

Assessment Update for Middle Atlantic Offshore
Surf Clam, Spisula solidissima, Populations -
Winter 1983-1984

by

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SUMMARY

Atlantic surf clam, Spisula solidissima, populations inhabiting offshore (Fishery Conservation Zone) waters of the United States East Coast have been managed since November 1977 under provisions of the Magnuson Fishery Conservation and Management Act (MFCMA). Prior to enactment of the comprehensive management plan, stock abundance and total commercial landings declined; landings decreased from 96.1 million pounds of shucked meats in 1974 to 49.1 million pounds in 1976. Regulation of the fishery has proceeded with one objective being the rebuilding of Middle Atlantic offshore stocks. Various regulatory devices to attain this and other objectives have included annual landings quotas, a moratorium on new vessel entrants, closure of areas to protect prerecruit sized clams, effort restrictions, and, most recently, a minimum clam size. This report provides an updated stock status review for Middle Atlantic waters (through December 1983) based on commercial vessel logbook data and catch sampling and the results of research vessel surveys conducted by the Northeast Fisheries Center.

Total surf clam landings during 1983 increased to 55.9 million pounds of meats, up 13% from the 1982 level of 49.7 million pounds. The proportion of total clam landings taken from the FCZ increased to 81% from 74% the previous year. Inshore landings (primarily from off New Jersey) declined 17% during 1983, to 10.8 million pounds.

Catch per unit of fishing effort (CPUE, in bushels per fishing hour) increased dramatically during 1983 in three of four Middle Atlantic surf clam assessment areas. However, increases in fishery productivity were due only in part to recruitment of strong 1976 and 1977 year classes off northern New Jersey and Delmarva, respectively. Much of the increase in CPUE (particularly during the last quarter of 1983) was due to increased utilization of undersized clams. Concomitant with increased catch rates was a substantial decline in discarding rates, from 50% of landings during the last quarter of 1982, to about 20% for the last quarter of 1983.

Surf clam resources in the Middle Atlantic FCZ continue to be dominated by strong 1976 and 1977 cohorts. However, subsequent year classes appear to be relatively weak. Given the long period between spawning and recruitment to the fishery (6-7 years), the 1976 and 1977 cohorts will support the fishery until at least the end of the decade.

Although the absolute size of prerecruit resources off New Jersey, Delmarva, and southern Virginia-North Carolina are not known, it is clear that adequate resource currently exists to support the fishery for about 14 years at 40 million pounds per year or 11 years at 50 million pounds per year. The effects of significant increases in the quota in the short term without relaxation of the 5½-inch size limit will be to reduce the long-term utilization of prerecruits off northern New Jersey and Delmarva, due to increased levels of discarding.

Introduction

Surf clams (Spisula solidissima) populations inhabiting the Fishery Conservation Zone (FCZ:3-200 n. miles from the U.S. coast) are currently regulated under a fishery management plan (FMP) for Atlantic surf clam and ocean quahog fisheries first implemented in November 1977. Objectives of the initial FMP were: (1) "to rebuild declining surf clam populations to allow eventual harvesting approaching the 50 million pound level, which is the present best estimate of the maximum sustainable yield (MSY), based on the average yearly catch from 1960-1976," (2) "to minimize short-term economic dislocations to the extent possible consistent with objective 1," and (3) "prevent the harvest of ocean quahog from exceeding maximum sustainable yield and direct the fishery toward maintaining optimum yield" (Mid-Atlantic Fishery Management Council 1977). Various regulatory devices used to attain these goals have included annual and quarterly landings quotas, weekly fishing effort restrictions (hours per week), a moratorium on new vessel entrants, closures of specific areas to protect small clams (future recruitment), and most recently (26 July 1981), a minimum clam size of 5½ inches (subject to a tolerance of 10% with a portion of clam cages reserved from enforcement).

This report presents an updated assessment of the status of surf clam resources in offshore Middle Atlantic areas of the FCZ. Previous resource evaluations were presented in the following assessment documents: Brown et al., 1977; Serchuk et al., 1979; Murawski and Serchuk, 1979; Serchuk and Murawski, 1980; Murawski and Serchuk, 1981; and Murawski and Serchuk, 1982. Research vessel survey data, commercial vessel performance, and biological characteristics of the landings during 1983 are analyzed

in an historical context to provide measures of relative resource abundance, recruitment levels, and the potential impacts of various management strategies. In addition, we discuss discarding of undersized clams and the potential effects of high clam densities on growth rates, and relate these effects to the current management program.

COMMERCIAL FISHERY

Total surf clam landings during 1983 were about 55.9 million pounds, an increase of 13% from the 1982 total of 49.7 million pounds (Table 1; Figure 1). FCZ landings (45.2 million pounds) increased 23% from 1982 while state landings (10.8 million pounds) declined by 17%. Total landings in 1983 were 35% greater than the annual average for the five previous years.

FCZ catches increased during 1983 even though annual FCZ landings quotas were identical for 1982 and 1983 (40 million pounds). Increased landings are primarily attributable to higher catch rates (bushels per hour fishing) during the last half of 1983 in three of the four fishery assessment areas (northern New Jersey, southern New Jersey, Delmarva; Tables 2-5; Figure 2). However, these higher catch rates were not reflective of dramatically increased abundance of legal-sized clams, but were associated with increased landings of clams less than 5½ inches (14 cm shell length) (Table 6), particularly off Delmarva.

During 1983 most Middle Atlantic FCZ surf clam landings were derived from off Delmarva (42%), and northern New Jersey (35%), with the remainder from southern Virginia-North Carolina (16%), and southern New Jersey (6%). These percentages are similar to those in 1982 except that the proportion from SVA-NC increased about 10% (Figure 3). Since 1978 the percentage of

total landings derived from the Delmarva region has declined from about 90%, reflecting improved resource conditions off northern New Jersey and the re-opening of areas off Atlantic City that were originally closed to protect dense concentrations of small clams.

Fishery Data Sources

Commercial vessel performance (number of trips, areas fished, landings, hours fished, and catch per unit of effort, CPUE) were derived from the mandatory weekly logbook submissions. These data were grouped by vessel size category (1-50 GRT: Class 1; 51-100 GRT: Class 2, 101+ GRT: Class 3) and analyzed within each of four assessment areas, by calendar quarter. These areas, along with the LORAN coordinates defining them, are given in Figure 2. Assessment areas generally reflect homogeneous regions with respect to the dynamics of clam populations inhabiting them, and relatively distinct fishery production areas. Tables 2-5 and Figures 3-10 summarize logbook data available since the inception of the mandatory record keeping program.

Length frequency sampling of commercial clam landings is routinely conducted in the major surf clam fishing ports of the Middle Atlantic (Atlantic City and Cape May-Wildwood, New Jersey, Ocean City, Maryland, and Chincoteague, Virginia). Samples are analyzed based on assessment areas (Figure 2B) from which they were caught. Sampling protocol is to measure 30 clams from each vessel trip. Since there are often large differences in the catches of individual vessels sampled, length frequencies are weighted by the number of bushels landed in each trip. Numbers of clams measured, mean shell lengths (mm), and percentages of clams above and below $5\frac{1}{2}$ inches are given in Table 6 for each of the

four assessment areas. Data are analyzed on a quarterly and annual basis for the period 1976-1983.

CPUE indices for the four assessment areas (by vessel size class) are given in Figures 4-10. To assess the influence of sub-legal surf clams (less than 14 cm or 5½ inches, shell length) on the indices, we calculated CPUE for the proportion of clams greater than 5½ inches, by using biological catch sampling data (Table 6). These results are plotted along with total clam CPUE data in Figure 4-9. A similar analysis was not performed for the southern Virginia-North Carolina area due to inadequate size distribution catch sampling (Table 6).

Additional data obtained during the vessel interviews include the estimated proportion of total catch discarded as undersized clams. The quantity is expressed as a proportion of the catch landed and is presented on a quarterly basis for the New Jersey (northern and southern combined) and Delmarva assessment areas (Figure 11).

Fishery Performance

Northern New Jersey

Average CPUE (all clam sizes) for vessel classes 2 and 3 increased steadily throughout 1983: vessel class 2 CPUE was 56% higher in the fourth quarter than in the first, class 3 CPUE increased 86% (Table 2, Figure 4). CPUE for class 1 remained stable during the first three quarters (27-29 bushels per hour), and increased 37% during the fourth quarter. Overall, CPUE for class 1 increased 36% from the 1982 total, class 2, 76%, and class 3, 23%, but were not as high as 1981 values (when significant harvesting of small clams was not regulated).

During 1983 about 53% of the landings of surf clams off northern New Jersey was taken by class 2 vessels, 37% by class 3, and 10% by class 1. This trend represents a significant change from previous years when class 3 vessels accounted for the largest proportion of NNJ landings (1982:57%; 1981:67%). The largest proportions of all vessel class 1 trips (54%) and vessel class 2 trips (66%) were conducted off New Jersey, but only 24% of class 3 trips were conducted there. Although 56% of the class 3 trips were conducted off Delmarva, average CPUE (all clam sizes) was nearly equal for the two areas during 1983 (northern New Jersey, 53 bushels per hour, Delmarva, 54 bushels per hour). Some of the class 3 vessel effort from northern New Jersey probably shifted to the southern Virginia-North Carolina region during 1983. Overall, class 3 trips declined 12% during 1983, while class 2 trips decreased by 0.01%. It is likely that the decline in class 3 trips was due to increased quahog fishing by these vessels.

Average clam size landed from the northern New Jersey area declined slightly from the previous year to 146 mm (5 3/4 inches) (Table 6) while the proportion of clams less than 5 1/2 inches increased 9%. About 25% of those clams sampled from northern New Jersey landings were less than the 5 1/2-inch size limit. The proportion of undersized clams was greatest during the second quarter (31%) and least in the third quarter (19%).

When CPUE indices for the northern New Jersey area were adjusted to only track clams greater than 5 1/2 inches, high CPUE values in 1980 and 1981 were reduced. During this period (prior to enactment of minimum size restrictions) considerable quantities of small clams were landed. The increase in CPUE throughout 1983, however, still persists after adjustment.

It is doubtful, however, that these large increases in catch per effort were due to increased abundance of harvestable sized clams (see "Survey Abundance Indices"). Rather, catch sampling for size distributions may not have been adequate to realistically characterize the landings, particularly during the fourth quarter of the year.

Southern New Jersey

The southern New Jersey assessment area accounted for a relatively minor proportion (6%) of the total Middle Atlantic FCZ landings in 1983. Average CPUE (all clam sizes) increased significantly for all three vessel classes during the fourth quarter of 1983 (class 1, 13%, class 2, 91%, class 3, 32%) (Table 3). The yearly CPUE average for class 3 was equal to that for the same vessel class off northern New Jersey (53 bushels/hour), but average catch rates for class 1 and 2 vessels off southern New Jersey were 50% and 66%, respectively, of the northern New Jersey values.

During 1983 about 46% of the southern New Jersey landings were generated by class 2 vessels, 42% by class 3, and 12% by class 1. This pattern was again different from previous years when class 3 vessels accounted for the majority of the catch.

Average clam sizes in landings samples from off southern New Jersey during 1983 were significantly greater than from the other three assessment areas. Mean shell size for the year was 160 mm (6.3 inches), with the proportion of undersized clams averaging 13.4% for the year (Table 6). However, no samples were taken from southern New Jersey catches during the fourth quarter of the year (when CPUE increased markedly). Considering the relatively low abundance of harvestable sized clams off southern New Jersey (see "Survey Abundance Indices") it is likely that the large

increase in CPUE during the fourth quarter was due to increased landings of small clams (particularly in the area adjacent to survey stratum 88 (Figure 2A). When CPUE indices are adjusted to only account for clams $\geq 5\frac{1}{2}$ inches (Figure 7), long-term trends are virtually identical to those for all clam sizes (Figure 6). The exception is the last calendar quarter for which we assumed that Delmarva catch sampling for size distributions was adequate for determining the proportion of landings represented by small clams (53.9% small clams during the fourth quarter of 1983).

Delmarva

CPUE indices for the Delmarva assessment area increased sharply during the fourth quarter of 1983 (class 1, 32%, class 2, 27%, class 3, 9%), but not as greatly as in the New Jersey assessment areas (Table 4). Average CPUE values for the three vessel classes during 1983 were significantly greater than corresponding 1982 values, and were relatively close to 1981 averages. Vessel class 3 accounted for 89% of the 1983 landings off Delmarva, class 2, 8%, and class 1, 3%. Only about 22% of total class 1 vessel trips and 13% of class 2 vessel trips were conducted off Delmarva, but 56% of all class 3 trips were located there. Average CPUE (all clam sizes) for class 3 (54 bushels per hour) was virtually identical to the corresponding value for the New Jersey assessment areas, but was well below the average CPUE figure for class 3 off southern Virginia-North Carolina (71 bushels per hour).

Average clam size for landings off Delmarva during 1983 was 149 mm (5 $\frac{7}{8}$ inches), nearly equal to that off northern New Jersey (Table 6). Average clam size, however, dropped abruptly during the fourth quarter

of 1983 to 140 mm ($5\frac{1}{2}$ inches). Correspondingly, the proportion of clams greater than $5\frac{1}{2}$ inches declined from 69% during the third quarter of 1983 to 46% in the fourth quarter. When CPUE indices are adjusted to account only for large clams (Figure 9), there was a decline in CPUE for clams $\geq 5\frac{1}{2}$ inches for all three vessel classes during the fourth quarter. Although the time series of CPUE for all clam sizes indicates a general increasing trend during 1978-1983 (Figure 8), exclusion of small clams results in a stable trend in CPUE throughout the entire time period (CPUE of large clams was virtually identical for class 3 vessels in the first quarter of 1978 and the last quarter of 1983). Thus, fishery landings of the 1977 year class off Delmarva (most of which is currently below $5\frac{1}{2}$ inches shell length), was significant during 1980-1981 and again during 1983 (Figures 8 and 9).

Southern Virginia-North Carolina

The southern Virginia-North Carolina (SVA-NC) assessment area accounted for about 16% of total Middle Atlantic FCZ surf clam landings during 1983. This represents an increase of about 10% from the previous year. Virtually all of the SVA-NC landings during 1983 were generated by class 3 vessels (85%), with the remainder contributed by class 2 (15%), and class 1 (<1%). Most of the catches from the SVA-NC assessment area were landed in the ports of Chincoteague, Virginia, and to a lesser extent Ocean City, Maryland (off the Delmarva coast).

Average CPUE for class 3 vessels increased 16% from the previous year, but showed a declining trend (13%) during the last quarter, in contrast to the other three assessment regions (Table 5). Average CPUE (all sizes) for class 2 increased slightly (12%) during the last quarter of 1983.

Average size of surf clams landed off SVA-NC was the smallest of all the assessment areas during 1983 (143 mm or 5.63 inches). The proportion of clams less than 5½ inches was about 34% during the year, greatest of the four assessment areas. Catch samplings were insufficient to prorate the CPUE time series for SVA-NC (Table 6). However, it is apparent from the limited catch sampling available that a large proportion of the SVA-NC catch is comprised of clams less than 5½ inches shell length. This conclusion is consistent with research vessel sampling which indicated a predominance of small clams off SVA-NC (see "Survey Abundance Indices").

Discards

Data on discarding at sea of small surf clams are reviewed in Figure 11 for the New Jersey (northern and southern combined), and Delmarva assessment areas. Quarterly averages were computed for 1982 and 1983. Percentage discard represents the amount of small clams in bushels in relation to the quantity landed. Thus, if the discard was 50%, then about one-third of the catch at sea was not retained. Trends in the discard rate were similar for the two assessment areas. Discarding peaked during the fourth quarter of 1982 (about 50%), and subsequently declined to about 20% during the last quarter of 1983. The dramatic decline in discarding (particularly in the last quarter of 1983) was associated with increasing CPUE indices (all sizes) in these areas (Tables 2-4). Considering the size distribution data (Table 6), the decline in discarding rate in the two areas was not as much a function of increasing numbers of harvestable size clams, but rather represented a larger proportion of small clams being landed rather than culled at sea.

SURVEY ABUNDANCE INDICES

Research vessel shellfish assessment surveys in offshore Middle Atlantic waters have been conducted since 1965 (Table 7). Sampling procedures, design, and gear specifications have previously been described in Murawski and Serchuk (1981).

Survey strata were grouped into four sets corresponding to the geographical boundaries of the principal offshore surf clam fishery areas (i.e., northern New Jersey, southern New Jersey, Delmarva, southern Virginia-North Carolina; Figure 2A) to facilitate comparisons with the commercial fishery data. Strata set groupings, areas, and depth ranges of the various individual strata are given in Table 8. For each strata set, relative abundance indices were calculated in terms of stratified mean number and mean weight per tow, standardized to a 1.5 m (60 inch) wide dredge towed for five minutes (see Murawski and Serchuk, 1979, for appropriate computational formulae). Length frequency data and shell length-meat weight relationships were used to derive survey catch per tow indices (numbers, meat weight) (Serchuk and Murawski, 1980). Weight per tow indices are presented for the SVA-NC assessment area for 1983 only, as this region has not been adequately sampled in recent years.

Catch per tow indices for the entire time series are presented in Tables 9-12. Included are percentages of the catch data (numbers and weights) above the current minimum harvestable size ($5\frac{1}{2}$ inches shell length). Survey length frequency distributions for northern New Jersey, southern New Jersey, and Delmarva, 1976-1983, are given in Figures 12-14.

As described above, time series data on length frequency sampling of the SVA-NC area are not sufficient for analysis. Survey catch data are described for each assessment area individually.

Northern New Jersey

Stratified number-per-tow indices declined steadily between May 1965 and April 1976, and more rapidly between 1976 and 1977 (Table 9). From May 1965 to April 1976 total numbers declined 66% while clams $5\frac{1}{2}$ inches or greater dropped in abundance by 53%, and those less than $5\frac{1}{2}$ inches by 85%. The proportion of total numbers per tow comprised of clams $\geq 5\frac{1}{2}$ inches increased from 59% in May 1965 to 82% in 1976, indicative of poor recruitment during this period. Biomass indices of clams $< 5\frac{1}{2}$ inches declined 90% during the period. Primarily as a result of the hypoxic water event off the New Jersey coast during 1976, the total number per tow index declined 81% between 1976 and 1977; total biomass 89%. Numbers and weight per tow further declined from 1977 to January 1978. The December 1978 survey revealed significant new recruitment in the northern New Jersey assessment area. Subsequent age and growth analyses indicate that these clams were spawned in 1976. Surveys conducted after 1978 have confirmed the presence of this cohort and provide data to track growth rate of this year class (Figure 12).

Total mean number per tow increased from 2.06 during the January 1978 survey to 44.88 in December 1978. In five subsequent surveys, total numbers per tow have averaged 62.01. Total numbers and weight per tow indices declined from 1982 to 1983; however, most of this decline was attributable to indices for small clams. Although the indices for

small clams declined between 1982 and 1983, these declines were not statistically significant as much of this resource is located in high density areas (particularly off Atlantic City) where abundance indices are apt to be highly variable. The 1982 and 1983 abundance indices in numbers and weights for small clams were the highest in the 19-year time-span of the surveys. Abundance indices for large clams remained relatively stable during 1982-1983. The percent of clams in the harvestable portion of the size distribution increased 3.6% indicating a slight (but not significant) increase in the proportion of clams in this size range. Nevertheless, 87% of clams (in numbers) off northern New Jersey remain below $5\frac{1}{2}$ inches shell length.

Total weight per tow indices have increased greatly since January 1978 (August 1980-1983 average 5.42 kg/tow) to levels equivalent to the mid- to late 1960's, primarily due to the large proportion of small clams in recent survey samples. Biomass of harvestable clams, however, remains significantly below levels of the mid- to late 1960's (the 1982-1983 average biomass index of 1.60 kg/tow is 36% of the 1965-1969 average of 4.4 kg/tow).

Year classes spawned from 1977-1981 appear relatively weak with respect to the 1976 cohort off northern New Jersey (Figure 12). Since clams first recruit to the survey gear at about age 2 (50-70 mm shell length), evaluations of the strengths of the 1982 and 1983 year classes cannot yet be performed.

The single year class nature of the clam resource off northern New Jersey (particularly in stratum 88) allows for comparison of growth rates with growth curves originally derived from specimens taken during the

December 1978 survey (Serchuk and Murawski, 1980). Average shell size of clams from stratum 88 (the location of the Atlantic City closure area) were computed from successive surveys during 1978-1983. These data were compared to calculated lengths at age from pre-1978 clams (accounting for the various times of the year during which the surveys were conducted):

Survey Date Month/Year	Mean Size (mm)	Calculated Mean Size (mm)	Difference	Percent Difference
Dec. 1978	76.21	75.15	+1.06	+1.41
Jan. 1980	107.91	98.52	+9.39	+9.53
Aug. 1980	108.67	108.50	+0.17	+0.16
Aug. 1981	118.38	122.39	-4.01	-3.28
Aug. 1982	118.45	132.97	-14.52	-10.92
Aug. 1983	118.81	141.01	-22.20	-15.74

These data indicate that for the first four years of life the 1976 year class off the Atlantic City area grew at a rate consistent with previous cohorts (that were much less dense). However, since 1981 the rate of clam growth has been retarded, and the difference between predicted and actual shell size has increased (to about 16% during August 1983). These data suggest that the high densities in the Atlantic City closure area may be inhibiting clam growth. However, it should be noted that the fishery operating during 1982 and 1983 may have differentially cropped large clams from the area, thus, the apparent lack of growth in mean size may be partially the result of differential fishing mortality on large clams. However, data presented herein and results of intensive sampling in the closure area (Dr. H. Haskin, Rutgers University, personal communications). suggests that at very high densities growth rates of surf clams are reduced. Results of the intensive sampling of the closure area have

revealed a similar pattern of reduced growth rate relative to historical patterns. However, the differences in observed vs. predicted shell size were not as great as in our analyses.

Southern New Jersey

Total stratified mean number and weight per tow indices for the southern New Jersey assessment area declined from 1965-1970, increased in 1974, and subsequently dropped to the lowest observed values in 1977 (Table 10; Figure 13). Since 1980 total indices have stabilized, but at a level considerably below that observed during the mid- to late 1960's. The August 1982 and August 1983 number per tow indices were 74 and 86% less than the 1965-1969 average, respectively. Similarly, weight-per-tow values observed in the August 1982 and 1983 surveys were 64 and 78% less than the 1965-1969 average (9.64 kg/tow). Prerecruit indices for the southern New Jersey area were highest in 1965. Although slight improvement in prerecruit indices was observed in the 1978-1980 surveys, the average number per tow of $<5\frac{1}{2}$ -inch surf clams off southern New Jersey during December 1978-1980 surveys (3.31) was 8% of the comparable average off northern New Jersey. Prerecruit indices in weight and numbers from the August 1983 cruise declined from 1982 values and were similar to those in 1980 and 1981, indicative of a relatively poor prerecruit resource in the southern New Jersey area. Since 1966, clams $\geq 5\frac{1}{2}$ inches have dominated the number and weight-per-tow indices (generally greater than 80%). Virtually the entire southern New Jersey surf clam resource (87%) is currently greater than the minimum legal size. Hence, although the abundance of clams in the southern New Jersey area is relatively low, their

large size was responsible for slight increases in commercial effort in southern New Jersey, in 1982 and 1983 (Figure 3) from 1980 and 1981 levels since much less culling of catches to meet the minimum size regulation is required. These data are consistent with commercial catch sampling which indicated that 87% of landings during 1983 were $\geq 5\frac{1}{2}$ inches (Table 6).

Delmarva

Indices of total numbers per tow were relatively stable between 1965 and 1976, but declined by approximately half between surveys conducted in 1977 and January 1978 (Table 11; Figure 14). Total catch-per-tow values (in numbers) for the last six surveys (1978-1983), however, have been the largest observed in the time series. Relatively large variations in recent prerecruit catch-per-tow indices (since December 1978) are due primarily to a few survey tows yielding extremely large numbers of young clams (primarily in strata 85 and 9). Abundance indices of exploitable sized clams have not exhibited such variability. As in northern New Jersey, the relatively high prerecruit indices in Delmarva reflect the successful settlement of a single year class. In this case, however, size frequency data and ageing analyses indicate the Delmarva prerecruit resource to be primarily composed of the 1977 year class.

During 1983 the total index (numbers) off Delmarva decreased 53%; the total weight index declined 33%. However, average numbers per tow of harvestable sized clams increased by 82%, and weight by 70%. Numbers of prerecruit clams declined by 62%, and prerecruit weight by 55%. These data, along with size distribution analyses (Figure 14), indicate that

considerable numbers of 1977 year class clams recruited to the harvestable portion of the population during 1983. Although some of the decline in prerecruit populations is attributable to growth into the exploited phase, most of the variability in prerecruit indices is likely due to normal sampling variation for highly aggregated populations, and some from catches and associated discards of this size group (Table 6; Figure 11). The proportion of the Delmarva stock biomass in the exploitable phase increased from 17 to 44% between August 1982 and August 1983 surveys. Growth rates of the 1977 year class off Delmarva appear to be consistent with historical patterns (Serchuk and Murawski, 1980); there does not appear to be significant density related growth inhibition off Delmarva. Average growth of the 1977 year class appears to have reached and surpassed growth rates of the 1976 year class off New Jersey. Thus, it is likely that the recruitment rates (into the exploitable phase) will be higher off Delmarva than off New Jersey during 1984 and 1985.

Southern Virginia-North Carolina

Stratified mean number per tow indices for the 12 cruises during which the southern Virginia-North Carolina assessment area was surveyed are given in Table 12. As noted before, average weight-per-tow indices were not computed for surveys prior to 1983. Currently, a large proportion of the southern Virginia-North Carolina population is comprised of prerecruit sized clams (89% in numbers, 80% in weight). Total number per tow in the southern Virginia-North Carolina area during 1983 was considerably less than in surveys during the mid- to late 1960's, when a large population of surf clams occurred off the mouth of Chesapeake Bay. Nevertheless, the resource has apparently increased from

the mid-1970's levels when populations were at very low levels, and fishing activity was virtually nil (Figure 3). The recovery of populations off southern Virginia-North Carolina appears coincident with that off Delmarva. Thus, it is probable that they are both dominated by the same strong year class (1977). Average shell lengths in southern Virginia-North Carolina and Delmarva landings sampling were similar in both areas, further evidence for the co-occurrence in both areas of the strong 1977 year class.

CURRENT STATUS AND PROJECTED FISHERY IMPACTS

Significant changes in the areal distribution of offshore surf clam fishing effort and landings occurred starting in the fourth quarter of 1980. Prior to this time, and for several successive years, between 80% and 90% of FCZ landings were derived off Delmarva. During 1981-1982, however, the Delmarva proportion of total landings decreased to about 48% and declined again in 1983 to 42%. Northern New Jersey landings increased from 10% in 1980 to 48% in 1981, and subsequently declined to 40 and 35% in 1982 and 1983. The proportion of landings from southern New Jersey remained relatively low and constant during 1978-1983, but landings from southern Virginia-North Carolina increased markedly from less than 1% in 1980 to 3% in 1981, 6% in 1982 and 16% in 1983. Part of the shift of effort by large vessels (class 3) to southern Virginia-North Carolina grounds resulted in declines in effort in other areas. However, the overall decline in class 3 effort during 1983 was 12%, some of which was probably transferred to the ocean quahog fishery.

The initial shift of effort from Delmarva to northern New Jersey (late 1980 and early 1981) occurred in response to the increased recruitment to the fishery of 1976 year class clams off northern New Jersey. However, with the implementation of the minimum shell size regulation (26 July 1981), the proportion of landings comprised of 1976 year class clams from off northern New Jersey has since declined.

Commercial CPUE indices sharply increased off northern New Jersey and Delmarva during late 1980-late 1981 in response to the increased harvest of the 1976 and 1977 year classes, respectively, in those areas. With the implementation of the minimum size limit CPUE subsequently declined to levels observed prior to the usage of small clams, reaching their lowest values during 1982. Since then, CPUE values have steadily and significantly increased in all assessment areas.

Catch sampling and research surveys reveal that the increased fishery catch rates are only partially due to the recruitment of harvestable sized clams. Most increases in catch rates are due to greater utilization of sublegal clams. This trend in increasing landings of small clams has been associated with large decreases in the proportion of the catch discarded at sea as undersized: from about 50% of landings during the last quarter of 1982 to less than 20% during the final quarter of 1983. Given a presumed high mortality rate on discarded clams (Dr. H. Haskin, Rutgers University) it is likely that at least some of the current landings of sublegal or undersized clams represents production that would otherwise be lost through discarding. In the Atlantic City closure area, inferential evidence suggests that growth rates may have declined significantly in areas

of very high clam density (more than 25 clams per square meter). It is likely that some clams in this area may not reach the minimum fishery size at current clam densities, and would thus likely be discarded heavily for the next several years. Further, it is problematic as to whether reduction of clam densities ("thinning") would result in increased growth rates of these clams.

Prerecruit survey indices for the northern New Jersey assessment area remained high during 1983. Not all the clams off northern New Jersey were located in the high density area off Atlantic City, and there was significant recruitment of these faster growing clams to the harvestable size range. Currently, about 26% of the northern New Jersey biomass is of harvestable size. Total weight-per-tow indices for the northern New Jersey area have recovered and exceeded levels exhibited during the mid- to late 1960's. Given that the productivity potential of the 1976 cohort has nearly been reached (considering yield per recruit), further significant increases in total biomass from the 1976 year class are unlikely. Rather, there will be a continued transfer of biomass from the prerecruit to harvestable sizes.

A parallel situation exists off Delmarva, where the yield per recruit potential of the 1977 year class has also nearly been realized. However, given the somewhat more rapid rate of growth of Delmarva clams (considering the growth-density relationship of clams in the Atlantic City area) recruitment to the fishery will be somewhat more rapid off Delmarva.

Implications

Total Mid-Atlantic FCZ clam biomass has recovered to levels higher than those observed in the mid-1960's (prior to the rapid increase in landings). Given annual harvest levels in the 40-50 million pound range (including discards), there appears adequate clam stock to prosecute the fishery until the early 1990's (at least a 10-year supply). This conclusion is based on the observations that total clam biomass has recovered and exceeds mid-1960's levels, and that number-per-tow indices for the 1976 and 1977 year classes remain stable despite significant catch and discard of these cohorts. Average FCZ landings during 1965-1977 were about 40.2 million pounds of meats, most of which was derived from clams that were available to the surveys conducted during 1965-1969. Total survey abundance (kg per tow, all sizes) was 4.14 during the 1965-1969 surveys, and 4.30 during 1982-1983. By analogy, then, a 40.2 million pound catch would last 14 years, and a catch of 50 million pounds could be taken for 11 years.

Survey sampling during 1979-1983 has failed to document additional strong year classes spawned after the 1977 cohort off Delmarva. Although historical periodicity of good recruitment occurring in FCZ populations is unknown, the lack of significant spawnings since 1978 implies that the 1976 and 1977 cohorts will have to support the fishery until at least 1988, and likely beyond. If the minimum clam size is reduced and results in a corresponding decline in discarding rates, then resulting resource yields would increase, from the present available resource. This increase in yield would be achieved from a gain in yield per recruit (which is maximized at the 4½ to 5-inch size), and a corresponding decline in the mortality rate on small clams.

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Table 1. Total USA commercial landings (thousands of pounds of meats), total landings from the Fishery Conservation Zone (FCZ), landings from state waters, and percent of total from the FCZ.

Year	Total landings	FCZ landings	State Waters landings	Percent landed ¹ from FCZ
1965	44,088	33,000	11,088	75
1966	45,113	32,400	12,713	72
1967	40,054	24,700	15,354	62
1968	40,552	20,000	20,552	49
1969	49,575	15,900	33,675	32
1970	67,318	14,100	53,218	21
1971	52,535	50,053	2,482	95
1972	63,371	55,272	8,099	87
1973	82,370	72,579	9,791	88
1974	96,110	74,430	21,680	77
1975	86,956	44,270	42,686	51
1976	49,113	42,558	6,575	87
1977	51,036	42,968	8,068	84
1978	39,237	31,393	7,844	80
1979	34,912	29,070	5,842	83
1980	37,737	34,718	3,019	92
1981	46,100	37,361	8,739	81
1982	49,720	36,792	12,948	74
1983	55,938	45,163	10,775	81

¹Prorations for 1971-1982 based on data presented in Fisheries of the United States. Earlier data are based on interviews conducted by the U.S. Bureau of Commercial Fisheries.

Table 2. Commercial surf clam catch and effort statistics for the Northern New Jersey Assessment area, 1978-1983. Data are presented by calendar quarter for each of three vessel size classes (see text), and were derived from vessel trip logbook reports.

Year-Quarter	Number of Trips analyzed			Total catch (bushels)			Total hours fished			Mean Bushels/hour			
	Vessel class			Vessel class			Vessel class			Vessel class			
	1	2	3	1	2	3	1	2	3	1	2	3	
1978	1	-	2	-	384	-	-	16.0	-	-	24	-	
	2	-	11	13	-	1782	6517	-	104.0	270.5	-	17	24
	3	-	37	12	-	4774	3370	-	385.5	159.0	-	12	21
	4	-	14	13	-	2290	3217	-	79.0	167.0	-	29	19
Total	-	64	38	-	9230	13104	-	584.5	596.5	-	16	22	
1979	1	6	17	8	1674	4363	2423	56.0	141.5	57.0	30	31	43
	2	3	26	27	1248	5754	5406	36.0	213.25	279.0	35	27	19
	3	-	6	6	-	1202	2257	-	70.0	56.5	-	17	45
	4	2	8	20	388	1475	12558	15.0	107.0	277.0	26	14	45
Total	11	57	61	3310	12794	22944	107.0	531.75	669.5	31	24	34	
1980	1	26	12	17	490	3374	8366	62.0	118.0	196.5	8	29	43
	2	6	31	23	1050	14600	11089	40.0	368.0	323.5	26	40	34
	3	3	20	38	902	29979	10924	24.0	178.0	273.5	38	52	109
	4	9	51	78	5663	21001	53733	82.0	449.0	577.5	69	47	93
Total	44	114	156	8105	48254	103104	208.0	1113.0	1371.0	39	43	75	
1981	1	24	134	150	7132	51009	81567	184.0	1147.8	1451.75	39	44	56
	2	39	225	186	10360	99540	117067	350.0	1817.5	1767.5	30	55	66
	3	42	200	267	10924	89405	192508	380.5	1895.0	2858.0	29	47	67
	4	28	108	242	6467	32983	143842	258.0	1120.0	2638.5	23	30	55
Total	133	667	845	34883	272937	534984	1172.5	5980.3	8715.75	30	46	61	
1982	1	72	212	252	16199	58544	117164	651.0	2142.5	2786.5	25	27	42
	2	48	213	275	10533	49391	122900	519.0	2366.0	3184.0	20	21	39
	3	61	222	114	11084	47938	57322	559.75	2300.5	1267.5	20	30	45
	4	54	236	136	11723	68744	71262	504.0	2329.5	1416.3	23	30	50
Total	235	883	777	49539	224617	368648	2233.75	9138.5	8654.3	22	25	43	
1983	1	51	214	204	16593	69714	90434	592.0	2044.0	2100.9	28	34	43
	2	46	175	121	15076	63964	61738	516.0	1727.0	1265.75	29	37	49
	3	48	242	83	14398	115887	40397	521.5	2459.75	677.0	27	47	60
	4	60	266	124	22846	126952	67208	619.5	2394.0	837.0	37	53	80
Total	205	897	532	68913	376517	259777	2249.0	8624.75	4880.65	30	44	53	

Table 3. Commercial surf clam catch and effort statistics for the Southern New Jersey Assessment area, 1978-1983. Data are presented by calendar quarter for each of three vessel size classes (see text), and were derived from vessel trip logbook reports.

Year-Quarter	Number of Trips analyzed			Total catch (bushels)			Total hours fished			Mean Bushels/hour		
	Vessel class			Vessel class			Vessel class			Vessel class		
	1	2	3	1	2	3	1	2	3	1	2	3
1978												
1	1	10	11	258	2354	3841	22	157	205.3	12	15	19
2	5	38	35	1243	8464	14862	77	542	760.5	16	16	20
3	27	32	28	2628	6720	9714	238.5	344.5	398	11	20	24
4	24	35	46	2585	7806	15910	199	360	561	13	22	28
Total	57	115	120	6714	25344	44327	536.5	1403.5	1924.8	13	18	23
1979												
1	3	11	53	716	2020	16418	26	99.5	675.5	28	20	24
2	2	38	78	727	5459	17562	23	253	943.5	32	22	19
3	20	90	37	5188	17089	13589	209.75	951	406	25	18	34
4	4	35	27	490	5339	13534	48	367	352	10	15	38
Total	29	174	195	7121	29907	61193	306.75	1770.5	2377	23	17	26
1980												
1	3	20	23	368	2958	12263	31.5	230	315	12	13	39
2	8	42	29	894	8827	13133	67	503	378	13	18	35
3	5	64	14	560	9072	8139	52	659	129	11	14	63
4	1	19	11	100	4010	4016	10	183	94.5	10	22	43
Total	17	145	77	1922	24867	37551	160.5	1575	916.5	12	16	41
1981												
1	5	8	16	186	2920	6883	30.0	72.0	178.0	6	41	38
2	11	1	4	1046	100	2573	114.0	10.0	41.0	9	10	63
3	2	4	4	160	1238	2392	20.0	35.0	43.0	8	35	56
4	10	5	5	707	1679	930	78.0	53.0	46.0	9	32	20
Total	28	18	29	2100	5937	12578	242.0	170.0	308.0	9	35	41
1982												
1	1	11	13	128	2083	5175	12.0	112.0	160.0	10	19	32
2	38	48	18	3946	13638	7132	388.5	646.0	197.5	10	21	36
3	41	53	73	4494	13495	32517	372.5	478.0	910.0	12	28	36
4	16	41	35	1938	13873	11606	140	416	386	14	33	30
Total	96	153	139	10506	43089	56430	913	1652	1653.5	12	26	34
1983												
1	8	13	8	578	2018	1243	63	118	86	9	17	14
2	14	15	4	1614	3469	1989	141	144	58	11	24	34
3	41	99	36	7441	23459	18122	460	1033	364.5	16	23	50
4	27	67	48	4878	27289	29104	275.25	616.5	443	18	44	66
Total	90	194	96	14511	56235	50458	939.25	1911.5	951.50	15	29	53

Table 4. Commercial surf clam catch and effort statistics for the Delmarva Assessment area, 1978-1983. Data are presented by calendar quarter for each of three vessel size classes (see text), and were derived from vessel trip logbook reports.

Year-Quarter	Number of Trips analyzed			Total catch (bushels)			Total hours fished			Mean Bushels/hour		
	Vessel class			Vessel class			Vessel class			Vessel class		
	1	2	3	1	2	3	1	2	3	1	2	3
1978												
1	5	31	71	1173	10165	47827	82.5	485.25	1632.5	14	21	29
2	72	357	509	16152	107092	282544	1044	5359.75	10511.15	16	20	27
3	85	380	641	17454	91566	256737	1022	4601.7	8451.75	17	20	30
4	56	319	536	9347	80159	216309	592.8	3961.1	7302.5	16	20	30
Total	218	1087	1757	44126	288982	803417	2741.3	14407.8	27897.9	16	20	29
1979												
1	38	198	477	5279	46509	188967	343.8	2377.2	6657.8	15	20	28
2	91	430	645	17146	92048	264054	1033.5	4628.3	8509	17	20	31
3	77	426	732	14428	96483	311218	899.95	4815	8520.5	16	20	37
4	50	265	493	8552	56922	244433	578	3166.75	7110.5	15	18	34
Total	256	1319	2347	45405	291962	1008672	2845.25	14987.25	20797.8	16	20	33
1980												
1	44	285	467	7248	55550	223366	494.0	3259.75	6693.5	15	17	33
2	57	173	515	6918	40101	284974	526.75	2207.5	7826.0	13	18	36
3	41	386	662	6197	87325	328747	421.0	4137.0	8741.5	15	21	39
4	17	138	537	3507	32371	265268	172.0	1448.75	5803.0	20	22	46
Total	159	982	2181	23870	217347	1102355	1613.75	11053.0	28794.0	15	20	38
1981												
1	6	105	431	1181	24731	232333	58.0	1148.5	4783.5	20	22	49
2	16	140	521	4683	42924	336062	186.0	1456.0	5843.45	25	30	58
3	16	45	185	5055	12277	117823	186.0	484.0	2036.5	27	25	58
4	1	45	100	252	9030	51767	10.0	428.5	1083.5	25	21	48
Total	39	335	1237	11171	88962	737985	440.0	3517.0	13746.95	25	25	54
1982												
1	8	75	337	1148	18495	154187	84.0	801.5	3792.5	14	23	41
2	37	109	383	8144	30697	191685	425.0	1245.0	4458.0	19	24	43
3	51	85	356	10622	21048	165641	544.5	955.5	3986.5	20	22	43
4	31	35	258	9910	8988	105674	318	365.1	2832	31	25	37
Total	127	304	1334	29824	79228	617187	1371.5	3366.6	15069	22	24	41
1983												
1	21	26	270	4216	8430	118126	215.5	305	2983.5	20	28	40
2	27	31	233	9475	7967	149455	259.2	329	2843.5	37	24	53
3	21	75	406	8311	28072	257939	244.0	857.5	4537.5	34	33	57
4	14	37	323	6765	17692	226675	151.0	417.0	3638.5	45	42	62
Total	83	169	1232	28767	62161	752195	869.7	1908.5	14003	33	33	54

Table 5. Commercial surf clam catch and effort statistics for the Southern Virginia-North Carolina Assessment area, 1978-1983. Data are presented by calendar quarter for each of three vessel size classes (see text), and were derived from vessel trip logbook reports.

Year- Quarter	Number of Trips analyzed			Total catch (bushels)			Total hours fished			Mean Bushels/hour		
	Vessel class			Vessel class			Vessel class			Vessel class		
	1	2	3	1	2	3	1	2	3	1	2	3
1978												
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	2	5	-	356	1175	-	34.0	106.0	-	11	17
3	-	1	1	-	74	420	-	9.0	15.0	-	8	28
4	-	-	1	-	-	147	-	-	12.0	-	-	12
Total	-	3	7	-	430	2342	-	43.0	133.0	-	10	18
1979												
1	1	3	1	272	482	123	17.0	39.0	6.0	16	12	21
2	9	3	3	2151	932	1446	86.0	36.0	27.5	25	26	53
3	3	8	1	759	2364	530	45.5	112.0	12.0	17	11	44
4	1	2	4	526	688	1192	36.0	36.0	57.0	15	19	21
Total	14	16	9	3708	4466	3291	184.5	224.0	102.5	20	20	32
1980												
1	-	2	3	-	241	480	-	14.0	33.0	-	17	15
2	-	-	2	-	-	690	-	-	30.0	-	-	23
3	-	1	7	-	148	2918	-	5.0	82.0	-	30	36
4	-	-	5	-	-	1666	-	-	48.0	-	-	35
Total	-	3	15	-	389	5754	-	19.0	193.0	-	21	30
1981												
1	-	4	5	-	667	2912	-	38.0	84.5	-	18	35
2	-	22	24	-	11603	14105	-	256.0	264.0	-	45	53
3	-	12	9	-	6040	4589	-	144.0	106.0	-	42	43
4	-	1	12	-	522	6797	-	12.0	127.0	-	44	54
Total	-	39	50	-	18832	28403	-	450.0	581.5	-	42	49
1982												
1	-	-	16	-	-	5342	-	-	175.0	-	-	31
2	-	-	14	-	-	6540	-	-	183.5	-	-	36
3	-	13	34	-	7425	25072	-	156.0	411.0	-	48	61
4	-	12	156	-	7814	124443	-	144	1876.7	-	54	66
Total	-	25	220	-	15239	161397	-	300	2646.2	-	51	61
1983												
1	-	4	57	-	2046	35749	-	48	676	-	43	53
2	-	27	129	-	15524	115970	-	298	1560	-	52	74
3	1	28	96	28	13665	88410	4	318.5	1124	7	43	79
4	-	30	40	-	16746	31742	-	346	459	-	48	69
Total	1	89	322	28	47981	271867	4	1010.5	3819	7	47	71

Table 6. Sampling of surf clam shell lengths from commercial catches in four Middle Atlantic assessment areas, 1976-1983. Northern New Jersey is NNJ; Southern New Jersey is SNJ, Delmarva is DMV, and Southern Virginia-North Carolina is SVNC.

Year	Quarter	Number of Clams Measured				Mean Shell Length (mm)				Percent of Clams <140 mm				Percent of Clams ≥140 mm			
		NNJ	SNJ	DMV	SVNC	NNJ	SNJ	DMV	SVNC	NNJ	SNJ	DMV	SVNC	NNJ	SNJ	DMV	SVNC
1976	1	0	0	160	10	-	-	158	153	-	-	11.9	10.0	-	-	88.1	90.0
	2	0	0	200	10	-	-	162	162	-	-	7.0	0.0	-	-	93.0	100.0
	3	40	40	270	30	158	169	160	152	5.0	0.0	7.4	16.7	-	100.0	92.6	83.3
	4	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-
	Σ	40	40	630	50	158	169	160	154	5.0	0.0	8.4	12.0	95.0	100.0	91.6	88.0
1977	1	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-
	2	20	0	0	0	161	-	-	-	0.0	-	-	-	100.0	-	-	-
	3	120	270	1,881	0	173	171	164	-	0.0	0.1	6.5	-	100.0	100.0	93.5	-
	4	180	55	1,399	0	176	178	165	-	0.0	0.0	4.5	-	100.0	99.9	95.5	-
	Σ	320	325	3,280	0	174	173	164	-	0.0	0.1	5.6	-	100.0	100.0	94.4	-
1978	1	0	119	779	0	-	175	161	-	-	0.0	11.5	-	-	100.0	88.5	-
	2	600	210	3,182	0	166	173	159	-	2.8	0.1	9.2	-	97.2	99.9	90.8	-
	3	330	0	2,999	0	170	-	160	-	0.0	-	10.3	-	100.0	-	89.7	-
	4	0	0	1,933	0	-	-	160	-	-	-	12.7	-	-	-	87.3	-
	Σ	930	329	8,893	0	168	174	160	-	1.8	0.1	10.4	-	98.2	99.9	89.6	-
1979	1	0	30	2,098	0	-	166	158	-	-	6.7	21.7	-	-	93.3	78.3	-
	2	0	0	2,384	0	-	-	150	-	-	-	28.4	-	-	-	71.6	-
	3	30	390	2,188	0	165	167	155	-	13.3	6.7	19.7	-	86.7	93.3	80.3	-
	4	0	30	1,687	0	-	176	160	-	-	0.0	15.2	-	-	100.0	84.8	-
	Σ	30	450	8,357	0	165	167	155	-	13.3	6.2	21.7	-	86.7	93.8	78.3	-
1980	1	0	0	1,333	0	-	-	160	-	-	-	16.3	-	-	-	83.7	-
	2	0	60	2,381	0	-	154	155	-	-	23.3	19.2	-	-	76.7	80.8	-
	3	60	210	1,942	0	106	165	156	-	100.0	11.3	16.1	-	0.0	88.7	83.9	-
	4	0	0	441	0	-	-	136	-	-	-	65.1	-	-	-	34.9	-
	Σ	60	270	6,097	0	106	162	154	-	100.0	14.3	22.9	-	0.0	85.7	77.1	-
1981	1	540	30	2,134	0	175	159	144	-	1.2	13.3	43.1	-	98.8	86.7	56.9	-
	2	369	30	2,528	0	149	168	140	-	38.3	3.3	52.6	-	61.7	96.7	47.4	-
	3	1,169	60	994	0	154	156	147	-	10.5	9.1	35.8	-	89.5	89.9	64.2	-
	4	690	30	692	0	151	157	133	-	16.6	6.7	50.9	-	83.4	93.3	49.1	-
	Σ	2,768	150	6,348	0	156	160	142	-	13.5	6.9	47.0	-	86.5	93.1	53.0	-
1982	1	270	60	1,681	0	147	163	161	-	36.2	1.3	6.3	-	63.8	98.7	93.7	-
	2	958	30	2,024	0	157	165	159	-	4.2	3.3	9.6	-	95.8	96.7	90.4	-
	3	1,500	360	2,108	90	152	171	155	150	8.5	1.6	18.3	16.3	91.5	98.4	81.7	83.7
	4	2,640	182	1,550	642	147	167	158	142	20.2	2.8	13.4	52.3	79.8	97.2	86.6	47.7
	Σ	5,368	632	7,363	732	149	169	158	143	15.5	1.9	12.2	48.3	84.5	98.1	87.8	51.7
1983	1	2,576	362	2,219	0	146	158	161	-	26.6	18.2	5.7	-	73.4	81.8	94.3	-
	2	1,568	60	1,170	300	145	159	143	143	31.3	3.3	34.0	36.9	68.7	96.7	66.0	63.1
	3	1,680	120	1,370	120	147	170	147	144	18.8	10.4	31.3	27.7	81.2	89.6	68.7	72.3
	4	2,549	0	724	0	146	-	140	-	23.0	-	53.9	-	77.0	-	46.1	-
	Σ	8,373	542	5,483	420	146	160	149	143	24.5	13.4	17.2	33.8	75.5	86.5	82.8	66.2

Table 7. Summary of research vessel survey cruises used in the analysis of surf clam population dynamics, 1965-1983.

Research Vessel	Dates of Cruise	Dredge Knife Width (cm)	Time of Tow (min)	Number of Stations	Ring Size or Bar Space ^a
UNDAUNTED	5- 6 1965	76	5	375 (293) ^b	5.1
UNDAUNTED	10-11 1965	76	5	217 (158)	5.1
ALBATROSS IV	8 1966	76	5	240 (210)	5.1
ALBATROSS IV	6- 7 1969	76	5	278 (166)	5.1
DELAWARE II	8 1970	122	4	199 (133)	3.0
DELAWARE II	6 1974	76	5	241 (142)	5.1
DELAWARE II	4- 5 1976	122	4	259 (133)	3.0
DELAWARE II	1- 3 1977	122	4	224 (92)	3.0
DELAWARE II	1- 2 1978	122	4	324 (192)	3.0
DELAWARE II	12 1978	122	4	163 (105)	2.5
DELAWARE II	1- 2 1980	152	5	229 (156)	5.1
DELAWARE II	8- 9 1980	152	5	231 (114)	5.1
DELAWARE II	8 1981	152	5	261 (119)	5.1
DELAWARE II	8 1982	152	5	272 (151)	5.1
DELAWARE II	8 1983	152	5	381 (169)	5.1

^aPortion of the dredge where catch is accumulated

^bNumber of stations located in surf clam assessment areas

Table 8. Designations of NMFS surf clam survey strata comprising four assessment areas in the Middle Atlantic Bight, New Jersey to Cape Hatteras, North Carolina (see Figure 1).

Assessment area	Stratum number	Area (n. miles ²)	Depth Range	
			Fathoms	Meters
Northern New Jersey	90	182	5-15	9-27
	89	382	5-15	9-27
	88	578	5-15	9-27
	25	648	15-25	27-46
	21	1650	15-25	27-46
Southern New Jersey	87	479	5-15	9-27
	17	749	15-25	27-46
Delmarva	86	203	5-15	9-27
	85	382	5-15	9-27
	84	417	5-15	9-27
	83	241	5-15	9-27
	82	180	5-15	9-27
	14	219	25-30	46-55
	13	1127	15-25	27-46
	10	152	25-30	46-55
	9	2171	15-25	27-46
Southern Virginia-North Carolina	81	360	5-15	9-27
	80	767	5-15	9-27
	6	62	25-30	46-55
	5	453	15-25	27-46
	2	175	25-30	46-55
	1	1163	15-25	27-46

Table 9. Stratified mean number and weight (meats only, kg) per tow of surf clams from NMFS surveys off northern New Jersey, 1965-1982. Data are standardized to a 60-inch wide dredge towed for five minutes.

Survey	Total index		<5½"		≥5½"		%≥5½"	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	38.07	4.79	15.44	1.17	22.62	3.62	59.4	75.6
Oct 1965	35.73	5.27	6.18	0.51	29.55	4.76	82.7	90.3
Aug 1966	30.44	4.51	5.44	0.36	24.99	4.15	82.1	92.1
Jun 1969	34.26	5.37	3.93	0.30	30.33	5.07	88.5	94.4
Aug 1970	25.73	4.12	4.84	0.30	20.89	3.82	81.2	92.9
Jun 1974	21.40	3.37	2.75	0.19	18.66	3.17	87.2	94.3
Apr 1976	12.92	2.06	2.39	0.12	10.53	1.93	81.5	94.0
Jan 1977	2.45	0.23	1.39	0.05	1.06	0.19	43.2	81.4
Jan 1978	2.06	0.16	1.48	0.06	0.58	0.11	28.3	64.9
Dec 1978	44.88	1.20	43.85	1.03	1.01	0.17	2.3	14.8
Jan 1980	31.70	1.95	27.52	1.22	4.17	0.75	13.2	38.1
Aug 1980	53.56	3.74	50.66	3.24	2.90	0.50	5.4	13.5
Aug 1981	39.10	3.23	31.15	2.04	8.03	1.19	20.5	36.0
Aug 1982	112.79	8.78	101.53	7.11	11.26	1.67	9.9	19.0
Aug 1983	72.91	5.94	63.06	4.42	9.85	1.52	13.5	25.6

Table 10. Stratified mean number and weight (meats only, kg) per tow of surf clams from NMFS surveys off southern New Jersey, 1965-1982. Data are standardized to a 60-inch wide dredge towed for five minutes.

Survey	Total index		<5½"		≥5½"		%≥5½"	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	105.98	8.88	78.08	4.37	27.93	4.49	26.4	50.7
Oct 1965	82.84	10.64	33.32	2.73	49.52	7.93	59.8	74.4
Aug 1966	69.55	9.95	14.62	1.39	54.93	8.56	79.0	86.0
Jun 1969	59.73	9.08	5.46	0.42	54.27	8.66	90.9	95.3
Aug 1970	16.18	2.65	2.73	0.20	13.45	2.45	83.1	92.1
Jun 1974	49.31	8.85	2.22	0.16	47.10	8.69	95.5	98.2
Apr 1976	5.20	0.97	0.64	0.03	4.57	0.94	87.8	96.1
Jan 1977	2.25	0.23	1.22	0.03	1.03	0.20	45.5	89.3
Jan 1978	14.91	2.23	3.85	0.22	11.06	2.00	74.2	89.9
Dec 1978	8.60	0.97	4.45	0.23	4.15	0.75	48.3	76.4
Jan 1980	13.59	2.29	2.53	0.22	11.06	2.09	81.4	90.7
Aug 1980	14.57	2.59	2.95	0.20	11.62	2.39	79.7	92.0
Aug 1981	10.47	2.06	0.56	0.03	9.91	2.03	94.7	98.5
Aug 1982 ¹	20.61	3.51	3.62	0.19	16.99	3.32	82.5	94.7
Aug 1983	11.51	2.15	1.50	0.10	10.01	2.05	87.0	95.3

¹Index does not include one survey tow made at a depth of seven meters that yielded 500 surf clams.

Table 11. Stratified mean number and weight (meats only, kg) per tow of surf clams from NMFS surveys off Delmarva, 1965-1982. Data are standardized to a 60-inch wide dredge towed for five minutes.

Survey	Total index		<5½"		>5½"		%>5½"	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	27.68	2.26	15.82	0.83	11.86	1.44	42.8	63.3
Oct 1965	28.02	2.81	10.76	0.58	17.25	2.23	61.6	79.3
Aug 1965	32.53	3.54	10.75	0.64	21.78	2.90	67.0	81.9
Jun 1969	26.26	2.78	8.03	0.50	18.22	2.28	69.4	82.0
Aug 1970	19.64	2.34	4.71	0.30	14.93	2.04	76.0	87.5
Jun 1974	36.66	4.59	6.68	0.42	29.98	4.17	81.8	90.7
Apr 1976	21.93	2.37	7.30	0.25	14.63	2.12	66.7	89.6
Jan 1977	11.37	1.40	2.68	0.09	8.69	1.31	76.4	93.2
Jan 1978	11.61	1.15	4.90	0.17	6.71	1.00	57.7	85.4
Dec 1978	621.33	6.02	616.44	5.32	4.88	0.72	0.8	88.2
Jan 1980	68.50	3.17	58.07	1.62	10.44	1.54	15.2	48.7
Aug 1980	48.53	2.64	39.39	1.26	9.14	1.37	18.8	52.2
Aug 1981	162.89	6.91	156.86	6.02	6.02	0.89	3.7	12.9
Aug 1982	109.14	5.68	102.53	4.71	6.61	0.97	6.1	17.0
Aug 1983	51.39	3.79	39.36	2.14	12.03	1.65	23.4	43.5

Table 12. Stratified mean number per tow of surf clams from NMFS surveys off southern Virginia - North Carolina, 1965-1982. Data are standardized to a 60-inch wide dredge towed for five minutes.

Survey	Total index		<5½"		>5½"		%>5½"	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	3.77		2.87		0.90		23.9	
Oct 1965 ¹	11.93		11.81		0.12		1.0	
Aug 1966 ¹	17.56		16.28		1.27		7.3	
Jun 1969	80.02		78.68		1.34		1.7	
Aug 1970 ¹	3.20		0.74		2.46		76.7	
Jun 1974	30.09		12.66		17.42		57.9	
Apr 1976	6.21		1.11		5.10		82.2	
Jan 1978	3.24		1.06		2.18		67.3	
Jan 1980 ¹	87.02		86.15		0.87		1.0	
Aug 1981 ¹	25.89		17.97		7.92		30.6	
Aug 1982 ¹	2.06		1.18		0.88		42.6	
Aug 1983	10.25	0.55	9.11	0.44	1.14	0.11	11.1	20.0

¹Only a small portion of the total Southern Virginia - North Carolina area was surveyed.

SURF CLAM LANDINGS -- 1965-1983

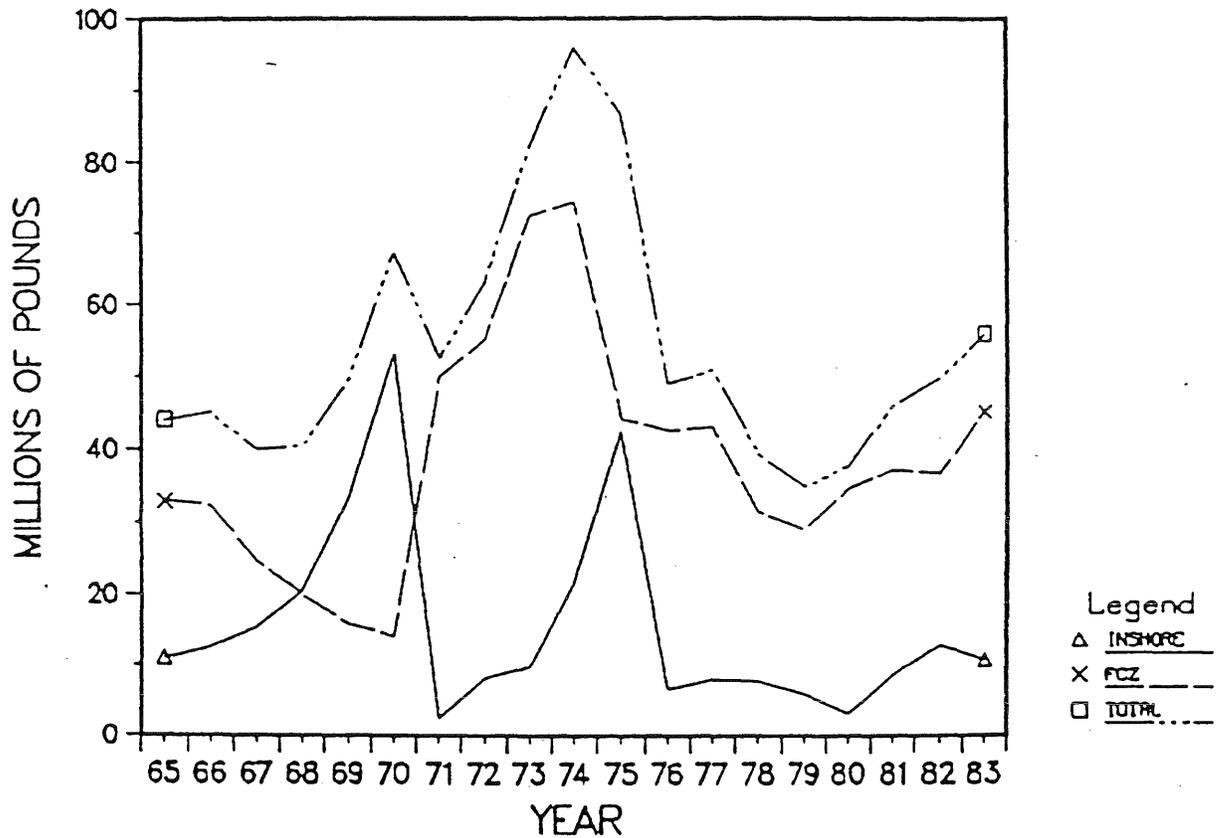


Figure 1. Surf clam landings (millions of pounds of shucked meats), 1965-1983. Data are given for state waters (inshore), the Fishery Conservation Zone (FCZ), and total.

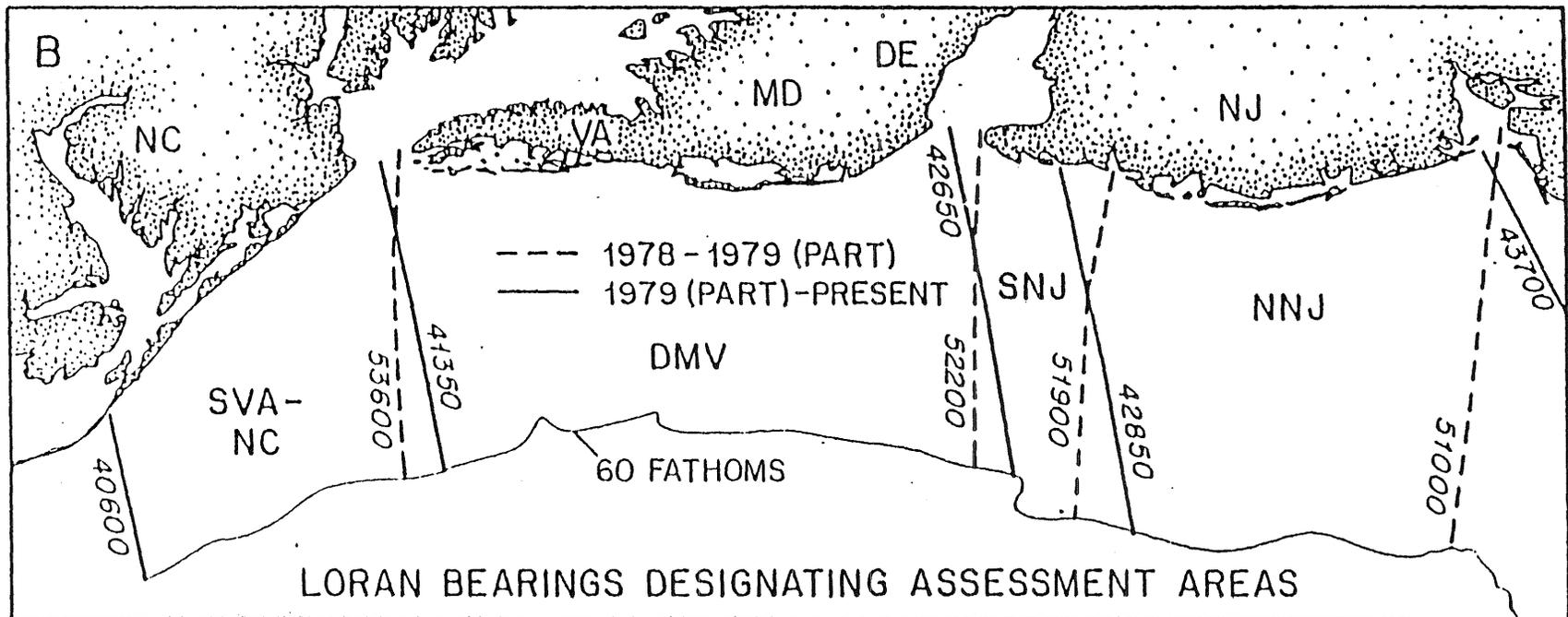
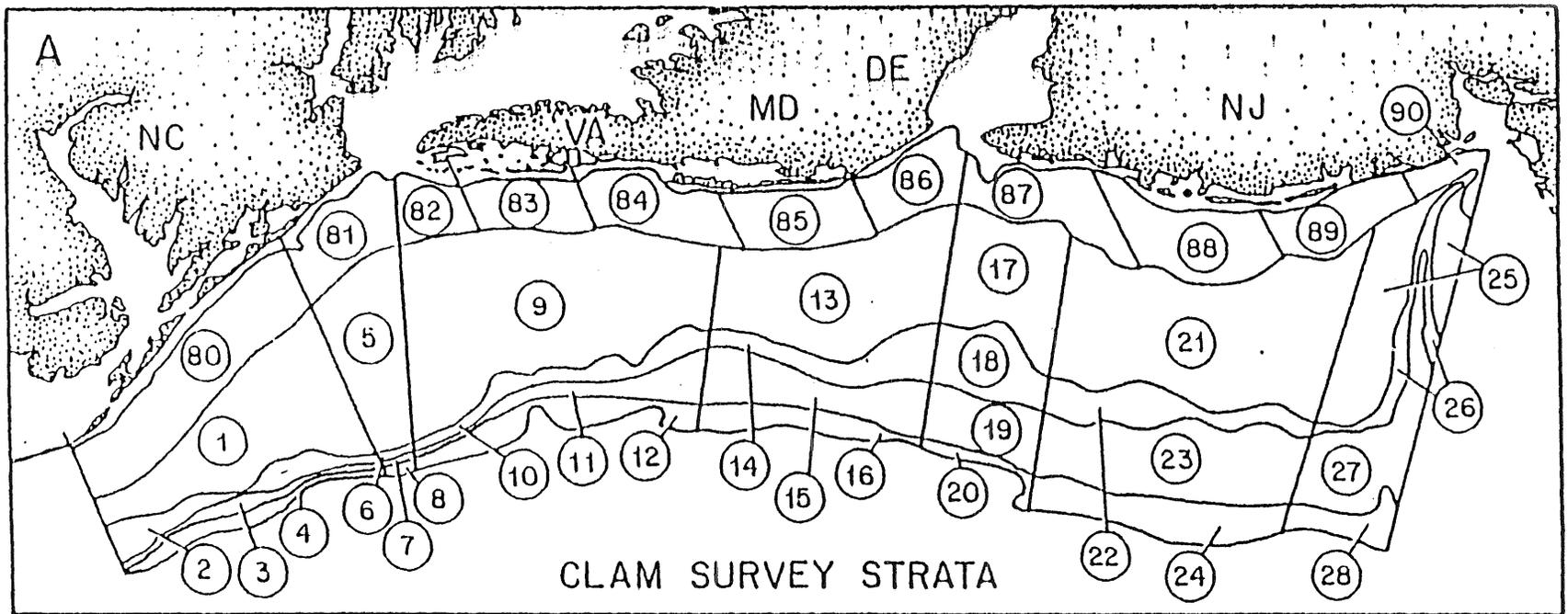


Figure 2. Offshore surf clam survey strata (A) in the Middle Atlantic Bight, New Jersey-North Carolina, and LORAN bearings designating four surf clam assessment areas (B).

PERCENT OF FCZ LANDINGS BY AREA

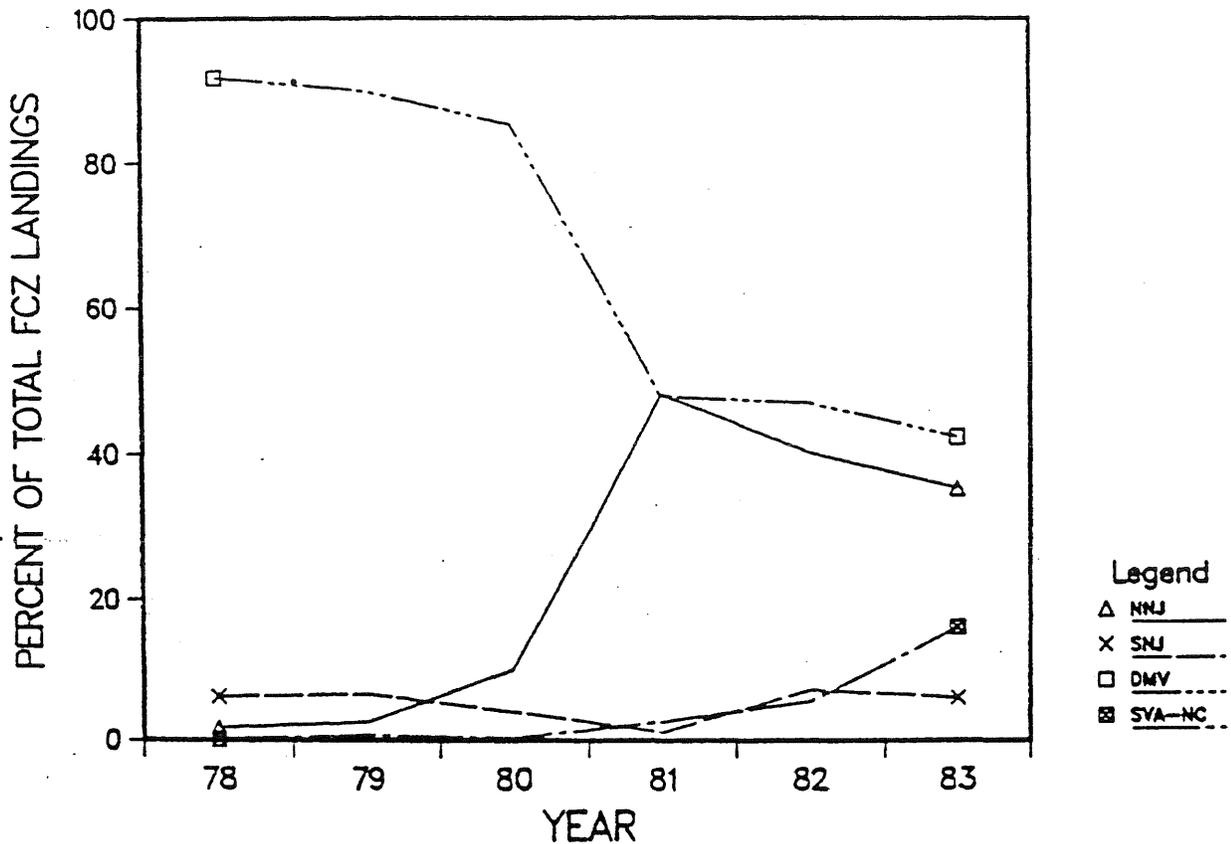


Figure 3. Percent of total FCZ surf clam landings from four Middle Atlantic assessment areas, 1978-1983. Data are derived from vessel trip logbooks. NNJ is Northern New Jersey, SNJ is Southern New Jersey, DMV is Delmarva, SVA-NC is Southern Virginia-North Carolina.

NORTHERN NEW JERSEY CPUE

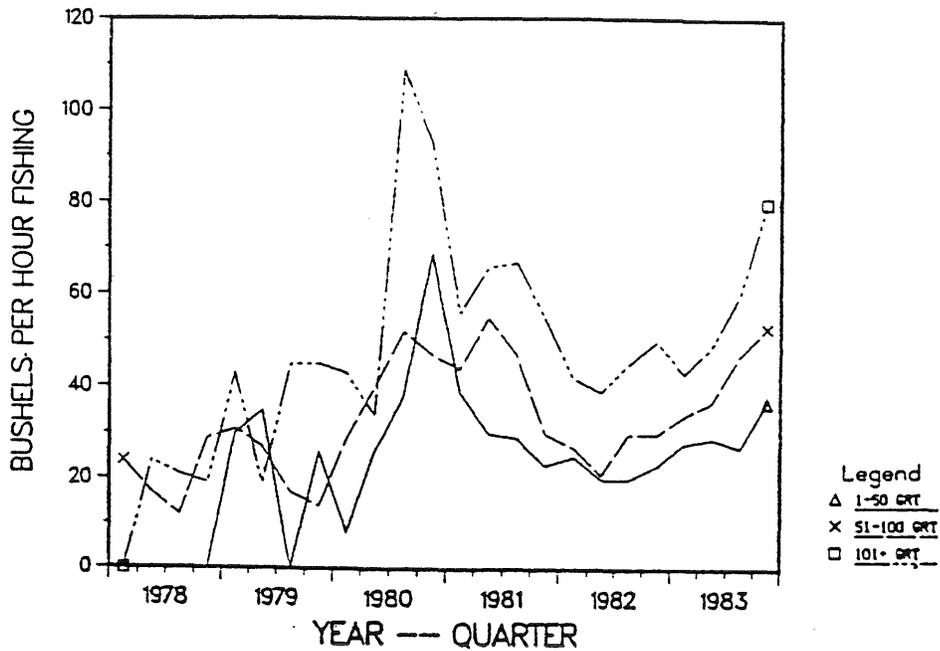


Figure 4. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Northern New Jersey, 1978-1983. Quarterly data were derived from vessel trip logbooks, and are for all clam sizes.

NORTHERN NEW JERSEY CPUE— $\geq 5 \frac{1}{2}$ INCHES

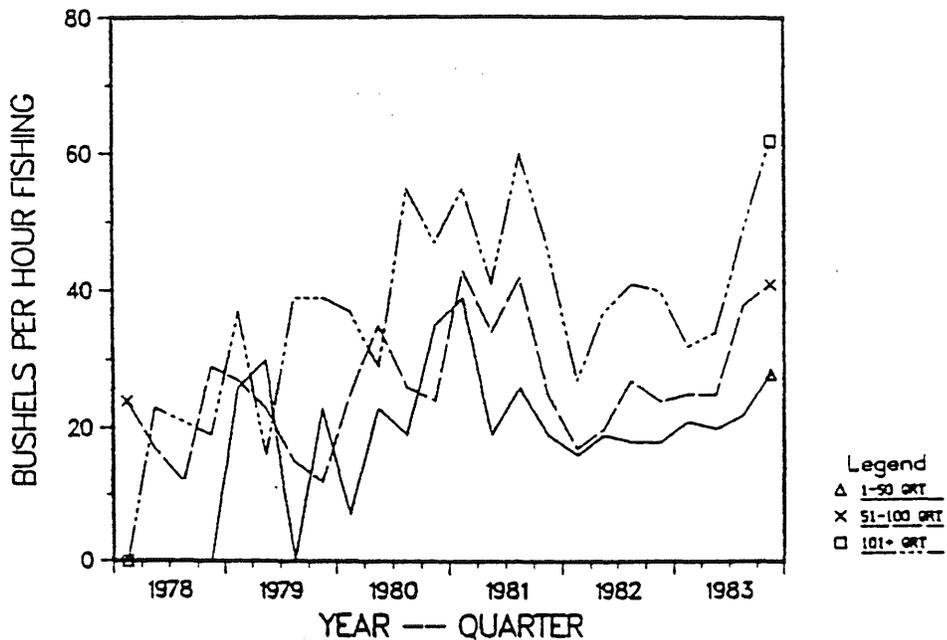


Figure 5. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Northern New Jersey, 1978-1983. Quarterly data are derived from vessel trip logbooks, and are for clams $\geq 5 \frac{1}{2}$ inches shell length (Table 6).

SOUTHERN NEW JERSEY CPUE

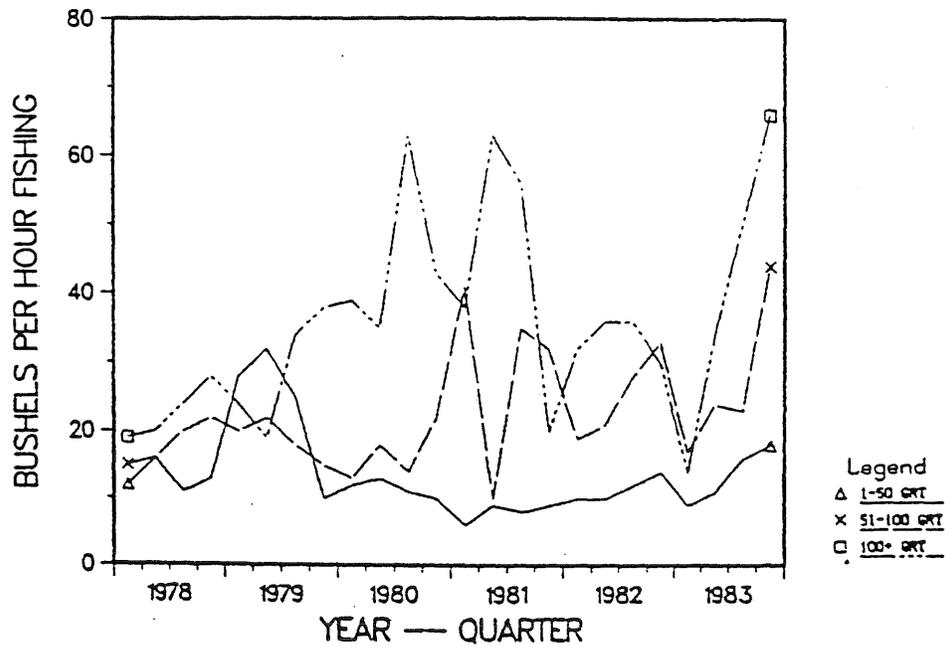


Figure 6. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Southern New Jersey, 1978-1983. Quarterly data were derived from vessel trip logbooks, and are for all clam sizes.

SOUTHERN NEW JERSEY CPUE— $\geq 5 \frac{1}{2}$ INCHES

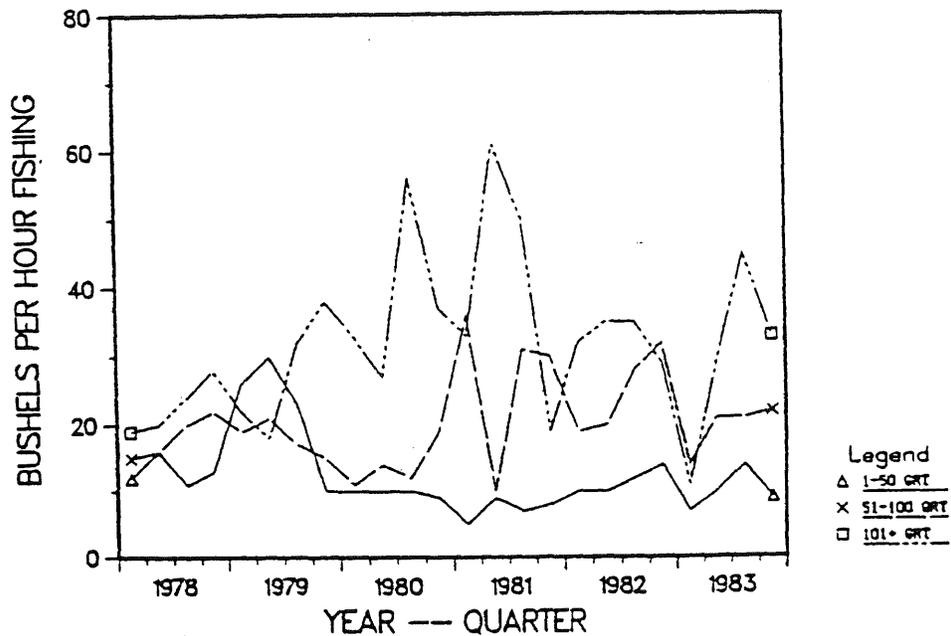


Figure 7. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Southern New Jersey, 1978-1983. Quarterly data were derived from vessel trip logbooks and are for clams $\geq 5 \frac{1}{2}$ inches shell length (Table 6).

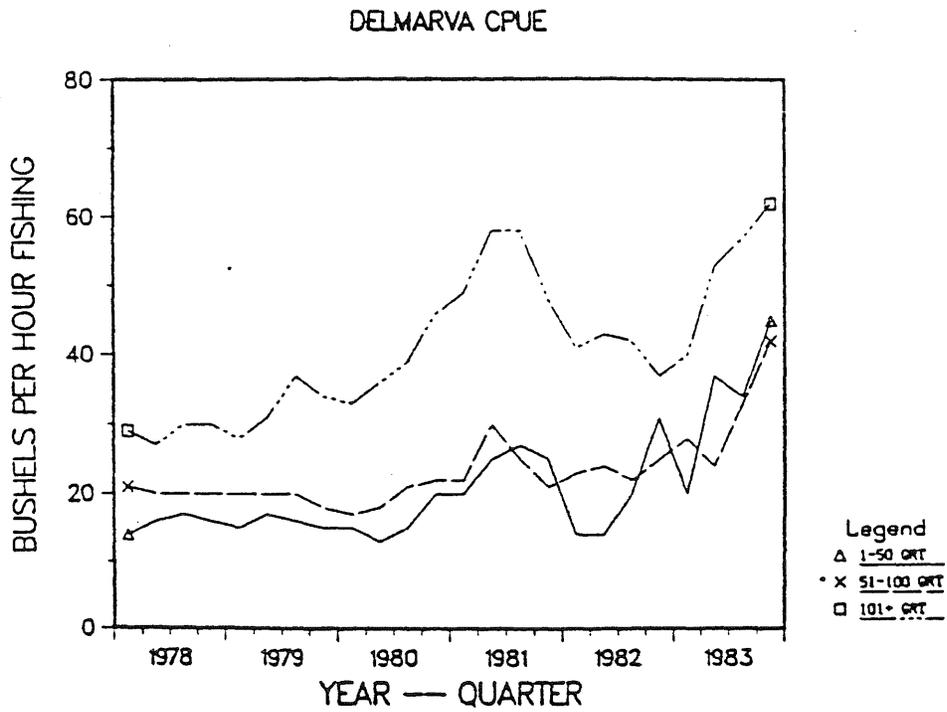


Figure 8. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Delmarva, 1978-1983. Quarterly data were derived from vessel trip logbooks, and are for all clam sizes.

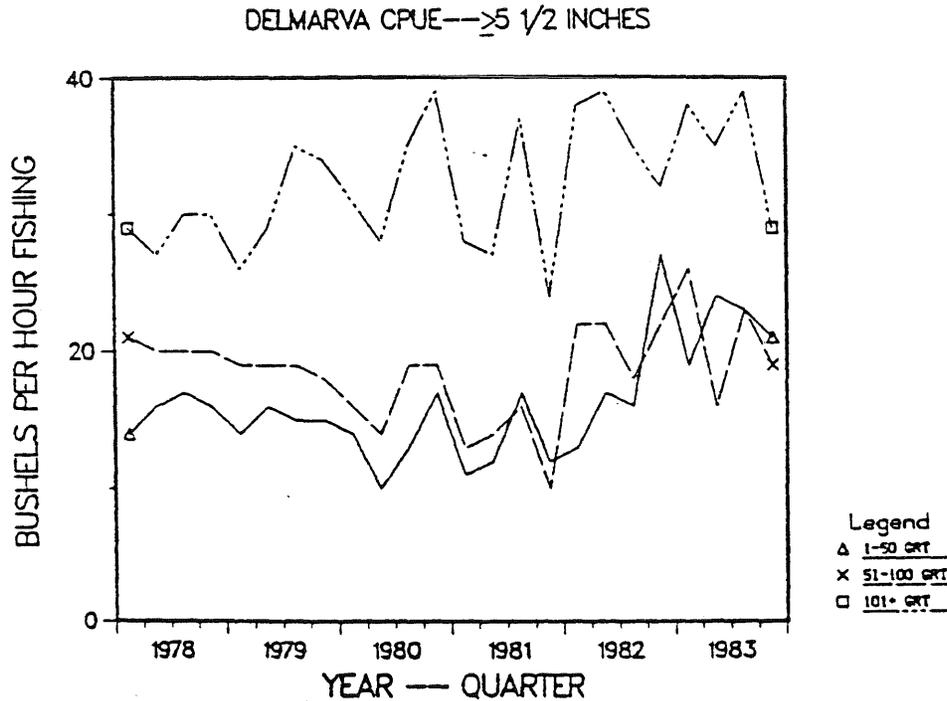


Figure 9. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Delmarva, 1978-1983. Quarterly data were derived from vessel trip logbooks, and for clams $\geq 5 \frac{1}{2}$ inches shell length (Table 6).

SOUTHERN VA - NORTH CAROLINA CPUE

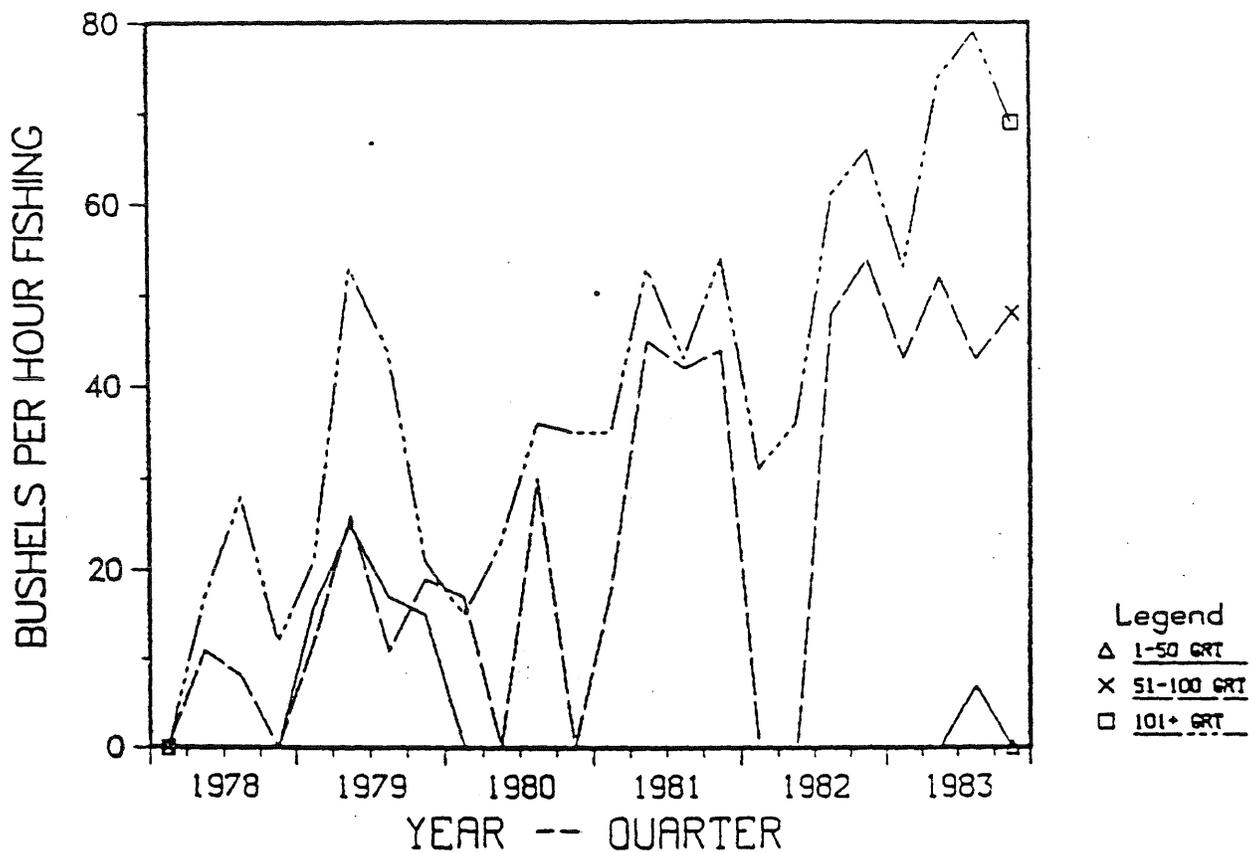


Figure 10. Catch per unit of effort (bushels per hour fishing) for three vessel size classes operating off Southern Virginia-North Carolina, 1978-1983. Quarterly data were derived from vessel trip logbooks and are for all clam sizes.

SURF CLAM DISCARD DATA 1982-1983

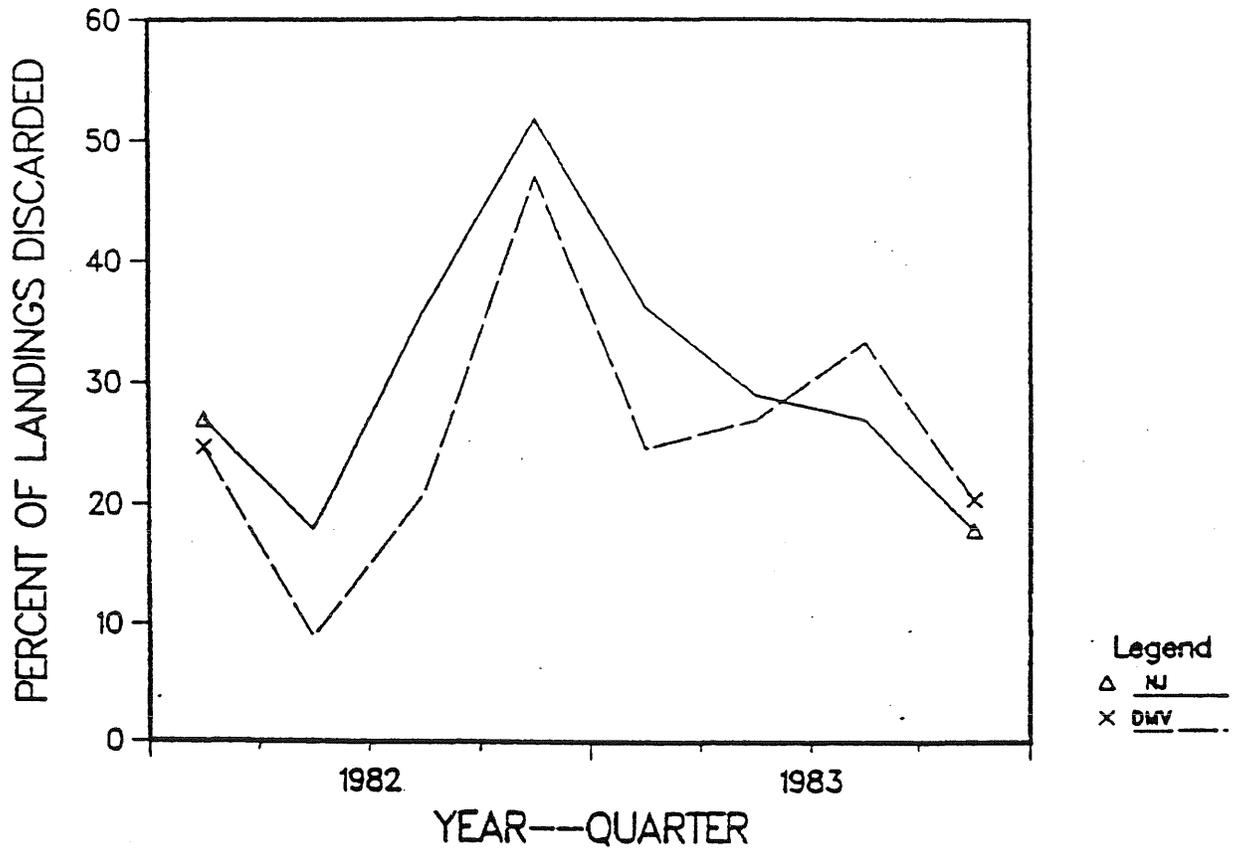


Figure 11. Discard of small surf clams as a percentage of landings (bushels) for two Middle Atlantic assessment areas (New Jersey, Delmarva), 1982-1983. Quarterly data were obtained through NMFS port agent interviews.

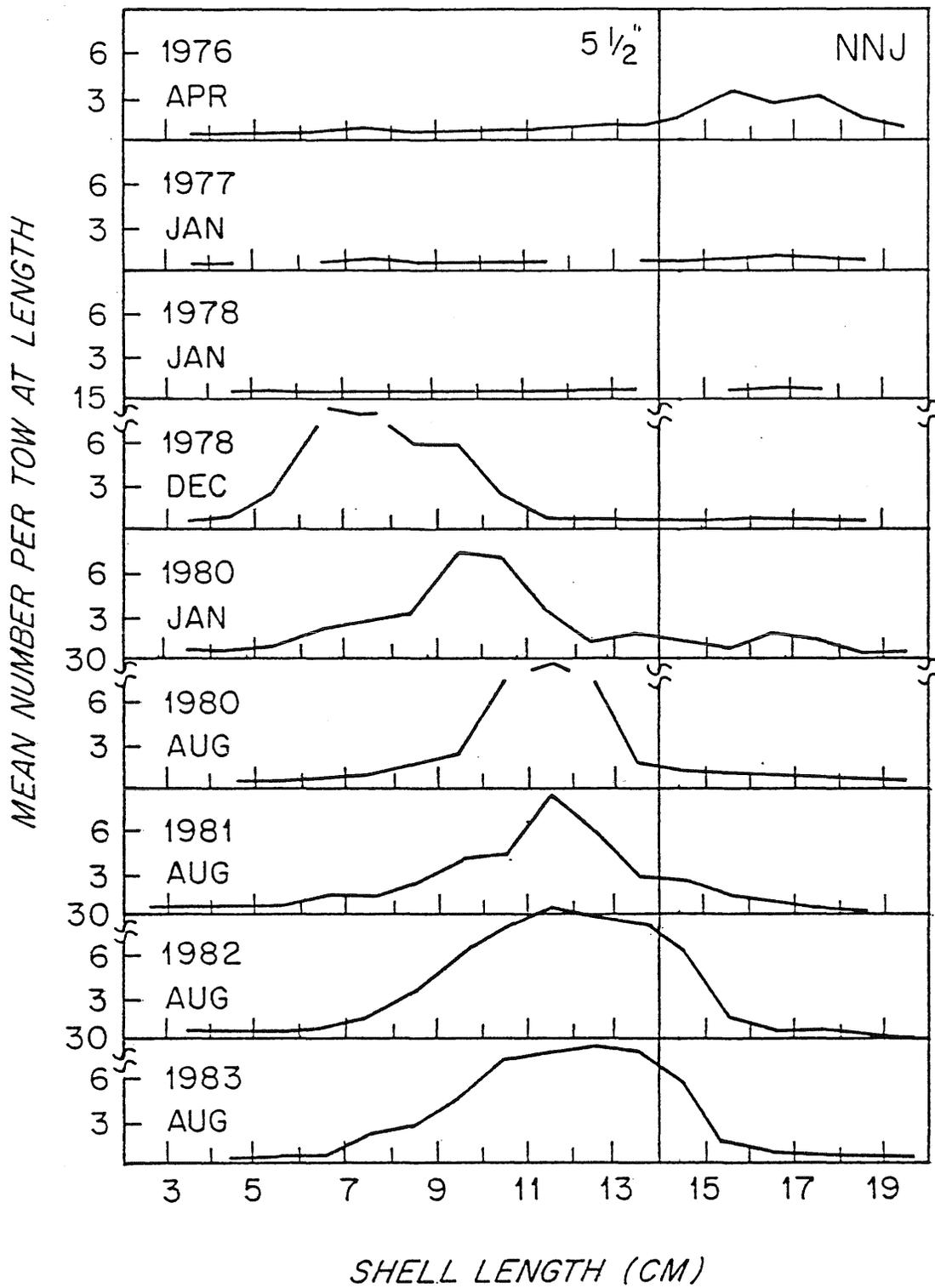


Figure 12. Stratified mean number of surf clams per standardized tow, at each 1 cm length group, in NMFS shellfish surveys off Northern New Jersey, 1976-1983.

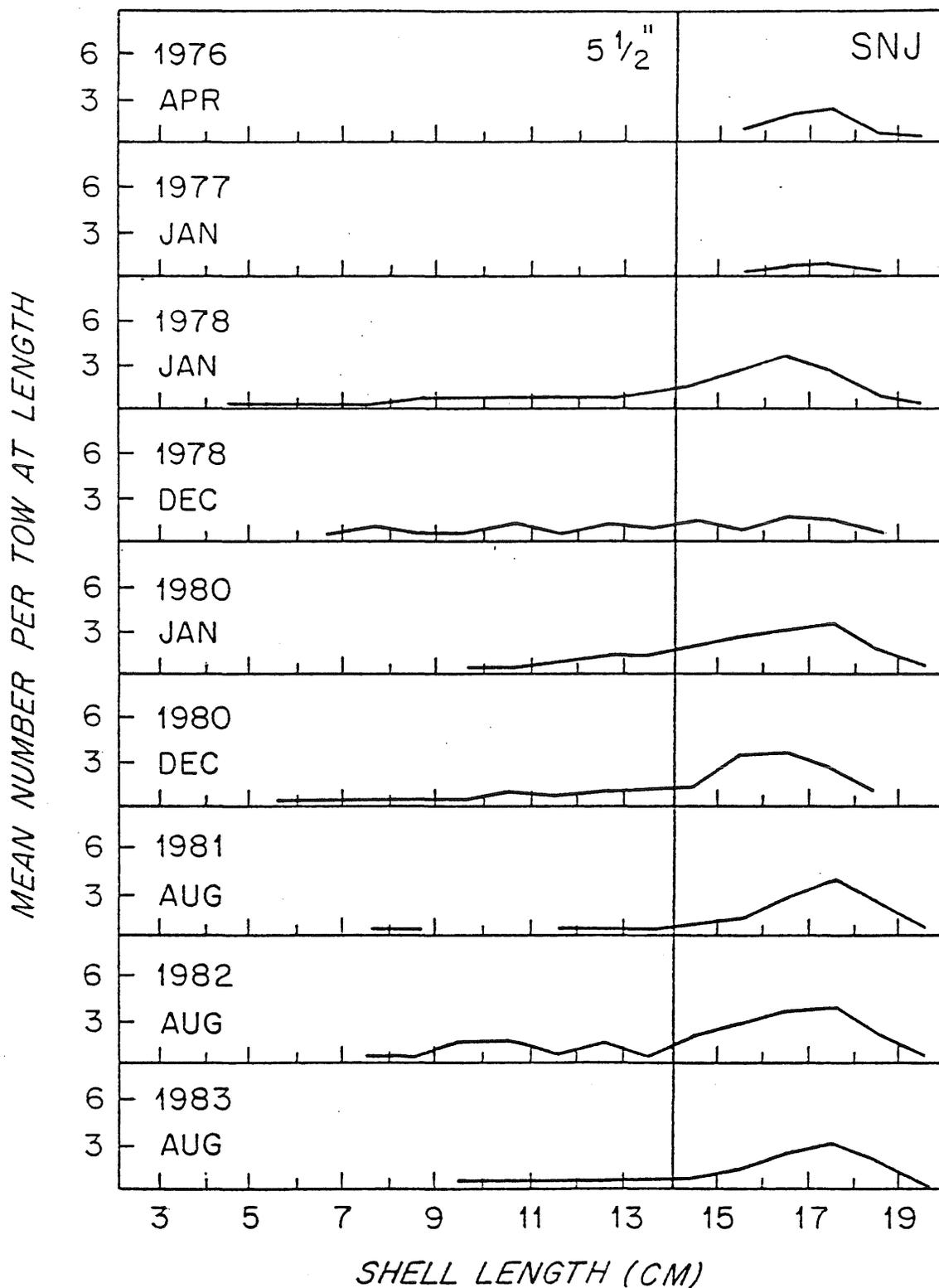


Figure 13. Stratified mean number of surf clams per standardized tow, at each 1 cm length group, in NMFS shellfish surveys off Southern New Jersey, 1976-1983.

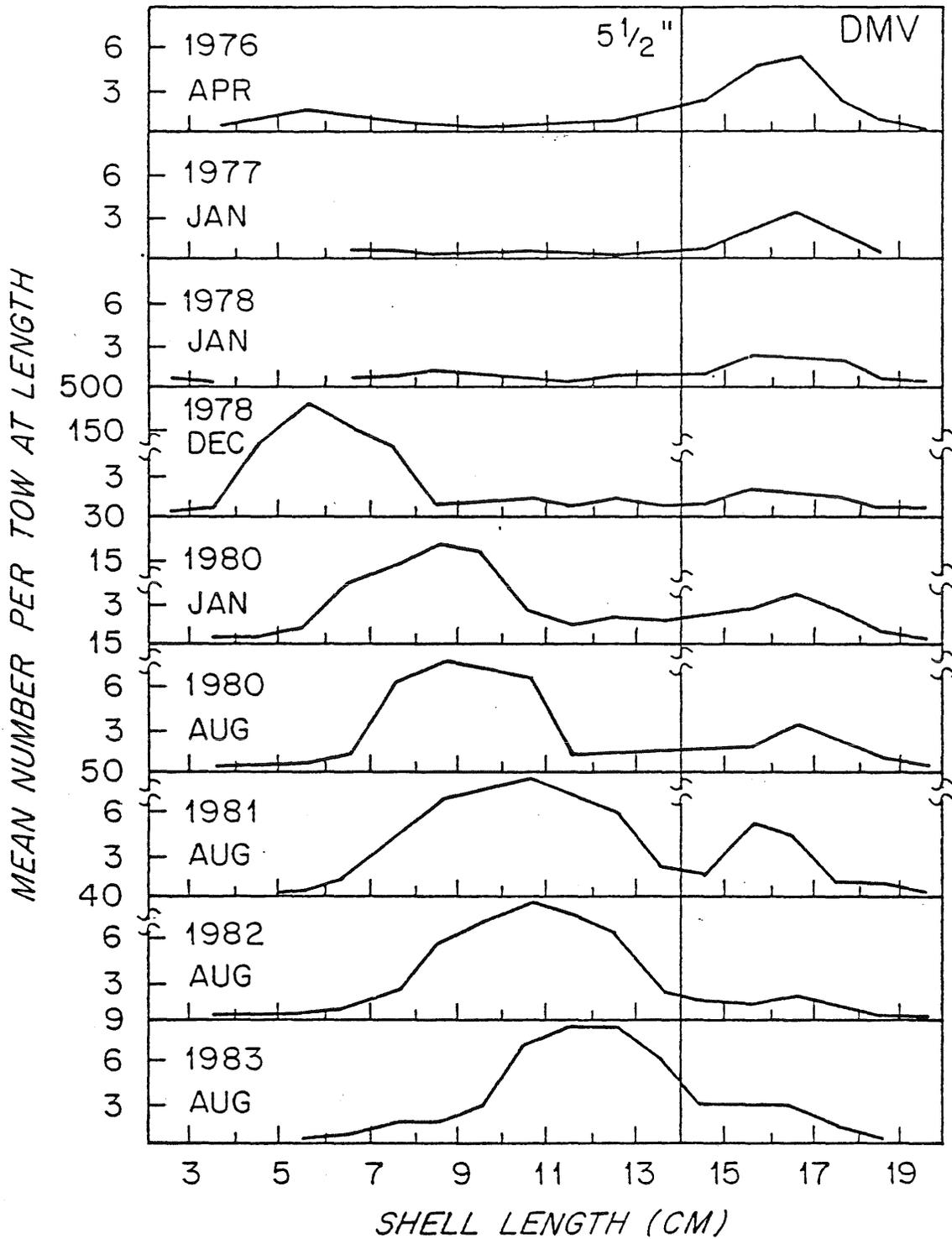


Figure 14. Stratified mean number of surf clams per standardized tow, at each 1 cm length group, in NMFS shellfish surveys off Delmarva, 1976-1983.