

ARTICLES

CLAM SURVEY OCEAN CITY, MARYLAND, TO CAPE CHARLES, VIRGINIA

By Phillip S. Parker*

During the summer of 1964 and the fall and winter of 1965, BCF made a clam survey off the coasts of Maryland and Virginia (Survey Area III). The purpose was to gather information on abundance, distribution, and size of surf clam (*Spisula solidissima*) and other species found with a potential for commercial use. Samples were taken at 1-mile intervals with a hydraulic jet dredge; 894 stations were surveyed. Catches of $\frac{1}{4}$ bushel or more per minute were made at 55 survey sites. Considerable variation in abundance, distribution, and size of surf clams occurred; these variations are related to bottom type and water depth. Limited beds of ocean quahogs (*Arctica islandica*) were found in some sections.

To maintain a steady production at present levels, the surf clam resource off the U. S. east coast is being subjected to increasing fishing pressure. Because of concern for future production, the fishery is now being investigated by several agencies: (1) BCF, (2) various state conservation departments, and (3) members of the surf clam industry. To determine the extent of the resource as a basis for future use, SCPA (Sea Clam Packers Association, an organization of members of the surf clam industry), working through the Oyster Institute of North America, initiated and supported a survey for sea clams that was done by BCF off New Jersey and Maryland coasts during summer 1963 (Parker, 1966).

The first survey covered only a small part of the area of interest, so SCPA and BCF agreed in fall 1963 to continue the work in the summer of 1964. SCPA provided funds to outfit BCF's research vessel "Rorqual" (fig. 1) for surf clamming, and BCF supplied the vessel, scientific personnel, and operating funds. From June 1-September 31, 1964, about half the proposed area had been surveyed.

In spring 1964, Congress authorized funds for a Sea Clam Research Program to be con-

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Notes: (1) This is Survey Area III.

(2) All statistics are in the appendix to reprint (Separate No. 791) of this article. For a free copy of the Separate, write to Office of Information, U. S. Department of the Interior, Fish and Wildlife Service, BCF, Washington, D. C. 20240.

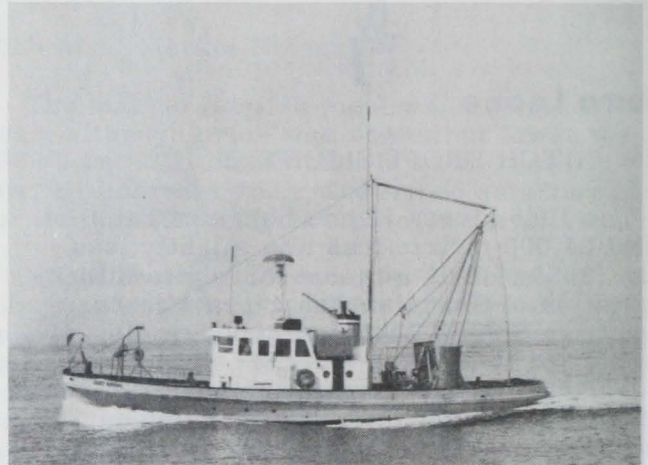


Fig. 1 - The Bureau's research vessel Rorqual used during the 1964 surf clam survey in Area III.

ducted jointly by BCF's Exploratory Fishing and Gear Research Base at Gloucester, Mass., and the BCF Biological Laboratory at Oxford, Md. With these funds, 2 additional sea clam survey cruises by BCF's "Delaware" (fig. 2) completed the work in Area III (see Area of Operation). The first cruise was February 19-March 18; the second, November 12-24, 1965. This report covers all results of the survey in Area III.

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Fig. 2 - The Bureau's motor vessel Delaware used during the 1965 surf clam survey in Area III.

AREA OF OPERATION

A large, rectangular area off the coasts of Maryland and Virginia, lying roughly between Ocean City, Md., and Cape Charles, Va., is Area III for survey purposes (fig. 3). The 4 corners of the area are located:

Corner	Latitude N.	Longitude W.
Northeast	38°00'	74°30'
Southeast	37°15'	75°00'
Southwest	37°25'	75°24'
Northwest	38°09'	74°49'

The first surf clam survey agreement between BCF and SCPA called for surveying 4 areas off the New Jersey and Delaware coasts. However, with the later expansion of the exploratory shellfish program in BCF

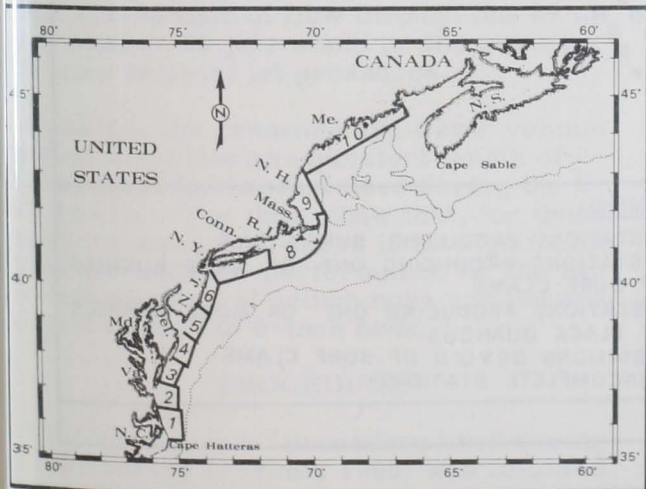


Fig. 4 - Chart of the eastern coast of the United States between Cape Hatteras, N.C. and Eastport, Me., showing the 10 survey areas.

Region III, we included all waters between Cape Hatteras, N.C., and Eastport, Maine, in overall survey area; we divided this area into 10 subareas designated survey areas. The survey areas extend from near shore to about the 30-fathom depth contour (fig. 4). New designating numbers were required for those areas already surveyed to allow each to fall into the logical numbering sequence of the new larger area (from Cape Hatteras, N.C., to Eastport, Maine). The areas originally numbered 1, 2, and 3 became 6, 5, and 7, respectively; area 4 remained 4.

GEAR

During February-March 1964, the Rorqual was converted for hydraulic jet dredging clam survey work. It is 65 feet long, has a 20-foot beam, and draws between 7 and 8 feet of water when fully loaded. Its aft deck is clear and provides a good working area.

A standard 40-inch hydraulic clam dredge was modified for survey work aboard the vessel. The changes were made primarily to reduce the escapement of many smaller clams that could have passed through the openings in the regular commercial dredge. These changes added steel screens to the sides, top, and bottom of the after cage; added steel bars between existing bars of the dredge's knife; and replaced the 3-inch steel rings of the chain bag with 1.5-inch rings.

During the 1965 Delaware cruises (65-2 and 65-10), modified 48-inch (wide) models of the regular commercial hydraulic dredge were used (fig. 5). Distances between steel



Fig. 5 - Modified 48-inch hydraulic dredge used during the 1965 surf clam surveys.

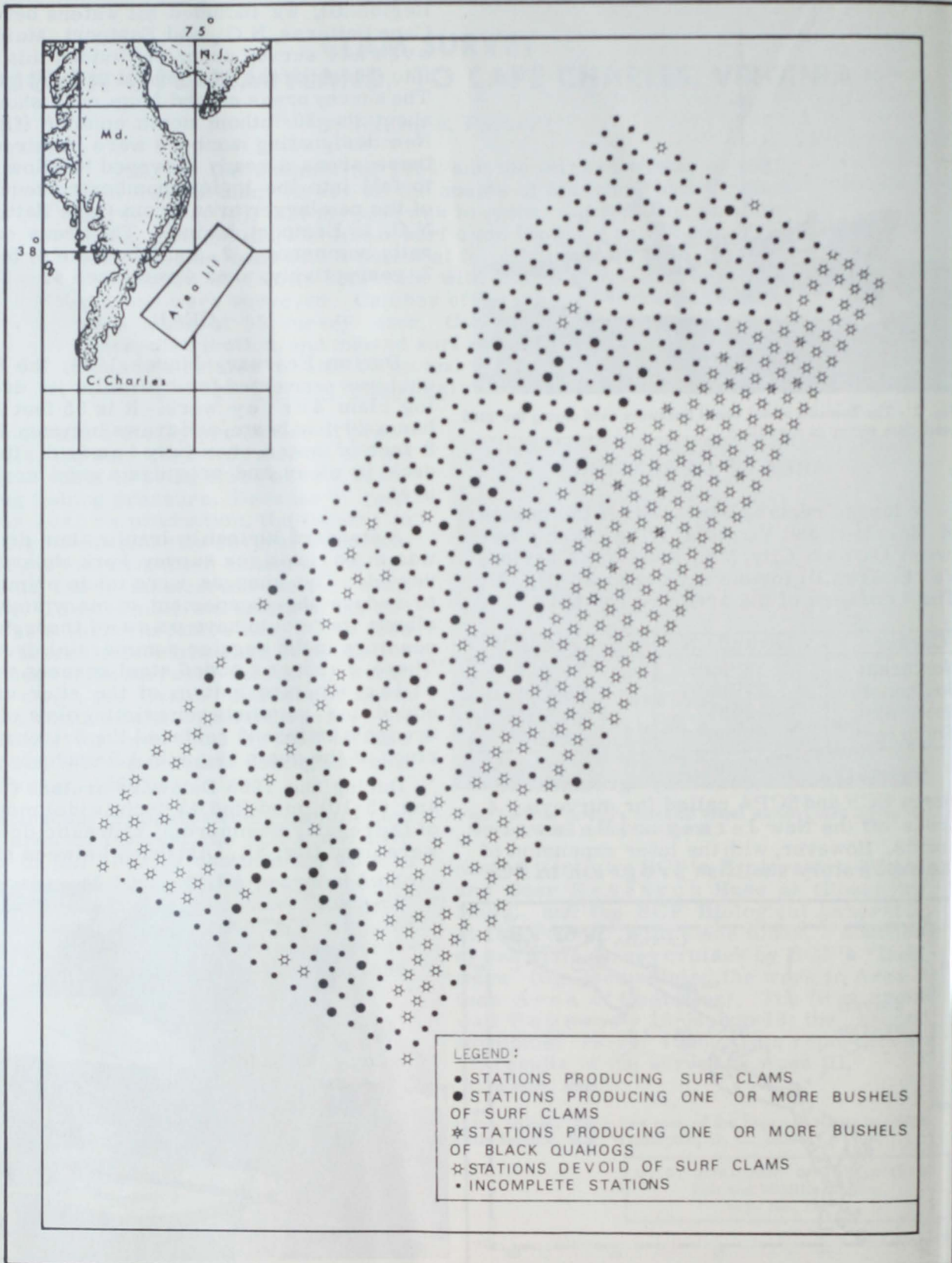


Fig. 3 - Chart of Area III showing survey stations.

lots of the dredge and the cage were reduced from 2 to 1 inch on the dredge used during cruise 65-2. The dredges had small clam retainer boxes built into the after cages for collecting very small specimens. During cruise 65-2, an odometer and thermistor probe were attached to the dredge to measure distance traveled by the dredge and to collect bottom temperatures.

Throughout each survey, an 1,800 gallon-per-minute centrifugal pump was used to furnish adequate water supply for operating the hydraulic dredge to depths of 150 feet. Water, at a deck pressure of 90 to 100 pounds per square inch, was furnished to the dredge manifold through 50-foot sections of either 5- or 6-inch inside diameter clam jetting hose. During cruise 65-2, two parallel lengths of 5-inch hoses were used, but before the cruise's end these were changed to a single 6-inch hose.

Water and pressure measurements obtained from instruments in the discharge line indicated the pump was pumping 1,775 gallons per minute of water through the manifold jets at 80 pounds per square inch manifold pressure (table 1--see note on p. 56) during dredging operations. This proved to be sufficient for successful dredging operations during all cruises.

We were unable to measure the water volume during tests made on the 6-inch hose because of a broken water meter. However, the volume of water (under the same manifold pressure) passing through the jets would be the same as that for an equal pressure measured during the tests on the 5-inch hoses--or about 1,625 gallons per minute for manifold pressure of 70 pounds per square inch. The volume of flow through one or an equal number of jets would be the same for both tests at equal jet pressures.

In table 1, the pressure and water volume were calculated for an equivalent length of 6-inch hose (190 feet) as that used during the 5-inch hose tests. The data show that, for those pressures measured, there is no significant difference between performance of the two 90-foot sections of 5-inch hose and the one 90-foot section of 6-inch hose.

PROCEDURE

The same general procedure used during the 1963 survey (Parker, 1966) was followed in sampling Area III. Stations were spaced

about 1 mile apart along selected 1-mile spaced grid lines (Loran lines) running north and south through the area (fig. 1). During Rorqual cruise 64-2, 5-minute tows were made at a towing speed of about 1 knot.

The first sampling station was located in the northwest corner (Loran bearings: 1H5-3080, 1H4-3050). Loran-bearing lines spaced at 4 microsecond intervals formed the main north and south grid lines (Channel 1H5). Loran bearings at 12 microsecond intervals positioned the stations along each grid line (1H4). When each tow was completed, the dredge was hauled back and dumped. Clams were measured before the next sampling station was reached. In small catches, all clams were measured; in large catches, an adequate number were measured for length-frequency analysis. Water temperatures, bottom textures, and species composition of catches were recorded.

During Delaware cruises 65-2 and 65-10, the towing time was reduced to 4 minutes or less, depending on bottom type over which tow was being made. At each station, a sample was taken from material collected in the small clam retainer and frozen for later analyses. In addition, on Delaware cruise 65-10, 53 tows were extended to 20 minutes to simulate commercial fishing--to determine size of catch that commercial fishermen might expect.

RESULTS

In Area III, 947 survey sites were occupied. Of these, 894 were standard sampling tows of 4- or 5-minute duration; the remaining 53 were simulated commercial tows of 20-minute duration. Sampling tows during each cruise were: 303 tows during Rorqual cruise 64-2, 397 tows during Delaware cruise 65-2, and 194 tows during Delaware cruise 65-10.

Catches

Of the 894 standard sampling tows, 284 caught no surf clams; 610 took catches varying from one surf clam to 8 bushels of clams. Fifty-five catches contained one-quarter bushel or more of clams per minute of towing--considered the minimum catch rate necessary for commercial use (appendix--see note on p. 56).

Surf clams were taken in 97 percent (295 tows) of the 303 tows made during Rorqual

cruise 64-2. Surf clams were taken in only 68 percent (271 catches) of the 397 tows made during Delaware cruise 65-2, and in 22 percent (44 catches) of the 194 tows made during its cruise 65-10.

Several factors could have influenced these variations in catch rate. These include mechanical and other variants of biological significance, such as: (1) catch efficiency of dredges varied. During Rorqual cruise 64-2, the dredge used for sampling retained surf clams of smaller size than did the two dredges of the Delaware cruises. In sections of Area III containing only small size clams, the probability of catching surf clams in the Rorqual dredge was greater than when using the other dredges. (2) The population density of surf clams (table 2--see note on p. 56) appears to be related to water depth (as well as other factors). In the sections surveyed during Delaware cruises 65-2 and 65-10, the average water depth at the stations was greater than at the stations surveyed during Rorqual cruise 64-2. From the abundance-depth relation of previous work, one would expect the number of zero catches from the deep-water sections surveyed by the Delaware to be greater than from the shallower areas surveyed by the Rorqual; this was found to be true.

The lower three-quarters of grid line 10 was chosen for commercial sampling because of good catches there during the survey tows. Only 1 tow of the 53 simulated commercial tows failed to take any clams; 14 caught 5 bushels or more per tow, and the remaining 38 took 1 to 5 bushels. Catches agreed in clam size and distribution for the long tows and the sampling tows made along grid line 10. These results may indicate that the procedure of sampling along a 1-mile grid gives accurate results and adds some credence to the validity of this survey procedure for assessing a resource.

Clam Sizes

The size of surf clams varied from 0.4 to 7.4 inches (10 to 189 mm.). Clams less than 0.4 inch (10 mm.) undoubtedly occur in the area, but the dredges used were not designed to collect smaller clams.

The most abundant size group of clams taken in Area III was between 5.5 and 6.7 inches (fig. 6, table 3--see note on p. 56), the size preferred by the industry for proc-

essing. Surf clams over 6.7 inches were rare and clams less than 5.5 inches were abundant, but they were far fewer than those in the 5.5- to 6.7-inch group.

No general pattern was observed as to size distribution within individual catches (table 4--see note on p. 56). Some tows took only clams less than 4 inches, others took only those over 4 inches, but most caught both sizes.

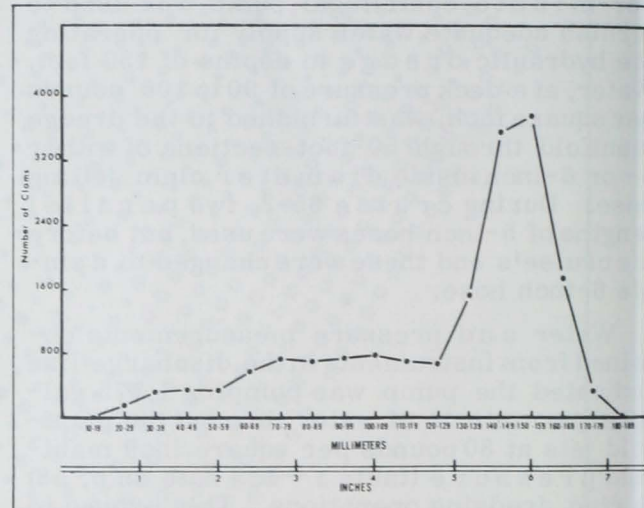


Fig. 6 - Length-frequency distribution of surf clams from Area III.

The length-frequency data collected in Area III do not conform with a normal length-frequency distribution. One would anticipate the number of clams in a smaller-size group to be considerably larger than the number in a larger-size group because of natural mortality. The curve (fig. 6) from our data shows that the number gradually increased from the 15-mm. (0.59-inch) to the 75-mm. (3.0-inch) class groups. After this, a small decrease occurs in the 85-mm. (3.3-inch) class, followed by an increase in the next two 10-mm. increments. The number then decreases to the 125-mm. (4.9-inch) class group, from which a very large increase takes place to the 155-mm. (6.1-inch) class group. The numbers in the following classes fall off sharply to the 185-mm. (7.3-inch) class.

As variable numbers of surf clams below 3.1 inches long pass through the bars of the dredge, the length-frequency curve plotted from our data does not represent truly the number of clams present below that size. The population of surf clams less than 3.1 inches is probably much greater than the data

low. All dredges used were constructed to catch and retain most, if not all, of the clams greater than 3.1 inches. Assuming nearly equal representation for all year classes contributing to the groups above 3.1 inches long, one would expect the number of clams between 3.1 and 5.5 inches to be greater than the numbers of 5.5 to 6.7 inches because of natural mortality.

This kind of population structure is possible if one or more dominant year classes exist at infrequent intervals, as Ropes and Martin (1960) suggested for the hard-clam population of Nantucket Sound. However, this does not seem likely for the surf clam because 5.5- to 6.7-inch clams have dominated the population for the past several years. A better explanation may be that surf clams grow rapidly during the first few years of life, then grow slowly for an extended period. Many rapidly growing small clams would enter the slow-growing period, so the number of large clams present would represent the cumulative total of a number of year classes, not a single year class. When the problem of determining the age of surf clams is solved, it may help to answer this question.

Bottom Types

A relation was found between the mean number of clams caught and the bottom type fished (table 5--see note on p. 56). The bottom in Area III was divided into 4 general classifications: (1) sand, (2) gravel, or a combination of gravel and sand, (3) mud, clay, or a mixture of both, and (4) unknown (tows taken where a bottom sample was not obtained). Of the general types identifiable from contents of the dredge, 65 percent were classified sandy, 14 percent gravel, 9 percent mud-clay, and 12 percent unknown. The types arranged with most productive listed in order are: (1) gravel, (2) sand, (3) mud-clay. The mean catch from stations with gravel bottom was $2\frac{1}{2}$ times that from sand, and $5\frac{1}{2}$ times that from mud-clay.

Water Depths

In Area III, depths of water fished ranged from 7 to 28 fathoms. The best catches were made between 14 and 18 fathoms (fig. 7, table 5). These data show that the average number of clams caught from 10 to 13 fathoms was fairly constant. The catch rate increased steadily between 14 and 18 fathoms, then declined to zero at 25 fathoms.

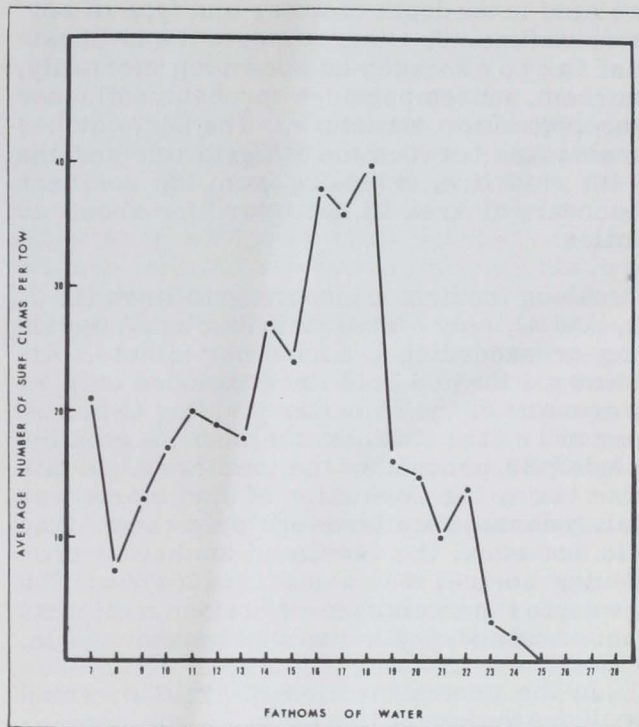


Fig. 7 - Depth distribution of surf clams in Area III.

Data analyzed according to depth increments seem to indicate some relation between depth of water and number of clams caught.

Catch rates by water depth and type of bottom are shown in figure 8 and table 6 (see note on p. 56). These data indicate that for each bottom sediment the best catches were made in those sections where depth varied between 15 and 19 fathoms.

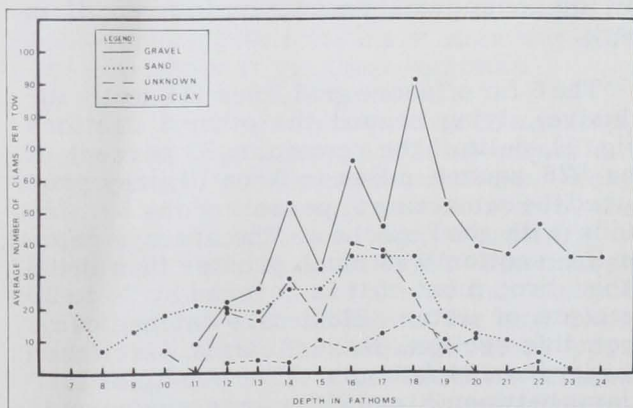


Fig. 8 - Relation of catch rate to water depth and different bottom sediments in Area III.

Populations

Most catches were less than 1 bushel. Generally, the density of clam population was

related to the depth of water and type of bottom sediments. Other biological and physical factors--such as spawning, mortality, current, and temperature--probably influence the population structure. The best catches were taken between the 4th grid line and the 14th grid line, extending from the southern boundary of Area III northward for about 40 miles.

Along the first 4 inshore grid lines (1, 2, 3, and 4), only 6 stations had a catch equaling or exceeding $\frac{1}{4}$ bushel per minute. Although these 4 grid lines included only 11 percent of the 55 better yielding ($\frac{1}{4}$ bushel per minute) stations, the inshore area included 22 percent of the total area. In this section, the population of surf clams was fairly dense in scattered spots; however, they did not equal the density in the better-producing central area described below. The greater percentages of bottom sediments were mud and clay in the shoal inshore area.

In the central section of Area III, which includes the 8 grid lines 5 to 12, the population density was much greater than in either inshore or far offshore sections. The area defined by these 8 grid lines, although including only 45 percent of total area, produced 78 percent of the tows taking $\frac{1}{4}$ bushel or more of clams per minute. The greatest percentages of high-yielding bottom sediments are within this section, overlain by the assumed optimum water depths. All stations that produced catches of 1 bushel or more per minute (up to maximum of 2 bushels) were located within this section. The best possibility for commercial production in Area III is here.

The 6 far offshore grid lines (13 to 18 inclusive), lying beyond the other 2 sections (fig. 1), delimit the remaining 33 percent of the 926 square miles in Area III; they produced the remaining 11 percent of the 55 stations with good catches. The average depth in the section was much greater than in the other two; most of it is covered by 20 to 28 fathoms of water. Most zero catches came from this section. No surf clams were taken deeper than 24 fathoms. The density of surf clams between 20 and 25 fathoms was considerably less than for under 20 fathoms.

The catch rate reflects the surf clam population available to the dredge. Catch data show that the number of clams for any unit of sea bottom is small. At an average tow-

ing speed of 1.25 miles per hour, 1,760 square feet of bottom could be covered during a 4-minute tow with a 48-inch dredge. Assume that all clams available were retained by the dredge, and use 60 as the number of commercial size clams needed to fill a bushel measure. At a catch rate of 0.2 bushel per 4-minute tow, there would be an average of one clam per 116 square feet of bottom area. At a catch rate of 1 bushel per 4-minute tow, one clam would be present per 30 square feet of bottom. A density of one clam per square foot of bottom would give a catch rate of 30 bushels per 4-minute tow, or about 150 bushels per 20-minute commercial tow. To our knowledge, this never has been reached during commercial fishing operations. The same process can be used for smaller size clams after adjusting the numbers of individuals in the bushel measure.

Within any area, the density of clams may vary considerably from subsection to subsection owing to spawning mortality, random distribution of the young clam, effects of ocean currents, varying bottom sediments, depth of water, natural mortality, predation and possibly migration of the clams. While the dredge is operating, it will pass through areas of dense, good, fair, poor, and zero populations of clams in a direct relation to the cumulative effects that environmental factors have had on the establishment of clam populations. Although these factors also affect the population structure of every small geographical subsection, the overall effect is more noticeable in larger areas, such as the middle section of Area III, where the depth and bottom sediments seem to have established the best surf clam populations in the area.

OCEAN QUAHOGS

Ocean quahogs (*Arctica islandica*) were found in varying numbers--from 1 to 879 per tow at 220 of the 894 survey sites in Area III. The best catches were made where the depth varied between 20 and 25 fathoms (fig. 9, table 2). In shallower waters, they were mixed occasionally with surf clams, but they were never the dominant species in the catch. Beyond 25 fathoms they occurred in intermediate numbers.

Geographically, the best catches of ocean quahogs were along the 25-fathom contour in the area's northeast section, where the bottom generally was quite flat and was com-

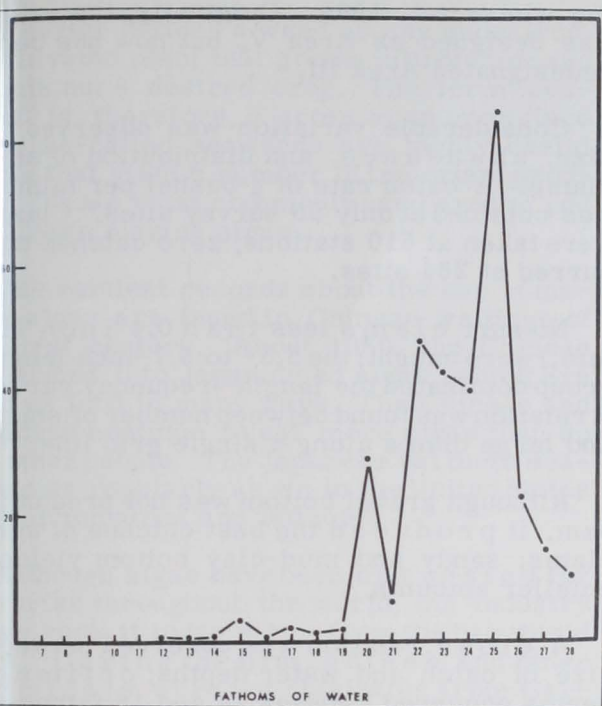


Fig. 9 - Depth distribution of ocean quahogs in Area III.

posed mostly of hard sand. Southward, as the water became shallower, the catches became smaller.

The production potential for this species is good in those sections where they are most abundant (table 7--see note on p. 56). From these sections, commercial fishermen can expect catches of about 15 bushels per 20-minute tow, which is sufficient for commercial exploitation.

PROBLEM OF THE CLAM FISHERY

Harry J. Turner, Jr. wrote in 1953: A fundamental problem that besets (clam fishery) is that mollusks are extremely erratic in their propagation and variable in their growth and survival. Isolated localities may be phenomenally productive at one time and completely barren for a long period. The gaps in our present knowledge of the chain of events that bring about a mature crop of shellfish are so extensive that the actual occurrence of such a crop appears almost accidental. During the general populations development pattern common to most clam species there occurs a large number of interesting physical and biological factors affecting the survival. The problem of achieving maximum production involves the determination of these factors and assessment of their individual relative importance in the hope that certain factors can either be regulated

or controlled to expand the actual production toward the theoretical potential."

Before any intelligent proposal could be made for the establishment of a management program for Area III, most, if not all, factors influencing any surf clam population must be investigated and evaluated. One of the most important factors in the life history of any living organism is its reproduction. In Area III, it seems that some relation exists between the number of large clams (over 4 inches) and the number of smaller surf clams (less than 4 inches) along each separate grid line (table 8--see note on p. 56). Turner (1953) quotes previous authorities as indicating that the reproductive products of one sex may influence the spawning reaction of others so that a chain reaction may be set off. If this situation applies to surf clams, then in those sections of Area III where the spawning populations are concentrated, enormous amounts of spat and eggs could be released into the surrounding water at one time. Based on Turner's (1953) assumption that each mature female produces a million or more eggs annually, the number of young clams available for setting and growth to maturity, even in relatively sparsely populated areas, could be tremendous.

The concentration of small clams as well as large clams in an area add some support to Turner's hypothesis (1953) that, during the surf clams' free-swimming (veliger) stage, their movement may be quite restricted. With increased knowledge of the larval stages and physiology of the surf clam, it might be possible to locate stocks of spawning surf clams in areas of greatest potential.

In any large sea clam producing area, bottom sediment concentrations may affect the size and extent of clam populations. Possibly because of these physical factors, the better concentrations of surf clams are in the central section of Area III. The coarse sand and gravel substrate of this section evidently are ideal habitat for surf clam growth and survival. Although these types of sediments occur in other sections of Area III, they never occur over as broad an area. Of course, it must be remembered that other factors also affect the populations in the central and other sections of Area III.

Turner (1949) states that in Massachusetts the growth of the surf clam varies with locality and year to year, but it is more uniform

than other commercial mollusks. A surf clam may reach $3\frac{1}{2}$ inches in $2\frac{1}{2}$ years; it reaches 4 inches in 5 years. Clams 5 to 6 inches are estimated to be at least 10 years old.

Belding (1910) stated that the surf clam may reach sexual maturity at 1 year, but the first important spawning season occurs in its second year. By 5 years, it would be about 4 inches long.

Studies to determine the age and growth of the surf clam are now under way by the BCF Biological Laboratory, Oxford, Md. Past indications are that the life span of the surf clam is fairly long and growth is rapid only during the first few years. Probably the growth rate of the surf clam in Area III gradually decreases (from the very rapid early growth rate) until it reaches about 6.5 inches, when very slow growth occurs for the remainder of its life span. Only a few clams reach the maximum length of over 7 inches.

SUMMARY

A surf clam survey with 894 sampling stations and 53 simulated commercial tows was made between Ocean City, Md., and Cape Charles, Va. BCF's Rorqual was used during summer 1964 and BCF's Delaware dur-

ing winter-fall 1965. Originally, the area was designed as Area V, but now has been redesignated Area III.

Considerable variation was observed in size, abundance, and distribution of surf clams. A catch rate of $\frac{1}{4}$ bushel per minute was obtained at only 55 survey sites. Clams were taken at 610 stations; zero catches occurred at 284 sites.

No surf clams less than 0.4 inch (10 mm.) were caught; the 5.5- to 6.7-inch length group dominated the length-frequency curve. A relation was found between number of small and large clams along a single grid line.

Although gravel bottom was not predominant, it produced the best catches of surf clams; sandy and mud-clay bottom yielded smaller amounts.

A close relation was observed between size of catch and water depths; optimum depths occurred between 14 and 18 fathoms.

Simulated commercial tows indicate our sampling method is reliable for assessing surf clam resource.

Smaller and fewer beds of ocean quahogs were found in Area III than in Areas I and IV.

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