THE SOFT-SHELL CLAM

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CONTENTS

ABSTRACT

Describes the soft-shell clam industry of the Atlantic coast; reviewing past and present economic importance, fishery methods, fishery management programs, and special problems associated with shellfish culture and marketing. Provides a summary of soft-shell clam natural history including distribution, taxonomy, anatomy, and life cycle.

THE SOFT-SHELL CLAM

by

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INTRODUCTION

The soft-shell clam, *Mya arenaria* L., has played an important role in the history and economy of the eastern coast of our country. Long before the first explorers reached our shores, clams were important in the diet of some American Indian tribes. Early colonists relied on the abundant clam stocks during periods of privation, although they rarely used clams as a regular food item. In the mid-1800's an important bait clam fishery, supplying trawl bait for cod fishermen, was established by some New England coastal communities. Later, with the decline in demand for bait clams, consumer interest developed in canned clams--maintaining the fishery at a high level up to the early 1940's. The modern trend is toward the marketing of fresh or frozen clam meats that are generally served as fried clams in most areas, but fresh clams, steamed in the shell, are still popular in coastal regions.

In recent years, clam supplies from the New England area have declined, primarily due to the activity of a voracious predator. With the introduction of mechanical digging methods, a new source of clam production has been developed in the Chesapeake Bay region, and the soft-shell clam continues to occupy a prominent position in our coastal shellfisheries.

New England has traditionally been the center of soft-shell clam production, though no commercial interest in clams was evidenced before the middle 1800's. Clams, of course, had been dug extensively before this period, but since they were everywhere available and demand for them as food and bait was probably on an individual basis, they were not a market item. In the period around 1850 the first real commercial fishery began with the demand for salted clams used as bait by cod fishermen on the Grand Bank. For the next 25 years this was the most important outlet for clams and was a source of wealth to some coastal communities. Many of the diggers earned up to $10 per day in this business during October to March, when other occupations were difficult to find. About 1875 a new demand for soft-shell clams arose as clam bakes and shore dinners became increasingly popular during the summer. Clams became important as a consumer item for the first time, and this demand for clams is still important to the northern fishery. Around 1900, canned clams became increasingly important, and for the next 40 years most clams went to the canneries. During this period clamming was prohibited in some areas during the summer by State law, thereby concentrating production in the winter when there was little competition from other industries for labor, and clam prices were low.

Since the late 1930's most clams have been used in the fresh shucked trade and recently cooked and uncooked frozen products have become popular. Clams are primarily used in the fried clam retail market and, with the increase in population, better preserving and marketing methods, and extensive publicity by large restaurant chains, the demand for clams is gradually increasing.

Early production records are not easily obtained, but the first figures given in the Federal statistics indicate a fairly high level of production had been established by 1880 (fig. 1). The New England fishery has been marked by a consistently high, but variable, level of production until recent years. The actual dollar value of the fishery reached the 2 million mark during the 10 years from 1945 to 1955 even though this period marked a drastic decline in

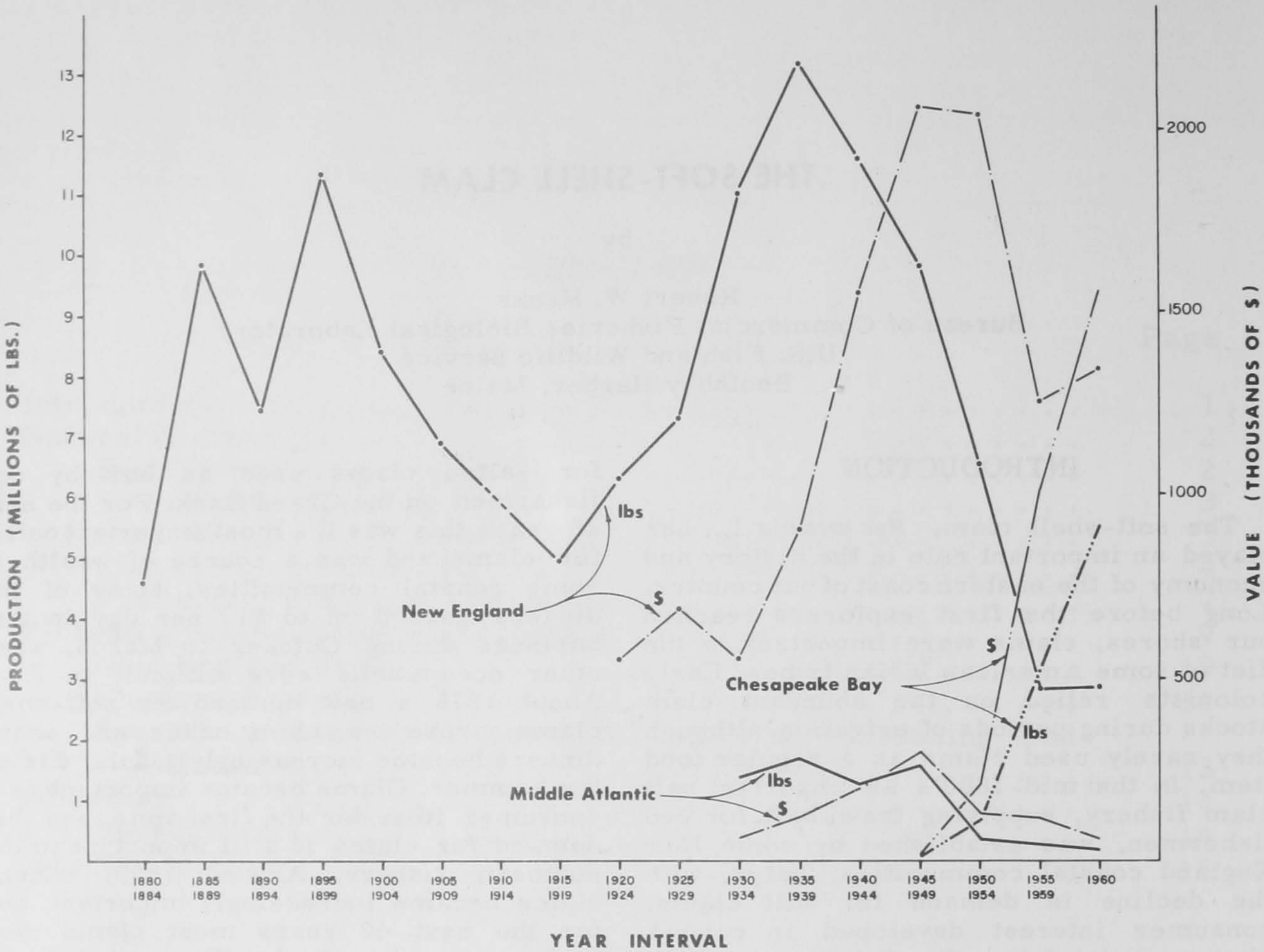

Figure 1.--Pounds of meat production and value of soft-shell clams from three major areas of the Atlantic coast.

production of almost 6 million pounds. New England clams have a decidedly favored price differential and are valued at almost twice the price of their southern counterpart. New England production figures for recent years are the lowest (between 2 and 3 million pounds) on record for nearly a century.

Following World War II, particularly after 1950 when the "Maryland" escalator dredge was invented and introduced, the soft-shell clam fishery in Chesapeake Bay rose to dominate production. Production was almost double the New England output in 1960 although the total value of clams from the two areas was nearly identical. The southern fishery is now limited only by market demand as great quantities of virtually virgin stocks are available. Almost all southern clams are shipped to the New England area, for the market demand is still centered in the north.

NATURAL HISTORY

Distribution

The soft-shell clam is found from the coast of Laborador to the region of Cape Hatteras, N.C. On the European coast it has been recorded from northern Norway to the Bay of Biscay, France. Around 1879, young clams were accidentally introduced into San Francisco Bay, Calif., with shipments of seed oysters from the Atlantic coast. Since then they have spread from Monterey, Calif., to Alaska. The soft-shell clam is also found along the western Pacific coast from the Kamchatka Peninsula to the southern regions of the Japanese islands. This species, therefore, lives on every coastline in the northern hemisphere, but it is only in the United States, particularly on our eastern coast, that these clams have become commercially important.

Taxonomy

The soft-shell clam belongs to that group in the animal kingdom known as the phylum Mollusca. They are further arranged, together with other bivalves, into the class *Pelecypoda* and because of certain characteristics of gill structure are placed in the order *Eulamellibranchia*. All of the structurally similar clams are then grouped in the family *Myacidae*. On the western Atlantic coast there are only two recorded species of clams in the genus *Mya;* they are *Mya arenaria*, our commercially important clam, and *Mya truncata*, characterized by a short, square-ended shell, which lives in deeper northern waters, and is of no commercial interest.

Anatomy

A discussion of clam anatomy requires the establishment of certain directional landmarks. The siphon (neck) is considered to be posterior while the opposite (head or mouth) end is anterior. The hinge area is the back or dorsal region while the front, with the exposed mantle edge (rim) is ventral. These terms are in underlined bold type in figure 2. It follows that having a front, back, and head, the clam will also have a right and left side.

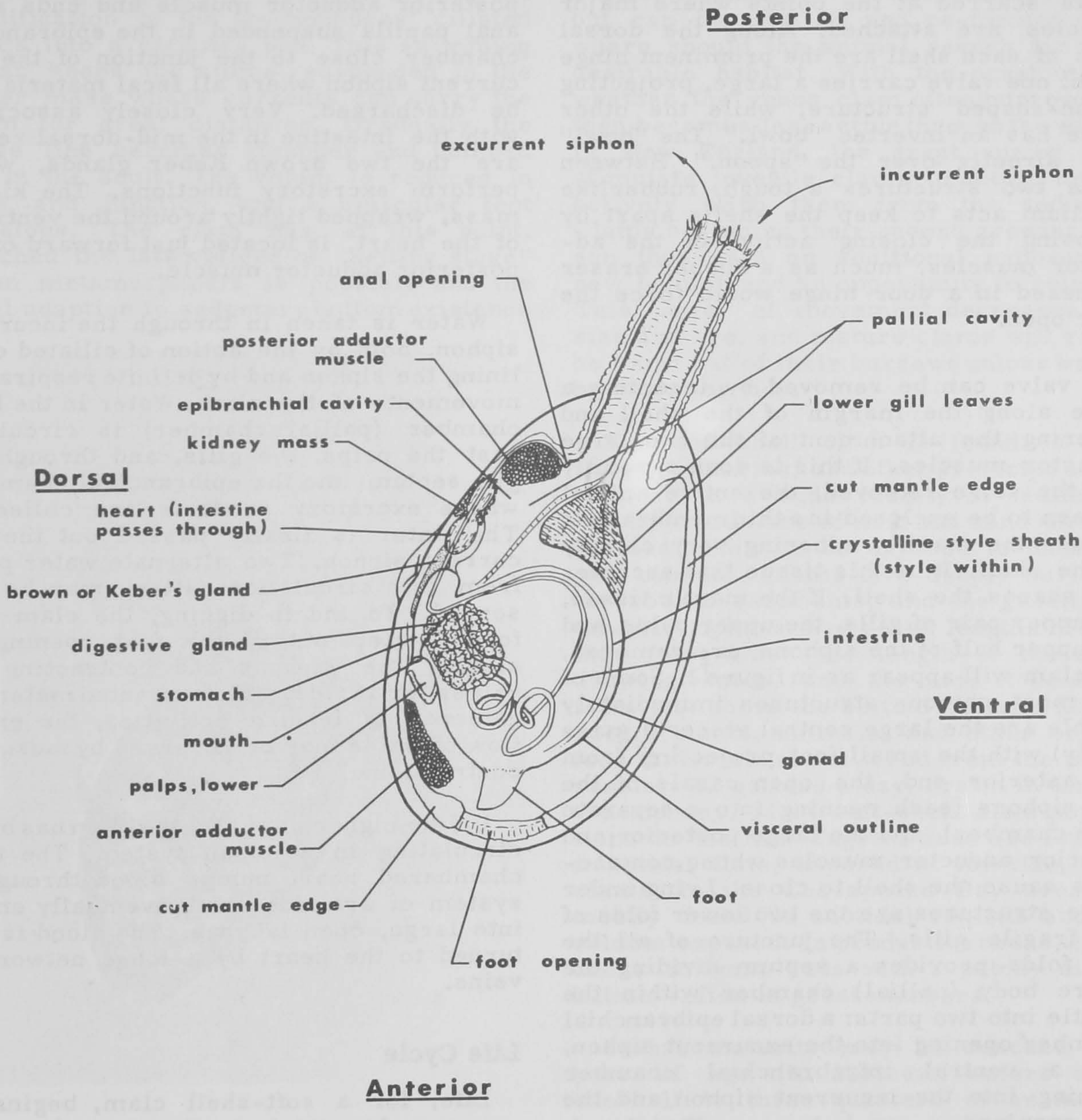

Figure 2.--Soft-shell clam internal anatomy

The external appearance of the soft-shell clam is an irregular ellipsoid with the two valves, or shells, about equal in size. The right shell is usually slightly larger than the left. When closed the two valves may touch along the ventral edge but gape widely in front, allowing passage of the foot, and in back, allowing extrusion of the siphons. The outer surface of the shell is covered with rough striations, some more pronounced than others. These are the annular marks or "rings" resulting from different growth rates during the year and, since cold winter temperatures restrict growth, these rings can indicate clam age. The interior of the shell is relatively smooth with certain areas scarred at the points where major muscles are attached. Along the dorsal edge of each shell are the prominent hinge teeth: one valve carries a large, projecting spoon-shaped structure, while the other valve has an inverted "bowl." The "bowl" lies directly over the "spoon." Between these two structures a tough, rubberlike resilium acts to keep the shells apart by opposing the closing action of the adductor muscles, much as a rubber eraser squeezed in a door hinge would force the door open.

A valve can be removed by inserting a knife along the margin of the shell and severing the attachment of the two large adductor muscles. If this is done carefully and the valve removed, the entire animal is seen to be enclosed in a thin membranous tissue, the mantle, adhering very closely to the shell. It is this tissue that secretes and shapes the shell. If the mantle tissue, the upper pair of gills, the upper palps, and the upper half of the siphons, are removed, the clam will appear as in figure 2. Some of the most obvious structures immediately visible are the large central visceral mass (belly) with the small foot projecting from the anterior end, the open canals of the two siphons (each opening into a separate body chamber), and the large posterior and anterior adductor muscles whose contractions cause the shell to close. Lying under these structures are the two lower folds of the fragile gills. The juncture of all the gill folds provides a septum dividing the entire body (pallial) chamber within the mantle into two parts: a dorsal epibranchial chamber opening into the excurrent siphon, and a ventral infrabranchial chamber opening into the incurrent siphon and the foot opening.

The interior of the visceral mass can be exposed by tearing away the outer wall, uncovering the large brown liver and the gonad (a tissue spread throughout the body). Embedded in this gonad and surrounding connective material lie the long, coiled intestine, the crystalline style within its sheath, and the stomach situated almost between the halves of the liver. The mouth opens on the anterior surface of the visceral mass just between the two pairs of palps, which gather and pass food to the mouth. The intestine leaves the stomach, coils within the gonad, then passes dorsally along the hinge line and through the heart. Finally, it passes around the base of the posterior adductor muscle and ends in an anal papilla suspended in the epibranchial chamber close to the junction of the excurrent siphon where all fecal material can be discharged. Very closely associated with the intestine in the mid-dorsal region are the two brown Keber glands, which perform excretory functions. The kidney mass, wrapped tightly around the ventricle of the heart, is located just forward of the posterior adductor muscle.

Water is taken in through the incurrent siphon, both by the action of ciliated cells lining the siphon and by definite respiratory movements of the clam. Water in the body chamber (pallial chamber) is circulated past the palps, the gills, and through the gill septum into the epibranchial chamber, where excretory products are collected. The water is finally passed out the excurrent siphon. Two alternate water paths from this circulation pattern may be observed. To aid in digging, the clam may force water out of the foot opening by closing the siphons and contracting the valves; or to rid itself of unwanted materials gathered in feeding activities, the entire flow of water may be reversed by muscular contraction.

Unlike higher animals, the clam has blood circulating in an open system. The two-chambered heart pumps blood through a system of arteries which eventually empty into large, open lacunae. The blood is returned to the heart by a loose network of veins.

Life Cycle

Life, for a soft-shell clam, begins as sperm and egg join in the coastal waters.

In cold New England water the fertilized egg develops into a swimming trochophore larva (fig. 3) in about 12 hours, probably sooner in warmer, southern waters. The larva moves by hairlike projections (cilia) arranged in distinct bands around the body. The larva also has a mouth and a minute shell gland which will give rise, during the next 24 to 36 hours, to the two, calcified valves that will envelop and protect the clam body throughout life. The formation of the shell results in a new larval stage (early veliger) that is typical of most bivalves. Early veliger larvae (fig. 4) are characterized by a straight hinge line and a swimming organ, the velum, formed by the modification of the trochophores' ciliated bands into a circular pad. This swimming organ keeps the animal suspended in the water mass where currents can carry the clam for great distances. Gradually the hinge line becomes stronger and humped as in the adult. The velum is reduced in size and function, and a muscular foot develops. The clam has, at this point, reached the late veliger or "setting stage" when metamorphosis is possible and the final adaption to sedentary bottom existence can begin. This is an extremely critical period in the life cycle for, once removed from transportation by the water, the clam must establish itself within a relatively small area and its future success may depend on the type of bottom material on which metamorphosis occurs.

Figure 3.- Trochophore larva of the soft-shell clam is actually much smaller than the period at the end of this sentence.

Upon setting, the clam immediately attaches to sand grains, plants, or other materials, by a tough horny thread, the byssus. Byssal threads are formed from water-hardened secretions of the byssal gland, located on the underside of the large, muscular foot. The byssal "anchor" reduces further washing by wave action and currents, but can be cast off and re-formed elsewhere should the animal search for more desirable habitat. With the onset of cold weather the young clam often burrows and then becomes less active through the winter. In New England, the great spring tides stimulate juvenile clams to move, or may actively wash them from the sediment. Clams beginning their second growing season thus gain an additional exposure to new habitat and an opportunity to relocate. This power of movement decreases with size and age, and mature clams will rarely be found out of their burrows unless washed by storm or tide.

The soft-shell clam is found in bays, coves, estuaries, and other protected areas. It lives in a wide variety of sediments, ideally a mixture of mud and sand where it is less likely to be exposed to predation and climate. Clams live deeply buried in the bottom sediments, and the greatly extensible siphons may reach lengths of more than four times the length of the shell, drawing water, and the food it contains, from just above the bottom surface. Microscopic plants, animals, and other organic food materials are filtered from the water, possibly 12 gallons a day, drawn in through the siphons. Most soft-shell clam populations in the New England area are found in intertidal flats, exposed at low tide, while clams in the Chesapeake Bay area are mostly found in subtidal regions and are seldom exposed. In productive areas, clams occur in vast beds with a patchy distribution--often in great numbers.

Sexual maturity may be reached at 1 year of age (in northern waters about one-half to three-quarters of an inch in length). The sex of clams can be determined only by microscopic examination. Each

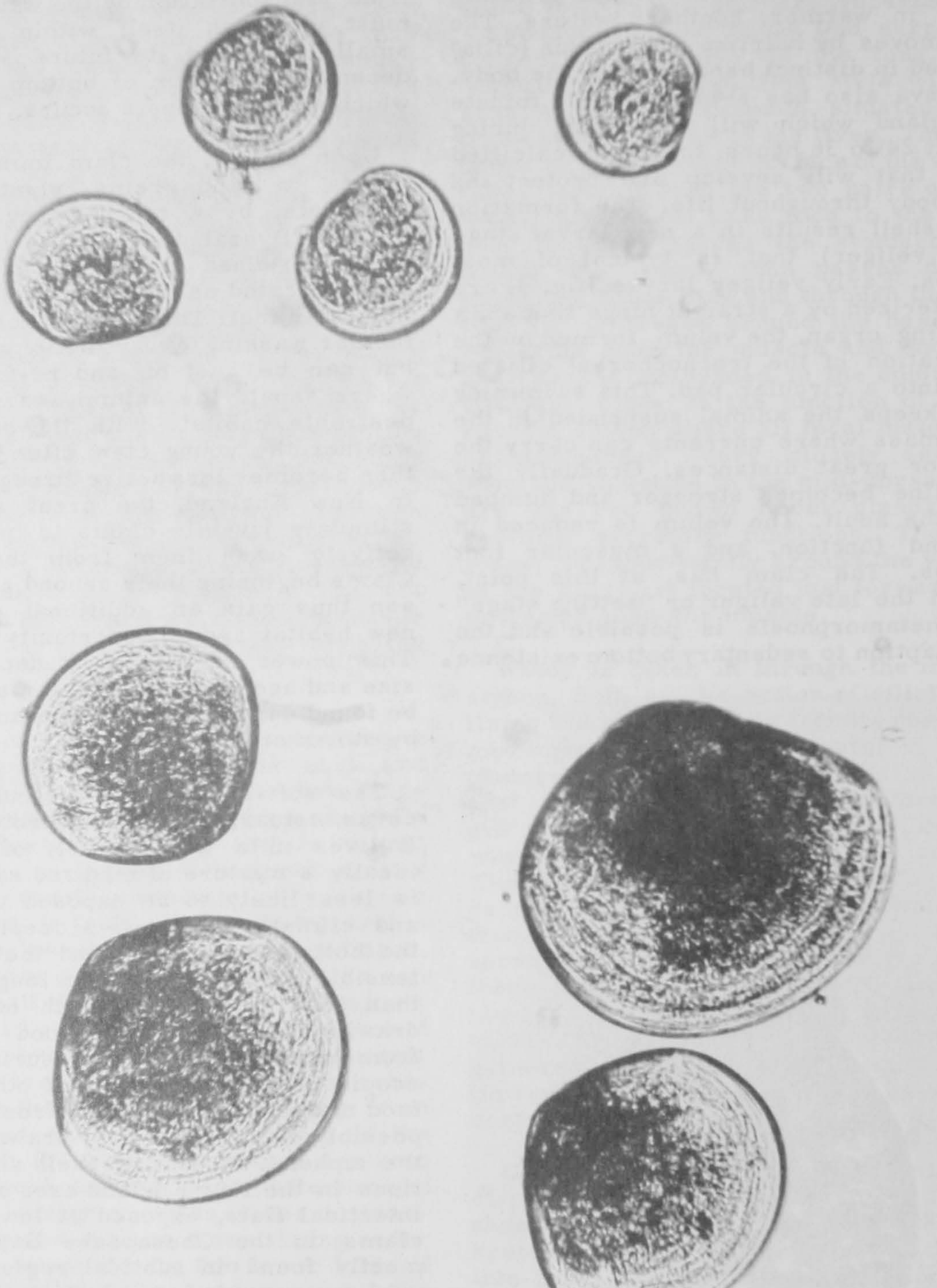

Figure 4.--Early veliger (upper section) and late veliger (lower section) larvae of clams. The animals are just visible to the naked eye.

clam can produce millions of eggs or billions of sperm. During spawning, sex cells are extruded from the gonad into the epibranchial chamber and out the excurrent siphon in successive puffs. Spawning is related to water temperature and occurs from early June to mid-August in northern areas. The summer spawning period becomes progressively later the further south a clam population is located. Clams north of Cape Cod have only one reproductive cycle each year, but clams south of Cape Cod may spawn twice in the same year.

Growth rates depend primarily upon temperature although many other factors may be involved. Southern clams may reach a shell length of 2 inches, an acceptable commercial size, within $1\frac{1}{2}$ or 2 years in Chesapeake Bay, but Maine clams may require 5 to 6 years to attain this length. Food abundance, water circulation patterns, tidal exposure, crowding, and sediment type are other elements influencing growth.

Predators, Diseases, and Parasites

Probably the most serious clam predator in recent years, exclusive of man, is the green crab, *Carcinus maenas* (fig. 5). Prior to 1900 this small, shore-living crab had a very restricted range south of Cape Cod, Mass. A gradual warming of the coastal waters allowed the crab population to expand northward, and by 1955 green crabs occupied the entire Gulf of Maine coast as far north as Nova Scotia. This tremendous range and population expansion intensified the effects of predation, and resulted in a drastic reduction in the clam catch from a high of about 13 million pounds in the period 1935-39 to a low of

Figure 5.--The green crab, *Carcinus maenas*, has been an important factor in reducing clam populations north of Cape Cod.

2 to 3 million pounds in the early 1960's. The development of several control methods, particularly fencing and pesticide barriers (figs. 6 and 7), have helped to reduce crab predation in local areas, but these measures have not been used extensively enough to be significant in total clam production. Cold winters apparently have an important effect in reducing crab abundance, and a reversal of the previous warming cycle could solve the crab problem in New England.

Other soft-shell clam predators, not comparable to green crabs but often of local importance, are moon snails, oyster drills, other crabs, ducks, gulls, horseshoe "crabs," starfish, and bottom feeding fish such as flounders, skates, and rays.

Mass mortalities of some clam populations have been recorded, but there is practically nothing known of the causative agents. The incidence of observed clam diseases is low and probably does not affect clam production, nor do any of these diseases affect man. A condition known as "water belly" is prevalent in some areas of New England, and clams with the watery, thin meats typical of this condition are not acceptable for market. "Water belly" may be caused by nutritional deficiencies, but some biologists believe that other factors such as parasitic infection, enzyme deficiencies, and disease can be involved.

Figure 6.--Green crab fence, developed by Bureau of Commercial Fisheries biologists to protect clams from predation. This low, wire fence with a metal flange prevents crabs from entering bays and coves. Note large number of siphon holes visible inside fenced area and absence of siphon holes outside fence.

Figure 7.--Bureau-developed pesticide barrier protects other coastal areas from green crabs. Pesticide-soaked fish are supported on long trawl lines placed across mouth of creeks, bays, or coves. Crabs, entering the area, feed on bait and die before reaching clam stocks.

Incidence of parasites appears to be low and probably does not influence the abundance of clam stocks. Several trematodes inhabit *Mya arenaria* during some period of their life cycle, and a parasitic ciliate, *Trichodina myicola,* has been recorded.

FISHERY--METHODS AND MANAGEMENT

New England Area

Armed with clam hoe and hod the New England clam digger waits for the tide to expose his prey. As the water drains from the clam flats, he begins to dig, sometimes in long trenches or pits, when clams are abundant, or he may search for the individual depressions on the surface that indicate clams in the soil below (fig. 8). In either case, he will have about 4 hours to gather his catch. Formerly, during the periods of great abundance, the fishermen could expect to dig a barrel or more of clams, but now 1 to 2 bushels per tide is considered an average catch (fig. 9). At the present time the digger can expect to receive about $6 for each bushel sold to the clam buyer, who, in turn, will receive a commission from the processing plant. At the processing plant the clams are cleaned, graded, and shipped directly to retail markets or may be shucked, washed, and canned (fig. 10).

Although it is believed that a great potential exists for shellfish farming and responsible management, only sporadic attempts have been made during the history of the fishery. In New England, the failure to establish reasonable management techniques is the result of a continued demand that the fishery be free and publicly owned. There is only a modest investment, clam hoe and boots, required by an individual to enter the fishery. Very few diggers work on a year-round basis; most are engaged in various seasonal work requiring unskilled labor, and clamming is a part-time source of income. Diggers rarely work for

Figure 8.- Methods of digging clams in New England have hardly changed since the commercial fishery began. Upper photo, taken on the Maine coast around 1891, is nearly identical to similar scenes on clam flats today (lower photo).

Figure 9.--New England clam fishery: Clam digger (upper left) removes clams from sandy mud with clam hoe or fork. His daily catch (upper right) is taken to central buying area (lower left) together with catch of other diggers in region. Buyer loads clams from one region on truck (lower right) for shipment to processing plant.

the maximum catch obtainable at each low tide, but rather aim for a daily income determined by the individual's need. Hand digging is inefficient and wastes the clam resource. Research workers estimate that 70 percent of the clams left in the flats will die from the effects of hand digging.

Recent management efforts in Maine and Massachusetts have been directed toward predator control, clam flat improvement, and protection of juvenile clams. In some areas, intensive management programs utilize frequent population surveys to establish digging periods, forecast production, and to plan rotation of harvest areas. Unfortunately, these techniques are not in general practice and are not typical of the fishery.

Chesapeake Area

About 1951 the escalator dredge (fig. 11) was introduced into the Chesapeake Bay region to harvest subtidal soft-shell clams. The dredge is attached to a boat, which slowly pushes it through the bottom sediments. Clams, loosened from the sediments by the high-pressure spray of water, are washed or scooped onto the chain-mesh belt. This belt then carries the clams to the crew where commercial clams are removed, and all debris and small clams fall back into the water (fig. 12). The method is efficient; it takes almost all commercial clams and does little damage to others, and does not appear to have detrimental effects on bottom sediments. Each boat takes about 30 bushels a day. Fishing is restricted to

Figure 10. --New England clam fishery: Clams delivered to processing plant (upper left), are washed and graded (upper right). Some clams are shipped directly to market as whole clams, but most are shucked, washed, and packed in cans (lower left to right).

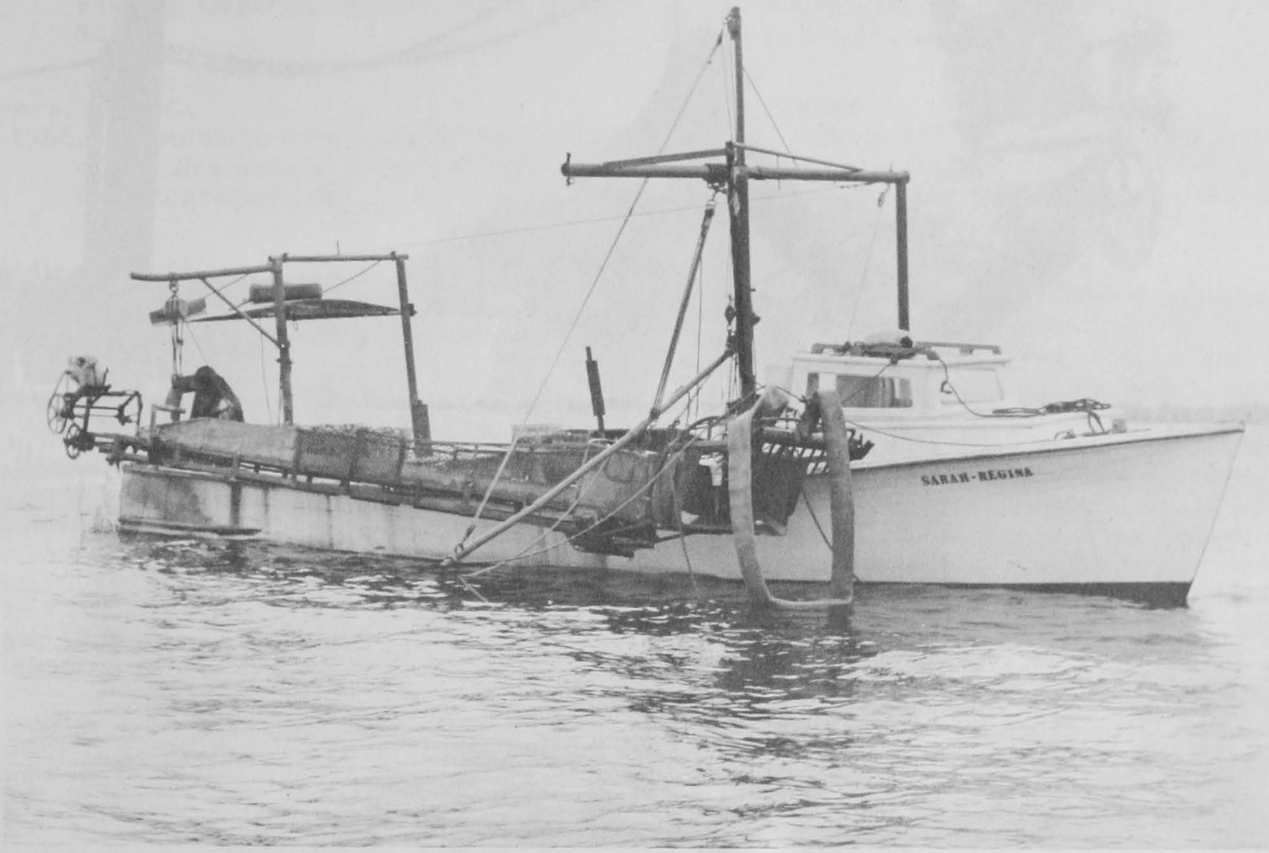

Figure 11.--Typical Chesapeake Bay dredge-boat with escalator dredge raised out of water. The large hose that carries water from a pump on the boat to high-pressure jets on the dredge hangs from the forward part of the dredge.

certain parts of a small number of open areas. The supply is greater than the present demand, and most dredges are restricted to a daily quota.

Although an expanded market is needed, the Chesapeake fishery is thought to be in good condition at this time, and no cultivation or extensive management of the fishery resource is being undertaken.

Special Problems of Paralytic Shellfish Poison and Pollution

Occasional outbreaks of paralytic shellfish poison are of serious concern to those responsible for the public welfare. The toxic agent is concentrated in clams and other bivalves when they feed on a small marine organism, *Gonyaulax* sp., that produces the poison and is noted for erratic population explosions. When *Gonyaulax* is in great abundance, clams become potentially lethal organisms for man. Fortunately, the species of *Gonyaulax* involved in paralytic shellfish poison are restricted to northern climates. U.S. and Canadian public health scientists continuously survey the toxicity of edible shellfish. Whenever shellfish from producing areas begin to show an increase in toxin toward scientifically established minimum levels, these areas are immediately closed to the clam fishery.

Vast supplies of clams are unavailable to the fishery because of domestic and industrial pollution. Pollution problems are unfortunately increasing as our population grows, and each year additional shellfish areas are closed. Bacterial pollution is probably of primary concern to man, since clams tend to concentrate pathogenic organisms from domestic pollution and may be involved in the transmission of serious

Figure 12.--Boat crew removes clams from the chain escalator belt. The small air-cooled motor (upper left) provides power for the belt.

diseases. Chemical pollution, such as fuel and industrial effluents, may kill shellfish or may flavor the meats so that they are unacceptable to the market. Physical pollution, such as the dumping of sawdust, masonry, and other industrial wastes, may kill clam populations by smothering and may remove producing areas from further production by changing physical characteristics of the shore.

SUMMARY

The soft-shell clam is one of our most delicious marine bivalves. It occurs on all of the major coastlines of the northern hemisphere, but is commercially important only on the Atlantic coast of North America. The clam has an interesting and hazardous life history, and is a source of food for many animals other than man. Although the clam fishery is beset by many problems, none are insurmountable and it is possible that continued research, responsible management of the resource, and improved marketing will bring the fishery to new levels of economic importance.

To those who have enjoyed the rare treat of a real "Down-East" clambake or have savored the special flavor of fried clams, the need for the continued success of the soft-shell clam industry will be apparent.

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