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ASSESSMENT OF SURF CLAM STOCKS IN NEARSHORE WATERS ALONG THE DELMARVA PENINSULA AND IN THE FISHERY SOUTH OF CAPE HENRY[1, 2]

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ABSTRACT

In 1974 the abundance of surf clams was sampled from Delmarva Peninsula, Delaware south to North Carolina. Surf clams were not found in commercial densities in the inshore waters along the Delmarva Peninsula. Off shore and south of Cape Henry, an area of intense surf clam fishing, the estimated standing crop was 10 million bushels. A length-age relationship was estimated and it implies that recruitment to the fishery occurs at approximately age 2, at an average annual rate of about 8%. It is concluded that because of the low recruitment rate relative to the heavy fishing pressure that Virginia surf clam stocks have been overharvested in recent years.

INTRODUCTION

The fishery for surf clams, *Spisula solidissima*, presently supplies meats for about 80% of all clam products in the United States. In the late 1940's and early 1950's the surf clam was a relatively unknown resource, but the fishery has since experienced dramatic growth. In 1950, for instance, only 8 million lbs. of surf clam meats were landed; by 1974, however, the reported meat landings were 96 million lbs. (Current Fishery Statistics, 1974). Beds located off the New Jersey coast were the major source of surf clams until the late 1960's (Ropes, 1972). Since then effort has shifted to beds off the Delmarva Peninsula and Virginia. Virginia landings of 58 million lbs. of surf clam meats in 1974 were 60% of the United States total.

Declining surf clam densities in the overfished beds off New Jersey promoted consideration of management plans for the fishery. In June, 1973, representatives from industry, the National Marine Fisheries Service (NMFS) and the States of New York, New Jersey, Delaware, Maryland, and Virginia formed a Surf Clam Technical Committee and a Sub-Council. The functions of the Technical Committee are to direct investigations of the resource and identify management alternatives. The Sub-Council, guided by the findings of the committee, is to formulate management policy. These two bodies are part of a more comprehensive State-Federal Fisheries Management Program administered by the Northeast Marine Fisheries Council.

This report is an account and analysis of the investigation of the surf clam resource in October, 1974, in the inshore waters of the Delmarva Peninsula, and in the area offshore of Cape Henry, Virginia and south to upper North Carolina. The

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inshore investigation along the Delmarva Peninsula complemented an offshore investigation in this region by NMFS in August, 1974. The main objectives of the study were to estimate the distribution and abundance of adult and juvenile surf clams along the Delmarva Peninsula and in areas of intense harvesting off the Virginia coast. The project was a joint undertaking by NMFS and the Virginia Institute of Marine Science (VIMS).

MATERIALS AND METHODS

Surf clams were sampled by a hydraulic tow dredge operated from the VIMS research vessel RETRIEVER. The dredge, supplied by the NMFS, is similar to those employed in the surf clam fishery, but smaller. It has a 76.2 cm (30 inches) blade versus blades ranging up to 254 cm (100 inches) on industrial models. The dredge has a retention bag constructed of 5.1 cm (2 inches) rings versus 7.6 cm (3 inches) rings or cage bars generally used throughout the industry. The relationships of sample catch and its size composition to the total population is unknown since the catch-efficiency of the dredge with respect to surf clams less than 5.1 cm is not known.

Vessel speed was estimated to be 0.5 knot while towing the dredge, thus it was assumed that a standard 5-minute tow provided a sampling unit of 58.8 m^2 (632.9 ft^2) for stock assessment.

Arbitrarily, a surf clam catch $\geq$ 45 clams was considered satisfactory in the sense that the immediate area would warrant future replicate sampling to determine a reliable average catch and the extent of the local distribution. This figure (45) was derived in consideration of the necessity to maintain a constant sampling unit, whereas an experienced fisherman would make gear adjustments to enhance catch according to sea conditions and bottom type.

Sampling stations along the coast of the Delmarva Peninsula were established along lines of latitude at intervals of 1.8, 3.7, and 5.6 km (1, 2 and 3 nautical miles) offshore of the 1 fathom line indicated on the National Ocean Survey chart no. 1109 (Figs. 1 and 2). These transects were spaced at intervals of 9.3 km (5 nautical miles) from just below Cape Henlopen (Rehoboth Beach area), Delaware, to Cape Charles, Virginia. An additional transect of three stations in a north to south direction was sampled inshore near Cape Henry,

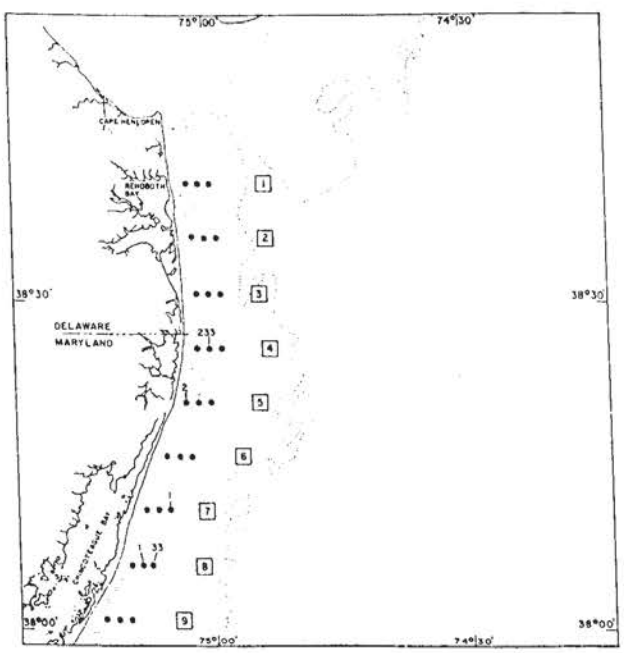

FIG. 1. *Location of sampling stations in the nearshore waters of the upper Delmarva Peninsula. Numbers above the stations indicate the catch of surf clams.*

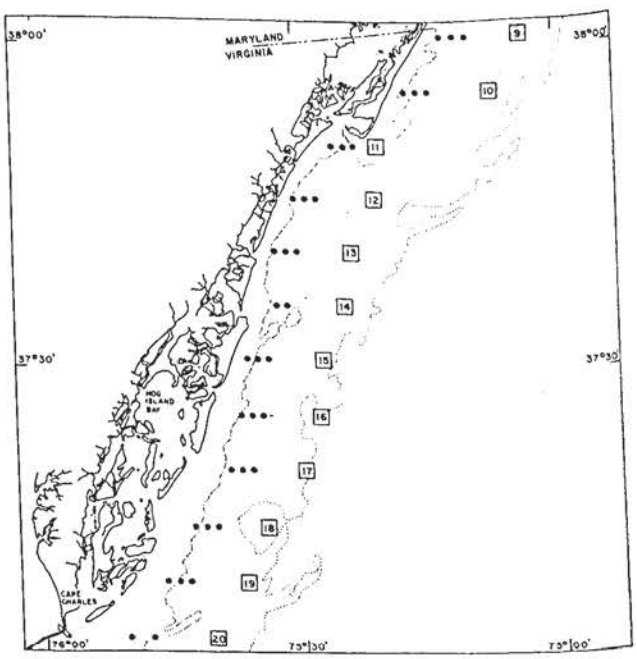

FIG. 2. *Location of sampling stations in the nearshore waters of the lower Delmarva Peninsula. Numbers above the stations indicate the catch of surf clams.*

Virginia (Fig. 3). Offshore of Cape Henry and further south, sampling was conducted along a rectangular grid constructed of six stations on each of 12 transects, in which both stations and transects were at intervals of 4.6 km (2.5 nautical miles). The grid duplicated one sampled by NMFS in August 1974.

Surf clam density was approximated from the product of average catch and area. Sampling did not follow a stratified random sampling procedure or systematic sampling as defined by Cochran (1963) since all station locations were selected. Because there was no underlying probability model, standard errors could not be validly calculated nor interval estimates of densities established.

A constant of 12.6 lbs. of usable meats per bushel was used to estimate standing crop in terms of meat weight. This value, an overall average yield per bushel for 1974 and 1975, was reported by Mr. N. Doughty, owner and operator of C & D Seafood Inc., Oyster, Virginia (Loesch, 1977). The constant of 17 lbs. of meats per bushel used in the U.S. Current Fishery Statistics for converting bushels to meat weight includes the viscera which is not used by the surf clam industry.

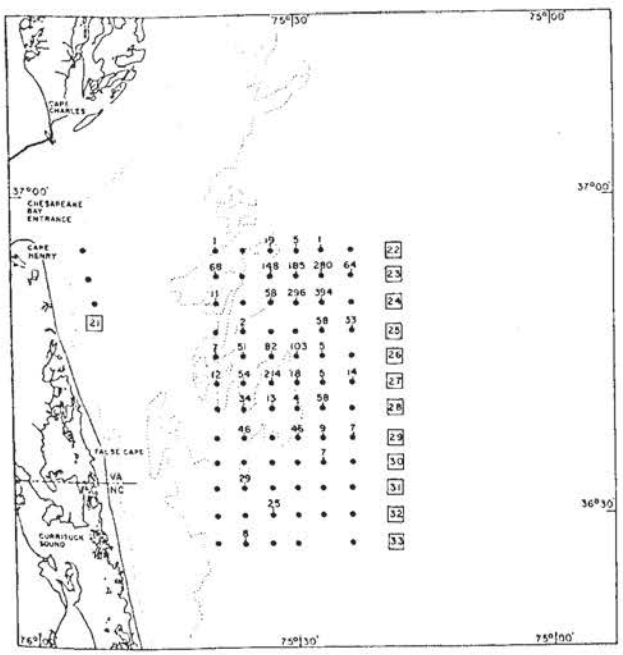

FIG. 3. *Location of sampling stations off the coast of lower Virginia and upper North Carolina. Numbers above stations indicates the catch of surf clams.*

A station is referred to by the transect number followed by its offshore position, e.g., T4(3) is the third station, counting from inshore to offshore, on transect 4 (Fig. 1). Three stations, T14(1), T20(2), and T33(5) were not sampled.

At each station, the catch of surf clams to the nearest 0.1 bushel of clams was measured for length (longest linear dimension).

Two growth curves published by Yancey and Welch (1968) for surf clam stocks of Long Island, New York and off New Jersey were re-evaluated in this report. The age-length relationship for the Long Island clams was ascertained from the growth curve in the unpublished manuscript of Westman and Bidwell (1946); the New Jersey surf clam data were supplied by Welch (personal communication). The Walford analysis (Walford, 1946) was used to transform asymptotic growth functions to the linear form:

$$L_{t+1} = L_\infty(1-k) + kL_t$$

where L_t = length at time t; L_{t+1} = length at the end of a constant time interval (one year in the present cases); $L_\infty(1-k)$ = regression line intercept; k = the regression coefficient; and L_∞ is the asymptotic size, i.e., the average maximum size. The equation is independent of age, but the age-length relationship was estimated by using 0.24 mm (0.01 inch), the midpoint of the general size range of newly settled surf clam spat reported by Loosanoff, *et al.* (1966). At this time, when the larvae leave the planktonic environment and become members of the benthic community, they were established to be age zero. Substitution of the estimated average (0.24 mm) at age zero into the growth function produced an estimate of length at age 1. Growth curves were generated by continuing this process until arbitrarily terminated at age 20.

Average annual recruitment since 1969, the year the area was last surveyed by NMFS, was estimated by assuming a maximum length for age 5 occurred at the mid-point between its average length and the succeeding age group's average length. The short-comings (size overlap by age groups) of this procedure are recognized by the authors, but methods for determining the individual age of surf clams and, thus, stock age

structure have not been developed. [Perhaps growth and age estimates from cross-sectioned shells as presently done with several bivalve species (e.g., Kennish and Olsson, 1975) may eventually be shown applicable.]

A Smith-MacIntyre benthic sampler was employed at each station to sample for juvenile clams. A single 0.1 m^2 (1.08 ft^2) grab sample was taken at each station and wet sieved on a 1 mm (0.04 inch) mesh screen. The portion retained was preserved in 5% formalin and returned to the laboratory for examination.

RESULTS AND DISCUSSION

Distribution and Abundance. A commercial density of surf clams was not found in the inshore waters along the Delmarva Peninsula (Figures 1 & 2). Surf clams were obtained at only six of 58 stations sampled. The total catch was 271 and the average catch was 4.7 clams per standard tow. Commercial abundance was indicated at only one site, T4(2) where the catch, 233 clams, was about 87% of the total catch along this Peninsula. This concentration of surf clams was very limited in its distribution since no clams were taken at the adjacent sites T4(1) and T4(3), nor along transect T3, and only two clams were taken along transect T5.

No surf clams were taken at the three inshore stations (T21) off Cape Henry (Fig. 3).

Offshore of Cape Henry and south to upper North Carolina, 71 stations were sampled (Fig. 3). A total of 2,474 surf clams were taken, averaging 34.8 clams per tow. Two areas of heavy surf clam density were apparent. One was along T23 and T24 where 8 of 12 catches ranged from satisfactory (≥45 clams) to the highest recorded (394 clams). Another group of five spatially associated high catches occurred along T26 and T27. Only four other stations had catches ≥ 45 [T24(6); T28(5); and T29(2&4)]. The catch distribution for the NMFS surf clam cruise in August, 1974, exhibited a similar trend (Ropes, 1974). Standing crop estimates, derived from the average catches, are presented in Table 1 for the entire area, transects T22 through T33 (343.75 $miles^2$), and also for the area between T23 and T29 (187.5 $miles^2$), the north-south boundaries of the highest observed densities for both the NMFS and VIMS cruises. Approximately 89% of the estimated standing crop of about 10 million bushels of surf clams occurred within the T23-T29 boundaries.

Estimation of Growth. The surf clam growth curve presented by Westman and Bidwell (not shown) does not appear realistic for Virginia stocks. By the 17th year the curve still does not tend toward an asymptotic size (L_∞) and the Walford analysis indicated that L_∞ would not be attained until about age 38. Thus, one would have to assume the surf clam lived for well over 40 years. Surf clam longevity is not known, but about 17 years has been suggested (Ropes, *et al.*, 1969).

The growth function ascertained from Welch's data by least squares analysis of length at successive check marks which he interpreted as annual marks is:

$$L_{t+1} = 47.05 + 0.6807\, L_t$$

where length is expressed in mm. Substitution of age zero length, i.e., 0.24 mm, the average length of newly settled spat, and the subsequent substitution of each estimated average length at 1 year intervals produced a curve which appears to be a reasonable approximation of surf clam growth in the Virginia fishery area (Fig. 4). This contention is supported by the reported size of juvenile surf clams of known age off Chincoteague, Virginia (Ropes, *et al.*, 1969). A more intense growth study

TABLE 1. *Standing crop estimates for surf clams in the Virginia fishery area south of Cape Henry. VIMS cruise, October, 1974.*

Area	Number Samples	Average Catch	Bushels Per Acre	Total Bushels (X 10^6)	Meat Wts. (lbs.) (X 10^6)*
T22-T33	71	34.8	34.2	9.96	125.50
T23-T29	42	56.6	55.5	8.84	111.38

*Estimates based on 12.6 lbs of usable meat per bushel.

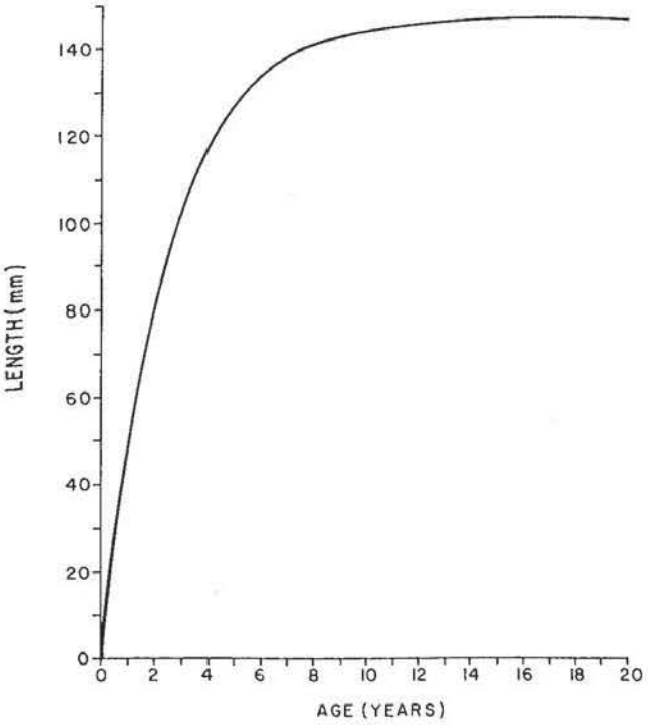

FIG. 4. *The length-age relationship for surf clams derived from the data of Welch.*

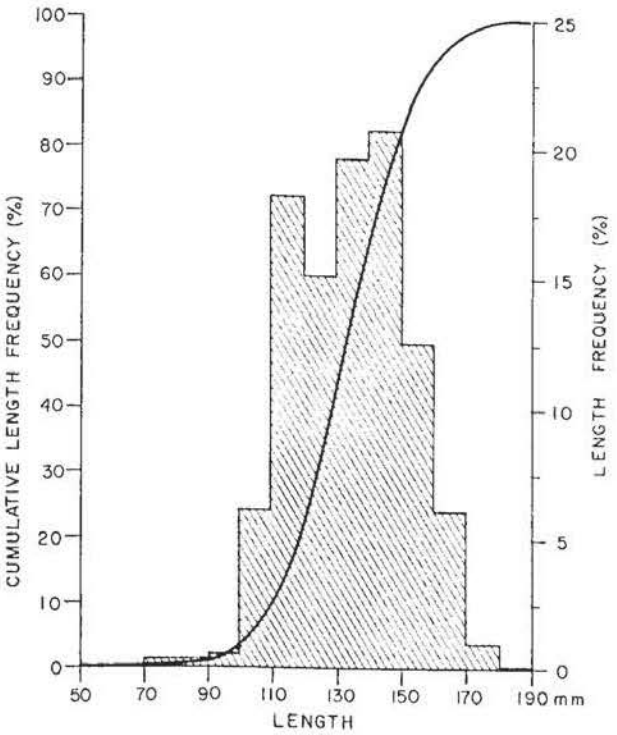

FIG. 5. *The cumulative length frequency percentages of surf clams sampled in the Virginia fishery area south of Cape Henry.*

is needed if long term management of the fishery is considered, since Figure 4 was derived from the data of Welch, who made only 90 check-mark measurements.

The average maximum length (L_∞) was estimated to be 147 mm (5.8 inches) and theoretically reached at about age 14 (Table 2). Of more practical importance are the estimates that 95% of L_∞ occurs at age 8 and 50% by about age 2. The growth curve indicates that recruitment to the Virginia surf clam fishery occurs at age 2, since 76.2 mm (3-inch) rings or cage bars are used in the commercial dredges. Thus, there are not several unexploited year classes which would tend to stabilize a fishery (assuming constant effort) when years of poor setting occur. Potential future recruitment is further reduced by some dredge retention of smaller sizes, and, in addition, a high mortality is suspected for clams which pass through the dredge because the mantle cavity is packed with sand by the hydraulic process.

Length Frequency and Recruitment Estimates. An average length of 133.5 mm (5.25 inches) was estimated from 1,273 surf clam measurements obtained in the Virginia fishery area. The cumulative length frequency curve (Fig. 5) in conjunction with

TABLE 2. *Estimated age-length relationship for surf clams derived from the data of Welch (personal communication).*

Age	Length (mm)	Age	Length (mm)	Age	Length (mm)	Age	Length (mm)
0	0.24	5	125.8	10	144.2	15	146.7
1	47.2	6	132.7	11	145.2	16	146.9
2	79.2	7	137.4	12	145.9	17	147.0
3	101.0	8	140.6	13	146.3	18	147.1
4	115.8	9	142.7	14	146.6	19	147.2

Table 1, indicates that about 40% of surf clams were age 5 or younger. This infers an annual recruitment rate (relative to dredge efficiency) of 8% since 1969 when, prior to 1974, the area was last surveyed by NMFS. Due to the inability to determine stock age structure and the absence of annual surf clam spat set data, it is not known if recruitment is relatively constant or if maintenance of the stocks is dependent upon an occasional strong year class.

If the surf clam harvest is to be managed in order to establish a stable fishery, future annual harvests will have to be reduced relative to those of recent years. An 8% harvest of the estimated standing crop in the total area sampled south of Cape Henry (Table 1) would be about 10 million lbs. of meat, or 9 million lbs. of meat when the smaller area of surf clam concentration (T23-T29) is considered. Virginia landings, based on 12.6 lbs. of usable meat per bushel, were about 32 million and 43 million lbs. of meat in 1973 and 1974, respectively. Mr. N. Doughty estimated that 98% of all Virginia surf clam landings come from an area that is approximately bounded by transects T23 and T27 (personal communication). Therefore, landings far exceed the 8% estimates of standing crop.

Surf Clam Spat. Thirty-two Smith-MacIntyre sediment samples obtained in the Virginia fishery area south of Cape Henry were examined for the presence of surf clam spat. Seven live young-of-the-year clams were present in six of the 32 samples. Size lengths of the young-of-the-year surf clams ranged from 2.2 mm (0.09 inch) to 18 mm (0.71 inch). The duration of surf clam spawning in Virginia waters is not know, but Ropes (1968) reported a major spawning period in summer and a minor period in fall in New Jersey waters. A protracted spawning period would, of course, result in a relatively large size range of the young clams.

The average young-of-the-year catch for the total fishery area (T22-T33) and also for the area of greatest adult density (T23-T29) was about 0.2 clam per grab, i.e., per 0.1 m^2 (1.08 ft^2). By extrapolation it is estimated that the young-of-the-year density was approximately 2.4 billion clams in the former area and about 1.3 billion in the latter. If an 8% survival to age 2 is assumed with an average size of 79.2 mm (3.1 inches), and averaging 170 clams per bushel (Ropes, unpublished data) with a yield of 12.6 lbs. of usable meats per bushel, the estimated recruitment in 1976 will be approximately 14 million lbs. of meat to the total area and about 8 million lbs. to the lesser area. These estimates are based on a few data, but are in reasonable agreement with the previous ones based on 8% of the adult standing crop, and they indicate that recent annual harvests exceed recruitment. This conclusion would still be reasonable even if recruitment was underestimated by 100%.

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