identification of planted clams, and provided a marker so that growth could be estimated more quickly. (L.M.M.)

109 Dey, N. Dean. 1978.


Sibling populations of hard clams were raised in a controlled environment with excess algal food. Wide variations were observed in shell length and volume. Populations were divided at an early stage into five successively larger size classes. Clams in the larger size classes always grew much more rapidly than smaller clams at 18°C and 25°C. Early setting clams grow more rapidly than late-settling clams but make up only a small fraction of the population. Late-setting clams never match the growth rate of early-settling clams and remain small relative to their larger siblings. During the first 4 weeks growth of spat continue at the larval rate. The rate of increase then decreases (growth pause) for the next 2 weeks, then rapid growth resumes but at a reduced rate typical of juvenile clams. The growth pause may be associated with growth of siphons. Fast-growing larvae make up fewer than 5% of the population, but with proper selection, fast-growing commercial strains, or uniform groups of clams, can be produced for studies of toxicology or nutrition. (L.M.M.)


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The quahog, *Mercenaria mercenaria*, supported essentially no commercial fishery in Texas since about 1900. Prior to 1900 a small fishery did exist. The species occurs in lower Galveston Bay near Port Bolivar and near Carancagua Reef in central West Bay and occupies a combined area of about 4 acres. A similar species, *M. campechien­sis*, occurs in Mesquite Bay and in South Bay. Charts are included showing waters closed to shellfishing. Some commercial fishery landings also are tabulated. (L.M.M.)


The smallest size class for clams, “seeds” (1 inch), were the most abundant group of clams at one of four transects in the Indian River Lagoon. An average of 8 clams per 1/4 m² indicated that this area had received a successful set and should continue to yield substantial quantities of harvestable clams as long as no significant die-off occurs. For size groups of clams >1-inch long, there were no obvious differences between sampling locations. At Grant (the location previously described) numbers decreased dramatically from the small “seed” clams. Either harvesting reduced the numbers of larger clams to levels similar to the other areas, or unsuccessful sets or mortality of juveniles reduced the numbers of larger clams. Successful recruitment of juvenile clams should sustain the harvest for the next 2 years at Grant, provided mortality remains low. But low recruitment in the other areas will not provide large numbers of harvestable clams. The sampling methodology used, a SCUBA-assisted suction dredge, provided a quantitative picture of shellfish populations, and should be a valuable tool in future studies. (L.M.M.)


Rates of calcium carbonate removal from shell pieces of *Mercenaria mercenaria* were dependent on the type of etching fluid used and not on shell origin. Etching was uniform over the entire shell surface, but surface morphology differed with etching fluids. Peak radioactivity was in early eluant fractions of shells etched immediately after radioactively labelling, and in later fractions when individuals were placed in isotop­free seawater after labelling. The etching technique can measure growth during the labelling period and subsequently by estimating the amount of calcium in fractions prior to the radioactive peak. Geometry of shell layers influenced the pattern of radio­activity seen in fractions. Peak location varied inside and outside the pallial line of individuals. A significant portion of the inorganic carbon used in shell formation was derived from metabolic CO₂. (Modified authors' abstract - J.L.M.)


The diatom *Thalassiosira pseudonana* was cultured in 10 µg/L benzo(a)pyrene (BaP) and subsequently fed to larvae of the hard clam *Mercenaria mercenaria*. The rate of direct uptake of BaP by seawater by the diatoms was much greater than the rate of trophic transfer of BaP from the diatoms to the clam larvae. This was attributed to greater efficiency of direct uptake and to the larger quantity of BaP available in the water. A comparison of direct uptake by bivalves (as reported in the literature) with trophic transfer measured in the present investigation indicated that the processes may be equally important in accumulation of BaP in natural populations of bivalves. (Authors’ abstract - J.L.M.)

115 Doering, Peter H. 1982.


In field and laboratory choice tests the sea star was attracted to distant upstream clams. Clams exposed to upstream sea stars were chosen less frequently by downstream sea stars than clams without sea stars upstream. Sea stars neither attracted nor repelled downstream conspecifics. When clams were exposed to upstream sea stars their oxygen consumption decreased, as did their pumping rate and activity as measured by the number of visible siphons. It was concluded that clams and sea stars sense each other over a distance by chemical cues. The response of the clam is a general lowering of activity which may result in decreased attractiveness to sea star predators. This response may serve as a defensive measure against distance detection by sea stars. (Modified author's abstract - J.L.M.)


*Mercenaria mercenaria* and several other bivalves were suspended near the surface, at mid-depth, and near bottom at two sites with different water depths in Long Island Sound in 1984. Growth through December was measured to determine if growth near bottom would be improved by upwelling of nutrient-rich bottom materials. Cumulative growth and relative growth rates showed best growth in summer at the nearsurface location at both sites for species deployed in July. Between August and November growth rates were highest near the bottom at both sites. For those species deployed in August, at the 10-m depth site, best growth was near the surface from August to October, but subsequent growth was greatest near the bottom. At the 20-m depth site growth was equal at all three depths from August to October Subsequently, growth at upper levels was greater than at the bottom. (Modified author's abstract - J.L.M.)


One group of juvenile hard clams (M. mercenaria) received continuous crabmeal supplements while the control group received only maintenance seawater flow. Final dry weights of crabmeal-fed clams were significantly greater than those of control clams. Overall, the increase in wet and dry weights was 2.5 times greater in crabmeal-fed clams than in control clams. Ongoing research is being conducted to determine optimum feeding rates and commercial scale applicability. (Modified authors' abstract - J.L.M.)

118 Easley, J.E., Jr. 1982.


Some shellfish have the ability to purge themselves of contaminants after they are placed in clean water. A North Carolina management practice is to mechanically move (or relay) shellfish from polluted water to clean water for purging and later harvesting. Significantly higher returns may be earned by fishermen if shellfish moved from polluted water are placed on private or leased bottom as opposed to bottoms in public
waters. The magnitude of this higher return is discussed in an example from North Carolina, and issues affecting the size of the gain are explored. Implications for management are discussed. (J.L.M.)

119 Eldridge, Peter J., and Arnold G. Eversole. 1981. Compensatory growth and mortality of the hard clam, Mercenaria mercenaria (Linnaeus 1758). Veliger 24(3):276-278. Clams raised at the same density were similar in mean shell length between replicates and tidal locations at the start of the experiment. However, mean shell length of clams formerly held at a density of 869/m² was significantly smaller than at 290/m², and clams formerly held at 1159/m² were significantly smaller than both of the lower densities. These differences persisted throughout the experiment. Adjustments to reduced population densities were observed in absolute and relative growth. Shell lengths of clams formerly held at 1159/m² and 869/m² increased approximately 10 mm and 8.5 mm during the experiment compared with only 5 mm for clams maintained at 290/m². According to Ricker’s (1975) definition this population of hard clams, 3-5 years of age, exhibited compensatory growth. Results also indicated that growth adjustments were influenced by reductions in population density. (J.L.M.)

120 Elfvin, Myra, Rhea J. C. Levine, and Maynard M. Dewey. 1976. Paramyosin in invertebrate muscles. I. Identification and localization. J. Cell Biol. 71(1):261-272. By sodium dodecyl sulfate-polyacrylamide gel electrophoresis and immunodiffusion, they identified paramyosin in two smooth invertebrate "catch" muscles including Mercenaria mercenaria opaque adductor. Paramyosin was also identified in five invertebrate striated muscles. Paramyosins of all these muscles had the same chain weights and were immunologically similar. All muscles were stained with specific antibody to Lumulus paramyosin using the indirect fluorescent antibody technique. Paramyosin was localized to the A bands of the glyceregated striated muscles, and diffuse fluorescence was seen throughout the glyceregated fibers of the smooth catch muscles. (J.L.M.)


123 Estes, Ernest Latham, III. 1972. Diagenetic alteration of Mercenaria mercenaria as determined by laser microprobe analysis. Ph.D. diss., Univ. N.Y. at Stony Brook, NY 11794, 83 p. [From Diss. Abstr. Int. B Sci. 34 (1973):275B-276B.] Modern, recent, and Pleistocene representatives of Mercenaria mercenaria were analyzed in great detail utilizing laser microprobe spectrographic techniques. The main purpose of the study was to determine if diagenetic chemical alteration exists in apparently unaltered skeletal material. Analysis of precision indicates that a coefficient of variation of 3.5% is possible if care is taken throughout the analytical procedure. The principal conclusions are: 1) A large range of Sr/Ca, Mg/Ca, and Na/Ca ratios is present within different portions of modern, recent, and Pleistocene representatives of hard clam and the range of values obtained decreases with increasing geologic age as internal equilibration proceeds. 2) There is no significant change in the amount of Sr deposited at different times in the hard clam's life cycle; Sr is largely incorporated in crystal lattice sites, although a portion appears to be bound either in the organic fraction or on crystalline surfaces; internal equilibrium with respect to Sr within the shell seems to occur shortly after death, apparently due to equilibration of non-lattice material. 3) There is a decreased discrimination against Mg as hard clam ages; the Mg/Ca ratio does not change from modern to recent specimens, but decreases from recent to Pleistocene samples; the decrease in Mg is due to an external re-equilibration of the organically-bound portion or the absorbed portion with the aqueous environment. 4) There is a decreased discrimination against Na as hard clam matures; Na appears to be present mainly as a contaminant, and is not present in the lattice; Na increases from modern to recent samples due to an external re-equilibration of non-lattice material with seawater, and decreases from recent to Pleistocene specimens due to re-equilibration of non-lattice material with fresh water. 5) The prismatic-lamellar interface is the main pathway by which Na and Mg enter and leave the shell. 6) The order of trace element mobility in hard clam is Na>Mg>Sr, which is mainly dependent upon the site in which each element resides. (J.L.M.)

124 Eversole, Arnold G., Peter J. Eldridge, and William K. Michener. 1981. Reproductive response to increased density: Some observations on molluscs. J. Shellfish. Res. 11(1):113-114 (abstract). A significant density-dependent reduction in growth of hard clams (Mercenaria mercenaria) is evident. Histological evidence gives no indication that gametogenesis is affected by increased density. The amount of gonadal tissue in clams grown at three population densities was compared. Clams at the lowest density were larger, weighed more, and had more gonadal tissue than clams from higher densities. Gonadal-somatic indices showed that density-dependent reduction of growth did not fully account for reductions in amount of gonadal tissue. Results are discussed in relation to existing literature on density-dependent changes in reproductive biology of molluscs with emphasis on ecological advantages and consequence of some changes. (J.L.M.)

125 Eversole, Arnold G., W.K. Michener, and Peter J. Eldridge. 1984. Gonadal condition of Mercenaria mercenaria (Linne) in a South Carolina estuary. J. Shellfish. Res. 4(1):88 (abstract). Changes in gonadal condition (GSI) reflected seasonal changes in gonadal development. Similar decreases in GSI were observed in spring (May-June) and fall (Sept.-Oct.) spawning peaks. GSI varied significantly with clam (M. mercenaria) size and age. Larger clams of the same age had proportionally more gonadal tissue than smaller clams. Older clams have larger GSI than younger clams of the same size. No statistical difference was detected between GSI of female and male clams of the same age and size. Clams grown at the lowest density level or at the subtidal location were larger and had proportionally more gonadal tissue than clams from high densities or the intertidal location. Size differences between treatments explained the variation in GSI between density treatments, but not between tidal locations. (Modified authors' abstract - J.L.M.)

126 Evjen, Arthur John. 1985. Above bottom bivalve growth in Long Island Sound and the influence of resuspended sediment. M.S. Thesis, State Univ. N.Y. at Stony Brook, NY 11794, 83 p. Mercenaria mercenaria and some other bivalves were suspended at the surface, mid-depth, and near bottom in Long Island Sound in summer. Growth through November was observed to determine if enhanced growth, as proposed by Rhoads et al (1975), occurred near bottom where resuspended sediment concentrations were highest. Cumulative growth and instantaneous growth rates showed best growth between June and August in clams at the surface. Between August and November growth rates were highest near bottom. Measured concentrations of chlorophyll-(a), phaeopigments, POC and PON all decreased with depth until October when distributions became more homogeneous. Sediment concentrations increased with depth. The dramatic change in October coincided with the breakdown of stratification. It is suggested that food trapped by stratification was then redistributed. Settling food material became available to nearbottom animals by sediment resuspension. Enhanced growth near bottom was observed after sufficient food combined with resuspended sediment. Food availability was apparently the overriding factor affecting growth. Best growth was at the surface, not the bottom. (Modified author's abstract - J.L.M.)


New Jersey's harvest of shellfish consisted primarily of hard clam (*Mercenaria mercenaria*), soft clam, oyster, blue mussel, and bay scallop. A survey was conducted to determine the numbers of shellfishermen in New Jersey, the effort expended, and their harvest. Over 1000 shellfishermen responded to the questionnaire. In 1978 there were 22,728 licensed bay shellfishermen. At least 90% of license holders went shellfishing. Effort expended was 211,473 man-days, 213 of which were recreational and 1,335 commercial. Licensed shellfishermen took 58 million hard clams. Although commercial fishermen made up only 5% of total shellfishermen, they accounted for 66% of hard clam landings. Recreational clammers averaged 164 hard clams per day, part-time commercial 418, and full-time commercial 622. Treading was the most popular method for recreational and commercial fishermen, which is restricted to water less than 5 feet deep and primarily from April to October. The tables give considerable detail on fishermen and their activities. (J.L.M.)

129 Figley, Bill, Tom McCloy, and Staff of Nacote Creek Research Laboratory. 1979. New Jersey's bay shellfisheries. NJ Inf. Bull., NJ Dep. Environ. Prot., Div. Fish, Game, and Shellfish., Nacote Creek Res. Lab., Absecon, NJ 08201, 6 p. New Jersey's oyster, hard clam, and soft clam stocks and their harvests have been declining since the late 1940s or early 1950s. The causes are pollution, habitat destruction, the tremendous demand for seafood which has led to overfishing, and in some cases environmental factors. In 1978, 58 million hard clams were harvested, which probably is conservative. The primary species sought was the hard clam, *Mercenaria mercenaria*, which is found throughout New Jersey estuaries where salinity is regularly above 155/0, and occurs from the intertidal zone to depths >30 feet. They may live for 20-35 years, and reach a maximum size of 5½ inches. In 1978 full-time commercial fishermen took an average of 622 hard clams per day, part-time commercial fishermen took 418 per day, and recreational fishermen took 164 per day. (J.L.M.)

130 Flagg, Paul J., and Robert E. Malouf. 1983. Experimental plantings of juveniles of the hard clam *Mercenaria mercenaria* (Linne) in the waters of Long Island, New York. J. Shellfish. Res. 3(1):19-27. Objectives were to determine how seed survival was influenced by (1) seed size at the time of planting; (2) presence, absence, and type of gravel aggregate; (3) season of planting; and (4) site selection. Site characteristics, particularly the types and abundance of predators present, were found to influence the results so strongly that general recommendations cannot be made. Mud crabs (*Necora puber*) and whelks (*Busycon canaliculatum* and *B. canaliculatum*) were the most damaging predators at sites tested. Gravel aggregate did not provide adequate protection for planted clams, and use of large (<25 mm) gravel appeared to have a negative impact on seed survival. Survival exceeded 10% only among clams that were at least 20 mm long at planting. Mortalities as high as 100% resulted from plantings of such seed (23 mm) at sites having significant populations of whelks. (Modified authors' abstract - J.L.M.)

131 Flimlin, Gef. 1986. Agent's odyssey reaps rewards. N.J. Sea Grant Ext. Serv., Rutgers Univ., New Brunswick, NJ 08903. The Jersey Shoreline 9(1):1. This project will attempt to rejuvenate populations of hard clam, *Mercenaria mercenaria*, in Barnegat and Little Egg Harbor bays. Leased bottom will be cultivated with a hydraulic cultivator, which reoxygenates the substrate, opens up the bottom to receive clam spawn, and raises the pH level by washing away acidic sediments. (J.L.M. and M.W.S.)


133 Foster-Smith, R.L. 1975. The effect of concentration of suspension and inert material on the assimilation of algae by three bivalves. J. Mar. Biol. Assoc. U. K. 55(2):411-418. Assimilation efficiency was found to be inversely related to total amounts of Phaeodactylum ingested over periods of up to 3 hours rather than related directly to concentration of suspension or rates of ingestion. *Mercenaria mercenaria* was not included in the experiments. (J.L.M.)


135 Franz, David R. 1982. An historical perspective on mollusks in Lower New York Harbor, with emphasis on oysters. In Mayer, G.F. (ed.), Ecological stress and the New York Right: Science and management, p. 181-197. Estuarine Res. Fed., Columbia, SC. *Mercenaria mercenaria* was included in a list of shallow bay and shore molluscan species of Staten Island in Smith (1887). Beds of quahogs were abundant locally over much of the lower harbor, and extensive populations occurred in Gravestone Bay, Jamaica Bay, and Raritan Bay. Hard clams raked in Staten Island and Jamaica Bay were marketed in N.Y. City. Most N.Y. City shellfish beds were closed for public health reasons by 1921. (I.L.M.)

136 Fritz, Lowell W., and Dexter S. Haven. 1983. Hard clam, *Mercenaria mercenaria*: Shell growth patterns in Chesapeake Bay. Fish. Bull., U.S. 81(4):697-708. Acetate peels of polished and etched radial shell surfaces of *Mercenaria mercenaria* showed growth cessation marks caused by low winter water temperatures present in some annual increments but were not formed each year by each individual clam. This was caused primarily by differences among age groups in seasonal band formation. Clams younger than 8 years tended to form light bands in fall and spring. Older clams tended to form light bands only in spring, and winter growth cessation marks were masked by dark bands deposited from summer through winter. These differ from clam-shell growth patterns found elsewhere along the range, suggesting that time of annulus formation varies with latitude. The percentage agreement between increments and days in annual shell increments decreased with increasing age. Thus, dividing total microgrowth increment counts by 365 could underestimate age in years. (J.L.M.)

137 Gabbott, P.A., D.A. Jones, and D.H. Nichols. 1975. Studies on the design and acceptability of microencapsulated diets for marine particle feeders. II. Bivalve molluscs, p. 127-141. 10th Eur. Symp. Mar. Biol., Ostend, Belgium, Sept. 17-23, 1975, Vol. 1. In contrast to many crustacea, marine bivalves swallow their food whole. This means that the wall of the microcapsule must be broken down in the gut, either by digestive enzymes or by a change in pH. The main aim of the paper was to demonstrate the feasibility of using microcapsules as artificial food particles for marine bivalves. In our laboratory, nylon-protein capsules were prepared on a routine basis and have been used in experimental studies on feeding and digestion and in simple growth experiments. As an experimental approach this has already been successful. Experiments were with *Mytilus edulis* and *Crassostrea gigas*, not *Mercenaria mercenaria*. (J.L.M.)


139 Gaffney, Patrick M., and Timothy M. Scott. 1984. Genetic heterozygosity and production traits in natural and hatchery populations of bivalves. Aquaculture 42(3/4): 289-302. Relationship between allozyme phenotype and physiological traits depends strongly on genetic structure of the population in several bivalve species. *Mercenaria mercenaria* was not studied but some discussion from the literature is included. (J.L.M.)

140 Gallagher, Scott M., and Roger Mann. 1984. Lipids and the condition of marine bivalve larvae. J. Shellfish. Res. 4(1):90 (abstract). Neutral lipids, predominantly triacylglycerides, are an important energy reserve in larvae of *Mercenaria mercenaria*, *Crassostrea virginica*, and *Ostrea edulis* and are metabolized under stress. Data from our laboratory and two commercial hatcheries suggest that a threshold relationship exists between egg lipid content and subsequent larval growth and metamorphosis. Under otherwise identical culture conditions eggs with a high lipid content give rise to larvae in better condition which complete metamorphosis with a higher degree of success than eggs with a low lipid content. Lipid levels in 24-hour straight hinge larvae, visualized with lipid-specific stains, may be used as an index of potential culture success. (Modified authors' abstract - J.L.M.)
141 Galtsoff, Paul S. 1940. 
Physiology of reproduction of Ostrea virginica. III. Stimulation of spawning in the male oyster. Biol. Bull. (Woods Hole) 78(1):117-135. The sexual reaction of Ostrea virginica is nonspecific. It can be provided by the sperm of Venus and others. (J.L.M.)

Comparison of energetics of hard clam predation by Neopompea sayi, Ovalipes ocellatus, and Pagurus longicarpus. J. Shellfish Res. 4(1):90 (abstract). The bioenergetics of ingestion, absorption, and respiration were used to examine the voracity of hard clam Mercenaria mercenaria predation by the mud crab Neopompea sayi, the calico crab Ovalipes ocellatus, and the hermit crab Pagurus longicarpus. Crabs were several orders of magnitude more voracious than sea stars or gastropods in terms of ingestion rate. On the basis of body-weight comparisons of the prey consumed per day, however, adult crabs, sea stars, and snails consumed similar amounts of prey. Predatory gastropods and sea stars have long search and attack procedures to pursue their prey. They have specialized diets and generally prey on relatively large prey. Crabs are scavengers, do not extensively pursue individual prey, have more flexible diets, and consume large numbers of small prey daily. Ingestion rates of predators are influenced by their metabolic rates and their ability to convert food into net energy. The mud crab, calico crab, and hermit crab have high absorption efficiencies and metabolic costs compared with predatory gastropods. Crabs lost larger percentages of energy via respiration than predatory gastropods. These data are consistent with the different methods of foraging used by crabs and predatory gastropods. (Modified author's abstract - J.L.M.)

Predation of juveniles of the hard clam Mercenaria mercenaria (Linne) by fifteen invertebrate species with special reference to crabs. J. Shellfish Res. 4(1):90 (abstract). Fifteen of 19 species tested consumed juvenile hard clams. Crabs had higher predation rates than gastropods, shrimp, and sea stars. Predation by crabs was influenced by clam size, crab size, crab species, temperature, and substrate. Crabs preyed upon hard clams with shell lengths up to 30% of their carapace widths. The size of prey affected the method of predation used by crabs. Predation decreased with declining temperature and resumed when water temperature rose in spring. The rock crab Cancer irroratus was observed to prey on hard clams at a seawater temperature of 0°C. Substrate type influenced predation. Crushed gravel aggregate and, to a lesser extent, sand provided protection for juvenile hard clams against predation by Neopompea sayi, Ovalipes ocellatus, and Pagurus longicarpus. (Modified author's abstract - J.L.M.)

Serotonin as an inducer of spawning in six bivalve species. Aquaculture 40(2):189-191. Injection of serotonin into the anterior adductor muscle of the hard clam Mercenaria mercenaria induced spawning. A dosage of 0.4 mL of 2 mM serotonin solution stimulated hard clams to spawn within 15 minutes. (J.L.M.)

Biological control of predation by crabs in bottom cultures of hard clams using a combination of crushed stone aggregate, toadfish, and cages. Aquaculture 47(2,3):101-104. Use of toadfish (Opsanus tau) to control predation by crabs on juvenile hard clams Mercenaria mercenaria was tested in this field study. Hard clams 3 mm long, planted in crushed stone aggregate beds, had significantly higher survival when enclosed in cages with toadfish than in cages without toadfish. Toadfish were effective in reducing predation by crabs (Callinectes sapidus, Neopompea sayi, and Panopeus herbstii). (Modified authors' abstract - J.L.M.)

146 Gibson, Ray. 1968. 
Studies on the biology of the entocommensal Rhynchocoele Malacocelidae grossa. J. Mar. Biol. Assoc. U.K. 48:637-656. Mercenaria mercenaria is not mentioned. No measurable effects are produced upon the host and the nemertean is a true commensal. Host and worm sex ratios are about 1:1. (J.L.M.)

Assessment of intertidal growth and capacity adaptations in suspension-feeding bivalves. Mar. Biol. 68(3):277-286. Langton and McKay (1974, 1976) found that growth was best in Crassostrea gigas spat fed discontinuously rather than continuously. The same phenomenon has been noted in hatchery-reared spot of Mercenaria mercenaria. (J.L.M.)

Variability in the calcium phosphate concretion load in the kidney of Mercenaria mercenaria. Mar. Ecol. Prog. Ser. 10(1):97-99. Appreciable differences in calcium phosphate concretion loads were found between different size classes of the hard clam Mercenaria mercenaria. Largest clams (41.3 mm) had significantly higher amounts of concretions than intermediate (36.5-41.2 mm) or small (25.4-36.4) clams. Comparison of concretion weights in clams of comparable size from two selected sites showed that clams from restricted areas (uncertified) had significantly higher loads than those from approved beds (certified). (Modified authors' abstract - J.L.M.)

The effect of feed density on the growth of juvenile Mercenaria campechiensis, the southern hard clam. Proc. World Maricult. Soc. 11:192-201. A Tahitian strain of Isochrysis sp. was grown in outdoor continuous culture and fed to juvenile Mercenaria campechiensis at five different cell densities: 5x10^5, 1x10^5, 5x10^4, and 1x10^4 cells/mL. A control group received only 1μL-filtered seawater. An additional control consisted of an identical experimental setup receiving 5x10^-5 cells/mL without animals. Each treatment went to duplicate populations of 100 animals of 0.1 g each and each population had a whole wet weight of 10.0 g. Total flow rate to each was 120 mL/min. The control treatment of 1μL-filtered seawater gave no growth. It was most concentrated treatment (50.01 μg-at PPN/L) gave good growth. But better growth was obtained at concentrations of 5.75 and 11.34 μg-at PPN/L. It is not clear if the algal concentration referred to in many studies on bivalves is an inflow, outflow, or some average concentration. The actual algal concentration experienced by the animals is equal to the outflow concentration in a perfectly mixed flowthrough system. The algal concentrations referred to in Winter and Langton (1975) and Winter (1978) are those immediately around the Mytilus edulis they used. Other workers are not as specific. The best feeding regime of this study resulted in 38% better growth than in the natural environment. Experience will determine if this improved growth can be attained in a production scale operation. (J.L.M.)

Nitrogen balance of juvenile southern quahogs (Mercenaria campechiensis) at different feed levels. J. Shellfish Res. 1(1):75-81. A Tahitian strain of Isochrysis sp. was grown in outdoor continuous culture and fed at four different cell densities to juvenile southern quahogs. Cell densities were: 1x10^5, 5x10^5, 1x10^6, and 5x10^6 cells/mL. Controls were trays without animals receiving an inflow cell density of 5x10^5 cells/mL and trays with animals receiving only filtered seawater. Duplicate populations of 100 animals each received each treatment; each population had a whole wet weight of 10 g. Total flow rate to each was 120 mL/min. Incoming filtered seawater, incoming algal culture, and effluent from each shellfish population were collected daily and analyzed for nitrite, nitrate, ammonia, urea, dissolved free amino acids (DFAA), soluble protein, total dissolved nitrogen, and particulate protein nitrogen (PPN). A nitrogen balance for juvenile M. campechiensis in a continuous flow system was calculated; 85% to 95% of all total incoming nitrogen was accounted for in the different treatments. Only those populations receiving an inflow algal protein concentration of 5.75 μg-at PPN/L showed a significant excretion of ammonium. Any excretion of DFAA or urea was absorbed by microorganisms present in the shellfish culture containers. Nitrite and nitrate were absorbed by algae present in the copious biodeposits of shellfish populations receiving an inflow algal protein concentration of 56.01 μg-at PPN/L, and a significant uptake of soluble protein by shellfish populations receiving 5.75 μg-at PPN/L was noted. (Modified authors' abstract - J.L.M.)

Management and development of the shellfish industry in South Carolina. Tech. Rep. 28, S.C. Wldl. Mar. Resour Dep., Mar. Resour. Cent., Off. Conserv. Manage, Columbia, SC 29202, 33 p. + charts. Commercial clam harvesting was not extensively practiced in South Carolina until recently. Newspaper reports indicated that 1120 bags of clams were shipped from Charleston, SC, to New York in 1900. Hydraulic patent tongs were used to sample clams (Mercenaria mercenaria) in the present survey. Data collected during the survey were sufficient to consider the feasibility of mechanically harvesting the clam beds. Greatest concentrations were found in the South Santee estuary (35.81% of samples contained clams). North Santee (33.74%), Little River (15.79%) and Bull Bay (10.12%). Controlled harvesting began in North and South Santee in 1974 under special permits, and the operators determined that harvesting clams with hydraulic escalator harvesters was financially feasible. Each vessel was required to complete daily log
forms with total catch per tow and fishing time, as a condition for renewal of permit. (J.L.M.)

152 Guthrie, James F., and Curtis W. Lewis. 1982. The clam-kicking fishery of North Carolina. Mar. Fish. Rev. 44(1):16-21. Traces the historical progression of methods and gear used in the clam-kicking Mercenaria mercenaria fishery. The anchor method, bedstead method, oyster drag method, and the clam trawl are figured and described. In the present fishery hard clams are blown from the bottom by wash from a boat propeller and are retained in a special 12-20 ft-wide trawl towed behind a 17-45 ft boat. The focus is on Carteret County, NC, where the fishery is believed to have started and which is still the leading clam-producing county. (J.L.M.)

153 Hadley, Nancy H., and John J. Manzi. 1983. Some relationships affecting growth of seed of the hard clam Mercenaria mercenaria in raceways. J. Shellfish. Res. 3(1):92 (abstract). Seed clams (size 3.9 mm) were held in raceways for 6 months at densities of 740, 2220, 6660, and 19,980 clams/m². Each density was replicated eight times in the raceways and the highest and lowest densities were replicated four times in substidal field controls. Raceway clam populations were stocked in four different positions relative to water flow and in 19 different positions relative to total raceway biomass. Growth was significantly reduced at the highest density in the raceway and the field. The lowest density showed greater growth in the raceway than in the field, while the highest density showed no difference in growth between the two locations. In the raceway, growth rate was inversely proportional to distance from water inflow and to effective density (number of clams/unit water). Although clams at the highest density consistently removed the greatest amount of chlorophyll-a, less chlorophyll was removed per clam as density increased. Growth was highly correlated with stripping rate (milligrams of chlorophyll-a per clam per day) and with effective water flow rate. (Modified authors' abstract - J.L.M.)

154 Hadley, N.H., and J.J. Manzi. 1984. Growth of seed clams, Mercenaria mercenaria, at various densities in a commercial scale nursery system. Aquaculture 36(4):369-378. Hatchery-raised Mercenaria mercenaria, mean size 3.9 mm, were placed in commercial nursery raceways at densities approximating 740, 2220, 6660, and 19,980 seed/m². Each density was replicated eight times in the nursery and the highest and lowest densities were replicated four times in adjacent substidal field controls. Growth was significantly affected by planting density in raceway and field controls. Total mean growths for the raceway and the field were similar, but different factors influence growth in the two locations. Growth in raceways was inversely proportional to distance from inflows and planting density. Greatest growth was observed in the lowest density nearest the inflow and slowest growth in the highest density nearest the outflow. Growth in the field was less variable throughout the study. Clams in the raceway grew much faster than those in the field in spring, but clams in field controls to distance from inflows and planting density. Greatest growth was observed in the lowest density nearest the inflow and slowest growth in the highest density nearest the outflow. Growth in the field was less variable throughout the study. Clams in the raceway grew much faster than those in the field in spring, but clams in field controls continued to grow in summer when there was little growth in the raceway. These differences suggest that conditions in the two locations were not as similar as believed. (J.L.M.)


156 Hall, C.E., M.A. Jakus, and F.O. Schmitt. 1945. The structure of certain muscle fibrils as revealed by the use of electron stains. J. Appl. Physiol. 16:459-465. Fibrils from adductor muscles of the clam Venus (Mercenaria) mercenaria were examined with the electron microscope and found to possess periodic variations in structure. To make these structural variations visible the fibrils were treated with reagents of high electron scattering power (electron stains). Phosphotungstic acid was found to be particularly suitable. This stain combines with specific regions in the fibrils, forming a remarkably regular geometric pattern. This pattern is described. (J.L.M.)


16 A single large hard clam weighing 110 g had a metabolic rate about 1/4 as great as rates of mussels. Oxygen consumption was very low for the first hour, increased to a maximum at 2.0 hours, then declined to zero at 3.5 hours. Heat production was also very low for the first 40 minutes, increased to a maximum at 1.5 hours, then decreased in a stepwise manner to 0.41 J/hr·gram between 3 and 4 hours. At 2.0 hours Qh was 0.66, Qm was 1.02, and the ratio Qh/Qm was 0.648. (J.L.M.)

158 Hanks, J.E. 1958. Shellfish predators. Studies on the reproduction and early life history of the clam drills, Polinices duplicatus and P. triseriaria. In Rep. on Investigations of the Shellfisheries of Massachusetts for 1957, p. 17-21. Ref. No. 58-40, Woods Hole Oceanogr. Inst., Woods Hole, MA 02543. Prepared for Commonwealth Mass., Dep. Nat. Resour., Div. Mar. Fish. Newly set P. duplicata are probably predators from the time of metamorphosis. Clam larvae and drill larvae settle over the flat over much of the same summer period, thus it is probably that predation at this size range is very high even though not readily observable. Such predation can account for apparent lack of set in some areas. P. triseriaria larvae complete their development within the collar and are released as juvenile drills. At a water temperature of 68°F, development from ova to collar break-up and release of juvenile drills was 30-35 days. Drills immediately attacked small clams and also fed on small mud snails. (J.L.M.)

159 Hart, Kathy. 1982. Clams today, none tomorrow, say kickers. Univ. N.C. Sea Grant Coll. Prog., Raleigh, NC 27695, Coastwatch, March 1982:2-3. Kicking is done with propeller wash, and the clams are picked up by towing a heavy net behind the boat. Kicking is a relatively new method, and it is much more efficient than hand raking, taking 20-25 bags of clams per day as compared with 5-6 bags. Kicking is also profitable because clam prices have risen. In 1978 the Marine Fisheries Commission closed grass beds to kicking, and now clam kicking is restricted to Core Sound. Catch per unit of effort is dropping, and the fishery has reached the point where it is limiting itself. Further restrictions may be necessary. More information is needed about clam biology and harvest methods. (Abstracter's note: It is doubtful that more information will help much. What is needed is a system to allow clams to grow to marketable size. Dividing Core Sound into three parts, closing two of them, and rotating seems to be a good thing to try. Limiting the numbers of vessels also might be good.) (J.L.M.)

160 Hart, Kathy. 1982. Researcher seeks hard facts about hard clams. Univ. N.C. Sea Grant Coll. Prog., Raleigh, NC 27695, Coastwatch, March 1982:4-5. To test how grass-cover affects whelk predation, 1-meter plots were denuded of grass, others were left untouched. Rates of predation on naked plots were 54% from October to May and 84% from July to November. Clams on plots with grass suffered little predation. Density of clams in an area did not affect the rate of predation. Whelks tended to choose the larger clams. In late summer or fall the clam growth rate slows by 50% and the clam adds a growth line. They also record daily growth lines and events in the shells. Most hard clams reach legal harvest size in 1½ years. But these clams at best have had only one reproductive season. Average age of clams in Core Sound is 9 years, ranging from less than a year to 32 years. This may mean that today's harvests are cropping several years of reproduction. The pea digger and the bull rake are also being compared. The pea digger dug up more large clams than the bull rake, and covered more area. In seagrass areas, on the other hand, the bull rake took more clams and covered a greater area. The bull rake also removed twice as much sea grass as the pea digger. Kicking neither increases nor decreases production of young clams, despite the claims of kickers that this method is good for the bottom. The more

161 Hart, Kathy. 1982. The case of the crushed clams. Va. Polytech. Inst., Blacksburg, VA 24061, Sea Grant Today 12(6):3-4. The big-clawed snapping shrimp (Alpheus heterochaelis) is an important predator of small hard clams (Mercenaria mercenaria), according to Brian Beal and Charles Peter­son, biologists at Morehead City, NC. Three problems of North Carolina clammers are predation, overexploitation, and pollution. Predation by blue crabs, whelks, and rays takes a heavy toll, and snapping shrimp may be responsible for some of the damage previously attributed to blue crabs. (J.L.M.)

When northern clam (Mercenaria mercenaria) beds wereiced up in the winter of 1976-77, seafood dealers began to look south for a supply and the hard clam in North Carolina supplied more of the harvest. Landings doubled in 1977 from the previous year and reached a peak in 1982 of more than 1.7 million pounds. Since that time landings have dropped, and many believe that hard clams are overfished. There are unresolved arguments between hand rakers and mechanical harvesters, and various restrictions have been placed on the harvest. Included are suggestions that grounds be rotated, and that clams be moved from polluted areas to cleanse themselves. (J.L.M.)

Kicking up more than clams. Studying the effects of clam kicking on seagrass. Univ. N.C. Sea Grant Prog., Raleigh, NC 27695, Coastwatch Nov/Dec 1985:4-5.

Clam (Mercenaria mercenaria) kicking is harmful to seagrass beds. Plots in Back Sound were left untouched and used as controls, others were used for raking, light kicking, and intense kicking. In raking and light kicking plots seagrass biomass dropped approximately 25% after harvest, but recovered within a year. In intensely kicked plots seagrass biomass fell about 65%, and the beds did not begin to recover for two years. Four years later these plots still had 35% less sea grass than controls. Sea grass provides food, refuge, and habitat for small marine organisms, and is important for productivity of clams. Removal of adult hard clams by kicking did not enhance recruitment of small clams, and in intensely kicked plots recruitment was 50% to 13% lower. Are the clams lost to fishermen if areas are closed to kicking? No, the clams can still be taken with rakes. If they are not harvested, the clams can act as brood stock. (J.L.M.)


FMRFamide is a cardioexcitatory peptide recently isolated and identified in molluscan ganglia. FMRFamide and 5-hydroxytryptamine (5HT), the cardioexcitatory neurotransmitter in molluscs, were tested on the ventricle of the bivalve Mercenaria mercenaria. Both agents increased myocardial contractility, the intracellular cyclic AMP concentration of intact hearts and the adenylyl cyclase activity of a myocardial heart. Eur. J. Pharmacol.


Hard clam (Mercenaria mercenaria) supports the major commercial fishery in Barnegat Bay. The most productive clam grounds in New Jersey extend from the southern part of Barnegat Bay to Cape May. Little Egg Harbor and Great Bay are consistently the most productive waters in the State. Lower catches in Barnegat Bay are due in part to higher levels of organic pollution which limit the area available for clamming. Nevertheless, recently it is the most valuable species landed commercially in Barnegat Bay. Maximum reported landings occurred from 1950 through 1957. In the early 1960s an outbreak of hepatitis in New Jersey caused a loss of public confidence in the industry. Landings picked up again in the mid and late 1960s, but declined thereafter. Recently the decline was caused by a failure of recruitment. (J.L.M.)


A variety of animals are known to be facultative anaerobes, capable of utilizing molecular oxygen when it is present and capable of sustained anaerobiosis when it is absent. During anaoxia these organisms rely upon the simultaneously catabolism of carbohydrate and amino acids. In probing the mechanisms utilized, the paper accounts for 1) maintenance of redox balance during oxia; 2) sources of energy in the form of ATP; and 3) formation of a multiplicity of anaerobic end-products. (Modified authors’ synopsis - J.L.M.)


Over the last two decades the number of license holders in the Rhode Island quahog fishery has varied from less than 800 to approximately 3,000. It is believed that this is related to the state of the economy: the higher the rate of unemployment the more licenses are bought. Between 1962-63 and 1978-79 the total number of licenses has more than doubled, and average of licensees has declined considerably. Over 60% of quahoggers derived less than 20% of their income from raking or tonging in 1962-63. In 1978-79 over 60% derived about half of their income from quahogging. The number of full-time handrakers increased over 100%. About 35% had some college education. About 18% had no alternative skills. About 23% said they could increase their income by doing other work. If income were to drop about 25%, approximately half the handrakers would leave the industry. Most handrakers worked on the west side of the Bay, about halfway down. (J.L.M.)

168 Hughes, Roger N. 1970.

There is no discussion of Mercenaria mercenaria. This paper probably would not have been abstracted if the title had been correct in the paper from which it was taken. The full title given in that paper was: Population dynamics of the bivalves. This paper deals with the general distribution of S. plana throughout the study area, the dispersion pattern of individuals in relation to one another, and the changes in density and size-frequency structure between Nov. 1966 and Nov. 1977. The results were used to estimate annual growth, recruitment, and mortality. Growth was also estimated by using marked animals and by measuring the distances between winter rings. Records of predation by oyster catchers were also kept. Because the structure and dynamics of bivalve populations do not normally reach a steady state, some conclusions were relevant only to the period of study. (J.L.M.)

Ecological genetics of the hard clams Mercenaria mercenaria Linne and Mercenaria campechianus Gmelin: Electrophoretic estimation of enzyme variation and the use of shell morphology as a species indicator. Ph.D. diss., Univ. Ga., Athens, GA 30602. [Disc. Abstr. Int. B. Sci. Eng. 42(10):3939] Six samples of Mercenaria mercenaria from the Georgia coast were analyzed, using protein electrophoresis. They showed high levels of population heterozygosity, but four loci showed large heterozygote deficiencies. Samples were also taken from Massachusetts, Virginia, and Florida, and samples of M. campechianus from Tampa and Port St. Joe, FL. It was concluded from these samples that heterozygote deficiency is caused by selection against heterozygotes. Shells were measured to see if shell shape could be used to differentiate M. mercenaria and M. campechianus, but it was concluded that shell morphology was not a species indicator. The nota form of M. mercenaria was also examined. Phenotypic frequencies ranged from 0.76% to 2.25%. Gene frequencies calculated from Maxima Likelihood Estimation were 0.04% to 0.11%. There were no significant differences between samples. (J.L.M.)


There is no mention of Mercenaria mercenaria in this study. (M.W.S. and J.L.M.)


Unexploited stocks of quahogas (Venus mercenaria) were found. (J.L.M.)

172 Jones, Douglas S. 1980.
Annual cycle of shell growth increment formation in two continental shelf bivalves and its paleoecologic significance. Paleobiology 6(3):331-340. By analyzing annual shell growth increments in Spisula solidissima and Arctica islandica two main items were determined: 1) age and growth rate; and 2) season of death. Such information can be important for several reasons. Mercenaria mercenaria was not mentioned. (J.L.M.)

Repeating layers in the mollusc shell are not always periodic. J. Paleonol. 55(5):1076-1082.

No daily, subdaily tidal, or fortnightly tidal cycles were found in shells of Spisula solidissima in samples from off the coast of New Jersey. Annual layers were the only ones found and confirmed. The five orders of periodic layers identified by Barker...


A series of recommendations is given on size limits, intense fishing pressure, opening areas in winter when shell life is longer, relaying of clams, and use of money from "clam diggers licenses." (J.L.M.)


A study, growing oysters and clams in rafts by the Wallace Groves Aquaculture Foundation of Freeport in the Bahamas, produced discouraging results. Another study, by Worldwide Protein Bahamas, Ltd., using imported spat of American and European oysters and hard clams, Mercenaria mercenaria, from Long Island, indicated that fouling by algae and particulate matter hindered production, but growth of hard clams continues. Since May 1972 the St. Croix Artificial Upwelling Project on the north shore of the U.S. Virgin Islands produced phytoplankton by pumping nutrient-rich seawater from 870 m depth into 100-m² ponds. This was used to feed oysters, clams, and scallops, which grew adequately. Molluscan mariculture in the Caribbean has a long way to go to augment catches from traditional fisheries. It is doubtful that it can soon achieve the production per unit area obtained in other parts of the world, because it is still in its infancy and many problems remain unsolved. (J.L.M.)


Predation remains one of the major hurdles to successful field mariculture of molluscs in many areas of the world. Traditional predator control methods include physical barriers such as trays and enclosures, off-bottom culture, chemical poisons, removal and trapping, dredges, mops, X-ray sterilization, and biological means. Most of these methods have produced only limited success, although two or more methods in combination, such as enclosures and active predator removal, are effective but expensive. Examples of recent attempts at predator control include substrate modifications for hard clams (Mercenaria mercenaria) and other methods for other molluscs. The ecological concepts of "size selective predation," "optimum patch use," "prey switching," "digestive conditioning," and "search image formation" and their relevance to effective predator control in molluscan field culture are discussed. Several guidelines based on these ecological concepts emerge. Juvenile molluscs should not be planted until they reach a size at which they are less vulnerable to predators. Relocating large numbers of molluscs in some areas allows predators to concentrate their efforts, and can result in some predators narrowing their diets and concentration on the most common prey, or in a density-dependent switch in prey choice in predators whose diets only occasionally include these animals. Digestive conditioning may reinforce these dietary adjustments. (J.L.M.)


Covers in great detail all State and local restrictions. (J.L.M. and M.W.S.)


Of various raft designs tested, economical, sand-filled wooden trays suspended from floats gave best growth and survival of hard clams (Mercenaria mercenaria). Seed quahogs reared in 1979 had over 80% survival of 480,000 clams. Seeds as small as 2 mm have been successfully cultured. (J.L.M.)

179 Kassner, Jeffrey. 1982.


The reproductive cycle of the hard clam, Mercenaria mercenaria, was determined over a 2-year period at five locations in the eastern third of Great South Bay. At one location, sampling was designed to include three sizes of clams, corresponding to clams marketed as sublegals, littlenecks, and cherrystones. The gametogenic cycle of spawning transplant clams also was compared. Differences between years were greater than among the five locations. In 1978 spawning went rapidly to completion, as evidenced by a high percentage of "spent" females. In 1979 the percentage of "spawning" females was much greater. No differences were apparent among the three size classes of clams or between the size classes and the other four stations. Two critical assumptions were found not to be valid: It was not true that the spawning period of native clams is defined and predictable, nor that transplant clams spawn later than native clams. This suggests that introduction of spawning transplants is of questionable value. (J.L.M.)

180 Kassner, Jeffrey. 1983.

Trace metals in shellfish and growing area designation. J. Shellfish. Res. 3(1):94-95 (abstract).

Hard clams (Mercenaria mercenaria) were sampled over five locations in Port Jefferson Harbor and five locations in Setauket Harbor, Long Island, N.Y., and analyzed for copper, lead, zinc, and cadmium. In both harbors, hard clams from the station with fewest coliform bacteria did not have the lowest metal concentrations. In Setauket variability of metal concentrations among sampling locations was much less than in Port Jefferson, and in Port Jefferson overall metal concentrations were higher than in Setauket. Concentrations of metals in hard clams does not appear to be reliably related to coliform levels. (Modified author's abstract - J.L.M.)

181 Kassner, Jeffrey. 1985.


Mariculture is not a recent development. In 1909 a New York shellfish dealer purchased 5,000 bu of naturally produced seed clams (Mercenaria mercenaria) from Massachusetts at $3 per thousand. He realized 4 bu of littlenecks for every bu of seed. Early hard clam mariculture in New York has not been well documented, but information available suggests that it may have been substantial, and Great South Bay was one area in which it was pursued. It was begun in Great South Bay some time prior to 1931 as an adjunct of the oyster industry. Conflicts developed and by 1931 many baymen believed that a minimum size limit should be established. As a compromise a ¾-inch minimum size was adopted. From 1933 to 1939 the number of bu sold in New York increased from about 30,000 to over 128,000 bu and the value of clams sold increased from slightly under $52,000 in 1933 to over $420,000 in 1942. Production of hard clams by mariculture was not recorded after 1942. Glancy was successful in spawning hard clams in the early 1930s and rearing them to over 1 inch in size, but large-scale production of hard clams was never tried. Somewhat later Shellfish Inc. became the first Long Island hatchery to sell hard clams commercially. Since that time the Town of Islip has planted seed clams on public bottom, and a few years later Babylon and Brookhaven began planting seed clams, and today these three towns and the Bluepoints Company are still planting. But mariculture accounts for only a small part of production from the Bay, and probably will not play a significant role in hard clam production from the Bay because private mariculture is vehemently opposed by baymen. (J.L.M.)


During the past 180 years the shellfish resource and its fishery in Great South Bay have undergone dramatic change, shifting from the American oyster Crassostrea virginica to the northern hard clam Mercenaria mercenaria. This came about from changes in management of shellfish and hydrography of the Bay. In the early 1800s the Bay supported a sizeable oyster fishery, but overfishing and oyster dredging depleted the natural beds by 1840. Beginning in 1880, oyster production increased, as large areas of the Bay were leased for oyster planting. Between 1910 and 1940 salinities in the Bay increased markedly caused by changes in flow through Fire Island Inlet and opening of Moriches Inlet in 1931. Oyster drills Euploea caudata and Urosalpinx cinerea increased in abundance and few oysters survived past setting. In the 1940s dense blooms of a small flagellate that interfered with oyster feeding caused a further decline in oyster abundance and no significant clam fishery existed after 1948. Conditions detrimental to oysters proved beneficial to hard clams, and hard clam production increased rapidly, peaking at 24,668 bu (700,000 bu.) in 1976. Landings have since declined by more than half from overfishing and further changes in the Bay. A variety of management measures are now being tried to stabilize landings. (Modified authors' abstract - J.L.M.)

183 Kennish, Michael J. 1977.

Microscopic analysis of 85 Mercenaria mercenaria from natural populations within a 1.6-km radius of the Oyster Creek Nuclear Generating Station showed that the thickness of daily growth increments in summer was reduced by 10 to 30% in comparison with those of clams outside the effect of thermal discharges. The accreting shell-growth pattern was occasionally interrupted by rapidly fluctuating temperatures, which caused physiological shocks to clams. Transplanted bivalves also showed similar reductions in microgrowth patterns. Also the normal prismatic shell structure was replaced by crossed-lamellar shell structure, immediately following transplanting. In addition, growth breaks appeared frequently in shell microstructure after transplantation. (J.L.M.)


Mortality of Mercenaria mercenaria in Barnegat Bay is normal and is not caused by thermal discharges. Mortality is high during the planktonic larval stages, low subsequent to spat settlement, and high again in the gerontic stage. Maximum frequency of death is between 50 mm and 65 mm in height and 5 to 6 years of age. Peak frequency of death is in summer. Mortality rates rise significantly after sexual maturity is attained. (J.L.M.)

185 Kennish, Michael J. 1978.

Thermal discharges from the Oyster Creek Nuclear Generating Station do not affect mortality in natural populations of Mercenaria mercenaria in Barnegat Bay, NJ. Hard clams collected at the mouth of Oyster Creek (strongly affected by thermal discharges) and at three control sites in the Bay showed that mortality rate curves, survivorship curves, and life tables were nearly identical for each assemblage. Mortality data recorded on life assemblages of hard clams transplanted to the substrate for 1 year at the mouth of Oyster Creek and at a single control site in the Bay showed that mortality was significantly greater in the assemblage transplanted to the control site. It was concluded that mortality of hard clams in Barnegat Bay was caused by the normal population dynamics of the species. Mortality was high during the planktonic larval stages, lower subsequent to spat settlement, and high again in the gerontic stage. Mortality rates rise significantly after sexual maturity is attained. (Modified author's abstract (J.L.M.))

186 Kennish, Michael J. 1980.

The shell of M. mercenaria is composed primarily of calcium carbonate (aragonite) and conchoïdin. A vertical section through a valve reveals four shell layers: 1) inner homogeneous layer, 2) pallial myostracum (muscle scar layer), 3) middle layer, and 4) outer layer. These are illustrated in a diagram. In youth (approximately 2 yr) the outer shell layer terminates in concentric ridges at the outer surface, with growth increments intersecting the outer shell surface nearly at right angles. When mature growth is attained, concentric ridges disappear and growth increments become recurved in shape. This stage corresponds with onset of sexual maturity and lasts 3-8 yr. The final stage is old age, and crossed lamellar structure replaces prismatic shell structure in the outer layer, growth increments become thin and perpendicular to outer shell surface and numerous growth breaks develop. Using acetate peels and thin sections shell microstructure patterns were studied. Cyclical growth patterns include subdaily, daily, bimonthly, and monthly, and annual types. These patterns come from variable rates of calcium carbonate deposition or dissolution or both. Environmental conditions and a biological-clock mechanism appear to control the formation of these growth patterns. Growth breaks reflect periods of environmental and physiological stress. Seven types have been documented, which develop from random or periodic events. They consist of growth breaks caused by freeze shock (winter), heat shock (summer), thermal shock, shell-margin abrasion, spawning, neap tides, and storms. These are described and figured in great detail. These can be applied to analysis of population dynamics of hard clam by using size and age distributions, growth rates, and recruitment patterns, and mortality, and inferences can be made on a variety of subjects, including varying rates of mortality, and the reason for higher mortality as the animals age. Young are added to the population only sporadically, but the population can be maintained by a single year of good recruitment. By using shells of death assemblages in stressed environments temporal and spatial changes in population structure can be related to anthropogenic factors. It is possible that analysis of growth patterns could be used to reconstruct paleoaltitudes, paleoclimates, and paleobathymetry through the Tertiary period. The entire chapter needs to be studied to recover all the fascinating facts contained in this paper. (J.L.M.)


Mercenaria mercenaria is the only bivalve of commercial importance in Barnegat Bay. The standing crop has declined since the mid-1960s, and commercial landings are at their lowest level since the early 1960s. Recruitment has not been successful since the early 1970s and recruitment failure, closure of shellfish beds due to poor water quality, and reduced fishing effort from adverse winter weather conditions have been largely responsible for lower commercial production. Hard clams are distributed in patches, and densities increase toward the southern margin of the estuary. Hard clam is currently the most valuable species landed commercially. (J.L.M.)


The Goemperz growth equation provides an accurate model of ontogenetic growth in hard clams from New Jersey waters. It yields a correlation coefficient of -0.982 when fitted to yearly height data collected from sectioned valves of 277 specimens from death assemblages from Barnegat Bay. It also predicts asymptotic height values and growth curves that are realistic in comparison with those derived from the logistic and monomolecular growth equations. Selection of the best fitting growth model for M. mercenaria depends on estimation of growth parameters in the Goemperz, logistic, and monomolecular functions. A new mathematical procedure is presented which allows for rapid calculation. It requires two steps: 1) linearization of growth functions, and 2) linear regression analysis of transformed data. Most bivalves exhibit a growth rate that decreases according to a nonlineair function with increasing age. The Goemperz, logistic, and monomolecular equations accurately describe this type of growth. (J.L.M.)


Commercially important and recreationally important bivalves, such as Mercenaria mercenaria, are particularly susceptible prey to such species as Limulus polyphemus, Callinectes sapidus, Polinices duplicatus, Bucephalus spp., Eupleura caudata, Urosiplex cinerea, and Asierias forbesi. Some fishes feed on young hard clams. Hard clams also sometimes feed on phytoplankton that fall to the estuarine substratum as water temperature rises in spring. (J.L.M.)

Effects of thermal discharges on the microstructural growth of Mercenaria mercenaria. Environ. Geol. 1:41-64.

Mercenaria mercenaria in Barnegat Bay, NJ, were affected mainly by temperature extremes, temperature variations, tides, type of substratum, and age. Growth patterns in hard clams within approximately a 1.6-km radius of Oyster Creek showed a lower summer growth rate (10% to 25% lower) and a greater number of growth breaks (2 to 6 more per year) than from away from the Creek. The lower summer growth rates in bivalves subjected to effluent occur because added heat in summer caused water temperatures to exceed a critical threshold for optimal growth of the species. Effluent also may upset natural spawning events in clams when abrupt changes in power station operations overlap breeding periods. Spawning may be precluded by sharp temperature changes which result in physiological shocks to the animal. (Modified authors' abstract - J.L.M.)


Details are given for embedding, sectioning, grinding, polishing, acid-etching, washing and drying, and application of acetone and acetate to acetate peels, and preparation of fractured sections of bivalve shells. (J.L.M.)

Shellfish. Chap. 7 In Kennish, M.J., and R.A. Lutz (eds.), Ecology of Barnegat
Bay, New Jersey. Lecture notes on coastal and estuarine studies, 6, p. 171-200. Springer-Verlag, NY.

Hard clam (Mercenaria mercenaria) and blue crab (Callinectes sapidus) are the only shellfish currently important in the fisheries of Barnegat Bay. The life history of the hard clam, its growth, recruitment, and mortality, and its distribution and density are described, and the status of the resource is reviewed. The hard clam has a mean longevity of less than 10 years and usually grows to less than 0.8 mm in shell height and length. Mortality peaks during the planktonic stages. Lowest mortality is between the ages of 1 and 5 years. It increases to a maximum in summer and winter and decreases to a minimum in spring and fall. The standing crop has declined since the mid 1960s. Poor recruitment of juveniles caused either by lack of successful larval settlement or heavy losses to predators after settling appears to be largely responsible. There is a paucity of juveniles in the population caused by year-class failure since the early 1970s. (J.L.M.)

Distribution of methylene and nonmethylene-interrupted dienoic fatty acids in polar lipids and triglycerides of selected tissues of the hardshell clam (Mercenaria mercenaria). Lipids 17(12):976-981.

Fatty acid profiles of polar lipids and triglycerides were determined for six tissues of the hard clam (Mercenaria mercenaria): mantle, gill, mouth, foot, digestive tract, gonadal tissue, and adductor muscle. Largest concentrations of nonmethylene-interrupted dienoic (NMID) fatty acids were found in gill, mantle, and foot. Structural analyses were undertaken to determine the double-bond configurations of the various NMID isomers. The major 22C NMID species were Δ7,13- and Δ7,15-docosadienoic acid. The major 20C NMID species were Δ7,11- and Δ7,13-eicosadienoic acid and Δ5,11-eicosadienoic acid. (Modified author's abstract - J.L.M.)


Total lipids and lipid classes from six tissues of Mercenaria mercenaria were determined. Polar lipids accounted for the largest fraction of lipids. The highest concentrations were found in the gill. Free sterols were found only in trace amounts in the gill, but were found in much higher quantities (up to 22.6%) in other tissues. The largest stores of triglycerides were in the digestive tract, gonads, and the adductor muscle. Relative tissue weights and lipid contents of six tissues from the hard clam were:

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Wet wt.</th>
<th>Dry wt.</th>
<th>Lipids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive tract-Gonads</td>
<td>48</td>
<td>33</td>
<td>5.35</td>
</tr>
<tr>
<td>Adductor muscle</td>
<td>18</td>
<td>34</td>
<td>0.44</td>
</tr>
<tr>
<td>Mantle</td>
<td>12</td>
<td>10</td>
<td>2.63</td>
</tr>
<tr>
<td>Gill</td>
<td>8</td>
<td>7</td>
<td>1.86</td>
</tr>
<tr>
<td>Foot</td>
<td>7</td>
<td>12</td>
<td>1.25</td>
</tr>
<tr>
<td>Mouth</td>
<td>7</td>
<td>3</td>
<td>0.43</td>
</tr>
</tbody>
</table>

(J.L.M.)

Sediment as a source of trace metals to the hard clam, Mercenaria mercenaria. Masters thesis, State Univ. N.Y. at Stony Brook, NY 11794, 111 p.

Metal concentrations of clams varied primarily with physiological state as determined by seasonal and genetic factors. Seasonal patterns of uptake of all metals were similar to seasonal changes in dry flesh weight. Maximum increases in body burden corresponded to periods of rapid growth in fall and spring. However, metal body burdens increased 1 or 2 months prior to dry flesh weight in spring, and with the exception of lead, metal content remained constant over winter. Possible differences in feeding activity, arising from small differences in grain size of experimental plots, may have contributed to observed differences in clam copper concentration. The six metals studied (Cd, Cu, Fe, Ni, Pb and Zn) only copper showed clear differences in concentration among clams from different plots. Exposure to more readily available dissolved and suspended copper sources was more critical in determining copper concentration than exposure to copper associated with sediment. However, in muddy environments, where clam filtering activity is reduced, exposure to dissolved and particulate copper sources is lower, and uptake from sediment may become more important. (Modified author's abstract - J.L.M.)

Feasibility of establishing a large scale, publicly supported hard clam seed hatchery/nursery system for rehabilitating bay resources after an oil spill disaster. Long Island Regional Planning Board, N.Y.S. Comptroller's Contract D000369, CEIP Grant-In-Aid Award NA-83-AA-D-C2035, Hauppauge, NY 11788, 103 p.

Objectives of the study were to: 1) estimate the potential impact of spilled oil on the hard clam (Mercenaria mercenaria) and its associated habitats; 2) identify the full range of techniques and methods to remove spilled oil and hasten recovery of habitats and hard clam populations; 3) discuss the shellfish hatchery, land-based nursery, and field-nursery facilities required to produce seed clams for planting; and 4) prepare and apply site selection criteria and identify potential sites for land-based facilities. If a decision were made to implement a massive hard clam seed-planting program to mitigate oil spill impacts, this report could be used to address the following questions: a) should a publicly-financed shellfish hatchery be constructed, and where? b) should land-based and field-based nursery facilities be constructed, and where? The appendix to the report contains capsule summaries of hard clam seed-planting programs being conducted by Long Island towns, and descriptions of the facilities and capabilities of the five operating shellfish hatcheries located on Long Island. (J.L.M.)


Carter and Canelmo have studied the efficiency of commercial depuration. Clams (Mercenaria mercenaria) taken from marginally contaminated waters could be effectively depurated and thus release 26,000 acres of condemned waters in New Jersey for harvesting hard clams. Also clam siphoning activity seems to increase under certain conditions, as if some clams are spurring others on to more active states. (J.L.M.)


Eggs were graded into three size categories, split into replicates, and these were replicate-sampled. A chi-square analysis compared the proportions of larvae (48-hr survival) with the proportions of eggs in each initial replicate experiment. Statistically significant differences attributed to egg size were found. Large eggs survived better than small eggs, while those of intermediate size showed no difference between expected and observed survival. (Modified authors’ abstract - J.L.M.)


The community of larger benthic animals is not dominated by finfishes but by dense populations of hard clam Mercenaria mercenaria. In the West Passage near the Jamesport Bridge an estimate of 35-40 bu. (80 pounds) per acre was determined by survey prior to the commercial dredging season. Although the subsequent harvest lowered the population to 14 bu/acre, it can be assumed that some replacement of the loss occurred, and 35 bu/acre was chosen as a reasonable stock estimate. Prorated population estimates ranging from 3.23 bu/acre near the mouth of the Providence River to 0.67 bu/acre near Newport were used (clams/m2). (J.L.M.)


Commercial catch-and-effort records for boats using patent tongs to harvest hard clams from the James River were obtained for 1978-81. Catch-per-unit-effort of the sample fleet was regressed against accumulated catch to give estimates of initial abundance. Estimates for 1978, 1979, 1980, and 1981 were 280,650 bu., 406,250 bu., 557,250 bu., 344,364 bu., and 397,142 bu., respectively. The mean for the period, 397,142 bu., was 30% below that estimated by Haven et al. (1981). Commercial catch records can be used in this application but limitations in the data must be understood. (Modified authors’ abstract - J.L.M.)


Mercenaria mercenaria was not mentioned. The collagen of Cryptochiton stelleri isolated from the visceral area had a different biochemical property from the mantle girdle, which was in direct contact with the ocean. The visceral area was protected from the environment by the eight plates. The collagen of Loligo pealei eluted as a single homogenous hydrophilic peak. Collagen from Octopus bimaculoides was also hydrophilic but exhibited great diversity within this region. (Modified authors’ abstract - J.L.M.)

Voluntary cooperation between the shellfish industry and government agencies has reduced the incidence of shellfish-borne disease. Contamination of bivalve mollusks including hard clams (Mercenaria mercenaria) by bacterial pathogens, viruses, and toxin-containing phytoplankton is controlled by harvesting shellfish only from approved waters and by use of sanitary food-handling practices. Although market shellfish in the United States are usually of high quality, control agencies and the shellfish industry cannot guarantee that raw shellfish will be free of disease producing organisms or toxic substances. (J.L.M.)


205 Le Borgne, Yves. 1981. Nursery culturing of postlarvae: Key to further development for bivalve molluscs hatcheries. In Claus, C., N. De Pauw, and E. Jaspers (eds.), Nursery Culturing of Bivalve Molluscs, p. 141-149. Spec. Publ. 7, Eur. Maricult. Soc., Bredeze, Belgium. Mercenaria mercenaria is among the species discussed. If the goal of the nursery is to provide customers with a product meeting their demands at a price competitive with natural spawls, nurseries play an essential role. Hatcheries can produce very large numbers of very small spat at low cost, but they are of no use to most professional growers. Only after an additional growth period in a nursery can the product reach a wide market. Success of the nursery stage is a condition for development of controlled reproduction. Nurseries' technical problems seem to be easier to solve than those of hatcheries that have received less attention in research. Yet here one may expect the most spectacular improvement in productivity, with survival rates increasing from 50% to 80%. The additional number of spat has indeed a much higher commercial value than an equivalent number of larvae. (J.L.M.)

206 Lehman, William, and Andrew G. Szent-Gyorgyi. 1975. Regulation of muscular contraction - Distribution of actin control and myosin control in the animal kingdom. J. Gen. Physiol. 66(1):1-30. Control systems regulating muscle contraction in approximately 100 organisms including Mercenaria mercenaria have been categorized. Myosin and actin-control operate simultaneously in most invertebrates, but single myosin control is present in muscles of molluscs and some other groups. (J.L.M. and M.W.S.)

207 Leslie, Mark D., and Robert S. Wilson. 1983. Effects of light and gravity upon the motile behavior of trochophore larvae of Mercenaria mercenaria (Linne). J. Shellfish Res. 3(1):96 (abstract). Results showed a random distribution of larvae in horizontal dark and horizontal light experiments, a substantial surface aggregation in the vertical dark chamber, and a decrease in surface accumulation with the light source shining from above and below the vertical chamber. Illumination from below caused a significant drop in vertical velocity and swimming speed and a small decline in rate of change of direction. Phototaxis was not observed. Photostimulation caused trochophores to exhibit a negative orthokinesis with a weakening in their negative geotactic behavior. (Modified authors' abstract - J.L.M.)

208 Levine, Rhea J. C., Myra Elvin, Maynard M. Dewey, and Benjamin Walcott. 1976. Paranyosin in invertebrate muscles. II. Content in relation to structure and function. J. Cell Biol. 71(1):273-279. By quantitative sodium dodecyl sulfate-polyacrylamide gel electrophoresis, paranyosin:myosin heavy chain molecular ratios were calculated for three molluscan muscles including Mercenaria mercenaria opaque adductor, and four arthropodan muscles. These ratios correlated positively with thick filament dimensions and maximum active tension development in these tissues. The role of paranyosin in these muscles was discussed with respect to the following characteristics: force development, "catch," and extreme reversible changes in length. (J.L.M.)

209 LoGrande, Michael A. 1983. Introduction. In Buckner, S.C. (ed.), Proceedings of a Management Perspective on the Hard Clam Resource in Great South Bay, p. 1. A seminar sponsored by the Town of Islip (NY 11751), March 10, 1983. The hard clam resource has produced tremendous reductions in harvest during the last few years, and recent outbreaks of shellfish-related disease have compounded the problems. This meeting was convened to discuss the situation and suggest solutions. (J.L.M.)

210 Longwell, A.C. 1976. Review of genetic and related studies on commercial oysters and other pelecypod mollusks. J. Fish. Res. Board Can. 33:1100-1107. Mercenaria mercenaria and M. campechiensis were crossed and the hybrids reared. Haven and Andrews (1957) found that the relative yield of hybrid clams grown in Virginia was superior to that of the original species. Menzel (1968) also reported the superiority of the hybrid in certain environments and questioned the species rank of these two clams. (J.L.M.)

211 Loosanoff, Victor L. 1962. Effects of turbidity on some larval and adult bivalves. Proc. Gulf Caribb. Fish. Inst., 14th Annu. Ses., p. 80-95. Silt is much more harmful to oyster (Cossatostrea virginica) eggs than to those of clams (Venus (Mercenaria) mercenaria). The percentage of eggs developing to straight-limbed larvae in different concentrations of turbidity-creating substances were:

<table>
<thead>
<tr>
<th>Concentration (GL.)</th>
<th>Oyster</th>
<th>Silt</th>
<th>Clam</th>
<th>Kainolin</th>
<th>Fuller's earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.125</td>
<td>95</td>
<td>95</td>
<td>99</td>
<td>82</td>
<td>100</td>
</tr>
<tr>
<td>0.250</td>
<td>73</td>
<td>96</td>
<td>100</td>
<td>82</td>
<td>100</td>
</tr>
<tr>
<td>0.500</td>
<td>31</td>
<td>99</td>
<td>100</td>
<td>52</td>
<td>100</td>
</tr>
<tr>
<td>1.000</td>
<td>1</td>
<td>79</td>
<td>100</td>
<td>37</td>
<td>98</td>
</tr>
<tr>
<td>2.000</td>
<td>0</td>
<td>39</td>
<td>94</td>
<td>49</td>
<td>79</td>
</tr>
<tr>
<td>3.000</td>
<td>0</td>
<td>0</td>
<td>76</td>
<td>42</td>
<td>26</td>
</tr>
<tr>
<td>4.000</td>
<td>0</td>
<td>0</td>
<td>76</td>
<td>42</td>
<td>26</td>
</tr>
</tbody>
</table>

(J.L.M.)

212 Losee, Brian. 1983. Shellfishing in Islip Town: A bayman's viewpoint. In Buckner, S.C. (ed.), Proc. of a Management Perspective on the Hard Clam Resource in Great South Bay, p. 49-53. A seminar sponsored by the Town of Islip (NY 11751), March 10, 1983. Illegal harvesting of seed clams, overharvesting of legal-size clams, poaching of clams from uncertified waters, and a general disregard for clam conservation laws are genuine threats to the industry. The initial group of baymen who operated from 1960 and before usually took legal-size clams only and returned smaller clams (seed) to the water. As clamming increased through good seas, a new group of clammers came in, and they did not have the same respect for the law. Illegal harvesting became common, and when law officers did summon and arrest violators, their efforts were negated by ridiculously low fines. The Southwest sewer construction further exacerbated the problem, and created a 'get it while you can' attitude. Attempts by the Town of Islip Shellfish Commission to manage the industry were negated by poachers. The State had some success in transplanting clams from uncertified areas, and also opening uncertified areas at times when clamming was safe, thus reducing the numbers of clams in uncertified areas and reducing the temptation to poach. But this led some baymen to take clams from dredges, illegally reducing abundance still further. This led many clamners to leave the industry for other jobs. Other environmental mistakes also have played a part: unrestricted residential development, no attempts at human population control, removal of sand bars in Fire Island Inlet, and the negative effects of the Southwest Sewer District. Even the law-abiding clammers eventually were forced to break laws to make a living from the greatly reduced clam stocks. Yet all is not yet lost. The Town must assume a role of leadership, and do the things necessary to manage the resource successfully. (J.L.M.)

size was at 46.6 mm, for females 48.3 mm, and for both sexes at 2 years of age. Fecundity was a direct function of gonad volume, and varied from 3,092 x 10^10 to 14,894 x 10^10 oocytes. Since this species has a continuous sexual cycle and a long spawning period, population renewal may be favored, thus overcoming fishing mortality. (Amended authors' abstract - J.L.M.)

214 Lunz, Robert G. 1949.
The clam situation in S.C. Contrib. Bears Bluff Lab. 6, 6 p.
The clam industry in South Carolina is small. Incomplete production figures show a high of slightly over 5,000 bu to a low of 40 bu. In general, production has declined over the years. No culture has been recorded, and management of the fishery has been confined to an occasional closed season. No estimate is available of the quantity of clams (presumably Mercenaria mercenaria) in South Carolina. (J.L.M.)

Most clams harvested in South Carolina are consumed locally, and the harvesting is done by children and farmers. Production of hard clams (Mercenaria mercenaria) from 1929 to 1940 ranged from 47 thousand pounds to 0. Statistics are given for North Carolina, Georgia, and Florida also. About the turn of the century the clam industry was apparently more productive. It is centered in Georgetown County, but clams are plentiful in other places although seldom harvested. The reason is lack of demand. Demand was increased during the middle 1940s because a food shortage caused by the war had stimulated sales, but this demand was not being met by local fishermen. Wholesale dealers still obtain clams from northern markets. (J.L.M.)


The elevator harvester is described in considerable detail, but this should be considered as a guide only. Many changes could be made, depending on the specific use. It is, however, extremely versatile, and takes clams (Mercenaria mercenaria) and other mollusks with high efficiency. Depths of 10-12 feet appear to be near maximum for best operation. (J.L.M.)

Experimental field manipulations were used to determine the natural survivorship of Mercenaria mercenaria during the first 3 years of life in a small protected island estuary (Pokusnook River, Groton, CT) and an exposed outer harbor (West Harbor, Fishers Island, NY). Clams were planted and recovered at monthly and full-season intervals from May 1982 to Nov. 1982. Three densities (25, 150, and 300 clams/25 m^2) and six sizes (1, 5, 10, 15, 18, and 21 mm) were tested. More than 99% of mortality at all sizes was the result of crustacean predators. Green crabs (Carcinus maenas) were the dominant predators of clams up to 10 mm, while lobsters (Homarus americanus) readily consumed 15-21 mm clams. Full season survival of all size classes was consistently higher in the estuary than at the outer harbor site. The dramatic difference between survival of 3-year clams was attributed to the absence of lobsters in the Pokusnook River. Survival was strongly density-dependent, particularly in West Harbor, where the mean monthly survival of 5- and 10-mm clams planted at the lowest density was more than four times higher than survival of clams planted at the highest density. (Modified authors' abstract - J.L.M.)

221 Malouf, Robert E. 1981.
Despite active research programs, little commercial use of heated effluents has been made for culturing bivalve molluscs. Some problems associated with nursery culture in heated effluents include: contamination from radionuclides discharged from nuclear power plants; contamination from heavy metals; toxicity problems from chlorine used to control fouling in power plants; temperature shock resulting from shutdowns; and lack of temperature control. Other problems, more closely related to the biology of the animals than to operation of the plant, include fouling and disease, and inability to provide supplemental food to offset increased energy demands. This last is the most important barrier to realizing the advantages of heated culture. High temperatures should be avoided when possible, as temperatures in the Poquonock River during the summer were more than 10° higher than ambient. This system includes some type of temperature control or that animals be removed from the heated effluent when necessary. Mercenaria mercenaria is not mentioned, but the general principles apply. (Modified author's abstract - J.L.M.)

222 Malouf, Robert. 1983.
Mariculture must be defined before it can be intelligently discussed. Intensive culture may involve complete control of every aspect of the life cycle. It is highly productive, but expensive and technically sophisticated. Extensive culture may involve only minimal control over the organism. It is less productive per unit area, but also less expensive and tends to be less technologically demanding. There is also a distinction between private and public mariculture. The methodology may be identical, but private mariculture produces a crop on ground that is privately controlled, whereas public mariculture supplements natural reproduction and increases the public harvest. Either method may be costly, and it is necessary to ask whether the costs can be justified. Mariculture has certain advantages over other options, like restrictions on harvest, but they are unpopular and hard to enforce. But high-percentage survival must be obtained from seed planting, if cost is to be justified, and this requires consideration of predators and site selection. The problem of scale is also important, and present attempts are simply too small to have significant effects. Mariculture is

The prognosis for clam aquaculture in the U.S. is encouraging. Commercial quantities of hatchery-reared seed are available from a number of private hatcheries. Pilot projects indicate the feasibility of nursery and field growout methods developed over recent years, and new materials make these methods more cost-efficient. Diseases and parasites, although not studied extensively, are under control in hatchery and nursery culture and have not been a common problem in field growout systems. The hard clam (Mercenaria mercenaria) seems particularly appropriate for aquaculture. They are in strong demand, highly valued, consumer demand and acceptance are high, extensive transportation and marketing networks exist, and the biology is well known. The chapter includes sections on basic biology, culture techniques, parasites and diseases, constraints, and status and economic overview. The entire chapter should be read. (J.L.M.)


Although the hard clam, Mercenaria mercenaria, makes up only about 15% of the national total annual clam landings, it accounts for nearly 50% of total value. Historically, the major hard clams fisheries have been to the north, but these traditional fishing grounds have not had sufficient production to meet the growing demand for this species. This has stimulated interest in the southeast. In South Carolina this has stimulated appreciable growth over the last 10 years, and in addition has started a commercial hard clam mariculture facility. The life history of the hard clam, the fishery and mariculture, the market, and local constraints to development are described. Future development of the industry depends upon events in the Santee delta, where redsiphon of the Santee River will decrease landings in that area. Increased harvests in other parts of the State, and increased aquaculture activities will compensate. Depuration also will increase production. (J.L.M.)


Clam farming is feasible if people start small, make sure they have the legal right to use the site, be certain that they have the permits and licenses necessary, have notified state and federal agencies about the activity, construct culture units with predator control and maintenance as primary considerations, and are prepared to dedicate sufficient time for regular and complete inspection of the site. The outlook is promising but is still a "high-risk" venture. (J.L.M.)


Adult hard clams were sampled monthly between Dec. 1977 and Feb. 1979 and semi-monthly from March to June 1981, from subtidal populations in North Santee Bay, South Carolina. Gonad development was monitored using standard histological methods and resulting slides were examined with light microscopy at 100 and 400 x. Observed genetogenic progression was best categorized by five states or phases of development: inactive, ripe, spawning, partially spent, and spent. Males and females displayed a complex progression of genetogenesis. Gonadal tissue was not uniformly dominated by clearly defined, distinct stages. Instead, gonads routinely exhibited several stages simultaneously and progressed through slow shifts in domination of stages in gonad tissue. Spawning in the population occurred continuously for 6 months (May to October) with at least two apparent peaks of spawning activity in summer. (Modifed authors' abstract - J.L.M.)


Abstracted elsewhere in this bibliography. (J.L.M.)


The State of South Carolina has established a demonstration-scale hard clam (Mercenaria mercenaria) culture project. The project operates on a two-stage growout protocol. Raceways provide initial growout (to 10 mm). Final growout is done in field units with protection from predators and substrate for support and orientation. Over 2.7 million imported seed are being planted in South Carolina estuaries over a 13-month period. Field units are stocked at three densities, 2,105, 4,300, and 6,450/m2, using intertidal and floating (raft) formats and a variety of substrates. Units are sampled monthly to determine growth and survival and coincidental monitoring of various environmental data. Small field units have shown that densities as high as 2,156 seed clams/m2 do not show density-limited growth, at least to a mean population size of 39 mm, but smaller seed at lower densities sometimes have shown density-limited growth. Thus, this needs to be repeated on a larger scale. Economic analysis is also necessary. The State also has a legislative committee to study existing shellfish lease policies and make recommendations for modifications. (J.L.M.)

Seed clam, Mercenaria mercenaria, culture in an experimental-scale upflow nursery system. Aquaculture 54:301-311.

The study was conducted to evaluate growth of seed clams in an upflow nursery culture system in South Carolina relying on natural productivity as the only food source. Experimental-scale passive upflow cylinders were stocked with small seed clams (initial mean size = 4 mm) at various densities (2.3, 5.0, 10.0, 20.0, 30.0, and 40.0 kg/m3) in trials begun quarterly. Cultures received a continuous uniform water flow rate of 2.5 L/min from an adjacent estuary, at ambient phytoplankton concentration, temperature, and salinity. Most rapid growth was obtained with seed stocked in April and October, when water temperatures were between 18 and 22°C. Monthly biomass increases as high as 267 g/100 g were achieved. Growth was positively correlated with flow rate in all seasons except winter. A flow:biomass ratio of 15:1 resulted in a doubling of biomass in 30 days, while a ratio of 30:1 resulted in a tripling over the same period. Under favorable environmental conditions, a biomass doubling could be achieved at stocking densities as high as 20 kg/m3. Maximum production over a 3-month period was 495 g (309 g/100 g) of 7-mm seed, corresponding to 62 kg/m2. Although water requirements were similar to those previously reported for raceway culture in South Carolina, results indicated much greater biomass carrying-capacities per unit area with upflow culture systems. (Modified authors' abstract - J.L.M.)


The nursery consists of 60 forced upflow silos used for initial growth of imported 1-mm seed and 120 passive upflow silos used for seed growth from ~3 mm in field planting size (~8 mm). At full operation the nursery requires a minimum total flow rate of ~5000 L/minute, has a holding capacity of 24 x 106 seed, and an optimum annual production capacity of 18-36 x 106 planting-size seed. Data generated from experimental-scale upflow systems operating in coincidence with a commercial nursery compared favorably with raceway data based on water use per unit biomass supported and biomass support capacities per unit area. (Modified authors' abstract - J.L.M.)


The model assumed that the volume of a hard clam is proportional to the cube of a linear dimension. Iterations allowed model refinements which produced positive correlations between predicted and observed data. Collected data were summarized on size/volume relationships in seed clams and a model was presented, based on truncated spheres, which attempts to relate size and volume characteristics in seed clams within the size range 1-15 mm. (Modified authors' abstract - J.L.M.)

Upflow nursery systems for culture of bivalve mollusc seed are attractive alternatives to traditional raceway systems. The potential benefits include maximizing space utilization, low construction cost, ease of maintenance, and operational longevity. A commercial nursery facility for raising Mercenaria mercenaria in South Carolina employs forced and passive upflow culture instead of traditional raceway systems. Biomass increases as high as 140% per month were achieved in forced flow systems at stocking densities of 0.3-0.5 g/cm² and flow rates of 80-120 L/min/kg. In passive-flow systems, biomass increases of as high as 800% per month were achieved at stocking densities of 0.2-0.6 g/cm² and flow rates of 23-117 L/min/kg. Results were compared with those from raceways and from an experimental-scale, passive upflow system. (Modified authors’ abstract - J.L.M.)


235 Maurer, Don. 1984. The pirates of picayune: Ethnography of illegal fishing in New Jersey. Ethnography 31(1):17-37. Clamping is one of the techniques used by the baymen. Hard clams (Mercenaria mercenaria) are easily available and abundant in the bays, and can be taken literally all year-round. “Shoal Harbor” baymen still consider themselves “clammers” despite the fact that pollution has resulted in “condemnation” of the shellfish beds of Raritan Bay since 1962. Piracy is their remaining alternative, and has become a custom in Shoal Harbor. This has been partly caused by conflicts between common-property clammers and the oyster corporations. Baymen in the area have been able to keep the State from engaging in a program of transplanting clams from the polluted waters of Raritan and Sandy Hook bays to purer waters elsewhere in New Jersey. This led in 1981 to a decision to license a pilot plant for depuration of clams, stimulated by this attitude on the part of baymen and by the costs to the State of trying to cope with piracy. (J.L.M.)

236 McCay, Bonnie J. 1983. Food habits of the toadfish, Opsanus tau (L.), in New Jersey waters. Proc. Pa. Acad. Sci. 38:64-71. Of 115 digestive tracts of Opsanus tau examined from Delaware Bay in 1952, 1953, and 1955, Mercenaria mercenaria was found only in one. Crustacea were the major food. (J.L.M.)

237 McCay, Bonnie J. 1981. The effect of an infaunal suspension feeding bivalve Mercenaria mercenaria (L.) on benthic recruitment. Mar. Ecol. 4(3):263-274. The hypothesis tested was that benthic recruitment is more successful in low densities of infaunal suspension feeders than in high densities. Densities of young hard clams Mercenaria mercenaria ranging from 82.5-330/m² were placed in defaunated boxes of sand. Mean number of species, mean number of individuals, mean wet weight biomass, mean species richness, and mean density index per sample were calculated per density of hard clams from May to October. The experiment did not support the hypothesis. It was concluded that feeding behavior of dense populations of Mercenaria mercenaria did not preclude successful recruitment of other benthic species. (J.L.M.)

238 McCay, Bonnie J. 1982. Divergent life history patterns in the co-occurring intertidal crabs Panopeus herbstii and Eurypanopeus depressus (Crustacea: Brachyura: Xanthidae). Mar. Ecol. Prog. Ser. 8:173-180. Panopeus herbstii, which consumes primarily oysters, hard clams, mussels, and barnacles, is prevented by its larger size from entering most of the narrow spaces between living oysters while the narrow spaces are the primary refuge for Eurypanopeus depressus, which has a less restricted, more omnivorous diet. P. herbstii is larger, faster growing, longer lived, and more fecund, while E. depressus matures earlier, produces more broods per lifetime, and has a shorter generation time. (M.W.S. and J.L.M.)

239 McCay, Bonnie J. 1982. Food habits of the toadfish, Opsanus tau (L.), in New Jersey waters. Proc. Pa. Acad. Sci. 38:64-71. Of 115 digestive tracts of Opsanus tau examined from Delaware Bay in 1952, 1953, and 1955, Mercenaria mercenaria was found only in one. Crustacea were the major food. (J.L.M.)

240 McDermott, John J. 1964. Divergent life history patterns in the co-occurring intertidal crabs Panopeus herbstii and Eurypanopeus depressus (Crustacea: Brachyura: Xanthidae). Mar. Ecol. Prog. Ser. 8:173-180. Panopeus herbstii, which consumes primarily oysters, hard clams, mussels, and barnacles, is prevented by its larger size from entering most of the narrow spaces between living oysters while the narrow spaces are the primary refuge for Eurypanopeus depressus, which has a less restricted, more omnivorous diet. P. herbstii is larger, faster growing, longer lived, and more fecund, while E. depressus matures earlier, produces more broods per lifetime, and has a shorter generation time. (M.W.S. and J.L.M.)

241 McDonald, Jack. 1982. An overview of the hard clam resource. In Buckner, S.C. (ed.), Proc. of a Management Perspective on the Hard Clam Resource in Great South Bay, p. 3-9. A seminar sponsored by the Town of Islip (NY 11751), March 10, 1983. The hard clam, Mercenaria mercenaria, has long been the leading marine resource in New York State. In the 1960s it produced over 50% of the value of New York landings of all shellfish, and continued to produce at least 50% or more until 1978. In 1947 landings reached a peak of over 10 million pounds of meats, and in 1976 produced a secondary peak of over 9 million pounds. In 1987, however, landings had dropped to less than 4 million pounds of meats. The cause almost certainly was overfishing. Even more ominous have been serious outbreaks of human disease, not definitely traced to Great South Bay, which caused demand and prices to drop substantially. Poaching in closed areas and poaching of undersized clams in open areas have
reduced egg production considerably. One way to improve the situation might be to
divide the area under control of the Town into three to five parts, each containing
approximately an equal number of harvestable clams. Only one part would be open
to clamming at any one time, and these parts would be rotated annually, so that each
would be open every third to fifth year. Adequate enforcement would be absolutely
necessary, and this is not now possible. In addition to sufficient inspectors to watch
for violations, adequate support in the courts is a must. It is possible also that licenses
should be restricted so that baymen can make a decent living. These actions will not
stabilize hard clam production, but they will maximize natural production, and preserve
a great natural resource. The Marine Sciences Research Center is hoping to establish
a Living Marine Resources Institute with primary mission to improve hard clam pro-
duction. (J.L.M.)

The importance of nutrients to phytoplankton production in New York Harbor. In
Mayer, G.F. (ed.), Ecological stress and the New York Bight: Science and manage-

Some enrichment from nutrients and other bioactive materials resulting from domestic
and industrial wastes may enhance biological productivity, but further enrichment may
begin to alter certain food webs, as was the case in Moriches Bay, Long Island, NY,
where nutrients from duck farm wastes altered the food stock of the hard clam,
Mercenaria mercenaria, by replacing diatoms with less suitable food organisms.
This caused deterioration of the fishery. Diatoms form the basis for some food webs
that are commercially important to man, such as the hard clam. (J.L.M.)

Endemic diseases of cultured shellfish of Long Island, New York: adult and juvenile
American oysters (Crassostrea virginica) and hard clams (Mercenaria mercenaria).

At monthly intervals between Feb. 1975 and Oct. 1976, hard clams were collected
from two hatcheries on Great South Bay, NY. A large unidentified ciliated protozoan
was observed within the water tubules of the gills in 4 out of 190 adult clams. A pro-
bable sporozoan parasite resembling a gregarine spore stage was found in four. Four
types of intracytoplasmic inclusion bodies were observed in several adult hard clams.
Rickettsia-like organisms and a chlamydial agent were observed. Single and multiple
small papillomatous growths were found on the mantle surfaces of clams. In
juvenile clams two types of intracytoplasmic inclusion bodies reported in adults were
observed. Hard clams had a lower diversity of parasitism and histologic abnormalities,
none of which provoked any host response or had any pathological significance. No
parasites were found with known significance to public health. (J.L.M.)

Marine bivalve mollusks as reservoirs of viral finfish pathogens: Significance to marine

Hard clams, Mercenaria mercenaria, can depurate human polio virus type I within
96 hours if placed in clean seawater at 15-13 °C. If certification procedures are exer-
cised for shellfish pathogens, some additional effort made in screening mollusk tissues
for incidental viral finfish pathogens would provide significant protection against in-
trusion of these agents by movement of shellfish stocks. Shellfish may be seasonal
reservoirs for some endemic finfish pathogens originating from finfish epizootics or
from subclinically diseased "carrier fish." Shellfish could introduce exotic finfish
diseases when transported to other waters for commercial or experimental purposes from
areas where such agents may be endemic. (J.L.M.)

Uptake of Zn$^{65}$ and Mn$^{54}$ into body tissues and renal concretions by the southern
oak hog, Mercenaria campeachienis (Gmelin). Effects of elevated phosphate and metal

M. campeachienis was examined for uptake and tissue distribution of Zn$^{65}$ and Mn$^{54}$
accumulated from seawater containing varied concentrations of inorganic phosphate,
total zinc and manganese. Highest 10-day tissue concentrations for both metals were
found in the kidney with results showing different uptake patterns for zinc and manganese.
Total metal and inorganic phosphate concentrations showed marginal ef-
facts on manganese distribution but produced significant variation in zinc distribution
between kidneys and gills. (J.L.M.)

Efficiency of particle retention in 13 species of suspension feeding bivalves. Ophelia
17(2):239-246.

Mercenaria mercenaria was not included. Species which possessed eu-lateral-fronatal
cirri, as the hard clam does, completely retain particles above 4 μm. Particles down
to 1 μm in most cases were efficiently retained. (J.L.M.)

248 Moore, Carol A. 1981.
Phagocytosis and degradation of a unicellular algae by hemocytes of the hard clam

Hemocytes of the hard clam were observed to phagocytize Chlorella vulgaris and
several other species of unicellular algae and cello red-stained yeast. "Blunt" cytoplasmic granules received degraded materials from the phagosomes containing
the algae but not those containing a yeast cell. Blunt granules were further observed
to participate in intracellular processing of the hemocyte of vital dyes and endotoxin.
It is suggested that blunt granules represent a mechanism whereby hemocytes can con-
tain or further degrade foreign material. (J.L.M.)

249 Moore, Carol A. 1972.
The cytology and cytochemistry of the ameobocytes of the hard clam Mercenaria

Ameobocytes of the hard clam were of three types: a small granulocyte, a large
granulocyte, and a lymphocyte-like cell. The similarity of the nucleus in all three cell
types might suggest that these cells represent different stages of maturity. This was
also suggested by the gradation of cytochemical reactions. Blunt granules were iden-
tified as mitochondria. They also exhibited unidentified material which was PAS-
positive-diastase resistant and metachromatic. Dot-like granules were identified as
lysosome. These probably serve as centers of digestion for phagocytized materials.

Accumulation of $^{105}$Cd in extracellular granules in the kidney of the bivalve

Preliminary results showed that cadmium is associated with large extracellular granules
in the lumina of the kidneys. The presence of radiocadmium cadmium was determined
morphometrically by counting developed silver grains on sections coated with a
photographic emulsion. The results were highly significant to show that more radioac-
tive cadmium was associated with large granules than with the background tissue.

251 Multer, H. Gray, Dennis M. Stainken, and J. Michael
Spatial/temporal patterns of macrobenthos, sediments and pollutants in Raritan Bay-
Gleneside Beach, OR. Estuaries 6(3):302.

Seasonal sediment sampling at 82 stations (1-mile spacing) throughout Raritan Estuary
was analyzed for macrobenthos, size-grade, metal and HC (22 stations). Distinct
allopatric communities of clams Tellina agilia and Mercenaria mercenaria showed
seasonal spatial distribution. Mercenaria density was lower than in earlier studies.
No major change in quality of the environment was indicated for the last 6 yrs. (from
authors' abstract). (J.L.M.)

Neuromuscular transmission and excitation - Contraction coupling in molluscan muscle.
Comp. 2 In Saladin, A.S.M., and K.M. Wilbur (eds.), The mollusca, Vol. 4, Physiology

Reference is made to Mercenaria mercenaria studied by other authors abstracted
elsewhere in this bibliography. (J.L.M.)

253 Murphy, Richard C. 1985.
Factors affecting the distribution of the introduced bivalve, Mercenaria mercenaria,

In Colorado Lagoon the mean total bivalve density was 143/m$^2$. Of this the density
of Mercenaria mercenaria was 78/m$^2$. In the Marine Stadium mean total clam den-
sity was 57/m$^2$ and Mercenaria was absent. Bivalve populations were dominated
by suspension-feeders in the Lagoon. In the Stadium deposit-feeders were most abun-
dant. Burrows of ghost shrimp, Calianassa californiensis appeared to be more abun-
dant in the Stadium than in the Lagoon. There was a strong negative correlation between
growth and survival of M. mercenaria and suspended particulate matter. Calianassa
are capable of levels of turbidity and sediment destabilization sufficient to reduce the
growth and survival of M. mercenaria. Absence of C. californiensis from the Lagoon
came from stress conditions such as elevated summer temperatures, low winter salinity,
periods of anoxia, and possibly pollutants. Hardiness of *M. mercenaria* and its need for elevated temperatures for spawning probably contribute to its success in the Lagoon. (Modified author's abstract - J.L.M.)


This brings up-to-date the report: *Guidelines for the management of Long Island hard clam resources*, published in 1974. The hard clam industry is presently in a state of crisis brought about by a precipitous decline in landings and a lack of consumer confidence caused by a series of disease outbreaks linked to ingestion of raw shellfish taken from polluted waters in New York and other states. The history of the industry is reviewed, public health issues discussed, and recommendations made for future research. (J.L.M.)


The hard clam, *Mercenaria mercenaria*, species plan is covered in Appendix D, pages 168-196. A critical review and in-depth summary of the literature should be completed. A series of pilot-growout demonstrations, and hatchery and nursery operations, should be established. Feeding and nutritional studies should receive high priority. Development of a prepared food or diet should be started. Existing hatcheries should be funded to increase production. To develop better seed-production methods, to furnish seed for experimentation, and to encourage aquacultural development, two regional research hatcheries should be constructed. Training courses and demonstrations should be established for commercial culturists and marine-extension personnel involved in clam aquaculture. Annual or biennial workshops should be held to review recent developments. Several other lesser recommendations are made. (J.L.M.)

256 Nelson, Julius. 1892.

Cause of the vividity of New Jersey clams. Tuckerton (NJ) Beacon, 3 November 1892.

The green color in clams (*Venus mercenaria*) was caused by a microscopic plant which the dryness of last summer caused to multiply. Clams ate it in large quantities. There was no disease or parasite present, and no copper. The color was confined mostly to the gills, but in some clams in the liver also. Fatness and flavor were excellent. There was no harm to people and no need for alarm. (From Baughman’s bibliography - J.L.M.)

257 Nelson, Thurlow C. 1941.


The sperm of *Venus mercenaria* has no effect on the pumping of the oyster. (J.L.M.)

258 New Jersey State Department of Environmental Protection. 1981.

Approved area charts 4 and 5. Bur. Shellfish. Control, CN-029, Trenton, NJ 08625. Shows areas approved and dates, from Island Beach to Long Beach. (J.L.M.)

259 Newkirk, Gary F. 1980.


We are at present far from having control over genetics and other aspects of biology of mollusks. Significant advances have been made recently toward understanding many aspects of genetics, however, and these are briefly reviewed in this paper. Included is some mention of genetics of hard clams (*Mercenaria mercenaria*). Chanley’s work on the notata shell markings in hard clams, Menzel’s hybridization experiments, and Chanley’s study of selection for growth rate are mentioned. Most of the paper, however, is concerned with oysters. (J.L.M.)


Applied breeding of commercially important molluscs: A summary of discussion. Aquaculture 33:415-422.

There are exciting possibilities for new approaches to the genetic improvement of molluscs for commercial culture. What is needed now is a refinement of techniques and a clear demonstration of gains that can be made, not general statements. The time is ripe to incorporate genetic improvement programs in development of this industry. No specific mention of *Mercenaria mercenaria* but the paper applies to all commercial molluscs. (J.L.M.)


Deleterious effects of turbidity on eggs of the hard clam, *Mercenaria (= *Venus*) mercenaria*, were documented by Davis (1960) and Loosanoff (1961). (J.L.M.)

262 Nylund, Steve. 1986.


Describes the Long Island Green Seal program, a new voluntary tagging procedure, which attempts to assure quality of clams (*Mercenaria mercenaria*) by placing a tamper-proof Green Seal on bushel bags of clams so that the origin can be traced if desired. (J.L.M.)


Bioconcentration factors (BCFs) for hard clams (*Mercenaria mercenaria*) were 10% for cadmium. (J.L.M.)


Polychlorinated biphenyls (PCBs) in the flesh of hard clams (*Mercenaria mercenaria*) from the Hudson River and New York Bight region were no greater than 0.2 µg/g wet weight. (J.L.M.)


Burrowing behaviour of juvenile hard clams in oil-contaminated sediment was examined in a series of laboratory experiments. At oil concentrations within the range that might occur after an oil spill, depth and rate of burrowing were altered. The depth to which clams in oil sediment burrowed after 96 hours was significantly shallower than the depth in controls, while the time taken to burrow beneath the surface was longer in oil-contaminated sediment. Alterations in burrowing were indicative of avoidance behaviour rather than oil-induced debilitation. Results suggest that such alterations may increase vulnerability of this species to predation. (Modified authors’ abstract - J.L.M.)

266 Osorio, Cecilia, Daniel Frassinetti, and Eduardo Bustos. 1983.


Results suggest that the valid name is *Venus antiqua antiqua*. Increasing harvests of clams in Chile caused state institutions to carry out biological and fishery studies of one of the most important species. *Mercenaria mercenaria* is not mentioned. (J.L.M. and M.W.S.)


Two species of hard clam are harvested in Florida, the northern hard clam, *Mercenaria mercenaria*, and the southern hard clam, *M. campechiensis*. *M. campechiensis* is more dominant in commercial harvests from the west coast. A subspecies, *M. mercenaria texana*, occurs along the northern coast of the Gulf of Mexico and extends westward beyond Apalachicola Bay. Marketability has been hampered by limited survival when placed in common refrigeration. *M. mercenaria* survived better in refrigeration than *M. campechiensis*, as did the hybrid. Clams from two places were tested. Those from Indian River survived better than those from St. Joe Bay in refrigerated storage at 40°F. Indian River is on the east coast of Florida near Cape Canaveral, St. Joseph
Bay is on the west coast near Panama City. Most clams from Indian River were *M. mercenaria* whereas those from St. Joseph Bay were mostly *M. campechiensis* with some possible *M. m. texana*. There was no discernible pattern in mortality in relation to clam size. Clams taken from warmer waters, e.g., in summer rather than in winter, had shorter storage life. (J.L.M.)

268 Pannella, Giorgio. 1980.
Infrared spectra obtained from powdered sagitta of *Merlucia bisinera* (silver hake) and homogenous shell layer of *Mercenaria mercenaria* are virtually identical, as shown by a graph. (J.L.M.)

A general review of the book, without reference to species. (J.L.M.)

270 Patterson, Captain R.A. 1986.

No specific mention of *Mercenaria mercenaria*, which does not occur that far south. (J.L.M. and M.W.S.)

Subcellular distribution of aminotransferases, and pyruvate branch point enzymes in gill tissue from four bivalves. Comp. Biochem. Physiol. 82B(1):129-132.
Aspartate aminotransferase (AAT), alanine aminotransferase (ALAT), malic enzyme (ME), malate dehydrogenase (MDH), pyruvate kinase (PK), and phosphoenolpyruvate carboxykinase (PEPCK) activities in cytosolic and mitochondrial fractions of gill tissue from ribbed mussel, sea mussel, oyster, and *Mercenaria mercenaria* were determined. AAT showed distinct mitochondrial and cytosolic isozymes in gills of all animals. ALAT showed the same in gills of oysters, sea mussels, and quahogs, but only mitochondrial ALAT was found in ribbed mussel gill tissue. PK and PEPCK were cytosolic in all. ME was found only in the mitochondrial fraction of ribbed mussel and quahog gill tissue whereas sea mussel gills showed distinct cytosolic and mitochondrial ME isozymes. MDH showed distinct cytosolic and mitochondrial isozymes in all gills. (Modified authors' abstract - J.L.M.)

Density of clams (*Mercenaria mercenaria*) was positively associated with seagrass cover in a meadow of *Halodule wrightii*. Seagrass provides these clams with a refuge from whelks (*Busycon spp.*). In the unaltered (control) seagrass meadow hard clam density remained constant over 13 months. Where seagrass was experimentally removed, marked individuals showed high rates of mortality in two successive experiments spanning 13 months. Whelk predation fell preferentially on larger size classes, while factors which contribute to clam disappearance usually acted more intensely on smaller sizes. Experimental exclusion of large predators by caging demonstrated that even in unvegetated areas survivorship of clams was high in the absence of whelks and other predators. (Amended author's abstract - J.L.M.)

274 Peterson, Charles H. 1983.
Quantitative reproductive senility occurs when older age classes achieve less reproductive effort than expected from the allometric (power) curve relating body size to reproductive effort among younger adults. Among *Mercenaria mercenaria* from North Carolina up to age 19, there is no evidence of either absolute or quantitative reproductive senility. (Modified author's abstract - J.L.M.)

Among 67 hard clams collected during spawning from Core Sound, NC, gonadal masses increased significantly with body size. Clam age did not explain a significant amount of the residual variance in logarithmic regression of log gonadal mass on log shell length. Because this collection contained 11 individuals over 24 yrs of age, including the oldest *Mercenaria mercenaria* ever reported, at 41 and 46 yrs, these results imply that gamete production in hard clams continues into old age at a quantitative level predicted simply by the power curve relating gonadal mass to body size. There was no suggestion of even partial reproductive senility in gamete production at old age. (Modified author's abstract - J.L.M. and M.W.S.)

The hypothesis that passive hydrodynamic influence of projecting sea grasses on larval and postlarval settlement is sufficient to explain higher *Mercenaria mercenaria* densities inside a seagrass habitat was tested. This was done by comparing the between-habitat ratio of 0-year-class recruits after each of two settlement seasons with the between-habitat ratio of densities of all older age classes. Differential survival after settlement must be invoked to explain at least half the seagrass enhancement in *Mercenaria* population density. (J.L.M.)

Thirteen monthly measurements of individually marked juvenile and adult specimens of *Mercenaria mercenaria* from field plots in North Carolina demonstrated similar seasonal patterns in size-adjusted monthly growth rates in shell volume. A large absolute maximum occurred in spring (April or May) and smaller relative maxima in midsummer and late autumn. The ratio of juvenile to adult size-adjusted growth rates in shell volume was nearly constant for 10 months but then increased eightfold in December and January. This growth anomaly between size classes could not be explained by examining dry weights of soma and gonads from additional marked juvenile and adult clams that were sacrificed monthly. Juveniles differed from adults by possessing negligible gonadal mass on all dates. However, knowledge of monthly changes in adult gonadal mass did not explain a significant amount of the residual variation in the regression of monthly juvenile volumetric growth on monthly adult volumetric growth. Seasonal changes in growth of adult gonadal mass and quarterly examinations of gonad histology suggested a winter period of negligible gametogenesis followed by a spring burst of intense reproductive activity. The best explanations for the anomalously high volumetric growth of juveniles relative to adults in December and January are: 1) winter availability of a food source accessible only to juveniles, or 2) biochemical storage of energy during winter by adults in preparation for the process of rapid gametogenesis in spring. If the second explanation is correct, adult clams exhibit a large seasonal change in allocation of resources between somatic growth and reproduction, with maximal allocation to reproduction in winter before gonad histology and growth of gonadal mass indicate reproductive effort. (Modified authors' abstract - J.L.M.)

278 Peterson, Charles H., and Millicent L. Quammen. 1982?
*Mercenaria mercenaria* is not mentioned. Siphon nipping by *Lepocosa armata*, *Hypopsis gunalanula*, and *Paralichthys californicus* reduced growth of *Protocatula staminea* in nature as compared with the same bivalve in cages that excluded large predators and crappers. (J.L.M.)

Average density of *Mercenaria mercenaria* in samples taken from an eelgrass (*Zostera marina*) bed in Back Sound, NC was 960 m⁻², more than five times average density (1.6 m⁻²) in samples from a nearby sand flat. Size-frequency distributions differed between environments, the sandflat contained a larger fraction of *Mercenaria* in the smallest group (0-1 cm). Age-frequency distributions also differed between environments but average *Mercenaria* age was identical. Average sizes of 0-, 1-, and 2-year-class *Mercenaria* were significantly greater in the seagrass collection. There
was also an implication of higher growth rates inside the seagrass environment. Seagrass baffles currents near the bottom, where Mercenaria feeds, to levels 50% lower than those measured simultaneously on the sandflat. The paradoxically higher growth rate of Mercenaria in the lower current regime inside the seagrass bed may be a consequence of higher particulate food concentrations produced by the hydrodynamic baffling of the emergent vegetation. (J.L.M.)


Habitat strongly influences the relative effectiveness of these clam rakes. In unvegetated sandy sediments the pea digger took significantly more legal-sized hard clams Mercenaria mercenaria per unit time than the bull rake. In a seagrass bed the relative effectiveness was reversed. The difference between rake effectiveness was not a consequence of greatly differing efficiencies of clam capture within raked areas, but rather of differing rates of areal coverage. Any habitat-specific regulation of a fishery requires exceedingly more intense monitoring to be effective than an outright prohibition of certain gear. But the deeper water and unvegetated mudbottom usages of bull rakes suggest that this gear deserves a place among legal clamming gear, despite its threat to seagrass. (J.L.M.)


Banding data from marked Mercenaria mercenaria after 24 months provided a compelling case for using major growth bands to age hard clams in the Cape Lookout region. Growth bands were recognized in sectioned shells. Of 89 individuals 17 showed insufficient growth or lacked a disturbance check to mark the precise size at the beginning of the experiment. Of the remaining 72, all but 2 deposited exactly 2 additional dark growth bands. Ages ranged from 0 to 17 years at the beginning of the experiment. (J.L.M.)


Individually marked and measured Mercenaria mercenaria were placed in field enclosures of three types near Cape Lookout, NC, in June 1978. Subsets were collected and sacrificed in Oct. 1979, May 1980, Oct. 1980, and Oct. 1981. Growth bands were deposited annually during the summer-early fall season. Enclosure type did not alter the regular annual band pattern. Only about 7% of recruits in spring samples failed to show an identifiable growth band from their first summer-fall period. Thus, southeastern M. mercenaria near Cape Lookout can be aged by counting internal growth bands, but, unlike northern populations, show slow growth and annual band deposition during summer-early fall rather than in winter. Aging of a Core Sound collection gave a high proportion of older clams (up to 32 years old) and a mean age of over 9 years. Growth rates gave an average legally harvestable size reached in 1½ years. A lower recruitment success was shown from the 1977, 1978, and 1979 year classes than for previous years. This corresponds with a fourfold increase in commercial harvest, and suggests that the spawner-recruit relationship should be examined. (Modified authors' abstract - J.L.M.)


Burrowing rates of small clams (not Mercenaria mercenaria) were significantly faster than those of larger clams. Above a threshold of 5.8 μg Cu/g added to dry sediment, the time for 50% of the clams (Protothaca staminea) to burrow (ET50) increased logarithmically with increasing sediment copper concentration. Previously exposed clams had a lower threshold to Cu and a longer reburrowing time. Clams exposed to sediment mixed with Chelsea-100-sorbed Cu showed no significant change in burrowing time. Biosediments based on clam burrowing behavior can measure bioeffectiveess of sediment-sorbed metals and a sublethal effect with ecological meaning. (J.L.M.)


Gravel sediment freshly enriched with over 4.4 μg Cu/g significantly increased the burrowing and reburrowing times of littleneck marine clams (Protothaca staminea). Mercenaria mercenaria is not mentioned. (J.L.M.)


No specific mention of Mercenaria mercenaria. The general morphology of the molluscan kidney is outlined. The excetration of nitrogenous waste by aquatic molluscs is described. (J.L.M. and M.W.S.)


FMRFamide has positive isotropic and chronotropic actions on the isolated heart of Mercenaria mercenaria. In addition, it causes a sustained contraction of the radula protractor muscle of Bathycon contrarium. The action of 5-hydroxytryptamine (5-HT) is similar to that of FMRFamide on Mercenaria heart, and the dose-response curves are parallel, but 5-HT cardioexcitation is blocked by methysergide; that of FMRFamide is not. Acetylcholine (ACh) also contracts the radula protractor; but the effect is qualitatively different from that of FMRFamide and the dose-response curves are not parallel. Benzochromione blocks ACh contractions, but not those of FMRFamide. A number of amino acid derivatives and peptides were screened for biological activity on these two muscles, but most were inactive. (Modified authors' abstract - J.L.M.)


Accumulation and retention of cesium-137, cerium-144, zircon-65, and gold-199 and the effects of radiation were followed on hard clams, Mercenaria mercenaria, oysters, Crassostrea virginica, and bay scallops, Aequipecten irradians. LD₅₀ for clams in the various dose groups was: 186,656 roentgens (r), 5.5 days; 163,324 r, 4.5 days; 156,816 r, 3.5 days; 149,992 r, 6.5 days; 116,600 r, 25.5 days; 93,328 r, 38.5 days. The remaining groups of irradiated clams (46,664; 23,332; 11,666, and 5,833 r) had not attained a 50% mortality after 60 days. (J.L.M.)


Abstracted elsewhere in this bibliography under College Marine Stud., Univ. Delaware, Newark, DE: 1976, NOAA Sea Grant 04-3-158-30, 13 p. (J.L.M.)


The information was presented at the 6th Annual Meeting of the World Mariculture Society, Seattle, WA, in January 1975. Three principal controlled-environment system configurations have been designed and utilized. Each has served a specific purpose. The technical feasibility of raising bivalve molluscs, including Mercenaria mercenaria, from egg to market size in a recirculating system with a diet of cultured algae has been demonstrated. Currently system optimization and cost reduction efforts are working toward achievement of an economically feasible system. System I was discon­tinued because algal cells could not be harvested efficiently from the media and because it had a limited capacity to produce massive quantities of algae. System II worked well but it was too small for scale-up to commercial operation. System III demonstrated the success of growing bivalve molluscs on cultured algal cells, productivity of algal cultures was increased, and the recycle potential to make the alga-mollusc route a reality was demonstrated. A 50-bushel system including a solar-powered mass algal culture facility is currently under design. (J.L.M.)


After several years effort the technical feasibility of raising bivalve mollusks from egg to market size in a recirculating system on a diet of cultured algae has been demonstrated. This system was developed for oysters, Crassostrea virginica, but the general features of the system apply also to the hard clam, Mercenaria mercenaria. (J.L.M.)


The University of Delaware Project is working toward development of commercial, closed-cycle, controlled-environment shellfish mariculture suitable for rapid growth of Mercenaria mercenaria and other bivalves. The paper reviews improvements in growth rate of oysters. (J.L.M.)


Total hydrocarbons in store samples were generally higher than in samples collected from a control location in lower Narragansett Bay. Polycyclic aromatic hydrocarbons concentrations were similar to levels reported for other shellfish species. Two substituted benzoaziridines also were detected in clam extracts. Levels of polycyclic aromatic hydrocarbons and substituted benzoaziridines were also generally higher than in samples from the control location in the lower Bay. The significance of these findings to human health was unknown at this time because human health standards for these compounds in seafoods have not been established. (J.L.M.)


In certain genera the digestive processes are now known to comprise a chronological sequence of events associated with some exogenous or endogenous rhythm. Thus, it will be essential to make adequate provision for this possibility in all future investigations. With respect to investigations on the Bivalvia, a tidal simulator and/or kymograph have become essential pieces of equipment to any biochemist. Mercenaria mercenaria is not mentioned. (J.L.M.)


Juveniles of Mya and Mercenaria were alizarin-stained and cultured for 12 weeks in flowthrough tanks containing one of three different species of macroalgae. Clams grown with Ascophyllum nodosum Linnaeus and Laminaria longicruris De la Pylaie were significantly larger in shell dimensions than controls and those grown with Ulva fasciata Linnaeus. Treatments with Ascophyllum and Laminaria were 12.6% and 9.6% larger than controls, respectively. (Modified author's abstract - J.L.M.)


Despite management and environmental problems the U.S. clam fisheries are operating at record levels. The hard clam is the most valuable of the four primary east coast species. Production has been under stress in New England and in the middle Atlantic coast, but this has been offset by increased production in the south, particularly in Fla. (J.L.M.)


This volume is a valuable literature review of skeletal growth which should be consulted by all workers on hard parts of aquatic organisms. The papers review Mercenaria mercenaria extensively, and many other mollusks, but other organisms also are covered, for example, corals, fishes, polychaetes, and barnacles, and others. (J.L.M.)


Species such as Mercenaria mercenaria are ideal candidates for study because their long life-span allows analysis of skeletal records that encompass predisturbance growth conditions and postdisturbance growth recovery. Ontogenetic growth records, demographic parameters, after-the-fact pollution studies, identification of adaptive strategies, and fishery management are some of the factors that can benefit from growth studies. (J.L.M.)

298 Rhoads, Donald C., and Giorgio Pannella. 1970.


The relationship of growth patterns to specific environmental factors was studied by transplanting larvae of bivalves from one environment to another. Juvenile Mercenaria mercenaria were transplanted from holding tanks to the intertidal zone and finally to a subtidal environment. The sequence of events was recorded accurately in the microgrowth patterns of all specimens. Growth over the period of study could be followed on a day-by-day level of resolution. Growth rate decreased after the transplant from holding tanks to the intertidal zone and from the intertidal to the surface of a turbid subtidal mud bottom. Growth increased, however, from the intertidal to subtidal environment in specimens elevated above the turbid mud bottom. Growth rate was higher in specimens living in sand than in those living in mud in all stages of the experiment. M. mercenaria deprived of its natural substratum exhibited marked changes in its macrogrowth patterns. Large variances, peristomial extensions, and sharply delimited daily growth bandings marked the period of growth without a granular substratum. Changes in shell structure were also observed during the period of growth without sediment. The molluscan shell may be considered as a long term continuous environmental recorder. Additional research is required to be able to identify particular recorded patterns with specific environmental conditions. (J.L.M.)


The benthic turbidity zone (BTZ) is an open adaptive zone for commercially important malaco-bivalves. It is possible that bioturbating activity might decrease if molluscs were grown in the BTZ. This negative feedback might have to be allowed for. (J.L.M.)


In two separate types of experiments with larvae of the northern quahog Mercenaria mercenaria and northern bay scallop Argopecten irradians irradians optimum concentrations of Isochrysis sp. galbana for growth were determined, and estimates made of algal consumption rates. This presented a clear picture of larval-food interactions in culture systems, and suggested some new feeding strategies. (Modified authors' abstract - J.L.M.)


Four main tubule types, signifying various stages of intracellular digestion, can be recognized: I, holding; II, absorptive; III, fragmenting; and IV, reconstituting. Digestive tubules and similar tubule types are not distributed randomly within the digestive gland, but are grouped together around common secondary ducts. In Mercenaria mercenaria variability of tubule types is high within individual digestive glands, as well as between individuals sampled at the same time. Based on calculations to minimize total variance, it is better to sample a small area from numerous individuals rather than a large area from one animal. Problems imposed by variability and tubule clustering have not been considered adequately in previous investigations of digestion. (J.L.M.)


The variability of the four tubule types previously recognized in the digestive glands of bivalve mollusks (e.g., holding, absorptive, fragmenting, and reconstituting) was investigated using photomicrographs. The clustering of similar tubule types around common secondary ducts was observed histologically and by statistical analysis. Intra-animal variances were approximately the same for each species. Inter-animal variances in common secondary ducts was observed histologically and by statistical analysis. Intra-animal variances were approximately the same for each species. Inter-animal variances were also similar but only 10% to 25% of the intra-animal variances. Sampling schemes involving large numbers of animals but few photomicrographs of each digestive gland would minimize overall variance. The necessity of taking numerical data and using proper statistical analysis is stressed. (J.L.M.)


Thesis not available at University of Southampton. (J.L.M.)


Four bivalve species were grown in the system, Ostrea edulis, Crassostrea gigas, Tapes decussata (=Venerupis decussata), and Chlamys varia. The system was less productive, per unit area, than some natural populations of bivalve, but probably approached the maximum attainable in a semi-closed system relying on in situ primary productivity. Mercenaria mercenaria is mentioned only with reference to papers abstracted elsewhere in this bibliography. (J.L.M.)

305 Romeril, M.G. 1979.


A change of metal concentration with age was the most easily recognized relationship. All metal concentrations were lower at the seaward end of the estuary, and sediments levels generally followed a similar trend. But tissue and sediment values appeared to correlate with each other only for iron. Effects attributable to the Marchwood Power Station were insignificant in relation to natural variability. (J.L.M.)


The extent to which shell chemistry of bivalves can be used to make environmental and evolutionary interpretations is, at present, unclear. Shell composition is complex, varying with position in the shell and with ontogenetic age. The distribution of elements in a shell must be fully described before interpretation can be made. The description of chemical ontogeny and its allostatic variations promised to be a long and difficult task with present analytical methods. (J.L.M.)


A combined tertiary sewage treatment-marine aquacultural system has been designed and successfully tested on a small, experimental scale. Effluent from secondary sewage treatment, diluted with seawater, is used as a source of nutrients for growth of unicellular marine algae, and the algae, in turn, are fed to oysters or other shellfish (e.g., Mercenaria mercenaria). The algae remove the objectionable constituents from the secondary sewage effluent (ammonia, nitrate, phosphate, etc.) and the algae are removed by the oysters or other shellfish. The products are purified waste effluent, which will not support further algal growth (undesirable "algae blooms") in nature, and a commercially-valuable crop of seafood. Using a continuous flow mode of operation the process was capable of removing 95-100% of the inorganic nitrogen content of the sewage effluent, the discharge from the system being unable to support further algal growth and often containing less nitrogen than the receiving seawater. Dissolved wastes, produced as excreta products of the oysters, are removed by a final "mop-up" step consisting of macroscopic algae (seaweeds), of which several species have been tested. It is projected that this basic system should be capable of providing advanced (tertiary) sewage treatment for a population of 50,000 people with the ancillary annual production of 900 tons of oyster meats or 250,000 bushels of whole oysters worth $1.5 million. Space required for an operation of that scale would be some 144 acres as compared with about 110 acres for a conventional filtered, land disposal system. (Modified author's abstract - J.L.M.)


During the first year the pilot plant operated, shellfish culture was largely unsuccessful. Seed clams (Mercenaria mercenaria) showed poor growth and high mortality. This was believed to be due to unresolved problems such as unfavorable culture conditions in the raceway system, unfavorable algal food of Phaeodactylum tricornutum, reported in the literature as poor to indifferent food for bivalves, or an inferior stock of shellfish whose growth was stunted prior to or after acquisition. Data from small-scale experiments and from the literature indicate that enough algae were produced from a million gallons per day of sewage effluent to grow 11 million market-sized oysters per year. This possibility must remain speculative until a successful method of shellfish production is demonstrated and evaluated. (J.L.M.)


It is suggested that the recent success of the Indian River clam fishery may have resulted from unusually heavy rainfall during 1982, and above-normal rainfall during 1983 and 1984. This is only theory, however, and must be confirmed by monitoring and meteorological data. (J.L.M.)


Division of Applied Biology. Harbor Branch Found., Inc., Fort Pierce, FL 33450, 4 p. Describes activities in algae culture, mollusc cultivation, fish culture, aquatic biomass research, and environmental research. An unusually successful natural set of hard clams (Mercenaria mercenaria) in the Indian River led to rapid growth of the clam fishery, aided by decline of Long Island's clam fishery and migration of diggers from the northeast. The Division has developed a hatchery, which presently is doing experimental propagation of hard clam seed. (J.L.M.)

311 Ryther, John H., and Joel C. Goldman. 1975.


The best food organisms were the small flagellates Isochrysis galbana and Monochrysis lutheri. For Mercenaria mercenaria best growth occurred at cell concentrations of about 2.5 x 10^5 cells/mL of either species. Most of the algae tested produced growth of M. mercenaria ranging in size from about 0.5 to 10.0 mm. Exceptions were the dinoflagellate Amphidinium klebsi and several species of Chloraella, Stichococcus, and coccoid algae, which usually gave less growth than unfed controls. Good growth was obtained with diatoms (Cosostera, P. tricornutum) and with several small flagellates, but the best results were obtained with mixtures of three or four diatoms and flagellates. Wa1ne (1970) also published an extensive survey of the relative food value of 25 species of 19 genera for juvenile (0.5-5.0 mm) clams (Mercenaria). got similar results. Large-scale sea farming operations involving use of cultivated microorganisms is not a reality at present. (J.L.M.)

312 Ryther, John H., Joel C. Goldman, Cameron E. Gifford, John E. Huguenin, Asa S. Wing, J. Philip Clarner, Lavergne D. Williams, and Brian E. LaPointe. 1975.


A combined tertiary sewage treatment-marine aquaculture system was developed, tested, and evaluated at Woods Hole, MA, and Fort Pierce, FL. Domestic wastewater effluent from secondary sewage treatment mixed with seawater was used as a source of nutrients for growing unicellular marine algae, and the algae, in turn, were fed to oysters, clams (Mercenaria mercenaria), and other bivalve molluscs. The output from each algal pond was fed into cement raceways which contained, among other molluscs, 150,000 seed clams ~1.25 cm long. The raceway containing hard clams was stocked with 1,400 "bait worms" (Nerita viridula) ~2 cm long. It was expected...
that these worms would grow on clam biodeposits. To provide worms with shelter and reduce cannibalism the bottom of the raceway was lined with beach stones because fine sand tends to become anoxic. (J.L.M.)


Environmental factors have a more or less gravitating influence upon organic life, and can lead to a reduction of growth development. For a temporary slowing down and a momentary stagnation growth functions can be modified as was recently shown by the author (Sager 1982). This method does not apply to stagnation over weeks or even months, however, as is the case for different species including fishes and clams. Therefore a second revision is necessary for such a special behavior. A new formula is presented and tested for the bivalve Mercenaria mercenaria of Southampton Water, English Channel. (Author’s abstract - J.L.M.)


Reference to Mercenaria mercenaria studied by other authors is included under references. (J.L.M.)

Contains numerous references to Mercenaria mercenaria, most of which are by other authors abstracted elsewhere in this bibliography, but some of which are previously unpublished observations. (J.L.M.)

This book continues the series begun with Wilbur and Yonge (1964). Chapters by Morton (65-147), Jones (189-238), Burton (291-352), Martin (353-405), and Bayne (407-468) are pertinent to Mercenaria mercenaria even in places where M. mercenaria is not mentioned specifically. The book should be read for information on feeding and digestion, circulatory system, ionic regulation and water balance, excretion, and immunobiology. (J.L.M.)

Mercenaria mercenaria larvae were sampled in Barnegat Bay, and densities up to 67,000/m2 were reported in Little Egg Harbor. (J.L.M.)

318 Santoro, Peter F., and Joel A. Dain. 1981.
B-N-acetylglucosaminidase was partially purified from the digestive gland of hard clam, soft clam, and surf clam and their properties compared. Heat inactivation studies on the B-N-acetylglucosaminidases preincubated at 45°C showed that the preparation from surf clam was stable up to 60 minutes, while that from soft clam and hard clam lost 47% and 91% of their original activities under the same conditions, respectively. D-glucurononolactone is more inhibitory towards the soft clam enzyme, while HgCl2 is less inhibitory towards the surf clam enzyme. The Vmax value for B-N-acetylglucosaminidase from hard clam was about 2.5-fold “greater” than that from the other two bivalves. The pH optimum, K,, molecular weight, energy of activation, and effect of ionic strength on enzyme activity were similar for all three species. The digestive gland of all three species also contained several other activities. (J.L.M.)

Movements of the oyster toadfish (Pisces: Barracoididae) about Solomons, Maryland. Chesapeake Sci. 15:155-159.
Toadfish are much less sedentary than formerly thought. No mention of food. (J.L.M.)

320 Scott, Roy F. 1981.

Present commercial fishery consists of a few individuals raking clams in summer, and 5 to 10 hydraulid dredges working in winter. Harvesters are restricted to 8,000 clams/day. The dredge fishery is expanding because prices are higher and the population is increasing, allowing a harvest of 4,000 to 5,000 clams per boat per day. Shell areas increase recruitment by providing a better opportunity for settling and reducing crab and fish predation. Hard clam is relatively long-lived and more susceptible to overfishing than short-lived soft clams or blue crabs. It is believed that Maryland’s hard clam fishery can best be served by: 1) a shell planting program to improve the habitat; 2) encouraging private clam culture; and 3) careful monitoring of the harvest and status of the clam population. The Tidewater Administration barged 43,000 bu of oyster shells from Chincoteague and planted on a 17-acre site east of Mills Island. The area will be cultivated and opened to clam harvesting in 3 yrs. Planting efforts will be continued. Hard clam culture has excellent potential. (J.L.M.)

321 Seed, Raymond. 1980.
On page 54 is a figure showing barrowing habit of Mercenaria. (J.L.M.)


Mercenaria mercenaria grown in raceways did not grow significantly in 18 months. A good food organism, Skeletonema costatum grew best only in winter, at temperatures between 0° and 9°C. During the remainder of the year the diatom Phaeodactylium tricornutum was dominant, but this species is known to be a poor food for most bivalves. In the author’s opinion using wastewater for aquaculture is limited. Yet one cannot overlook the role these wastes could play at the hatchery level, when shellfish are small and food demand is not great. (J.L.M.)


Mercenaria mercenaria was not included among the six bivalve species experimented with. (J.L.M.)

Reviews papers by Weiner and Hood, Crenshaw, Gordon, and Carriker and Young, Crenshaw and King abstracted elsewhere in this volume. (J.L.M.)

Effects of pollutants on fishes. In Mayor, G F. (ed.), Ecological stress and the New York Bight: Science and management, p. 23-38. Estuarine Res. Fed., Columbia, SC. Data on commercial landings of most species caught in New York Bight show no signs of adverse effects on abundance. Mercenaria mercenaria landings are somewhat lower, but there is no evidence that pollution in New York Bight has been a cause. (J.L.M.)

326 Squires, Donald F. 1983.
A rather complete review of the potential for aquaculture in New York State including hard clams (Mercenaria mercenaria). Includes discussion of present status of aquaculture, aquaculture and the law, social and political attitudes toward aquaculture, economic constraints, marketing constraints, and biotechnical constraints. (J.L.M.)
327 Stanley, Steven M. 1969.

328 Stanley, Steven M. 1975.
Why clams have the shape they have: An experimental analysis of burrowing. Paleobiology 1(1):48-58.

329 Steimle, Frank W., Jr. 1982.


A quantitative study of benthic fauna in lower Chesapeake Bay with emphasis on animal-sediment relationships. Masters thesis, College of William and Mary, Williamsburg, VA 23186, 40 p.

Mercenaria mercenaria is mentioned only in connection with the work of others, abstracted elsewhere in this bibliography. (J.L.M.)

335 Sunderlin, Judith Baab. 1975.

10 species of shellfish were screened for growth and survival in the St. Croix mariculture system. Eight species, all except Crassostrea virginica and Mercenaria mercenaria, grew well and reached market size quickly. M. mercenaria grew poorly and sustained high mortalities at all locations. (J.L.M.)


Initial community development was relatively unpredictable. Larval recruitment patterns varied markedly from year to year. Instead of preparing the way for subsequent arrivals, most resident adults strongly inhibited recruitment and growth of other species. Mercenaria mercenaria was not included in fouling communities. (J.L.M.)


Lists Venus verrucosa from the English channel, the southwest of Ireland, Irish Sea, and west coast of Scotland, south to the Iberian Peninsula, into the Mediterranean, Canary Islands, Cape Verde Islands, Madeira, and down the west coast of Africa to Mosamedes (Angola) and from the Cape of Good Hope around to Durban and Delagoa Bay. Venus casino, common around the British Isles, south to the Iberian Peninsula, the Mediterranean, the Atlantic coast of Morocco, Canary Islands, Senegal, and Dahomey. Venus (Timoclea) ovata, widely distributed around the British Isles, northern Norway and Iceland to the Iberian Peninsula, Mediterranean, Black Sea to the Atlantic coast of Morocco, Canary Islands, Venus (Chamelea) striata, very common around the British Isles, Lophotrochoidea south to the Iberian Peninsula, Mediterranean, Black Sea, Atlantic coast of Morocco, to Madeira and the Canary Islands. And Venus (Mercenaria) mercenaria, the first living specimens of which in the United Kingdom were found in the Humber River in 1860 (a dead shell, probably originating in a ship’s ballast, was found in the Mersey River in 1859). Since that time it has been reported from the Menai Strait. Unsuccessful attempts have been made to introduce it into the Dee (Cheshire) and Mersey estuaries. Large colonies have become permanently established in the Solent, Southampton Water, and Portsmouth Harbor, possibly introduced from the kitchens of Transatlantic liners. Recently, experimental colonies have been introduced into the River Yealm, Devon, Poole Harbor, Dorset, the Rivers Crouch, Roach, and Blackwater, and at Walton, Essex. It was introduced into various places in France, but none of these was successful until 1910 when a population deposited in the basin of the River Seudre became properly acclimatized. This was the basis for a now flourishing clam fishery. It has also been reported from various places in Britain, where colonies still survive, in Zeeland, the Netherlands, and in Ostend Harbor, Belgium. Shell solid, equivale; inequilateral, beaks in the front half of the shell rarely more than 5° (12.7 cms) long, broadly oval in outline; dirty white, light varnish-brown, dull grey or grey-brown, occasionally with red-brown zig-zag markings near the margins. Penislustrum grey-brown. Ligament a deeply inset, dark brown ellip­tical band, behind the beaks reaching half-way to the posterior margin. Lunule well defined, broad, heart shaped. Escutcheon indistinct. Sculpture of concentric lines, raised here and there into ridges, and fine radiating lines. In young specimens ridges are present all over the shell, but in the adult they persist, after wear and tear, only near the anterior and posterior margins. Growth stages prominent. Both valves with three cardinal teeth; in addition there is present in each valve a rough tooth-like area behind the beaks and immediately below the ligament; this area has the appearance of a supplementary posterior cardinal tooth which has been broken off. No laterals. Inside of shell white, sometimes deep violet about the adductor muscle scars. Pallial sinus not deep, triangular. Margin crenulate. Venus mercenaria lives in mud, with stones and shells, from between tidemarks to depths of a few fathoms, being most abundant a short distance above low-water mark. It is native to the coast of North America from Nova Scotia to Yucatan where it is harvested in some places as a wild crop for sea food. (J.L.M.)

338 Terry, Orville W. 1974.

A general discussion of aquaculture in New York without reference to species. (J.L.M.)

Larvae of Venus mercenaria are easily nourished by a quantity of different ultraplankton organisms, most of which are disregarded by the much more particular larvae of Crassostrea virginica. No other mention of Mercenaria (Venus) mercenaria. (J.L.M.)


Mercenaria mercenaria is not mentioned. (M.W.S.)


The study includes Mercenaria mercenaria. They dig into the sand by a series of steps, which continue until the animal is beneath the surface. Digging cycles consist of six different phases of activity, and involve integration of pedal protraction and retraction with opening and closing of valves, much of the musculature of the body playing a part in each cycle. The hinged shell acts as the basis of a fluid-muscle system which allows the strength of addition to be used in digging. The fluid-muscle system consists of two separate fluid-filled chambers, the haemocoele and the mantle cavity, adduction generating high pressures in each equally and simultaneously. In the haemocoele this pressure gives rise to the characteristic dilated form of the foot which ensures a secure pedal anchorage so that at retraction the shell is drawn down. From the mantle cavity the pressure produces powerful jets of water which assist movement of the shell by loosening the adjacent sand. Subsequently the foot is protracted with probing movements by means of the intrinsic pedal musculature at relatively low hydrostatic pressures, while the shell is held still by the elastic ligament pressing the valves open against the substrate. The hinge tooth function to maintain contact between the valves dorsally during digging, when the valves are gaping ventrally. The possibility that the tissues adjacent to and between the teeth contain tactile receptors is considered and the nervous coordination of digging is discussed. (Modified author's synopsis) (J.L.M.)


While a largely muscular tissue suffices to supply the necessary forces for movement over hard surfaces, burrowing requires greater forces and has resulted in the convergent but separate development of a large pedal haemocoelic cavity in Bivalvia and Gastropoda. There is no evidence for the development of a large coelomic cavity for locomotory purposes in the Mollusca, as occurs in the Annelida, and the origin of the molluscs from a pre-annelidan acoelomate worm is likely.


Reference is made to Mercenaria mercenaria studied by other authors abstracted elsewhere in this bibliography. (J.L.M.)


Mercenaria mercenaria, M. m. notata, and M. compexrhia are assigned to the Superfamily Veneracea. The northern hard clam has a shell subtriangular to roundly ovate, posterior half narrower and slightly drawn out; heavy, inflated; equivaleual; inequilateral, umbones prominent in anterior third of shell, beaked anteriorly and directed toward each other, nearly touching; rarely more than 127 mm (5 inches) in length; color white, dull gray or straw-yellow to flesh tones. Lunule conspicuous, heart-shaped. Escutcheon indistinct. Periostracum often worm and conspicuous, fawn to chocolate-brown. Lигament dark brown, posterior to beaks and reaching halfway to posterior margin. Sculpture of strong concentric ridges and radiating ribs, center of valves often worm smooth; growth increments prominent. Interior of shell flat white or blue-violet in color; sculpture lacking. Three teeth in each valve, left with anterior tooth large and posterior bifid; right with large posterior tooth and two oblique contiguous teeth; rough irregular points below hinge interlocking with those of opposite valve; laterals lacking. Muscle scars subcircular and impressed, often having colored sculpture. Sinus triangular, shallow, apex directed toward ventral portion of anterior muscle scar. Margin crenulate. Siphons short and united. Found abundantly in a wide variety of substrates intertidally to channel depths. In Virginia it is found where salinities are above 15%/o; under laboratory conditions Chanley (1958) states 12.5% is the lower survival limit. The form M. m. notata is rarely found in Virginia. It coexists with M. mercenaria in the same habitat. The shell is shiny, white, tinged with sand-brown and with red-brown zig-zag markings; the surface is almost smooth. Range: Nova Scotia to the Gulf of Mexico; introduced to California, United Kingdom, Netherlands, Belgium, and France (Tebble 1966). The southern hard clam has the following distinguishing features from the northern: shell thicker, heavier and more obese; up to 168 mm (8 inches) in length (Sims 1965); growth ridges deeper and retained longer in young specimens; color white, rarely with blue or violet stain on escutcheon and brown zig-zag lines on the side. Lunule usually as wide as long. Internal color usually white. It is uncommon in Virginia and exists only in the lower reaches of the Bay and offshore. Range: New Jersey (offshore) to Cape Canaveral and the Gulf of Mexico (Abbott 1954). (References abstracted elsewhere in this bibliography - J.L.M.)


Samples of Mercenaria mercenaria were obtained from Moriches Bay, Long Island, NY, a shallow lagoon which in 1980 had a breach in the barrier island separating the Bay from the Atlantic Ocean. The breach was closed artificially by 1981. Shell growth rates in eastern Moriches Bay averaged 1.7 mm per 30 days in 1980, and 1.8 mm per 30 days in 1981. No significant differences were seen between years at any station except Narrow Bay in western Moriches Bay, where growth rates in 1980 averaged 1.6 mm per 30 days and those in 1981 averaged 2.3 mm per 30 days. Results can be related to salinity conditions within the Bay, and how those conditions may have changed in response to the breach. (Modified author's abstract - J.L.M.)


In a previous report an experiment was described which demonstrated that quahaug (Mercenaria mercenaria) eggs exposed to dense suspensions of sperm usually develop into abnormal larvae which fail to survive to the setting stage. When sperm first penetrates the egg, a change in the surface occurs which prevents any other sperm from entering. However, when sperm suspensions are thick, two or more sperms may enter the egg before the barrier is developed, and the resulting chromosome number may be 54 or 72 rather than 36. Cells receiving more or less than 36 chromosomes develop abnormally, and even cells receiving exactly 36 sometimes develop in peculiar fashion. They seldom lived more than a few days. (J.L.M.)


The major finding of the impact assessment is that as a result of salinity increases projected for Great South Bay from complete souring in contiguous areas of Nassau and Suffolk Counties, there could be an 8% decrease in standing crop of hard clams Mercenaria mercenaria in the study area of Great South Bay. The most probable reason for the present decline in hard clam production is overharvesting. Clam resources in South Oyster Bay and in Nassau County bays will not be affected as much, and the projected decline in Brookhaven town will also be lower. Increased predation on clam resources will result in economic losses to the local economy amounting to $9.8 million. (J.L.M.)


Extension of siphons was used as a criterion of activity to examine the response of the hard clam Mercenaria mercenaria to various combinations of test and acclimation temperatures and salinities. A quadratic regression model for the percentage of clams active as a function of the test temperature and salinity was assumed, and response surface contours for various percentages of activity were calculated and plotted. The regression model accounted for 72 to 88% of the observed variability in the 13 experiments considered. Contours are hyperbolic instead of elliptical for five of the...
experiments. No biologically meaningful estimates of lower and upper temperature and salinity limits can be obtained in such cases. Low levels of activity, even at optimal T-S combinations, occurred in summer. Some observed shifts in position and shape of T-S response surfaces were expected in light of shifts in acclimation temperature or salinity. Other shifts in response surface could not be accounted for. The results suggest T-S limits necessary for purification of hard clams. *M. mercenaria* is only moderately euryhaline. Purification of hard clams should not be considered at salinities below 20% is and is likely to be most successful at salinities above 22 to 25%. The two March experiments suggest that purification of hard clams should not be considered at temperatures below 10°C and are likely to be most successful at temperatures above 30°C and are likely to be most successful at temperatures above 30°C and below 30%.

Results of summer experiments suggest that purification should not be considered at temperatures above 30°C and are likely to be most successful at 25°C and below. Results of summer experiments suggest that it may be difficult to purify hard clams from June to August, regardless of temperature and salinity conditions. Other studies at Rutgers have led to conclusions that depuration of hard clams should not be attempted when activity levels drop below 50%.


Increased predation is the most important effect that the projected salinity increase caused by construction of sewers could have on the clam resources of Great South Bay. Predators that probably will increase in distribution and abundance are whelks, moon snails, calico crabs, oyster drills, and hermit crabs. The average clam harvest loss from increased predation will be 8% of the 1978 standing stock. The projected salinity increase is not likely to have a substantial effect on hard clam reproduction and survival. The increased predation could bring economic losses - the Towns of Babylon, Islip, and Brookhaven could have a combined loss of about $2.8 million at current prices, per year.

### 350 Walker, Randal L. 1983.

Feeder creeks (generally less than 4.5 m wide and several hundred m long) appear to be the best habitat for clam mariculture in Georgia. Many clam predators do not occur there. Seed clams (6 mm) planted in densities up to 3027/mm² can be grown to shell lengths greater than 20 mm within 7 months with greater than 80% survival if planted in spring or summer and if crabs are removed from their cages at least once a month. Once clams reach a shell length of 25 mm they can be transplanted into plots with baffles or into creeks using shell cover and/ or tent structures as protective cover, or left in cages after densities have been reduced. Baffles, cages, and pens placed in major creeks or open areas in Georgia sounds do not protect clams. Beds in small feeder creeks are nominally protected from boats, vandals, and wave action.


Growth of stocks of *Mercenaria mercenaria* planted in the coastal waters of Georgia were as follows: Virginia > Georgia > Massachusetts. No significant difference in survivorship was determined. Annual production, standing crop, and turnover ratios also decreased as follows: Virginia > Georgia > Massachusetts. Growth, production, and the effects of fishing pressures were observed for three natural clam populations in Wassaw Sound, GA. Growth rates between stations did not vary significantly. Annual production, mean standing stock, and average clam density decreased from commercial fishing for Cabbage and Wassaw Island clams, but remained about the same for the Little Tybee Island clam population, which had no substantial fishing pressure. A minimum legal size limit of 44.4 mm shell length or 25.4 mm shell height is recommended for the commercial harvest of Georgia hard clams. At this size clams are approximately 3 years old and have passed through at least one reproductive cycle. If a clam fishery is to exist in Georgia several events must occur: 1) a thorough survey for clam populations; 2) establishment of a water quality monitoring program; 3) enforcement of current shellfish handling laws; 4) reevaluation of the shellfish leasing system(s); and 5) development of local markets. (Modified author's abstract - J.L.M.)


Hard clams, *Mercenaria mercenaria*, were planted in predator-free cages on an intertidal sandflat at Cabbage Island at densities of 509, 1009, 2018, and 3027 clams/m². Replicate plots per density were sampled monthly and seasonally. Clams at all four densities sampled seasonally grew significantly more in shell length than those sampled monthly and within the same time period. The seasonally sampled cage was lost after 6 months. Clams planted at the lowest density and sampled monthly reached commercial size (44 mm) in 16 months, and 52% of the clams were of legal size. After 19 months 83% of clams at 509/m² had obtained legal size as compared with 57, 13, and 3% for clams grown at 1009, 2018, and 3027/m². Overall clam survival increased from 77% after the first month to 99% or better 3 months later, and remained greater than 99% throughout the remainder of the experiment. Survival of clams less than 18 mm shell length depends on monthly removal of newly-metamorphosed crabs from the cages. (Modified author's abstract - J.L.M.)


Clams were planted in predator-exclusion cages at 1000 clams/m² at a mean initial shell length of 10.4, 11.0, and 12.8 mm for Georgia, Virginia, and Massachusetts stocks, respectively. Georgia clams grew from 10.4 to 28.7 mm in the first year and 45.2 mm in the second year. Virginia clams grew from 11.0 to 36.9 mm in the first year to 31.6 mm after 2 years. The Virginia and Georgia stocks reached commercial size (44.4 mm) in 24 and 33 months, respectively. Massachusetts clams grew from 12.8 to 23.9 mm in the first year. First year survival for Georgia, Virginia, and Massachusetts stocks was 29%, 31%, and 14%, respectively. No significant difference in survival between stocks was observed. Survival in the second year for Georgia, Virginia, and Massachusetts stocks was 64%, 8%, and 0%, respectively. Mortalities in the first year were caused by blue crab and common mud crab predation. In the second year mortalities were caused by storm activity. (Modified authors' abstract - J.L.M.)


Sampled 2227 stations representing 1383 m² of bottom for hard clams. Clams occurred at 11.6% of stations and most (61.5%) occurred intertidally. Of subtidal clams 65% were in water less than 1 m deep. Highest densities were in shell (3.1 m²), and decreasing amounts in sandy-mud, mud, and sand. They occurred most frequently in feeder creeks, with lesser amounts in headwaters of creeks, in creeks and rivers, and were absent from sounds and nearshore areas. Of 1575 clams collected 40% were chowders, 27% cherrystones, 21% legal littlenecks, 2% prelegal littlenecks, and 4% juveniles. Large subtidal populations do not occur in coastal Georgia, and mechanical clam harvesters do not appear to be feasible. (Modified authors' abstract - J.L.M.)


Hard clams, *Mercenaria mercenaria*, occurred in four intertidal habitats in the outer, high salinity (18‰) region of Wassaw Sound, GA.: small feeder creeks (x = 36/m³); oyster shell bar deposits (x = 31/m³); headwaters of shell, sandy-mud, sand, and mud bottom creeks (x = 26, 19, 13, and 3/m³), respectively; and among live oysters (x = 1/m³). Clams from creek bottoms were larger (x = 7.3 cm) than those from intertidal flats (x = 4.7 cm) from differences in predation or harvesting pressures, not from differing rates of recruitment. Juveniles were absent from most areas, possibly because of increased juvenile mortality, natural spooradic setting, or restricted gonadal development from abnormally low spring salinity from 1977 through 1979. Clams from Little Tybee Island, where sediments are sandy-mud, had faster growth rates than those from North Cabbage and Wassaw Islands, where clam beds were in shell deposits. Clams older than 7 years dominated at Wassaw and Little Tybee Islands (64 and 71%, respectively) and younger clams dominated at North Cabbage Island (82%). These differences in age-class structures were attributed to different harvesting or predation pressures. Clams from Little Tybee and Wassaw Islands occurred in creek bottoms, whereas clams from North Cabbage Island occurred on an intertidal flat in the open Sound. A greater variety of clam predators and greater densities of *Urosalpinx cinerea* and *B. saxatilis* spp. occur on intertidal flats of the open Sound than on creek bottoms. Net reproduction of hard clams was 7.7 g ash-free dry weight (AFDW/m²)/yr at Little Tybee Island, 6 g AFDW/m²/yr at Wassaw Island, and 2.7 g AFDW/m²/yr at North Cabbage Island. Differences were attributed to differences in standing stocks, age class structure, and growth rate. Standing stocks were low (11 g AFDW/m²) at North Cabbage, moderate at Little Tybee (50 g AFDW/m²), and high (120 g AFDW/m²) at Wassaw Island. Turnover rates of Wassaw, Little Tybee, and North Cabbage Island populations were low (0.05, 0.14, and 0.23, respectively) because a high percentage of clams older than 7 yrs made up the populations. (Modified authors' abstract - J.L.M.)
The problem arises when one wants by analyzing many years of data. (J.L.M.)

Reference is made to Mercenaria mercenaria studied by other authors abstracted elsewhere in this bibliography. (J.L.M.)

American oyster (Crassostrea virginica) and northern hard shell clam (Mercenaria mercenaria) are the primary forms being reared for market, based on technology developed in the 1950's by Wells and Glancy of the New York State Fish and Game Commission and at the Bureau of Commercial Fisheries Biological Laboratory at Milford, CT. Selected parents are cultured in the laboratory as a source of egg and sperm. Selection for growth rate, size, meat quality, and certain shell characteristics is being made. Because both species have very high fecundity, very few breeding parents are required. When spawning is desired, selected parents are transferred to tanks for growth and testing. Some recruitment failure may have been caused by recent high predation or from low salinity or spawning stress from heavy runoff. Predation was exerted by weakly, drills, rays, and crabs, especially blue crab, Callinectes sapidus. Density of weakly peaked in fall and spring and was low in winter and summer. Drills were primarily Urosalpinx cinereus. Greatest density of clams occurred in substrates containing shell. (J.L.M.)

Invertebrate communities associated with hard bottom habitats in the South Atlantic Bight. Estuarine Coastal Shelf Sci. 17(2):143-158.
No mention of Mercenaria mercenaria. (M.W.S.)

The study examines the statistical aspects of shellfish sanitation data for the period 1973-1977 in Great South Bay, Moriches Bay, Flanders Bay, and the Huntington area. The complex of the multitude fermentation tests greatly limits the information content of the data. The statistical fluctuations make it difficult to untangle the relative importance of storm runoff and tides and to compare focal and total coliform results. The problem arises when one wants to use the data for purposes for which they were not intended. Nevertheless, the study shows that it is possible to obtain some answers by analyzing many years of data. (J.L.M.)

Predation was affected significantly by temperature and by the size of predators and prey. Larger P. herbstii opened more clams and preyed more successfully on larger clams than did smaller crabs. Increase in seed clam size and decrease in water temperature significantly reduced predation. Claw size appeared to be more important than crab satiation in reducing predation rate. Planting larger seed clams in cooler waters should help to improve clam survival by reducing the impact of P. herbstii in culture operations. No crabs less than 20.1 mm carapace width were successful in opening clams. Clams greater than 35 mm were not opened by any size of crab tested. Tests in pilot clam culture conditions are required before these methods can be recommended to clam culturists. (J.L.M.)

Benthic studies in Greenwich Cove showed that the Cove was an excellent environment for culture of hard clams (Mercenaria mercenaria), although commercial shellfishing could not be considered an appropriate course of action at this time. Soft clams also abound in the cove. Some zinc readings appear to be rather high and may relate to heavy use of galvanized pipe in the area. Few, if any, of the remaining metals are naturally found in clams at the levels indicated here, but some (except zinc) appear to be exceptionally high. (J.L.M.)

Reference is made to Mercenaria mercenaria studied by other authors abstracted elsewhere in this bibliography. (J.L.M.)

A letter taking issue with Levinton (abstracted elsewhere in this bibliography) with respect to the number of alleles with depth of burial. Levinton disagrees in part. (J.L.M.)

The extent of genetic variability at enzyme gene loci is assessed in 12 species of marine bivalve molluscs including Mercenaria mercenaria. The data presented, although they are probably the most comprehensive yet available, are only the beginning of the application of biochemical genetics to molluscan mariculture. For the immediate future, the study of variability in wild populations is likely to remain the most pressing aspect of this work. (J.L.M.)

No remains of Mercenaria mercenaria were found in digestive tracts of 312 fish taken in 1978 and 1979. Mud crabs (Panopeus herbstii and Eurypanopeus depressus) dominated in 65% of digestive tracts in 1978 and in 22% in 1979. (J.L.M.)

Mercenaria mercenaria is mentioned with reference to a paper by Rice and Smith (1958) abstracted elsewhere in this bibliography. It is noted that the filtration rate with different particle concentrations of Nannochloris did not show significant results. (J.L.M.)

369 Yount, James Locke. 1950.
Observations on the morphology and physiology of the blood cells of Venus mercenaria are included. There are three major types of blood cells: lymphocytes (or hyaline leucocytes), finely granular leucocytes, and coarsely granular leucocytes. Coarse granules are probably composed of nutritive material. Other materials in the blood are bacteria, cellular debris, and hyaline cell-like bodies. Blood cells probably play a prominent role in defense of the animal from microorganisms. Blood cells are important in nutrition, serving the functions of ingestion, distribution, and digestion. They have been shown to contain enzymes that digest margarine and gelatin. The plasma has been shown to contain enzymes that digest starch, margarine, and gelatin. (J.L.M.)

Possible explanations of heterozygote deficiency in bivalve molluscs. Malacologia 25(2):583-591.
In Crassostrea virginica heterozygotes attain larger size, thus producing more gametes than homozygotes, and may also have lower post-settlement mortality rates. The plausibility of models is judged by comparing predicted heterozygote deficiencies to values commonly reported in the literature for C. virginica and other species of bivalve. No specific mention of Mercenaria mercenaria. (J.L.M.)

All blue crab size classes showed a preference for sand, mud, and sand/mud sediments rather than crushed oyster shell or gravel gravel. Sediment feeding tests showed that clams were significantly more vulnerable to predation by crabs in sand and sand/mud than in crushed oyster shell or gravel gravel, although the outcome of such predatory encounters depends on the interaction between clam and crab size. When crabs were given a choice of clam sizes, with no sediment present, small crabs (<75 mm carapace width (CW)) consumed 5-10 mm size-class clams equally. Medium crabs (75-125 mm CW) preferentially consumed 10-mm size-class clams. Large crabs (>125 mm CW) consumed 10-25 mm size-class clams equally. Clams larger than 40 mm CW were not consumed by even the largest blue crabs, suggesting that hard clams may achieve a size refuge from blue crab predation. (Modified author's abstract - J.L.M.)


Only little necks (mean length 60.9 mm) and cherrystones (mean length 77.9 mm) were retained, chowder clams were discarded. Highest average daily catch of retained clams (Mercenaria mercenaria) was 4330 clams/hr (72 clams/min). Average catch was 2888 clams/hr (48 clams/min). Catch rates varied considerably during the day. High was 105.6 clams/min during a 33-min period to a low of 0 clams/min many times for short periods. Three dives were conducted after the experimental plots had been worked. Four days after operation of the hydraulic dredge, troughs left by the gear were about 4 ft wide and 5 ft in. deep in the center. During subsequent dives, the troughs became less distinct and shallower, filling in about 2 in., 21 days after being formed. Much of the oyster shell that was on the surface after the first dive was covered by a layer of silt and mud by the third dive. The area worked by patent tongs was also observed 4 days later, and holes left by the gear were about 4 x 3 ft and 6-8 in. deep. The holes collected large amounts of drifting sponge. The holes did not fill with sediment to the same degree as did the troughs. The holes were about 6 in. deep 21 days later. The catch rate of the hydraulic dredge was 7.5 times greater for little necks and cherry stones than patent tongs. About 1 in 2000 clams was damaged by the dredge. (Modified authors’ summary - J.L.M.)

BIBLIOGRAPHY: Part 2


375 Bearden, C.M. 1976.


Over a broad range of environmental conditions, survival of molluscan populations is a result of highly complex and interrelated attitudes toward individual factors. Apparently simple responses, such as growth rates, may be greatly influenced by age, heredity, or nutrient salts and vitamins naturally present in the environment in only trace amounts. The effect of temperature on growth rates of hard clams (Mercenaria mercenaria) was shown by clams from Rhode Island replanted in Florida. These clams added about 75% of new shell in December-January, but would have been hibernating had they remained in their native habitat. Another group of clams from Milford, Connecticut, also replanted in Florida, were sorted into two lots of approximately equal length. These were planted in protected boxes on two sides of the laboratory island where conditions were believed to be similar. After 2 years, although mortality was negligible, there were very significant differences in size range and average size. The larger-size group had 24% more meats than the smaller. A supply of seed hard clams derived from reciprocal crosses of pairs of the northern (M. mercenaria) and southern (M. campechiensis) quahog was held for over 4 years in protected boxes hung from the laboratory pier. At the end of that time the stock of pure M. mercenaria was on the average 50% longer, and the meat yield of shocked clams was nearly double that of the hybrid stock. Knowing these different growth responses, we need the complete background of test animals before guessing the observed growth rates in any particular situation. We must know the age of the animal, its genetic background, and the similarity of test sites before we can suggest responses to environmental factors. Only by understanding the role of beneficial and harmful factors will we be able to reach maximum utilization of our estuaries. (J.L.M.)
Management of a multiple cohort fishery: The hard clam Mercenaria mercenaria in Great South Bay, NY. The steady-state optimum calls for exclusive harvesting of the younger, and more valuable, littleneck cohorts, leaving the older, and less valuable, cherrystone and chowder to specialize in regeneration. (Modified authors’ abstract - J.L.M.)

The paper develops a reasonably general multiple cohort model and derives conditions for optimal harvest and age structure based on a discrete time control problem which maximizes the present value of net revenues subject to recruitment and spawning constraints. The model is applied to the hard clam Mercenaria mercenaria resource in Great South Bay, NY. The steady-state optimum calls for exclusive harvesting of the younger, and more valuable, littleneck cohorts, leaving the older, and less valuable, cherrystone and chowder to specialize in regeneration. (Modified authors’ abstract - J.L.M.)

Management of a multiple cohort fishery: The hard clam Mercenaria mercenaria in Great South Bay, NY. The steady-state optimum calls for exclusive harvesting of the younger, and more valuable, littleneck cohorts, leaving the older, and less valuable, cherrystone and chowder to specialize in regeneration. (Modified authors’ abstract - J.L.M.)


The problem was that Conrad measured cohort stocks and yields in bushels, while the spawning constraint was measured in numbers of clams. Thus, the right-hand side of the spawning constraint must be divided by 500 to be consistent with the unit of measurement defined on the left-hand side, and thus a steady-state solution does not exist. (J.L.M.)


Evidence supporting the relationship between Gymnodinium breve and human illness became available in December 1962, when several persons became ill after eating oysters Crassostrea virginica and clams Mercenaria mercenaria taken in Sarasota Bay, Florida, during a “red tide” outbreak. A crude toxic substance was extracted from these shellfish, similar to ciguatera fish poison. Consideration of potential health-related aspects of G. breve “red tides” prompted this investigation. Hard clams taken from the head of Venice Inlet, 550 meters from the Gulf of Mexico, contained 270 mouse units per 100 grams of meat. Long-range goals of the project were: (1) identify and isolate the causative microorganism(s); (2) develop methods to maintain laboratory cultures; (3) isolate and purify samples containing the active material; (4) determine the chemical nature and structure of the poison; (5) investigate the conditions and mechanisms by which shellfish accumulate, retain, and eliminate the toxin(s); and (6) assist in developing analytical techniques for rapid determination of the poison. These objectives were satisfied. (J.L.M.)

386 Doering, Peter H., and Candace A. Oviatt. 1986

Gross sedimentation of 14C labelled carbon was 58% greater in mesocosms (13 m3) containing the bivalve Mercenaria mercenaria (16 indiv./m3) relative to controls without this filter feeder. The difference was attributable to the activities of M. mercenaria and presumably due to filtration of particles from the water column. Of this increase, 32% and 47% respectively were attributable to assimilation into clam tissue, and respiration by the benthic community. Permanent biodeposition by clams contributed the least (21%). The ability of eight filtration rate models to predict the increase in gross sedimentation was examined. Those models (four) which were based on data for bivalves filtering natural suspensions of particulate matter gave estimates which agreed well with observed differences. Those models (four) which yielded poor predictions used dyed or algal monocultures to generate data and overestimated gross sedimentation due to bivalves by up to an order of magnitude. Such overestimation may exaggerate the role of bivalves in enhancing sedimentation and controlling phytoplankton biomass in shallow waters. (Modified authors’ abstract - J.L.M.)


See Ritchie (1977) in McHugh (1982), citation 1552. (J.L.M.)


Nursery culture of the hard clam, a necessary step in the production of seed for field growout, is not considered economically feasible by many workers. This is because costs to supply large quantities of food for juveniles are too high. Commercially available crabmeal, a byproduct of crab-picking houses, was tested as supplemental food with various sizes of juveniles. Six 30-day feeding experiments were conducted from July to December 1983. Control and crabmeal fed groups received filtered seawater at flow rates which contained enough natural food to support clam maintenance activities. Test groups also received crabmeal supplements at different ration proportions to total live weight of clams. Growth was considered as the increase in shell height, and total live, dry, and ash weights. Greater increases in shell height and weight were seen in supplemented clams compared with controls when crabmeal was fed in proper amounts. Optimum feeding rates for smaller clams (4-6 mm) were crabmeal rations of 20-25% of total clam live weight per day, and for larger clams (7-10 mm) rations were 10 to 12% of clam live weight per day. Overall, crabmeal fed clams showed increases in weight and shell height from 10 to 100% greater than in controls. (Modified authors’ abstract - J.L.M.)


The kidney of the hard clam has two different types of cortical epithelia: the shellside epithelium is in juxtaposition to the shell and closely resembles the shellside mantle epithelium with which it is contiguous; the mantle-cavity epithelium faces the pallial cavity and is partially covered with a portion of the gills. The shellside cortical epithelium is simple columnar with basally situated nuclei; the cytoplasm is faintly eosinophilic and contains many bundles of microfilament of microvillous-like structures oriented in the long axis of the cells. The mantle-cavity epithelium is also simple columnar in construction and is supported by a dense collagenous connective tissue. Some details have been excluded from this abstract. (Considerably modified authors’ abstract - J.L.M.)

The use of the toadfish Opsanus tau (Linnaeus) as biological control of crabs preying on juveniles of the hard clam Mercenaria mercenaria (Linne) in field cultures. J. Shellfish, Res. 5(1):16 (abstract).

The oyster toadfish, a hardy and abundant fish that feeds primarily on crustaceans, was tested as a biological control against crabs. Hard clams (3-mm shell length), planted in cages under gravel aggregate, were protected against crab predation by toadfish. Crabs found in the experimental area were blue crab Callinectes sapidus Rathbun and mud crabs Neopanope tessana soyi (Smith) and Panopeus herbstii Milne-Edwards. After 6 weeks, 49.2% of hard clams in cages with toadfish had survived, while only 1.6% survived in cages without toadfish. Predation by crabs in bottom cultures of hard clams protected by a combination of gravel aggregate and plastic nets may be reduced by placing toadfish under the nets. (Modified authors’ abstract - J.L.M.)


Hard clams (presumably Mercenaria mercenaria) were very abundant in the Intracoastal Waterway of Brunswick County. Of a total of 79 random samples, 32% produced catches in commercial abundance (10 clams/min) and an additional 6% produced catches in near-commercial abundance (7 clams/min). Almost all high density areas were located outside of the 90-ft authorized channel in water depths of 2 to 8 feet MLW and were consistently associated with heavy bottom shell deposits. Most clams were chowder and cherrystone sizes, with one notable exception which produced 62% littleneckes. Size data indicated that most clam areas had good recruitment, adequate growth, and a uniformly low harvest rate. Survey results show that the best utilization of these resources would be achieved by allowing mechanical harvesting. (J.L.M.)


Two species of clams are currently harvested in North Carolina: hard clam Mercenaria mercenaria) and brackish water clam Rangia cuneata). Exploratory fishing has revealed undeveloped stocks of surf clams Spisula solidissima) and southern quahogs Mercenaria campechianus). Reported landings of clams have declined in recent years, although value has increased to the highest level since 1951. Clams are harvested year-round. Greatest landings occur in winter and spring. Harvesting is done with rakes or by hand. In some areas hydraulic dredges are coming into extensive use. No definite
reasons can be given for the general decline in clam landings. An important factor is probably pollution, which has resulted in closing of many areas. Little scientific effort has been expended on clam research. A tremendous increase of clams occurred in Core Sound following the opening of Drum Inlet by a hurricane in 1933. A similar situation occurred in the southern part of the State when Hurricane Hazel opened an inlet across Long Beach in 1954. (J.L.M.)


Except for FMRFamide and its analogs, most of the known neuropeptides are inactive on the isolated clam heart (Mercenaria mercenaria). However, and unexpectedly, the red-pigment concentrating hormone of prawns, and the chemically related adipokinetic hormone of locusts, are potent excitors of this preparation. The effect is especially intriguing in that only half of the hearts tested responded to these peptides. The mechanism of this unusual action is not known, but it is not related to sex or subspecies. Clam ganglia contain a red-pigment concentrating factor active in crustaceans, but its physiological significance in the clam is unknown. Much of this abstract was deleted because the mechanisms described have been described before, but it probably should be read by those not familiar with the earlier literature. (Modified author's abstract - J.L.M.)


Heterotrophic microflagellates are potential bivalve foods that may be more easily cultured in shellfish hatcheries than conventional algal strains. Microflagellates, which ranged in length from 2.6 to 7.8 μ included Paraphysomonas vesuita, a colorless chrysophyte, two bodonids, and a choanoflagellate. Microflagellates were raised on estuarine bacteria cultured on brewer's condensed solubles (BCS), a syrupy byproduct of the brewing industry. Groups of 10 clams (Mercenaria mercenaria), with initial weights ranging from 5.3 to 6.8 g, were raised in 1-L beakers. Clams grew on diets of P. vesuita and the unidentified colorless chrysophyte but not with the bodonids or the choanoflagellate. Clams fed comparable quantities of the alga Tetraselmis suecica showed greater growth than those fed microflagellates. Microflagellates, however, produce significantly greater growth rates than phytoflagellates and can be raised in the dark at high cell densities. The sections that dealt with oysters (Crassostrea virginica) were not included in this abstract. (Modified author's abstract - J.L.M.)


The hard-clam fishery (Mercenaria mercenaria) in New Jersey operates in coastal bays from Raritan Bay to Cape May. Production has fluctuated from 453,600 to 2,268,000 kg (1 to 5 million pounds) per year since records began in 1889. Peak harvests in the late 1940s and early 1950s were followed by a sharp downward trend, coincident with closing of clam beds in contaminated areas. Since 1960 the reported harvest has been between 453,600 and 1,360,800 kg (1 to 3 million lbs). Because the price of clams increased from about $1.10 to $5.50 per kg ($0.50 to $2.50 per lb) between 1967 and 1983, however, the total value of the harvest has increased. The 1983 harvest of 590,000 kg (1.3 million lbs) was valued at $3.3 million. Since 1970 clammers have relaid stocks from restricted (70-700 MPN/mL) and condemned (700 or more MPN/mL) areas to privately leased grounds in approved waters. Clams are marketed after 30 days at temperatures above 10°C. Relaid clams account for 5 to 18% of each year's total production. In July 1983, a depuration plant opened which can process clams from restricted water only. Between July and Dec. 1983, the depuration plant handled approximately 3 million clams (about 10% of annual production and equal to the number of relaid clams). Two individuals have operated hatcheries to provide seed for their own growout grounds for about 10 yrs. However, they produce less than 1% of the total New Jersey harvest. A third hatchery/growout operation started this spring. (Modified authors' abstract - J.L.M.)


Mercenaria mercenaria is covered on pages 20-26. (J.L.M.)

The recent increase in landings in the North Carolina hard clam fishery has triggered concern about potential overfishing. This is investigated by contrasting historical data and the empirical supply curve with the long-run steady-state supply curve. The steady-state supply curve is derived from intertemporal maximization of social welfare subject to population dynamics. The empirical supply curve is estimated using a simultaneous equation model. The model components of the steady-state supply curve are estimated. The results show that the North Carolina hard clam fishery shows decreasing returns to scale with respect to resource stock. The maximum sustainable yield is not significantly different from 2 million pounds of meats per annum. Historical records show that the suspected biological overfishing has not been serious yet. But economic overfishing has occurred in the past and has reached serious levels recently. Since these results are based on the mean value estimated from the past 20 years' catch-effort data, the maximum sustainable yield may be underestimated, and the economic overfishing statement may be too conservative. (Modified authors' abstract - J.L.M.)

400 Kellogg, Robert L. 1985.
The study examines how dynamic bioeconomic models and optimal control theory can be used to help fishery managers promulgate regulations consistent with economic efficiency and gains in social welfare. The model was estimated and applied to two North Carolina fisheries: bay scallop and New River shrimp. Mercenaria mercenaria was not used, but the general principles might apply. (J.L.M.)

401 Kvatrenik, A.C.

The hard clam (Mercenaria mercenaria) is found along the eastern and Gulf of Mexico coasts of North America from the Gulf of St. Lawrence to the Yucatan Peninsula. It is the focus of an important commercial fishery. Larger clams (>80 mm) are used in chowder; littlenecks (<60 mm) and cherrystones (61 to 80 mm) are steamed or eaten raw. The fishery in Chesapeake Bay is understood only on a broad scale. Landings in Virginia have decreased from a high of 2.4 million pounds of meats in 1965 to a low of 0.4 million pounds in 1978. Maryland landings peaked at about 0.8 million pounds of meats in 1969 and reached a low of about 0.02 million pounds in 1979. Total landings and number of permits are the only catch and effort data collected, so catch-per-unit-of-effort as a measure of abundance is not possible. Accurate determination of catch and catch-per-unit-of-effort is not possible now either in the commercial or the recreational fishery. Varying price according to size of clam is not possible from published statistics. Also published statistics are less than actual landings by a considerable amount. Acquisition of accurate landings data can be obtained only through increased dealer participation. (J.L.M.)

Price flexibility coefficients estimated for exvessel prices of Virginia hard clams (Mercenaria mercenaria) show that a very small (4.292 x 10^-6 to 6.994 x 10^-6) decrease in price would occur given a 1% increase in the quantity supplied by Virginia harvesters. Data used were monthly landings of Virginia, New Jersey, Rhode Island, Maryland, and North Carolina over the period 1960-79. Fifty-eight percent of the exvessel price changes are not explained by the supply response model used, suggesting other market and consumer demand factors play a large role in determining exvessel price. Possible legislative changes to aid the fishery are: 1) use efficient harvesting technologies on private leased bottom; 2) seasonal use of efficient harvesting
technologies to take advantage of seasonal peaks in exvessel prices; 3) a new statistical reporting system that reports the catch/day of each harvester and the proportion of each market grade caught; 4) establishment of subaqueous bottom areas specifically for field culture of hard clams; and 5) set and enforce a minimum legal culm size. (J.L.M.)

404 Langdon, Christopher J. 1985.
The culture of clams (Mercenaria mercenaria) is mainly dependent on algae as a source of nutrients. But algae are expensive and undependable. One way of overcoming these difficulties is to use artificial diets as a food source, but problems in presenting microparticulate foods and in determining their optimum dietary composition have hindered development of satisfactory artificial diets. Recent advances are reviewed. Application of microencapsulation technology and use of dispersants and antibiotics to control food particle clumping and bacterial growth are discussed. (Modified author's abstract - J.L.M.)

In the late 1940s and early 1950s a series of mark-recapture experiments were conducted. Two specimens were recovered alive in 1980. Interpretation of surface and internal growth patterns of the prenotch shell regions suggested that each was approximately 3 yrs old at the time of notchting. The age estimates of 36 and 33 yrs for these specimens are, to the best of the authors' knowledge, the oldest reported to date for this species from long-term monitoring studies. (Modified authors' abstract - J.L.M.)


Juvenile "seed" hard clams are being produced by four commercial hatcheries on Long Island. Seed from these hatcheries and from hatcheries in Maine and Massachusetts have been planted on public grounds by seven Long Island towns. Ranging in size from 0.1 to 3.0 million clams, these plantings are being carried out in an effort to supplement natural recruitment. Most town programs include some type of nursery system designed to grow clams from their 0.5-6.0 mm size at purchase to 10-20 mm at planting. The programs have been carried out for several years, but their contribution to the fishery has not been rigorously determined. Our preliminary evaluation of these programs and experimental plantings on Long Island suggest that they are too small to make a significant quantitative contribution to the private harvest. The plantings might be useful to establish self-sustaining populations at specific sites. Private hard clam culture involving rafts, floating stacks of trays, bottom boxes, etc. has been carried out on Long Island by Blue Points Co., F.M. Flower Co., and Shellfish Inc., among others. Nursery costs, lack of suitable underwater land, and opposition from baymen continue to inhibit the expansion of private clam culture on Long Island. (Modified authors' abstract - J.L.M.)

The fishery in South Carolina began at the turn of the century but remained small and localized until recently. Mechanical harvesting began in 1973 and greatly increased annual yields. Latest available statistics (Sept. 1982-May 1983) show that the wildstock industry now accounts for 3.5% of the national harvest and for the first time exceeds the value of the state's oyster (Crassostrea virginica) landings. A summary of fishery techniques and historical statistics is given for the state's wildstock hard clam fishery. Mariculture began in South Carolina with tray growout experiments in the mid-1970s. These led to a commercial-scale project involving public and private resources. The cooperative project used a 3-step culture protocol: nursery culture to field planting size; high-density primary field growout; and lower-density secondary field growout to minimum market size. A discussion of the progress enjoyed by the project, its production to date, and a summary of the potential of, and constraints to, hard-clam mariculture in South Carolina is given. (Modified author's abstract - J.L.M.)

Adult hard clams were sampled monthly between Dec. 1977 and Feb. 1979 and semi-monthly from March to June 1981 in North Santee Bay. Observed gametogenic progression was best categorized by five stages of development: inactive, ripe, spawning, partially-spent, and spent. Both sexes showed a complex progression of gametogenesis. Gonadal tissue was not uniformly dominated by clearly defined, distinct stages. Instead, gonads routinely exhibited several stages simultaneously and progression was documented through slow shifts in domination of stages in gonad tissue. Spawning occurred continuously over a 6-month period (May-October) with at least two apparent peaks of spawning activity in summer. Stages of gametogenesis encountered are described for both sexes and seasonal progression of gonad development is discussed. (Modified authors' abstract - J.L.M.)

The potential benefits of upflow nursery systems compared with traditional raceway systems include maximization of space utilization, low construction cost, ease of maintenance, and operational longevity. A commercial nursery facility for raising hard clam seed in South Carolina uses upflow culture. The first year of operation of this system shows how seed growth is analyzed in relation to seed density, water flow, and environmental factors. Growth rates of seed from three different broodstocks is reported. Performance of passive and active upflow systems are compared. Results are compared with those from raceways and from an experimental-scale, passive upflow system. (Modified authors' abstract - J.L.M.)

See Ritchie (1977) in McHugh et al. (1982), citation 1552. (J.L.M.)

The hard clam (Mercenaria mercenaria) has a remarkable capacity to remain closed under adverse conditions, which helps it to survive. North of Cape Cod in New England they exist only in certain bays where oceanographic conditions favor spawning. Abrupt and spectacular changes in abundance and distribution occur as water temperatures rise and fall in relatively long-term environmental change. The nucleus for resurgence is provided by the relatively few that survive cold periods. (J.L.M.)

413 McHugh, J.L. 1985. 
Among subjects covered are the detrimental effects of oil on clams, and the responses of clams to other pollutants. Shell uniformity and the ability of clams to remain closed for weeks out of water are discussed. The production of antibiotic agents by clams, the effects of certain neurosecretions on clam hearts, the effects of environmental factors on shell growth increments, and the functioning of the catch-muscle mechanism are described. General fishery topics covered include techniques for preventing predation, and certain aspects of a new hard-clam fishery in the Santee River delta in South Carolina following the diversion of Santee River water to the Cooper River. (Modified author's abstract - J.L.M.)

See Ritchie (1977) in McHugh et al. (1982), citation 1552. (J.L.M.)

See Ritchie (1977) in McHugh et al. (1982), citation 1552. (J.L.M.)
Northern quahog Mercenaria mercenaria has a significantly longer shelf-life than southern quahog M. campechenensis and the Texas quahog M. mercenaria texana. Survival response across all storage temperatures was significantly longer for all species harvested during January through April compared with harvest from June through August. All species in 4°C refrigeration experience stress which would be interpreted as death by commercial standards. Survival was longer in 10° and 15°C, but potential adverse microbial consequences and objectionable odors resulting from single deaths would preclude use of this storage temperature. Fecal coliform and aerobic plate counts (35°C) of live clams remained relatively constant during storage. However, aerobic plate counts conducted at 25°C showed a marked increase for clams stored at all temperatures. Further considerations with use of initial, temporary wet storage in ambient and refrigerated water for acclimation offered advantages, but do not appreciably extend subsequent shelf-life. (Modified authors' abstract - J.L.M.)

417 Parker, Kenneth M. 1975.
An experiment was conducted to determine if protection of Mercenaria mercenaria using Argopeelen gibbus, calico scallop shells, as a covering is feasible. A total of 150 L/5 m² samples were gathered, 75 from control areas and 75 from experimental areas. Comparisons were made of overall numbers of clams, natural recruitment of clams, substrate analysis, and size frequency. Results show that there was a substantial increase in numbers of clams in experimental areas, apparently caused by protection provided by Argopeelen gibbus shells. (Modified author's abstract - J.L.M.)

Seagrass beds provide some natural refuge for hard clams Mercenaria mercenaria from predatory whelks. If mechanical clam harvesting is prohibited in seagrass beds, these habitats can shelter older, economically less valuable clams to serve as a "spawning pump" for heavily harvested areas. Mechanical harvesting in seagrass beds causes long-term damage to the seagrass and does not enhance settlement success of hard clams. Consequently, the benefits of habitat-specific clam management that prohibits mechanical harvesting in seagrass beds outweigh the costs, as judged from field experiments in North Carolina. (Modified author's abstract - J.L.M.)

Commercial mariculture of Mercenaria mercenaria (Linne) at Aquacultural Research Corporation, Dennis, Massachusetts. J. Shellfish Res. 5(1):42 (abstract).
In May and June, 5- to 8-mm hatchery-produced quahog seed is planted in a field nursery. Two types of nursery are used: surface-suspended and bottom-suspended trays. In September and October nurseries are harvested. Seed-size ranges between 15 and 25 mm, and recovery is between 90 and 95%. Within 48 h of harvest, seed is bottom planted in an intertidal area and covered with 0.5-in. Conwed mesh. Field growout including nursery time requires 2.5 to 3 growing seasons, and a recovery of 65% is expected. (Modified author's abstract - J.L.M.)

See Ritchie (1977) in McHugh et al. (1982), citation 1552. (J.L.M.)

421 Strand, Ivar. 1976.
See Ritchie (1977) in McHugh et al. (1982), citation 1552. J.L.M.
BIBLIOGRAPHY: Part 3


To investigate the extent to which populations of Mercenaria mercenaria might be genetically adapted to local conditions, adult clams were collected from three natural populations in Massachusetts, Virginia, and South Carolina. Three sets of females from each location were mated with males from all three locations to produce the nine possible combinations of a factorial cross. Data from the first samples, all bred in one location, showed a strong effect of parental origin on shell length. The second set of samples, from each of the nine crosses raised in each of the three locations, continued to show a significant effect of parental origin. However, in the second samples, location of the rearing nursery explains an even larger portion of the variation than does the geographical origin of parental stocks. The more northerly the rearing hatchery, the larger the mean shell length achieved. Each cross performed better in northern waters, but within any one nursery clams with higher proportions of southerly parentage demonstrated a significant growth advantage. This trend to grow larger was greater the stocks from southern areas were able to take greater advantage of preferred growing conditions. (Modified author's abstract - J.L.M.)


The aim of this study was to compare the consumption of two kinds of food: bacteria and phytoplankton. (J.L.M.)


Hard clams (Mercenaria spp.) were sampled in the Indian River Lagoon in summer 1986. Clams were abundant throughout the central region of the sampling area, but were scarce at the northern and southern extremes. Patterns of environmental variability are invoked to explain the macrodistribution of the animal in the Lagoon, whereas water depth and sediment composition influence small-scale distribution patterns. A study of internal growth lines is utilized to explain the recent history of hard clams in the Lagoon. Information on age distribution in the population elucidates the pattern of annual recruitment in the population. This is considered in light of macroscale disturbances which impact on the Lagoon. (Modified authors' abstract - J.L.M.)


A manipulative field experiment was conducted to determine the covarying effects of juvenile clam patch size and density on survivorship (2 SL = 3.24 mm, SD = 0.38 nm). A complete 3 x 4 factorial design was used with three densities (25, 150, and 300 clams/0.25 m²). Patch size had a very significant effect (p<0.005) on survivorship; the larger the patch, the greater the mortality. The density effect was only slightly significant (p=0.10). The interaction of both variables was not significant. Clams show an escape response caused by foraging activities of predators. A laboratory experiment demonstrated a significant decrease in growth of juvenile hard clams (2 SL = 1.2 mm, SD = 0.275, at start) subjected to foraging by hermit crabs (Pagurus longicarpus, 128/0.25 cm²) when compared with a treatment with no predators (t-test, p = 0.05). This effect caused individuals to grow at a slower rate and be available longer to a more diverse predatory milieu. The shelter related behavior of some crustacean species restricts the area searched during each of 24 hour period. The densities of shelter sites and predators, and apparent diet patterning of search area by predators may affect the spatial/mortality patterns of prey species. (Modified authors' abstract - J.L.M.)


Supersaturated seawater was produced in a flowthrough system by injecting air into a pressurized seawater line. Mercenaria mercenaria, Malumia lateralis, and Mya arenaria were exposed to several different levels of supersaturated seawater at temperatures ranging from 5 to 17°C. Gas-bubble disease occurred at total gas saturation levels of 108% in juveniles of M. lateralis and 114% in juveniles of M. arenaria. Air blisters in the tissue, fluctation, and mortality were observed at these levels. Reduced growth in juveniles of M. mercenaria was found at a total gas saturation level of 115%. (Authors' abstract - J.L.M.)


Blue crabs Callinectes sapidus of 77.8-105.3 mm carapace width (CW) were exposed to toadfish of 196-322 mm total length (TL) in the presence of hard clams Mercenaria mercenaria of 4.3-6.5 mm shell height with sand, gravel or hard-bottom substrate for 24-96 hrs. in the laboratory. Toadfish could injure or kill blue crabs of almost one-third their size. Crab predation on clams was reduced with the presence of toadfish or gravel. The use of toadfish as a biological control of crab predation in molluscan aquaculture is discussed. (Modified authors' abstract - J.L.M.)


Five families of Mercenaria mercenaria were produced by spawning adults of known genotypes. Following fertilization, polyplody-altering treatments of 1 mg/L cytochalasin B or 0.1% dimethyl sulfoxide were applied at two times. Polar body production, growth, survival and ploidy alteration were analyzed with respect to treatments and families. (Modified authors' abstract - J.L.M.)


Reference to Mercenaria mercenaria is made in a paper by Chanley (1960), abstracted in McHugh et al. (1982) (J.L.M.)


Mud crabs such as Neomaneurops sayi are significant predators of juvenile hard clams Mercenaria mercenaria in Long Island waters. Abundance and survival of mud crabs and hard clams are affected by substrate type and predatory risk. In binary substrate-choice experiments, mud crabs preferred broken oyster shell most, followed in order by large gravel (>30 mm diam), small gravel (<17 mm diam), mud, and sand. Mud crab preference for substrates such as gravel or broken oyster shell may result in decreased susceptibility to predation. When substrate combinations contained juvenile hard clams (250 8 8:11.0 mm clams/substrate; 1000 clams/m²), crab predation was lower in sand than in small gravel (82.2% less), large gravel (64.8% less), or small gravel overlaid with sand (64.8% less). Crab behavior and activity patterns in these substrate combinations were determined from video time-lapse recordings and visual observation. Addition of a predator on mud crabs, the toadfish, Opsanus tau, caused a reduction in crab-induced mortality of clams in individual substrate trials (97.6% less in sand, 91.3% less in small gravel). This effect is primarily a result of depressed crab activity, rather than direct crab mortality. In areas where mud crab predation is of primary concern to mariculturists, clam survival may be increased by planting in sand substrates, for which crabs have a low preference. Mud crabs also may be more vulnerable to their natural predators in such substrates. (Slightly modified authors' abstract - J.L.M.)


Eelgrass meadows serve as nursery and habitat for many shellfish species including the bay scallop (Argopecten irradians) and hard clam (Mercenaria mercenaria). Previous studies have demonstrated the importance of eelgrass (Zostera marina) in providing optimal hydrodynamic regimes for bay scallop and hard clam feeding, and providing protection from predators. Recolonization rates of eelgrass are relatively slow (years to decades) even without a recurrence of algal blooms (Aureococcus anorex-
areas of the Indian River Lagoon. Temperature, salinity, dissolved oxygen and
chlorophyll concentration were monitored biweekly during this same time period. Hard
clams of a variety of size classes were collected from three stations in each area, sec-
tioned for histological examination, and classified according to developmental stage
based on visual appearance of the gonads and average monthly oocyte diameters. The
relationship between reproductive development and potentially influential physical fac-
tors is discussed. (Modified authors' abstract - J.L.M.)

Heterozygosity, growth, and linkage disequilibrium in hybrid populations of Mer-
Lines of the hard clam, M. mercenaria, have been selected for fast growth by
Aquaculture Research Corporation and Virginia Institute of Marine Science. These
lines do not seem to be inbred, judging from allele frequencies at seven enzyme loci,
although there is evidence of genetic drift and loss of rare alleles. Very little relation-
ship between heterozygosity and growth was detected in the offspring of individual
crosses between these two lines, nor does variance at any particular enzyme locus
seem to affect growth. We do, however, report evidence of loose linkage disequilibrium
between alleles at a variety of enzyme loci and alleles at loci affecting growth in the
nursery. (Authors' abstract - J.L.M.)

437 Duncan, Patricia L. 1986.
The use of crab meal as a supplemental food for juvenile hard clams (Mercenaria mercenaria). Masters diss., College of William and Mary, Williamsburg, VA 23186.
In all experiments significantly greater increases in clam shell height and weight were
observed in supplemented clams compared with controls when crab meal was fed in
proper amounts. There appeared to be a direct relationship between percentage in-
crease in shell height and crab meal ration at optimum feeding rates. Optimum feeding
rates for smaller clams (4-6 mm) were crab meal rations 20-24% of total clam live
weight per day. Crab meal sieved through 100 or 134 micron mesh, autoclaved, and
mixed with 25-micron filtered seawater produced the greatest increases in clam weight
and shell height. This indicates the potential for use of crabmeal in commercial nurseries
as partial replacement for cultured algae. (J.L.M.)

Physiological effects of Protogonyaulax tamarensis on bivalve mussels. J. Shellfish.
Res. 7(1):15 (abstract).
After exposure to Protogonyaulax tamarensis (clone GT429), shell valve and/or siphon
closure was unchanged in Mytilus edulis, Spisula solidissima, Arctica islandica,
and Modiolus modiolus; increased in Mercenaria mercenaria, Ostrea edulis, Placopecten
magellanicus, Geukensia demissa, Mya arenaria, and Mytilus edulis. Clearance rates
were increased in Mytilus from Maine, and Ostrea; were unchanged in Mytilus from Rhode
Island, and Spisula; were decreased in Mercenaria, Geukensia, and Mya; and
were unchanged in Mytilus from Maine, and decreased in Placopecten. Cardiac ac-
tivity was unchanged in Spisula, Mercenaria, Arctica, and Placopecten. There was
a transient decrease in heart rate in Mya after exposure to GT429 which was cor-
related with increased siphon closure. There were significant changes in cardiac activity
in Ostrea (22% of individuals tested), Geukensia (60%), and Mytilus (57%). These
changes were increased heart rates in Geukensia and Mytilus, periods of cardiac
arythmia and decreased heart rates. (Modified authors' abstract - J.L.M.)

Responses of the hard clam Mercenaria mercenaria (Linne) to induction of spawning
Clam size, sex of clam, concentration of serotonin, and site of administration of
serotonin were found to influence the induction of spawning in the hard clam
Mercenaria mercenaria. Overall male clams greater than 36.4 mm thickness were
more likely to spawn in response to serotonin injection at concentrations of 0.2 or
2.0 mM. Administration of serotonin by injection in the anterior adductor muscle
resulted in significantly more spawnings than intragastric injection or dispersal in
water surrounding the incurrent siphon. (Modified authors' abstract - J.L.M.)

Preliminary results of a study of the relationship between reproductive development of
the quahog (Mercenaria spp) and environmental factors in the Indian River
The northern quahog (Mercenaria mercenaria) shows a distinctly cyclical pattern of
gonadal development throughout most of its range along the eastern seaboard of
the United States, but little information is available for the species at the southern limit
of its range. Discerning the reproductive cycle in Florida is complicated by the oc-
currence of Mercenaria campechiensis and hybrids in this region. Hard clams were
collected monthly from September 1986 to June 1987 in two geographically distinct areas of the Indian River Lagoon. Temperature, salinity, dissolved oxygen and

A comparative analysis of larval and early postlarval shell morphology of the hard
clams Mercenaria mercenaria, Mercenaria mercenaria texana, and Mercenaria
Postlarval size and length and height and larval hinge structure did not appear
significantly different among offspring of the three parental types. Mercenaria
campechiensis larvae appeared to exhibit increased external shell sculpturing and in-
creased shell depth at late larval and early juvenile stages. (Modified author's abstract
- J.L.M.)

The relative effects of seston flux and sediments on individual growth rates of
Mercenaria mercenaria: Results of a factorial field experiment. J. Shellfish. Res.
Preliminary descriptive/correlative field studies on wild Mercenaria mercenaria in
a coastal lagoon in southern New Jersey suggested that individual growth rates are
affected by 'food provision equivalent to the horizontal flux of seston,' flux units:
mg seston/cm2/s and deposited sediments. Ten clams (30-45 mm shell length) were
selected from each of 36 experimental plots (12 per site), each a round excavation of
0.3 m2 area and 10-15 cm deep in the ambient sediment filled with either mud,
sandy mud, or sand. Clams were also put in undisturbed sediment at each site as con-
trols for the sediment transplant procedure. An ANOVA, with change in shell length as
the dependent variable, showed significant differences between sites (P<0.001) and
sediment type (P<0.01). Combining all data by site and sediment type showed a 13%
difference in growth rates between the slowest and fastest sites, and a 6% difference
between sediment types, with slowest growth in mud and fastest in sand. Tidal cur-
rent velocities and four seston parameters (chlorophyll a, particulate inorganic and
organic matter (PIM and POM), and energy content) were measured 20 times in near-
bottom waters at each site. Flux of POM was well-correlated with growth rates. Neither
seston concentrations nor current velocities alone were correlated with growth rates.
Hence the significant 'site' differences are attributed to differences in seston flux.
This experiment provides further support for the importance of seston flux in con-
trolling growth rates of suspension-feeding bivalves. It also provides the first estimate
of the relative importance of seston flux and sediment type. (Modified author's abstract
- J.L.M.)

The use of brewers condensed solubles in bivalve mariculture. Ph.D. diss., College
of William and Mary, Williamsburg, VA 23186.
Brewers condensed solubles (BCS) was used to culture bacteria which were fed to
coloreless flagellates which were in turn fed to juvenile oysters (Crassostrea virginica)
and clams (Mercenaria mercenaria). Growth of clams fed colorless flagellates, BCS
enrichment cultures, and bacteria was compared with growth of starved controls and
animals fed Terasaelis suecica. Paraphysomonas vastia was the only species of color-
less flagellate to consistently grow greater than the starved control. BCS enrich-
ment culture varied greatly in its nutritional value. Average oyster growth on P. vastia
was 55% of growth obtained with T. suecica. Oysters fed combinations of T. suecica
and P. vastia did not grow as rapidly as on a pure diet of T. suecica. No growth
occurred when oysters and clams were fed on a purely bacterial diet. (J.L.M.)

444 Heffernan, Peter B., Randal L. Walker, and John W.
Growth of Georgia Mercenaria mercenaria (L.) juveniles in an experimental
Four cohorts of Mercenaria mercenaria seed were stocked at various densities (0.3-3.3
kg/m3) on experimental scale downweller systems and growth was analysed for the
period Oct. 15 to Dec. 1, 1986. To ensure maintenance of each cohort's inherent genetic
variance, seed were never graded or separated according to size. Mean flowrate to
biomass ratios are shown to have a great effect on growth rates. Differences are attrib-
uted to differences in seston flux. (Modified authors' abstract - J.L.M.)

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(1986) for experimental upweller systems in South Carolina. Cohorts can be divided into groups which grew faster in the first (Oct. 15-Nov. 11) or second half (Nov. 11-Dec. 1) of the study period. Growth rates achieved by these groups were shown to be significantly different during the second half, and are thought to be dependent on the flow rate to biomass ratio. (Modified authors’ abstract - J.L.M.)

Variation in phenotypic traits such as production characteristics may be studied using either quantitative or single locus genetics. An analysis of juvenile growth rate in the hard clam Mercenaria mercenaria is underway and will be discussed later. (Modified author’s abstract - J.L.M.)

The occurrence of Mercenaria mercenaria form notata in Georgia and South Carolina: Calculation of phenotypic and genotypic frequencies. Malacologia 23(1):75-79.
Genotypic and phenotypic frequencies of the notata form of Mercenaria mercenaria were calculated from data provided by four studies: two natural populations from Georgia, one from South Carolina, and one hatchery brood. Phenotypic frequencies calculated for the study ranged from 0.76% to 2.25%. Gene frequencies calculated by Maximum Likelihood Estimation were 0.04 to 0.11%. There were no significant differences between samples of natural populations. The natural populations and the hatchery brood were not comparable. The notata variant is the only morphological character inherited as if controlled by a single gene that has been found in M. mercenaria. The uses of such a marker are numerous. One application would be the marking of offspring from controlled matings to determine their subsequent success. (J.L.M.)

The manual outlines the processes and equipment required to culture four shellfish species, including the hard clam, Mercenaria mercenaria. Methods of producing food for shellfish are also included. (Modified authors’ abstract - J.L.M.)

448 Kassner, Jeffrey. 1987.
In 1986, the Town of Brookhaven undertook a hard clam population survey in eastern Great South Bay, an area of 3238 hectares, that in 1985 produced 40,000 bushels of hard clams. Replicate 1.20 m² grates were taken at 140 stations according to a block random design with 1.7 x 105 m² quadrants. Length and thickness of all clams greater than 20 mm in length were measured. A hard clam distribution map was prepared using a 5 clam/m² (apparent minimum density for harvesting) cutoff. Five distinct areas were defined based on the cutoff, and three areas with densities below the cutoff (non-beds) were identified. Size (age) frequency distributions were calculated by area and for each bed and non-bed. Bottom type in beds was sand or mud while in non-beds it was mud or mud sand with shell fragments, while non-beds had muddy sand or mud without shell fragments. The population structure was similar for beds and non-beds even though the mean density of all beds and all non-beds was 10.6 and 2.4 clams/m², respectively, and both beds had annual recruitment. However, individual bed stations had a greater range of sizes than did non-bed stations. This suggests that population dynamics in beds and non-beds are different. Field, laboratory, and literature data provide some insight as to causes. Management implications are considered. (Modified author’s abstract - J.L.M.)

449 Kassner, Jeffrey, and Robert E. Malouf. 1982.
A traditional management practice in New York’s hard clam (Mercenaria mercenaria) fishery has been to transplant adult clams from cooler northern waters to the relatively warmer waters of Great South Bay. It is believed that such spawner transplants increase the length of time that clam larvae are present in the bay and, thereby, enhance the probability that at least some of the larvae will encounter favorable conditions for survival and settlement. Histological analysis of the gametogenic cycle of native and transplanted clams showed that two critical assumptions were unsound: 1) that spawning by the native clams is defined and predictable, and 2) that the transplanted clams spawn after the native clams have ceased spawning. Other considerations, including the scale of the transplant projects relative to the natural stocks suggest that these programs are unlikely to significantly increase recruitment in Great South Bay. (Authors’ abstract - J.L.M.)

Suffolk County is the center of the marine fishing industry in New York State. The industry has been dominated by landings of hard clams (Mercenaria mercenaria) but the hard clam fishery has fallen on hard times recently. By 1985 hard clam landings in the County declined 76% from the last peak production year of 1976. In response to this decline a report was funded by the County and completed by the Marine Sciences Research Center of SUNY entitled “Suffolk County’s hard clam industry: An overview and a analysis of management alternatives." With funding from the National Marine Fisheries Service a Suffolk County hard clam advisory group was formed to screen these management alternatives and suggest others. The charge made to the Advisory Group was to assist the County’s Planning Department in preparing a plan for management of the hard clam resources. The goals of the plan were to: 1) identify actions that should be taken to assure the survival of a viable commercial hard clam industry capable of supporting a significant number of baymen harvesting clams on a full-time basis; 2) identify actions that should be taken to preserve a hard clam industry that provides baymen with a source of income, and others with the opportunity to enjoy clam harvesting on a recreational basis; 3) identify actions that should be taken to: a) maintain environmental conditions in local marine waters that are conducive to the reproduction, growth, and survival of hard clams; and b) maintain the certification of these waters for the harvest of shellfish resources. The rest of the report summarizes these goals in some detail, under the headings: 1) hard clam stock enhancement strategies and recommendations; 2) fishery management information, enforcement strategies, and recommendations; 3) marine water quality monitoring, fishery habitat protection strategies, and recommendations. (J.L.M.)

Seed size at planting is the dominant factor affecting hard clam survival to marketable size when field growout techniques are used. The use of plastic mesh nets, crab traps, and wire mesh bags (filled with oyster shells) alone or in combination can be used to increase survival of hard clams of >6 to 8-mm shell height. These techniques do not provide sufficient protection for 2-mm seed. The combination of net + crab trap + shell bag was nearly twice as effective as the net alone when 10-14 mm seed was used and over five times as effective as the net alone when 6-8 mm seed were planted. Survival in excess of 50% slows the growth rate and yields higher percentages of submarketable <25-mm thick (New York legal limit) clams. Local markets and dealers would accept all clams > 22 mm. (Authors’ abstract - J.L.M.)

In the 1800s and early 1900s Raritan Bay had commercial fisheries for five shellfishes, including hard clam Mercenaria mercenaria. Oyster and soft clams fisheries have ceased to exist, and hard clam, blue crab, and lobster fisheries have had periods of substantial decline. The hard clam fishery was limited by pollution and increasingly smaller areas of the bay were open for marketing clams. The entire bay was closed in 1961. The eastern end has been reopened for clamming since 1983 when a depuration plant was constructed to process hard clams. These clams can be and have been relayed to clean beds in Barnegat Bay. (Modified author’s abstract - J.L.M.)

The purpose of this manual is to acquaint the reader with farming techniques to raise hard clams (Mercenaria mercenaria). Site selection is the most important decision that must be made. The upwelling system is used to grow very small seed clams to field planting size (5-8 mm). Field growout must provide protection from predators, be inexpensive and easy to maintain. Legal requirements are complex, and a minimum of 3 months is needed to obtain a) required permits. Expenses depend on site, culture methods, clam growth, and survival, among other things. Guidelines are: 1) prepare to confront new problems each day, and devise cheap solutions; 2) write everything down; 3) never expect something to work until it actually has; and 4) when things get tough, never lose sight of why you are doing this. The appendix contains criteria for selection of sites. (J.L.M.)
The results of the cost-analysis model indicated that removing slow growing animals from the production system would not result in a net reduction in production costs, since the value of the animals discarded exceeded the savings realized by confining production to fast growing individuals. (Modified author's abstract - J.L.M.)

Selected broodstocks from Aquaculture Research Corporation and Virginia Institute of Marine Science were spawned on three occasions at different times of year for production of inbred and reciprocal outbred lines. Growth and survival were monitored at regular intervals for two years and the populations were sampled at one year of age to determine allomazine frequencies. In each trial one of the outcrossed lines demonstrated more rapid growth than the parental lines, but not the same line in each case. Early growth was not a good predictor of subsequent growth. Early growth was strongly affected by the time of spawning, resulting in great disparities between trials. But this difference disappeared by the time the lines reached 18 months of age. There was some indication that the fastest growing lines were more heterozygous than other lines, but no relationship between heterozygosity and rapid growth could be demonstrated within lines. Some of the population reached market size in 18 months and a large portion were market size in two years from spawning, an increase of at least 6 months over growthout expectations of South Carolina wildstock. (Modified authors' abstract - J.L.M.)

456 Pline, Marc J. 1984.

Experiments in 1986 were designed to determine whether larval settlement of Mercenaria mercenaria occurred at specific sites around the perimeter of Long Island Sound, and the relative growth rate of clams at those sites. Stations were located at the 5-m depth contour, were out of the influence of major riverine inputs or polluted harbors, and were chosen to be relatively uniform in substrate type. Settlement was measured in 21 x 21 x 5 cm plastic boxes, filled with either natural substrate from the site or with a standard sand, and covered with 8-mm plastic mesh. Growth of 10-mm hatchery-reared clams was determined by measuring groups held at a density of 500/m² in 0.4 m² plastic-coated wire mesh cages with 8-mm openings. The cages were buried approximately 10 cm into the substrate. Divers were used for all gear deployment and subsequent sampling. Mercenaria settlement occurred at all stations, and site differences are discussed. Seasonal growth of planted clams was statistically different at the four Connecticut stations for which complete growth data were obtained. Growth of the clams did not simply reflect known east-west gradients of salinity, temperature, phytoplankton abundance or pollution levels. Based on 1986 results, three sites that produced very different growth results were chosen for further study in 1987. (Modified authors' abstract - J.L.M.)

This report was prepared with support provided by Suffolk County through the Suffolk County Planning Commission and by the William H. Donner Foundation. It includes: History and current status of the hard clam (Mercenaria mercenaria) fisheries in Suffolk County; A selection of management alternatives for individual water bodies; Information priorities; The hard clam fishery; Histories of Suffolk County's hard clam fisheries; The history of the hard clam fishery of Moriches Bay and Shinnecock Bay; History of the Peconics and North Shore hard clam fisheries. The recreational hard clam fishery in Suffolk County; Hard clam management in New York - a historical overview; Suffolk County's changing coastal environment; Salinity and Great South Bay; Effects of dredging activities on hard clams; Management alternatives; Seed planting; Spawner sanctuaries; Preditor control as a means of improving hard clam production; Selected closure of harvest grounds; Limited entry and harvest quotas as tools for managing Suffolk County's hard clam fishery; The economics of management alternatives for the hard clam in Great South Bay, New York - Executive summary; Private mariculture; Law enforcement aspects of hard clam management; The hard clam relay; New Jersey's program and the outlook for Suffolk County; The economics of management alternatives for the hard clam in Great South Bay, New York; and Glossary. (J.L.M.)

Interidal populations of four species of whelks (Busycon) in Wassaw Sound, Georgia. J. Shellfish. Res. 7(1):22 (abstract).
Hard clams, Mercenaria mercenaria, and oysters, Crassostrea virginica, occur interdially in Georgia, and intertidal whelks prey upon these commercially important shellfish, the abundance, migrational and feeding habits of intertidal whelks were studied. A small percentage (8%) of whelks was found actively feeding on these two species, 54% on Mercenaria and 48% on Crassostrea. (Modified author's abstract - J.L.M.)

The Northeast Fisheries Center has compared and ranked, under laboratory conditions, five algal species as nutritional sources for juvenile hard clams (Mercenaria mercenaria). A pennate diatom, Nitzchia sp., common to eastern Long Island Sound's phytoplankton, promotes rapid growth. But a chain-forming centric diatom does not support growth. - J.L.M.
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Errata

Following are two corrected references from the earlier hard clam bibliography by McHugh et al. (1982) published as NOAA Technical Report NMFS SSRF-756.


Kinetics and effects of DDT in a tidal marsh ditch. Trans. Am. Fish. Soc. 94(2):152-159. (Corrected page numbers)