Northeast Fisheries Science Center Reference Document 93-01

Surfclam Populations of the Middle Atlantic, Southern New England, and Georges Bank for 1992

by

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This document was presented to and reviewed by the Stock Assessment Review Committee (SARC) of the 15th Northeast Regional Stock Assessment Workshop (15th SAW)

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by J. Weinberg

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SUMMARY

An assessment of surfclam *(Spisula solidissima)* populations from the Middle Atlantic, Southern New England, and Georges Bank was last conducted in 1989. The current report represents an update, with data available through October 1992, on the status of this species. Two types of data were analyzed: 1) commercial landings/fishing effort and 2) catch per tow from National Marine Fisheries Service research vessel surveys. Currently, vessel logbooks are obtained from all participants in the fishery.

Landings of surfclams from the Exclusive Economic Zone (EEZ; 3 to 200 mi from the coast) have remained fairly stable at 20,000 to 25,000 mt of shucked meats since 1984. This is attributable to the near constant catch quotas that have been in effect throughout this period. Catch from the EEZ was greater than from state waters. Over the same period (1984-1991), state landings ranged from 4,900 to 11,000 mt. Landings from state waters have been more variable than in the EEZ, as measured by the coefficient of variation. Landings from all waters totalled 30,000 mt in 1991. This represents a drop of 2,500 mt compared to 1990's landings, but is close to the average annual catch for the last 5 years. Between 1990 and 1992, more than 95% by weight of the surfclams landed commercially from the EEZ were taken from the Middle Atlantic region.

Landings per unit effort (LPUE) data are potentially valuable because they can provide an estimate of population abundance through time. In the case of surfclams, however, these data are difficult to interpret because several factors that affect LPUE, other than clam abundance, were not constant over time.

For large vessels fishing in the Middle Atlantic, LPUE ranged from 200 to 700 kg per hour during 1978-1984, increased to 1550 to 1850 kg per hour during 1985-1990, and then dropped to 900 to 1100 kg per hour during 1991-1992.

Of all clams harvested from the Middle Atlantic region during 1990-1992, 75 to 87% were taken from the area designated as Northern New Jersey. The 1992 Northern New Jersey LPUE has fallen to 51% of the 1989 LPUE. Trends in LPUE over time in the Delmarva area match those of Northern New Jersey. The 1992 Delmarva LPUE has fallen to 61% of the 1989 LPUE. In the Delmarva area, LPUE has fallen in spite of the fact that this has not been the primary surfclam harvesting area. In contrast with other Middle Atlantic areas, LPUE has increased through time off Southern New Jersey. Relative to Northern New Jersey and Delmarva, Southern New Jersey is a small area. Catch rates off Southern New England were about one order of magnitude less than in the Middle Atlantic during 1983-1990. Catch rates on Georges Bank were slightly lower than those of the Middle Atlantic during 1984-1989. The Georges Bank surfclam fishery has been closed since 1989 due to paralytic shellfish poisoning. No logbook data are available to compute LPUE for Southern New England in 1991-1992 or for Georges Bank in 1990-1992.

Research vessel survey data collected in 1992 indicate that surfclam populations from the Middle Atlantic, Southern New England, and Georges Bank continue to be dominated by adult individuals. No strong year classes have been identified in any of the Middle Atlantic assessment areas subsequent to the 1976 and 1977 cohorts. These populations are declining in abundance over time due to natural and fishing mortality. For Northern New Jersey, where most surfclam harvesting has taken place in the last 10 years, abundance has declined between 1982 and 1992 from an average of 112 to 47 individuals per tow, and mean weight (shucked meat) has declined from 8.78 to 4.41 kg per tow. The instantaneous rate of total mortality, Z, in the Northern New Jersey area between 1982-1992 was estimated to be 0.06 (S=0.94). In the Delmarva area between 1984 and 1992, surfclam abundance declined from an average of 129 to 36 individuals per tow, and weight declined from 5.58 to 2.81 kg per tow. In the Delmarva area between 1984-1992, Z was estimated to be 0.17 (S=0.84).

Assuming natural mortality rates remain at their current low levels, commercial catch and research vessel survey data indicate that the Mid-Atlantic region can support its current level of catch for another 11 to 14 years. Almost 75% of surfclam stock biomass is in the Mid-Atlantic region. In recent years, landings per unit effort have decreased, and LPUE will continue to decrease by a substantial amount each year in the major clamming areas. Unless a major recruitment event takes place in the Mid-Atlantic region, those stocks of surfclams will become depleted. Surfclams from this region require as much as three years to attain a shell length of only 7 cm. If a major larval recruitment event were to occur in 1993, it would take at least until 2000 for the clams to grow to the size at which they are typically harvested now. Although LPUE has declined,

Northern New Jersey and Delmarva still have higher surfclam densities and weights per tow than other geographical areas (based on the 1992 survey); thus, it is unlikely that the fishery will migrate to a new area yet.

Considering the decline in LPUE in the Mid-Atlantic region, the Georges Bank surfclam population may be targeted for harvesting, assuming it is reopened. Surfclam biomass on Georges Bank is relatively high, and LPUE was historically almost as high as in the Middle Atlantic.

INTRODUCTION

The status of the surfclam, *Spisula solidissima*, off the Atlantic coast of the United States is updated through 1992. Data analyzed include commercial landings and effort, as well as research vessel surveys conducted by NMFS using a hydraulic dredge. Spatial and temporal trends in resource abundance and size frequency distribution are reported, along with a medium-term prognosis for the resource.

Results and conclusions augment previous assessment reports (Brown *et al.* 1977; Serchuk *et al.* 1979; Murawski and Serchuk 1979; Serchuk and Murawski 1980; Murawski and Serchuk 1981; 1982; 1983; 1984a; 1984b; 1984c; Murawski 1986; Murawski 1989), and associated research projects (Jones *et al.* 1978; Fogarty and Murawski 1986; Murawski and Serchuk 1989; Murawski and Idoine 1989). The 1989 assessment (NEFC 1989) stressed the lack of prerecruit sized clams in the population and noted some indication of declining catch rates.

Management of the surfclam resource has changed significantly over time, due to implementation of the FMP in 1977 (Mid-Atlantic Fishery Management Council 1992). Since the inception of the Plan, there has been an overall quota on commercial landings. To limit harvesting and to protect prespawning individuals, a variety of regulations have been in effect for various amounts of time between 1977-1990. Regulations have included closures of areas where there were concentrations of small clams (off Atlantic City, N.J., Ocean City, Mary., and Chincoteague, Vir.), regional and annual quotas, weekly and quarterly time restrictions, and minimum size limits. Minimum size limits changed from 5.5 inches (14.0 cm) in 1981-1984, to 5.25 inches (13.3 cm) in 1985, to 5 inches (12.7 cm) in 1986-1989. During this period, 1981-1989, discards may have been substantial. In 1990, when the Individual Transferable Quota (ITQ) system was initiated, regulations on harvesting time and legal size were dropped. As a result, discards have represented a negligible fraction of total catch from 1990-1992.

ANALYSIS OF COMMERCIAL DATA

Commercial landings data are from vessel logbooks, obtained from all participants in the fishery. These data are stored in the VAX computer's S1032 database. Logbook data collected before 1980 are not currently available for analysis. Files contain information on landings, effort, date and location of catch, and ship weight.

Previous assessments were done totally within S1032. This approach was abandoned because of problems retrieving data for analysis. The major obstacle to analyzing the SFyyVR datasets in S1032 was in determining the locations of clam catches. Data have not been entered in a consistent manner under the variables named LAT and LONG. Often, loran numbers are given instead of latitude and longitude. During retrieval, S1032 effectively multiplies these latitudes and longitudes by ten, because the four-digit numbers are left justified. This leads to retrieval of erroneous data. A second problem that leads to retrieval of incorrect data occurs when one maps between S1032 files to determine ship weights. This is related to the fact that some canceled permit numbers have been reused.

These problems were overcome by converting the S1032 files into ASCII files which were then analyzed using SAS. Location and ship weight are not available directly as variables, but this information was obtained by decomposing composite variables, and by using multiple criteria (*e.g.*, loran number, latitude, longitude, ten minute square, and sometimes, the state where the port was located) to assign catches to geographical areas. Every attempt was made to assign catches to the same geographical areas used in previous assessments (*e.g.* NEFC 1989; Murawski 1989).

For 1980-1992 data, all tables and figures in the current report have been updated and converted to metric units (1 bushel of surfclams = 17 lbs = 7.711 kg). By necessity, a minor change was made from previous assessments in the vessel size class categories: Class 1 was not changed, Class 2 was changed from 51 to 100 GRT to 51 to 104 GRT, and Class 3 was changed from 101+ GRT to 105+ GRT.

COMMERCIAL FISHERY

Total surfclam landings in 1991 were 30.0 thousand metric tons of shucked meats (Table 1; Figure 1), representing a 7.7% decrease from landings in 1990. Landings from the EEZ decreased from 24.0 thousand metric tons in 1990 to 20.6 thousand metric tons in 1991 (-14.1%). For 1991, EEZ landings were the lowest since 1983. Surfclam landings from state waters increased from 8.5 thousand metric tons in 1990 to 9.4 thousand metric tons (+10.2%) in 1991.

Catch quotas for the Mid-Atlantic region have been in effect since 1984, and EEZ surfclam

Table 1. Total U.S. surfclam landings (metric tons of meats), total landings from the Exclusive Economic Zone (EEZ), landings from state waters, and percent of total from the EEZ[1]

Year	Landings			Percent Landed From EEZ
	Total	EEZ	State Waters	
1965	19,998	14,968	5,029	75
1966	20,463	14,696	5,766	72
1967	18,168	11,204	6,964	55
1968	18,394	9,072	9,322	49
1969	22,487	7,212	15,275	32
1970	30,535	6,396	24,139	21
1971	23,829	22,704	1,126	95
1972	28,744	25,071	3,674	87
1973	37,362	32,921	4,441	88
1974	43,595	33,761	9,834	77
1975	39,442	20,080	19,362	51
1976	22,277	19,304	2,982	87
1977	23,149	19,490	3,660	84
1978	17,798	14,240	3,558	80
1979	15,836	13,186	2,650	83
1980	17,117	15,748	1,369	92
1981	20,910	16,947	3,964	81
1982	22,552	16,688	5,873	74
1983	25,373	20,485	4,887	81
1984	31,862	24,776	7,086	78
1985	32,894	23,691	9,204	72
1986	35,720	24,923	10,797	70
1987	27,553	22,147	5,406	80
1988	28,823	23,950	4,873	83
1989	30,423	22,334	8,089	73
1990	32,555	24,027	8,528	74
1991	30,036	20,637	9,399	69
1992[2]	-	20,737	-	-

[1] **Proportions for 1971-1988 based on data presented in "Fisheries of the United States, 1991" (U.S. Department of Commerce 1992). Earlier data based in NMFS/BCF dockside interviews.**

[2] **1992 landings were estimated from data available as of Oct. 20, 1992.**

landings have stabilized between 20.4 and 24.9 thousand metric tons. This stability is reflected by a reduction in the CV (SD/Mean). The CV for EEZ surfclam landings decreased from 0.51 for the 1965-1976 period, to 0.06 for the 1984-1991 period. The CV for state landings for the period 1984-1991 was 0.26. Thus, restrictive management in the EEZ since 1984 has stabilized the annual catch when compared with that in the EEZ before 1984 and compared with catches from state waters since 1984.

The previous clam assessment (NEFC 1989) evaluated the surfclam resource as three separate regions: Middle Atlantic, Southern New England and Georges Bank (Mid-Atlantic Fishery Management Council 1989; Figure 2). To maintain continuity with past assessments, results are presented here for each of the three areas (Table 2). The Middle Atlantic region is further divided into five areas for analysis: Long Island, Northern New Jersey, Southern New Jersey, Delmarva, and Southern Virginia-North Carolina. The entire surfclam EEZ resource is now managed under a single quota. The 1992 surfclam quota for the EEZ was set at 2,850 thousand bushels (22.0 thousand metric tons of shucked meats) (Mid-Atlantic Fishery Management Council 1992).

DISTRIBUTION OF LANDINGS AND LANDINGS PER UNIT EFFORT (LPUE)

Between 1990 and 1992, more than 95% of the commercial EEZ surfclam landings were taken from the Middle Atlantic area, and EEZ landings have been fairly stable in this region since 1983 (Table 2). Landings from Southern New England and Georges Bank have always been approximately one order of magnitude lower than the Middle Atlantic landings. While they

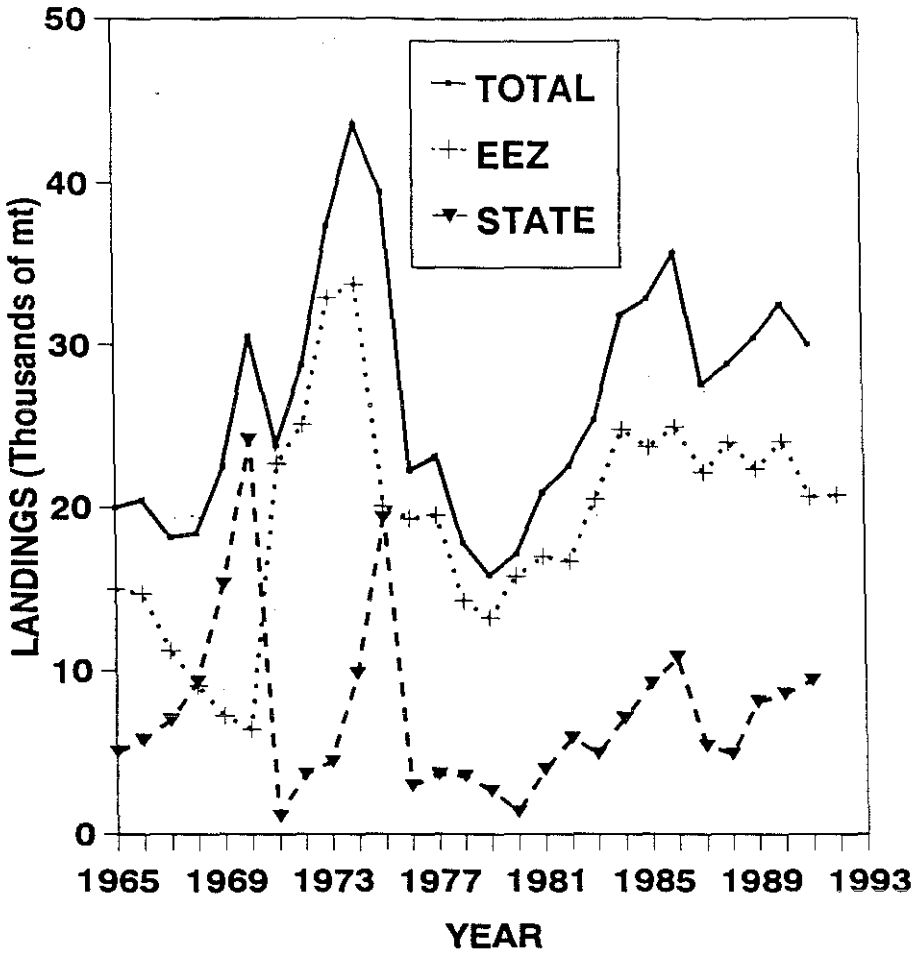

Figure 1. Landings of surfclams (1000 mt of meats), 1965-1992. Data are for all areas (Total), the Exclusive Economic Zone (EEZ, 3 to 200 mi from the coast) and inshore (State) waters. For 1992, EEZ landings are a prediction for the entire year based on logbook data available as of October 20, 1992.

have always been relatively low, Southern New England landings declined drastically in 1991 and 1992. Georges Bank has been closed since 1989 due to paralytic shellfish poisoning (PSP).

The first full year of mandatory logbook submissions was 1978. In 1980, 86% of the Mid-Atlantic region's catch came from the Delmarva area (Table 3). Beginning in 1981, recruitment by an abundant 1976 cohort in Northern New Jersey was accompanied by increased fishing effort in that area. By 1984, the majority of the catch was being taken from Northern New Jersey. Since 1986, approximately 80% of the EEZ catch has been from Northern New Jersey (Table 3). The fishery has concentrated in Northern New Jersey because that area has had a greater proportion of large clams (>12.7 cm in length) (see RESEARCH VESSEL SURVEYS) and, reportedly, because shucked meat yields per bushel were greater than those of Delmarva.

Landings per unit effort data are potentially valuable because they can provide an estimate of population abundance through time. In the case of surfclams, however, these data are difficult to interpret because several factors that affect LPUE, other than clam abundance, were not constant over time. The most significant of these are changes through time in discard rates, changes in fishing gear and suspected changes in accuracy of reported time fishing. These changes are assumed to be due to changes in fishing regulations and growth of a cohort over the minimum size. Recognizing these problems with interpreting LPUE data for surfclams, there are trends in this statistic over time.

Landings per unit effort was computed annually by region and by vessel size class (Table 4). Within a region, LPUE increases with vessel size class. Among the three regions, LPUE is typically lowest for Southern New England. In certain years, LPUE from Georges Bank has been approximately as high as that in the Middle Atlan-

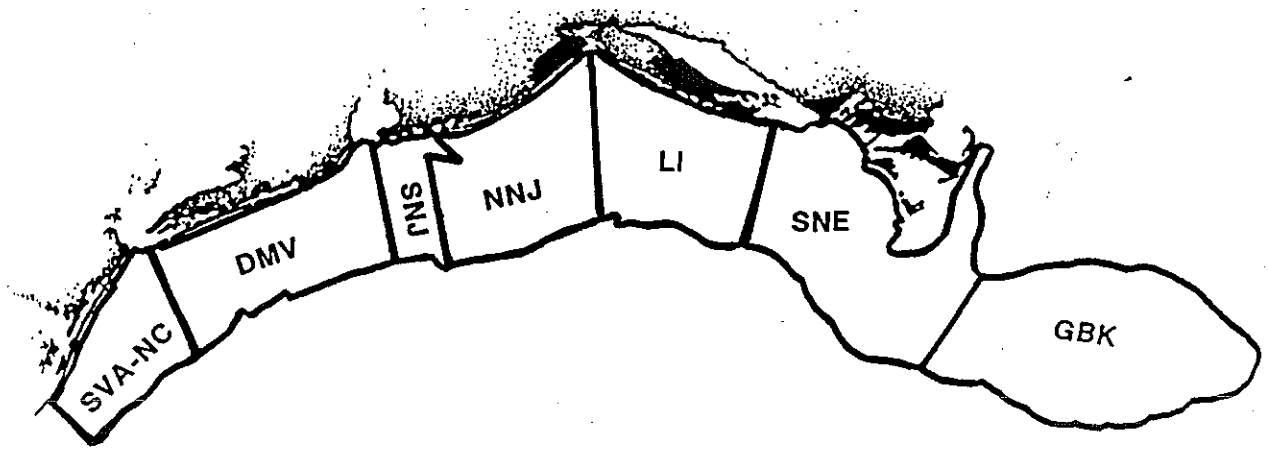

Figure 2. Ocean shellfish survey assessment areas off the Northeast United States.

Table 2. Total annual EEZ surfclam landings (metric tons), by management area as reported in mandatory logbooks reported by each vessel

Year	Middle Atlantic	Southern New England	Georges Bank	EEZ Total	FSUS Total[1]
1983	17,913	679	-	18,591	20,488
1984	19,763	486	2,637	22,886	24,775
1985	19,331	918	2,236	22,478	23,688
1986	21,074	1,596	1,851	24,521	24,922
1987	19,702	1,172	871	21,745	22,146
1988	21,136	1,504	740	23,380	23,950
1989	20,095	1,357	432[2]	21,884	22,331
1990	23,010	1,010	0	24,020	24,027
1991	20,612	0	0	20,612	20,635
1992[3]	20,730	6	0	20,737	-

[1] From "Fisheries of the United States, 1991" (U.S. Department of Commerce 1992)
[2] Fishery closed due to PSP contamination as of late summer, 1989
[3] Estimated

tic, the region which typically had the highest LPUE. Since 1986, LPUE has declined steadily (Table 4; Figures 3-5) in the region where the surfclam fishery is focused, the Mid-Atlantic (Table 2).

Large "Class 3" vessels take the majority of landings (Table 5). Landings per unit effort of Class 3 vessels in the Mid-Atlantic has changed drastically through time (Figure 3). During 1978-1984, LPUE ranged from 200 to 700 kg/hr. It increased to a range of 1500 to 1850 kg/hr during 1985-1990, and dropped to 900 to 1110 kg/hr during 1991-1992. The increase in LPUE was primarily the result of recruitment to the fishery by clams born in the mid-1970s. The recent decline in LPUE probably reflects lower abundance and biomass per tow of surfclams in the Middle Atlantic region.

Most of the Mid-Atlantic catch is taken from the Northern New Jersey area; between 1986 and 1992 the average percentage of total Mid-Atlantic catch from this area was 84% (Table 3). The LPUE generally declined for all three vessel classes after 1986 off Northern New Jersey (Table 5; Figure 4).

Southern New Jersey is a relatively small area, that typically accounts for 3 to 10% of the landings from the Middle Atlantic region. In contrast to Northern New Jersey, catch rates increased in recent years off Southern New Jersey (Table 5; Figure 6).

For Delmarva, the pattern of change in LPUE

Table 3. Annual EEZ surfclam landings and percent of catch from areas of the Mid-Atlantic region

	Long Island		Northern New Jersey		Southern New Jersey		Delmarva		Southern Virginia-North Carolina	
	mt	%	mt	%	mt	%	mt	%	mt	%
1980	-	-	1244	(10.1)	504	(4.1)	10,556	(85.6)	33	(0.2)
1981	-	-	5546	(45.5)	137	(1.1)	6196	(50.8)	321	(2.6)
1982	-	-	3879	(37.0)	692	(6.6)	4886	(46.7)	1016	(9.7)
1983	8	(0.0)	5634	(35.4)	802	(5.0)	7170	(45.1)	2300	(14.5)
1984	0	(0.0)	8964	(50.1)	1501	(8.4)	6127	(34.2)	1315	(7.3)
1985	0	(0.0)	8504	(51.3)	899	(5.4)	6630	(40.0)	558	(3.3)
1986	0	(0.0)	14,294	(75.0)	1420	(7.4)	3102	(16.3)	249	(1.3)
1987	0	(0.0)	16,815	(88.3)	560	(2.9)	1545	(8.1)	139	(0.7)
1988	0	(0.0)	18,780	(91.5)	123	(0.6)	1441	(7.0)	186	(0.9)
1989	1	(0.0)	15,907	(82.3)	59	(0.3)	3347	(17.3)	14	(0.1)
1990	0	(0.0)	16,589	(75.2)	740	(3.4)	4678	(21.2)	49	(0.2)
1991	0	(0.0)	17,092	(85.7)	1234	(6.2)	1625	(8.1)	0	(0.0)
1992[1]	0	(0.0)	17,657	(86.8)	2158	(10.6)	537	(2.6)	0	(0.0)

[1] **1992 landings were estimated.**

Table 4. Comparison of surfclam landings per unit effort (LPUE, kilograms per hour fishing) by region: Middle Atlantic (MA), Southern New England (SNE) and Georges Bank (GB), as reported in mandatory logbook submissions, 1978-1992[1]

Year	1-50 GRT			51-104 GRT			105+ GRT		
	MA	SNE	GB	MA	SNE	GB	MA	SNE	GB
1978[1]	123	-	-	154	-	-	216	-	-
	(275)[2]	-	-	(1269)	-	-	(1922)	-	-
1979	131	-	-	147	-	-	247	-	-
	(310)	-	-	(1566)	-	-	(2612	-	-
1980	147	-	-	185	-	-	308	-	-
	(375)	-	-	(2162)	-	-	(2438)	-	-
1981	170	-	-	285	-	-	432	-	-
	(324)	-	-	(1473	-	-	(2185)	-	-
1982	154	-	-	216	-	-	324	-	-
	(509)	-	-	(1947)	-	-	(2624)	-	-
1983	216	-	-	308	154	-	432	848	-
	(399)	-	-	(1913)	(10)	-	(2203)	(80)	-
1984	316	77	-	532	247	447	702	517	1033
	(308)	(7)	-	(1618)	(70)	(15)	(1344)	(25)	(186)
1985	609	85	-	1018	185	532	1542	293	679
	(188)	(2)	-	(1171)	(24)	(20)	(1237)	(79)	(109)
1986	702	77	-	1272	270	1373	1851	308	1095
	(159)	(5)	-	(839)	(59)	(46)	(1244)	(85)	(114)
1987	694	193	-	1195	177	1033	1720	378	864
	(103)	(55)	-	(901)	(143)	(34)	(1268)	(42)	(63)
1988	709	193	-	1157	154	856	1712	177	1843
	(129)	(76)	-	(970)	(150)	(39)	(1380)	(69)	(32)
1989	748	170	-	1180	231	1087	1619	131	1126
	(106)	(71)	-	(903)	(123)	(19)	(1377)	(47)	(23)
1990	478	131	-	1164	308	-	1542	162	-
	(93)	(140)	-	(919)	(33)	-	(1551)	(39)	-
1991	170	-	-	979	-	-	1110	-	-
	(45)	-	-	(815)	-	-	(1450)	-	-
1992	362	-	-	1102	-	-	910	-	-
	(15)	-	-	(602)	-	-	(1313)	-	-

[1] **Values for 1978-1979 are from Murawski 1989. The vessel size categories are 1-50, 51-100, and 101+ GRT.**
[2] **Numbers of trips with logs shown in parentheses**

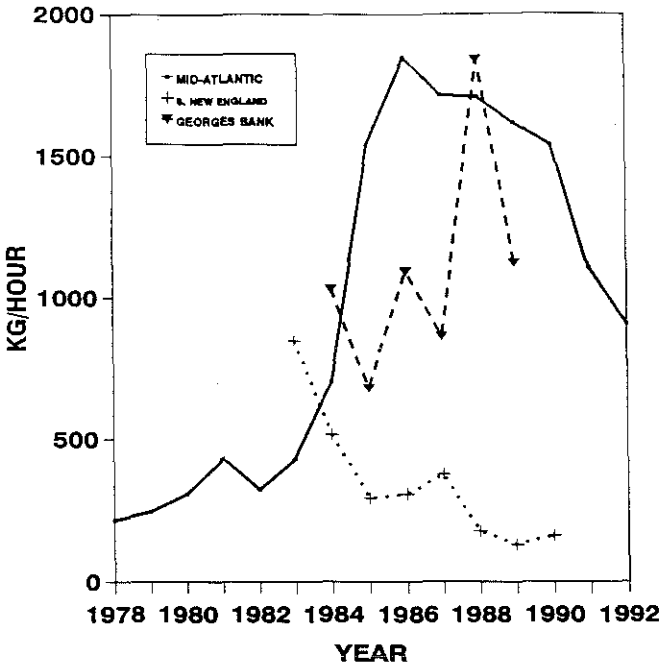

Figure 3. Landings per unit of effort (kilograms per hour fishing) for Class 3 vessels (defined in Table 5) operating in Mid-Atlantic, Southern New England, and Georges Bank waters, 1978-1992. Data were derived from vessel trip logbooks and are for all sizes of clams combined.

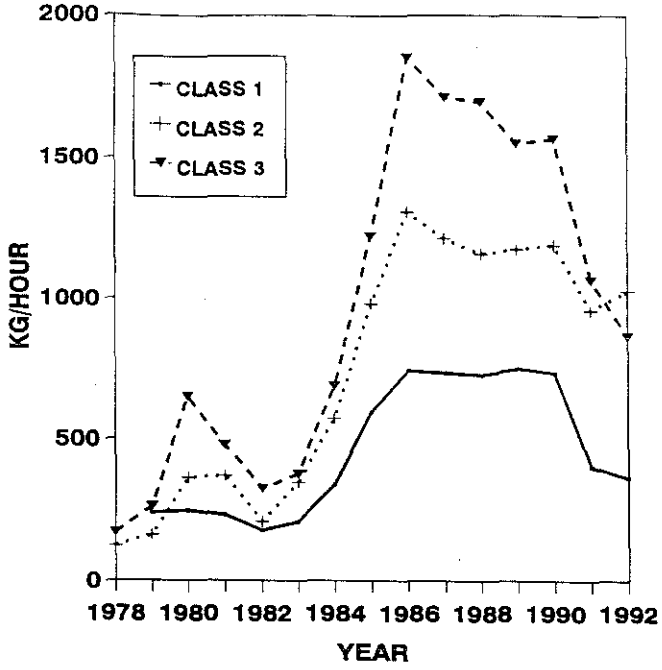

Figure 4. Landings per unit of effort (kilograms per hour fishing) for three vessel size classes (defined in Table 5) operating off Northern New Jersey, 1978-1992. Data were derived from vessel trip logbooks and are for all sizes of clams landed.

with time is similar to that described for the Northern New Jersey area (Table 5; Figures 5 and 6). LPUE was high for Class 3 vessels between 1985 and 1989, in the range of 1850 to 2050 kg/hr. LPUE fell steadily from 1989 to 1992. Current LPUE levels are slightly higher in Delmarva than Northern New Jersey. In the previous assessment (NEFC 1989), the Delmarva area was viewed as an unused supply of surfclams. While it is true that there has been relatively little exploitation from the Delmarva area to date, the reduction in LPUE (Table 5; Figure 5) suggests that natural mortality has reduced surfclam abundance in the Delmarva area (see RESEARCH VESSEL SURVEYS). Therefore, the resource will probably not be as large as had been expected.

There were no reported logbook landings from Southern New England in 1991 or 1992. In previous years Southern New England LPUE was about an order of magnitude lower than the LPUEs from the Middle Atlantic and Georges Bank (Figure 3). Although LPUE on Georges Bank was relatively high, there are no estimates of LPUE after 1989 because the region has been closed to shellfishing due to PSP contamination. This fishery is still in an exploratory phase.

RESEARCH VESSEL SURVEYS

A series of 19 research vessel survey cruises have been conducted between 1965 and 1992 (Table 6) to evaluate the distribution, relative abundance, and size composition of surfclam and ocean quahog populations in the Middle Atlantic, Southern New England, and Georges Bank (Figure 2; Table 7). Information from these surveys is used to predict relative year-class strength, and to evaluate the effects of fishery management measures. Assessments of both short- and long-term fishery productivity are based on correlating trends in survey abundance indices with fishery yields. Figure 6 demonstrates that, for the three major Mid-Atlantic surfclam areas, there is not a close correspondence between survey biomass and LPUE through time. However, as explained earlier, LPUE data for surfclams are problematic.

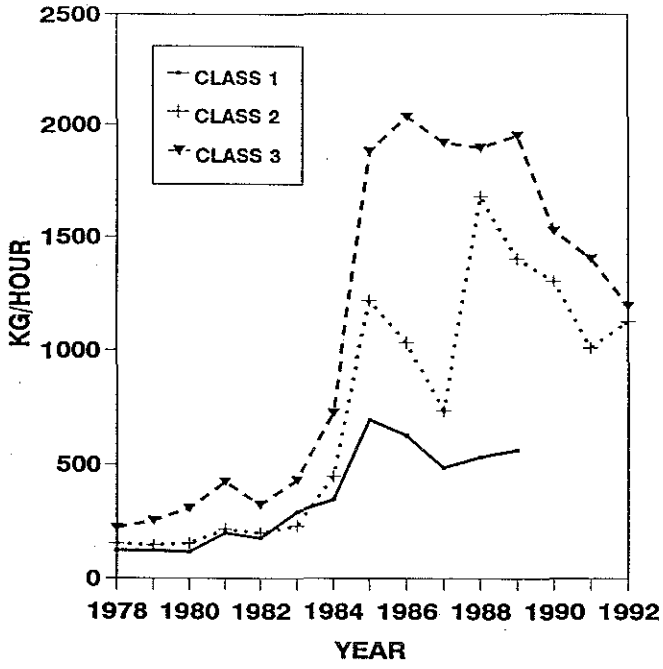

Figure 5. Landings per unit of effort (kilograms per hour fishing) for three vessel size classes (defined in Table 5) operating off Delmarva, 1978-1992. Data were derived from vessel trip logbooks and are for all sizes of clams landed.

The surveys are performed using a stratified random sampling design, allocating a predetermined number of tows to each stratum. Standardized sampling procedures used in these surveys are described in Murawski and Serchuk (1989). Strata are assigned to assessment areas (Table 7). One tow is collected per station, and tow duration is 5 min. Survey catches have been standardized to the catch of a 60-in. wide survey dredge towed for 5 min. Catch in meat weight per tow is computed by applying appropriate length-weight equations to numbers caught in each 10 mm size category. Representative size frequency distributions per tow are presented for each assessment area and each survey date since 1983 (Figures 7-13). The sum of the individuals in each size-frequency distribution is equal to the stratified mean number of clams per tow for a particular assessment area. Stratified means are weighted by the proportional area of each stratum in the assessment area. Tables 8-12 present, by assessment area, a time series of abundance and biomass per tow for two size categories. For the calculation of confidence intervals, the standard deviation of the stratified mean regional abundance per tow was computed as the square root of

$$V\left(\sum_{j=1}^{m} a_{jl}\bar{Y}_{jl}\right) = \sum_{j=1}^{m} \left(a_{jl}^2\, V(\bar{Y}_{jl})\right) \qquad \text{where,}$$

V = variance,

a_{jl} = probability{stratum j | region l}, and

$\bar{Y}_{jl}$ = mean abundance in stratum j, region l.

NORTHERN NEW JERSEY

The total number and weight per tow declined slowly between 1965-1974, and then declined sharply between 1976 and 1978 (Table 8, Figure 6). The rapid decline is attributable to hypoxic water conditions in 1976 (Murawski and Serchuk 1989). Subsequent to that event, an abundant 1976 cohort has dominated the population. Stratified mean numbers per tow at length are shown in Figure 7. There is no evidence of another strong cohort that will recruit to the fishery and replace the 1976 cohort. Between 1982 and 1992, surfclam abundance declined from an average of 112 to 47 individuals per tow, and meat weight declined from 8.8 to 4.4 kg (Table 8).

Northern New Jersey is composed of five survey strata. Examining the average number of clams of a given length per tow in the 1992 survey for these five strata also demonstrated that small surfclams were rare in this area. For strata #21, #25, #88, #89, and #90, average number of individuals per tow were 37.1, 20.3, 95.2, 88.7, and 0.0, respectively. For the same five strata, average number of individuals per tow smaller than 7 cm in shell length were 1.4, 2.7, 0.2, 1.3, and 0.0. Based on studies by Jones *et al.* (1978), surfclams from this region require approximately 3 years to attain a shell length of 7 cm.

A regression model was fit to ln(abundance) *vs* time to estimate the instantaneous rate of mortality, Z, under the assumption of no migration or recruitment between 1982 and 1992. Both assumptions are fairly reasonable because adult clams do not move, and there is no evidence of any substantial recruitment during the last ten years. The estimate of Z from these data is 0.06, or equivalently, a probability of annual survival, S, of 0.94. Because a minor amount of recruitment has occurred, 0.06 is probably an underestimate of Z. Furthermore, the estimate of Z is

Table 5. Comparison of Middle Atlantic surfclam landings per unit effort (LPUE, kilograms per hour fishing time) statistics, as reported in mandatory logbook submissions by kilograms per hour fishing, 1978-1992[1]

Year/Area	Vessel Class 1		Vessel Class 2		Vessel Class 3	
	LPUE	% of Total Catch Taken	LPUE	% of Total Catch Taken	LPUE	% of Total Catch Taken
Northern New Jersey						
1978	-	0	123	42	170	58
1979	239	8	185	33	262	58
1980	247	6	362	38	648	56
1891	231	4	370	35	478	61
1982	177	4	208	40	324	55
1983	208	6	347	68	378	26
1984	339	5	571	71	686	23
1985	594	4	979	57	1218	38
1986	740	3	1303	36	1851	61
1987	733	2	1211	35	1712	63
1988	725	2	1157	33	1696	64
1989	748	3	1172	35	1550	62
1990	733	2	1187	32	1565	66
1991	401	0	656	29	1064	71
1992	362	0	1026	24	864	75
Southern New Jersey						
1978	93	9	139	33	177	58
1979	177	8	139	33	200	59
1980	93	3	123	40	324	56
1981	69	11	270	33	339	56
1982	93	7	224	36	270	57
1983	123	11	231	48	424	41
1984	270	11	355	24	601	65
1985	578	5	833	11	1303	84
1986	547	3	1110	16	1542	81
1987	-	0	941	25	1550	75
1988	-	0	771	38	1388	62
1989	-	0	864	43	1342	57
1990	231	0	1072	41	1157	58
1991	247	0	1465	40	1866	59
1992	-	0	1581	46	2090	54
Delmarva						
1978	123	4	154	25	224	71
1979	123	3	147	22	254	75
1980	116	2	154	22	308	76
1981	200	2	216	13	424	85
1982	177	4	200	11	324	85
1983	293	4	231	12	432	83
1984	347	4	447	12	725	84
1985	694	3	1218	11	1881	86
1986	625	3	1033	10	2036	87
1987	486	2	733	3	1920	95
1988	532	2	1681	5	1897	93
1989	563	0	1403	11	1951	88
1990	-	0	1303	15	1527	85
1991	-	0	1010	20	1403	80
1992	-	0	1126	28	1195	72

[1] **Values for 1978-1979 are from Murawski 1989. The vessel size categories are 1-50, 51-100, and 101+ GRT.**

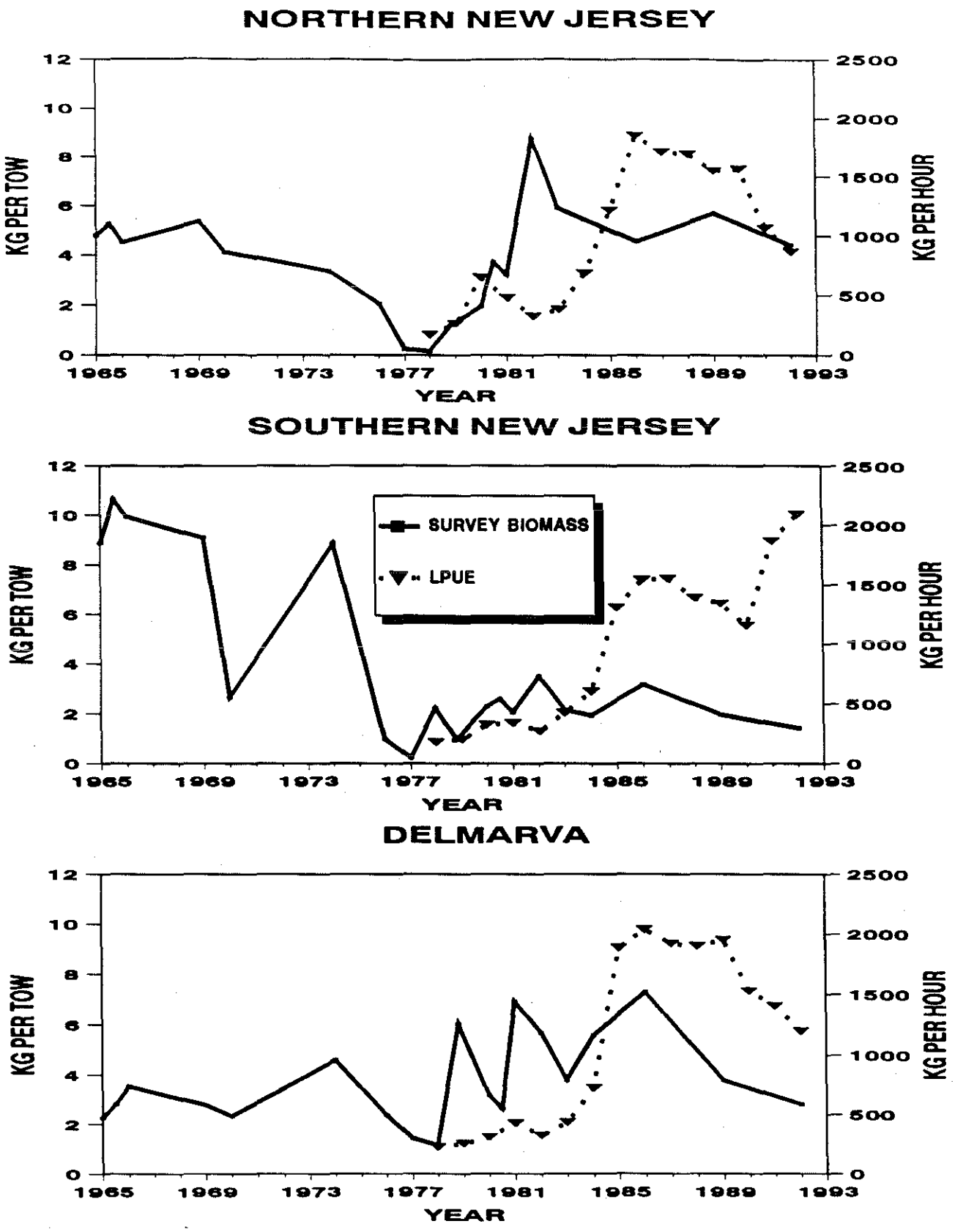

Figure 6. Surfclam biomass (meat weights per tow) and landings per unit of effort (kilograms per hour fishing by Class 3 vessels as defined in Table 5) in three assessment areas. Biomass values for 1965-1983 are from Murawski 1989.

Table 6. Summary of research vessel survey cruises used in the analysis of EEZ surfclam population dynamics, 1965-1992

Research Vessel	Dates of Cruises	Dredge Knife Width (cm)	Time of Tow (minutes)	Number of Stations		Ring Size or[1] Bar Space (cm)
Undaunted	May 1965	76	5	375	(293)[2]	5.1
Undaunted	Oct 1965	76	5	217	(158)	5.1
Albatross IV	Aug 1966	76	5	240	(210)	5.1
Albatross IV	Jun 1969	76	5	278	(166)	5.1
Delaware II	Aug 1970	122	4	199	(133)	3.0
Delaware II	Jun 1974	76	5	241	(142)	5.1
Delaware II	Apr 1976	122	4	259	(133)	3.0
Delaware II	Jan 1977	122	4	244	(92)	3.0
Delaware II	Jan 1978	122	4	324	(192)	3.0
Delaware II	Dec 1978	122	4	163	(105)	2.5
Delaware II	Jan 1980	152	5	229	(156)	5.1
Delaware II	Aug 1980	152	5	231	(114)	5.1
Delaware II	Aug 1981	152	5	261	(119)	5.1
Delaware II	Aug 1982	152	5	272	(151)	5.1
Delaware II	Aug 1983	152	5	381	(169)	5.1
Delaware II	Jul 1984	152	5	448	(241)	5.1
Delaware II	Jun 1986	152	5	334	(296)	5.1
Delaware II	Jul 1989	152	5	340	(290)	5.1
Delaware II	Jul 1992	152	5	496	(388)	5.1

[1] **Portion of the dredge where the catch is retained.**
[2] **Number of stations located in surfclam assessment strata.**

imprecise because the coefficient of determination, R^2, for the regression model is only 55%.

SOUTHERN NEW JERSEY

Average numbers and weights per tow off Southern New Jersey are currently much lower than in the 1960s (Table 9). Based on the 1992 survey, abundance off Southern New Jersey is substantially lower than off Northern New Jersey. Furthermore, the Southern New Jersey population is dominated by much larger clams than are found in other Middle Atlantic assessment areas (Figure 8). Most of the survey catches in this area are composed of individuals larger than 15 cm. While densities of recruits are low, there appears to have been some recruitment into the fishery between 1986 and 1992 (Figure 8).

DELMARVA

Based on the 1992 survey, Delmarva has the second highest clam density of all areas (behind Northern New Jersey) (Table 10). Stratified mean numbers per tow at length are shown in Figure 9 for surveys conducted between 1983-1992. There is inconsistency between the 1983 and 1984 survey data sets; the 1984 size frequency distribution could not be derived from the 1983 distribution given what is known about surfclam growth rates (Jones *et al.* 1978). Thus, either one or both of the distributions must be wrong. If one assumes that the 1984 distribution is correct, then a recruitment event is evident from the 1984 survey, and numbers have declined steadily since 1984. There is no evidence from subsequent surveys of another new cohort that will recruit to the fishery (Figure 9). Between 1984 and 1992 surfclam abundance declined from an average of 129 to 36 individuals per tow, and mean meat weight declined from 5.68 to 2.8 kg (Table 10).

The Delmarva area is composed of nine strata. Examining the average abundance per tow by size in the 1992 survey demonstrates that small surfclams are rare in these strata. For example, in strata #9, #10, #13, #14, #82, #83, #84, #85, and #86, the mean number of individuals per tow were 69.1, 0.3, 23.3, 0.0, 0.0, 1.0, 7.0, 11.8, and 0.3, respectively. For the same nine strata, mean numbers of clams that were smaller than 70 mm (*i.e.*, less than 3 years old) in shell length were 1.7, 0.0, 0.1, 0.0, 0.0, 0.5, 0.8, 0.4, and 0.0.

Noting that there may be a problem with the 1984 data (see above), a regression model was fit to ln(abundance) *vs* time to estimate Z, under the assumption of no migration or recruitment be-

Table 7. Designations of NMFS surfclam survey strata comprising seven assessment areas in the Middle Atlantic Bright, Southern New England, and Georges Bank (see Figure 2)

Assessment Area	Stratum Number	Area (nsq mi)	Depth (fathoms)	Range (m)
Middle Atlantic				
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-	81	360	5-15	9-27
North Carolina	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
Long Island	93	83	5-15	9-27
	92	191	5-15	9-27
	91	340	5-15	9-27
	34	203	25-30	46-55
	33	363	15-25	27-46
	30	669	25-30	46-55
	29	1096	15-25	27-46
Southern New England	96	495	5-15	9-27
	95	446	5-15	9-27
	94	229	5-15	9-27
	51	139	30-40	55-73
	50	150	25-30	46-55
	49	244	15-25	27-46
	47	871	30-40	55-73
	46	416	25-30	46-55
	45	392	15-25	27-46
	41	602	15-25	27-46
	38	280	25-30	46-55
	37	672	15-25	27-46
Georges Bank	74	433	25-30	46-55
	73	501	15-25	27-46
	72	504	15-25	27-46
	71	146	25-30	46-55
	70	520	25-30	46-55
	69	938	15-25	27-46
	68	370	15-25	27-46
	67	210	25-30	46-55
	66	266	40-60	73-110
	65	164	30-40	55-73
	64	988	40-60	73-110
	63	694	30-40	55-73
	62	701	40-60	73-110
	61	576	30-40	55-73
	60	810	40-60	73-110
	59	538	30-40	55-73
	58	300	40-60	73-110
	57	184	30-40	55-73
	56	209	40-60	73-110
	55	364	30-40	55-73
	54	278	30-40	55-73
	53	268	40-60	73-110

Table 8. Stratified mean number and weight (meats only, kilograms) per tow of surfclams from NMFS surveys off Northern New Jersey, 1965-1992[1]

Survey	Total Index		<14 cm		>14 cm		%>14 cm	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	38.07	4.79	15.44	1.17	22.62	3.62	59	76
Oct 1965	35.73	5.27	6.18	0.51	29.55	4.76	83	90
Aug 1966	30.44	4.51	5.44	0.36	24.99	4.15	82	92
Jun 1969	34.26	5.37	3.93	0.30	30.33	5.07	89	94
Aug 1970	25.73	4.12	4.84	0.30	20.89	3.82	81	93
Jun 1974	21.40	3.37	2.75	0.19	18.66	3.17	87	94
Apr 1976	12.92	2.06	2.39	0.12	10.53	1.93	82	94
Jan 1977	2.45	0.23	1.39	0.05	1.06	0.19	43	81
Jan 1978	2.06	0.16	1.48	0.06	0.58	0.11	28	65
Dec 1978	44.88	1.20	43.85	1.03	1.01	0.17	2	15
Jan 1980	31.70	1.95	27.52	1.22	4.17	0.75	13	38
Aug 1980	53.56	3.74	50.66	3.24	2.90	0.50	5	14
Aug 1981	39.10	3.23	31.15	2.04	8.03	1.19	21	36
Aug 1982	112.79	8.78	101.53	7.11	11.26	1.67	10	19
Aug 1983	72.91	5.94	63.06	4.42	9.85	1.52	14	26
Jul 1984	64.88	5.47	52.71	3.70	12.17	1.77	19	32
Jul 1986	45.57	4.57	30.81	2.37	14.76	2.20	32	48
Jul 1989	58.89	5.71	35.95	2.77	19.94	2.94	34	51
Jul 1992	47.44	4.41	32.65	2.17	14.80	2.23	31	51

[1] **Data are standardized to a 60-in. wide dredge towed for 5 min**

Table 9. Stratified mean number and weight (meats only, kilograms) per tow of surfclams from NMFS surveys off Southern New Jersey, 1965-1992[1]

Survey	Total Index		<14 cm		>14 cm		%>14 cm	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May1965	105.98	8.88	78.08	4.37	27.93	4.49	26	50
Oct 1965	82.84	10.64	33.32	2.73	49.52	7.93	60	74
Aug 1966	69.55	9.95	14.62	1.39	54.93	8.56	79	86
Jun 1969	59.73	9.08	5.46	0.42	54.27	8.66	91	95
Aug 1970	16.18	2.65	2.73	0.20	13.45	2.45	83	92
Jun 1974	49.31	8.85	2.22	0.16	47.10	8.69	96	98
Apr 1976	5.20	0.97	0.64	0.03	4.57	0.94	88	96
Jan 1977	2.25	0.23	1.22	0.03	1.03	0.20	46	89
Jan 1978	14.91	2.23	3.85	0.22	11.06	2.00	74	90
Dec 1978	8.60	0.97	4.45	0.23	4.15	0.75	48	76
Jan 1980	13.59	2.29	2.53	0.22	11.06	2.09	81	91
Aug 1980	14.57	2.59	2.95	0.20	11.62	2.39	80	92
Aug 1981	10.47	2.06	0.56	0.03	9.91	2.03	95	99
Aug 1982	20.61	3.51	3.62	0.19	16.99	3.32	83	95
Aug 1983	11.51	2.15	1.50	0.10	10.01	2.05	87	95
Jul 1984	10.30	1.93	0.84	0.06	9.46	1.87	92	97
Jun 1986	18.96	3.17	4.29	0.19	14.67	2.98	77	94
Jul 1989	13.20	1.96	3.80	0.20	9.40	1.76	71	90
Jul 1992	10.51	1.42	4.44	0.24	6.07	1.18	58	83

[1] **Data are standardized to a 60-in. wide dredge towed for 5 min**

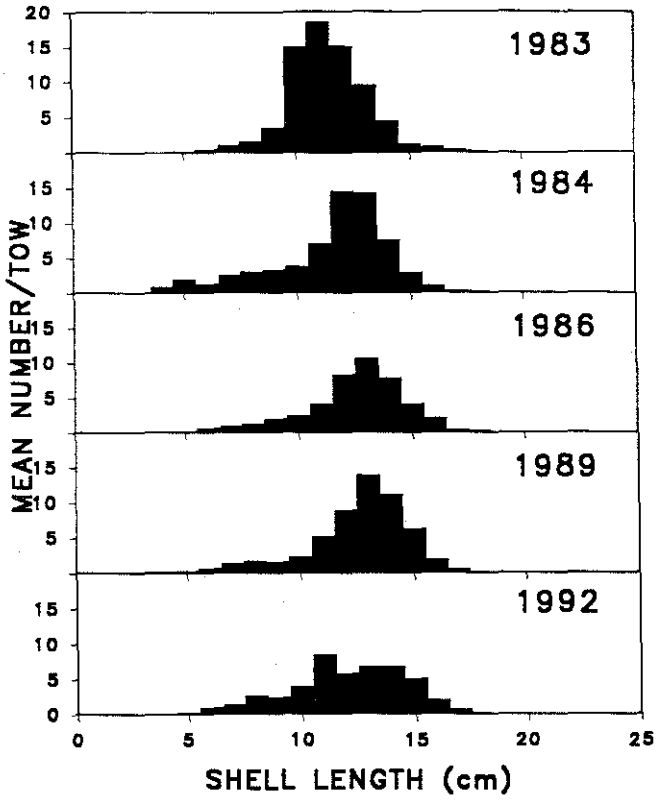

Figure 7. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys off Northern New Jersey, 1983-1992.

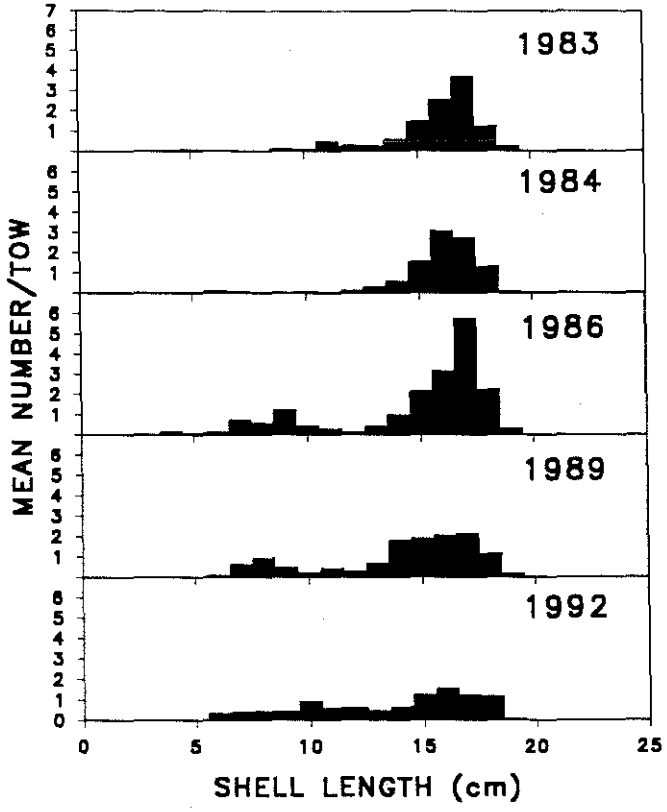

Figure 8. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys off Southern New Jersey, 1983-1992.

tween 1984 and 1992. Both assumptions are fairly reasonable, for the same reasons stated earlier. The estimate of Z from these data is 0.17, or equivalently, S=0.84. This parameter estimate is more precise because the coefficient of determination, R2, for the regression model was 97%. Thus, it appears that the total mortality rate in this area has been greater than in the more heavily harvested area, Northern New Jersey.

SOUTHERN VIRGINIA-NORTH CAROLINA

Relative abundance and size frequency distributions in the Southern Virginia-North Carolina area are similar to those in the Delmarva area (Table 11; Figure 10). The abundance per tow is approximately half that of Northern New Jersey. Based on the 1992 survey, 90% of the surfclams in this area are 100 to 149 mm in length (Figure 10), and approximately 11% of the individuals are greater than 140 mm in length (Table 11). Of the six strata in this area (Table 7), none had a high density of small clams (*i.e.*,< 70 mm).

SOUTHERN NEW ENGLAND-LONG ISLAND-GEORGES BANK

Based on surveys conducted between 1986 and 1992, Southern New England and Long Island populations have low density and therefore, low weight per tow (Table 12; Figures 12 and 13).

Based on four surveys, Georges Bank has a relatively high abundance of surfclams (Table 12; Figure 11). Size structure has been variable over time, and too little information is available to explain this variability. Based on the 1992 survey, only 15% of the Georges Bank population is greater than 14 cm in shell length. Clams less than 7 cm make up a larger fraction of the Georges Bank population than in other areas surveyed. Strata with high surfclam abundance include #67, #68, #72 and #73.

COMPARISON OF ALL AREAS

For the three most recent research vessel surveys (1986, 1989, 1992), minimum 95% confidence intervals were computed for the stratified mean of each region (Figures 14 and 15; Table 13). These are minimum sized intervals because

Table 10. Stratified mean number and weight (meats only, kilograms) per tow of surfclams from NMFS surveys off Delmarva, 1965-1992[1]

Survey	Total Index		<14 cm		>14 cm		%>14 cm	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	27.68	2.26	15.82	0.83	11.86	1.44	43	63
Oct 1965	28.02	2.81	10.76	0.58	17.25	2.23	62	79
Aug 1966	32.53	3.54	10.75	0.64	21.78	2.90	67	82
Jun 1969	26.26	2.78	8.03	0.50	18.22	2.28	69	82
Aug 1970	19.64	2.34	4.71	0.30	14.93	2.04	76	88
Jun 1974	36.66	4.59	6.68	0.42	29.98	4.17	82	91
Apr 1976	21.93	2.37	7.30	0.25	14.63	2.12	67	90
Jan 1977	11.37	1.40	2.68	0.09	8.69	1.31	76	93
Jan 1978	11.61	1.15	4.90	0.17	6.71	1.00	58	85
Dec 1978	621.33	6.02	616.44	5.32	4.88	0.7	21	88
Jan 1980	68.50	3.17	58.07	1.62	10.44	1.54	15	49
Aug 1980	48.53	2.64	39.39	1.26	9.14	1.37	19	52
Aug 1981	162.89	6.91	156.86	6.02	6.02	0.8	94	13
Aug 1982	109.14	5.68	102.53	4.71	6.61	0.9	76	17
Aug 1983	51.39	3.79	39.36	2.14	12.03	1.65	23	44
Jul 1984	129.19	5.58	119.17	4.27	10.02	1.3	18	24
Jun 1986	104.62	7.28	94.49	5.91	10.13	1.37	10	19
Jul 1989	48.86	3.78	39.49	2.64	9.37	1.14	19	30
Jul 1992	36.31	2.81	28.18	1.75	8.13	1.06	22	38

[1] **Data are standardized to a 60-inch wide dredge towed for 5 min**

Table 11. Stratified mean number and weight (meats only, kilograms) per tow of surfclams from NMFS surveys off Southern Virginia-North Carolina, 1965-1992[1]

Survey	Total Index		<14 cm		>14 cm		%>14 cm	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
May 1965	3.77		2.78		0.90		24	
Oct 1965[1]	11.93		11.81		0.12		1	
Aug 1966[1]	17.56		16.28		1.27		7	
Jun 1969	80.02		78.68		1.34		2	
Aug 1970[1]	3.20		0.74		2.46		77	
Jun 1974	30.09		12.66		17.42		58	
Apr 1976	6.21		1.11		5.10		82	
Jan 1978	3.24		1.06		2.18		67	
Jan 1980[1]	87.02		86.15		0.87		1	
Aug 1981[1]	25.89		17.97		7.92		31	
Aug 1982[1]	2.06		1.18		0.88		43	
Aug 1983	10.25	0.55	9.11	0.44	1.14	0.11	11	20
Jul 1984	20.78	1.32	15.50	0.82	5.28	0.50	25	38
Jun 1986	16.56	1.14	12.91	0.83	3.65	0.31	22	27
Jul 1989	11.70	0.77	6.30	0.33	5.40	0.44	43	43
Jul 1992	22.67	1.26	20.12	1.05	2.55	0.26	11	17

[1] **Data are standardized to a 60-in. wide dredge towed for 5 min**

[2] **Only a portion of total assessment area surveyed**

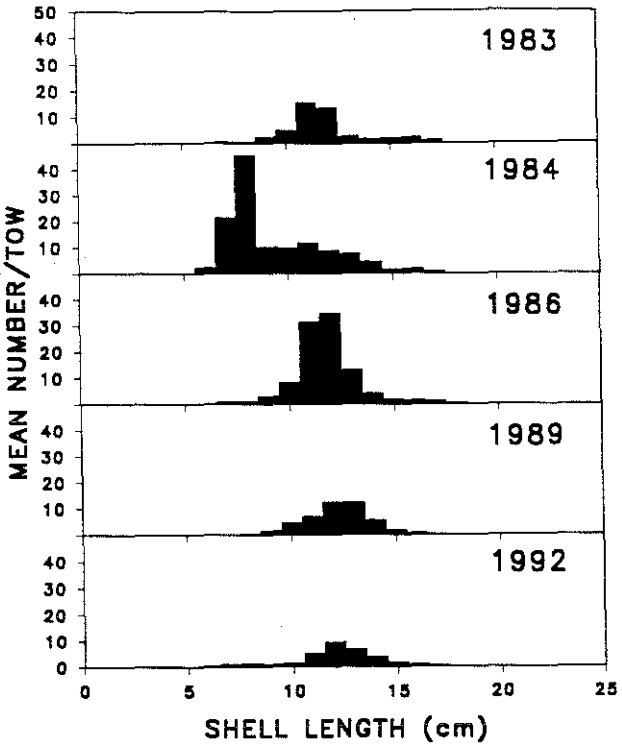

Figure 9. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys off Delmarva, 1983-1992.

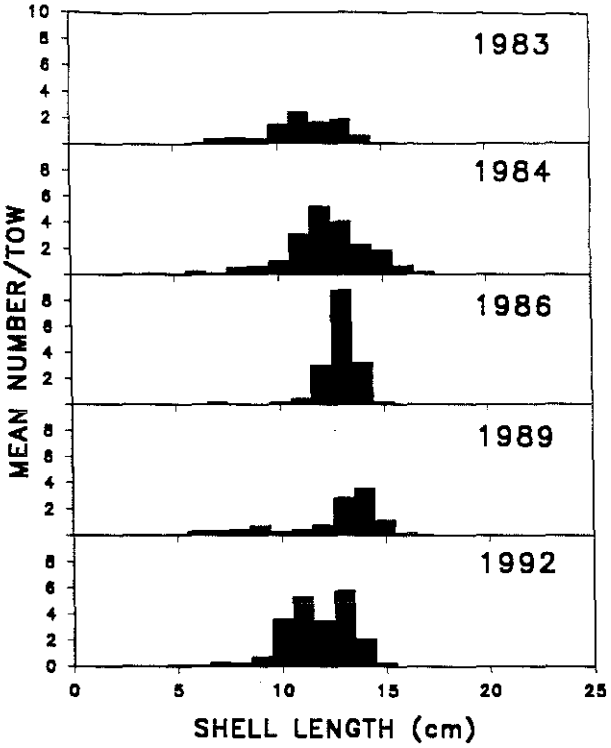

Figure 10. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys off Southern Virginia-North Carolina, 1983-1992.

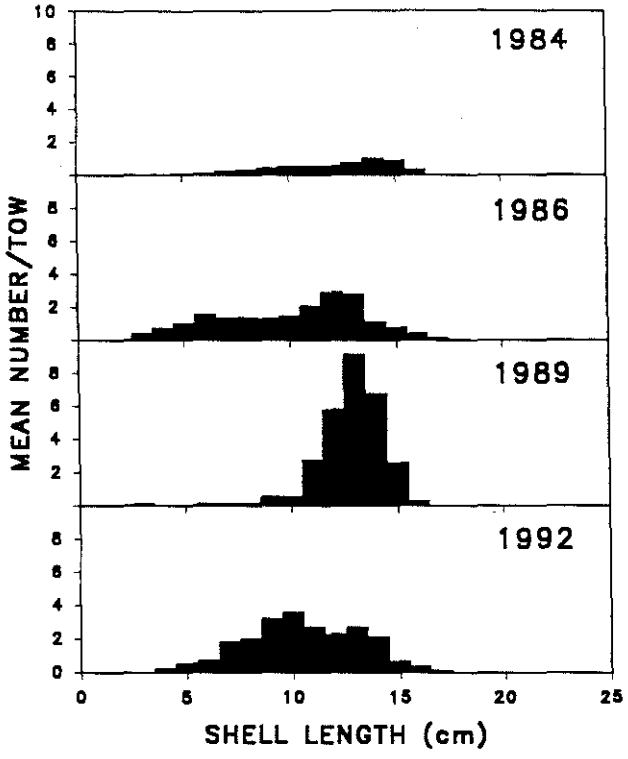

Figure 11. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys on Georges Bank, 1984-1992.

the maximum possible degrees of freedom for the stratified means were used in the computations (see Cochran 1977). While the size of the intervals might be reduced if they were recomputed using log transformed data, the intervals are in general wide. Therefore, apparent changes in stratified mean abundance (or biomass) per tow should be interpreted with caution. There appears to have been a decrease in surfclam density in the Delmarva region from 1986 to 1989-1992. Although 75 to 87% of the 1990-1992 surfclam landings were taken from Northern New Jersey, the decline in average abundance from 1989 to 1992 does not appear to be statistically significant (Figure 14).

Table 14 gives the minimum stock biomass in each geographical area sampled in the 1992 survey. With respect to biomass, the areas can be ranked from high to low as follows (Figure 16):

1. Northern New Jersey
2. Delmarva
3. Georges Bank
4. Southern Virginia-North Carolina
5. Southern New England
6. Southern New Jersey
7. Long Island

Table 12. Stratified mean number and weight (meats only, kilograms) per tow of surf clams from NMFS surveys off Long Island, Southern New England and on Georges Bank, 1984-1992[1]

Survey	Total Index		<14 cm		>14 cm		%>14 cm	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
Long Island								
June 1986	1.79	0.23	0.58	0.03	1.20	0.21	67	88
July 1989	5.87	0.67	2.57	0.15	3.30	0.52	56	77
July 1992	6.20	0.46	5.53	0.35	0.67	0.10	11	23
Southern New England								
June 1986	6.34	0.84	1.51	0.06	4.83	0.78	76	93
July 1989	7.14	0.99	2.14	0.13	5.00	0.86	70	87
July 1992	3.75	0.43	1.37	0.04	2.38	0.39	63	90
Georges Bank								
July 1984	6.25	0.58	3.88	0.24	2.37	0.34	38	58
June 1986	19.77	1.31	17.21	0.93	2.56	0.38	13	29
July 1989	29.34	3.01	19.58	1.71	9.76	1.30	33	43
July 1992	23.71	1.63	20.20	1.13	3.52	0.49	15	30

[1] **Data are standardized to a 60-in. wide dredge towed for 5 min**

The depletion equation,

$B_{t+1}=(B_t-C_t)e^{-m}$, where

t = time,
B = stock biomass,
C = annual catch, and
m = instantaneous natural mortality rate,

was used to estimate how long the stock can support current rates of harvesting. Estimates were made for two values of m, both of which seem reasonable based on survey data. Although the equation does not consider growth, recruitment, or the possibility of rare but high m values in some years, the results suggest that the entire stock can support the fishery for 14 to 18 more years (Table 14). The biomass of the Mid-Atlantic can support its current annual catch for another 11 to 14 years. The biomass of the Northern New Jersey area can support its annual catch for 6 to 7 more years. Assuming m=0.06, the corresponding estimate for Delmarva is 30 years; however, if m is as high as 0.1, as suggested by the regression model (see RESEARCH VESSEL SURVEYS: Delmarva), then the supply will last only 22 years at the current harvest rate. Because some areas will last for less than a decade, assuming present harvest rates, the fishery will have to shift to new areas to exploit the entire Mid-Atlantic stock over an 11 to 14 year period.

OVERVIEW AND PROGNOSIS

Assuming natural mortality rates remain at their current low levels, commercial catch and research vessel survey data indicate that the Mid-Atlantic region can support its current level of catch for another 11 to 14 years. Almost 75% of surfclam stock biomass is in the Mid-Atlantic region. In recent years, landings per unit effort have decreased, and LPUE will continue to decrease by a substantial amount each year in the major clamming areas. Unless a major recruitment event takes place in the Mid-Atlantic region, those stocks of surfclams will become depleted. If a major recruitment event were to occur in 1993, it would take at least until 2000 for the clams to grow to the size at which they are typically harvested now. Although LPUE has declined, Northern New Jersey and Delmarva still have higher surfclam densities and weights per tow than other geographical areas (based on the 1992 survey); thus, it is unlikely that the fishery will migrate to a new area yet.

Considering the decline in LPUE in the Mid-Atlantic region, the Georges Bank surfclam population may be targeted for harvesting in the future, assuming it is reopened. Surfclam biomass on Georges Bank is relatively high, and LPUE was historically almost as high as in the Middle Atlantic.

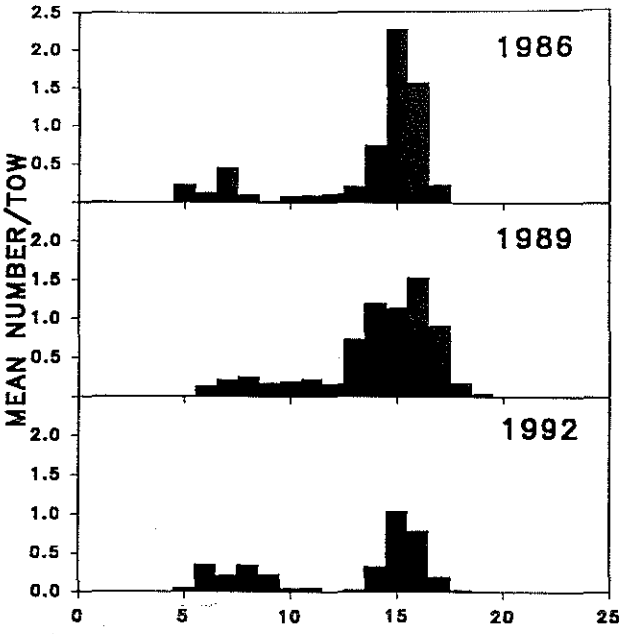

Figure 12. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys off Southern New England, 1986-1992.

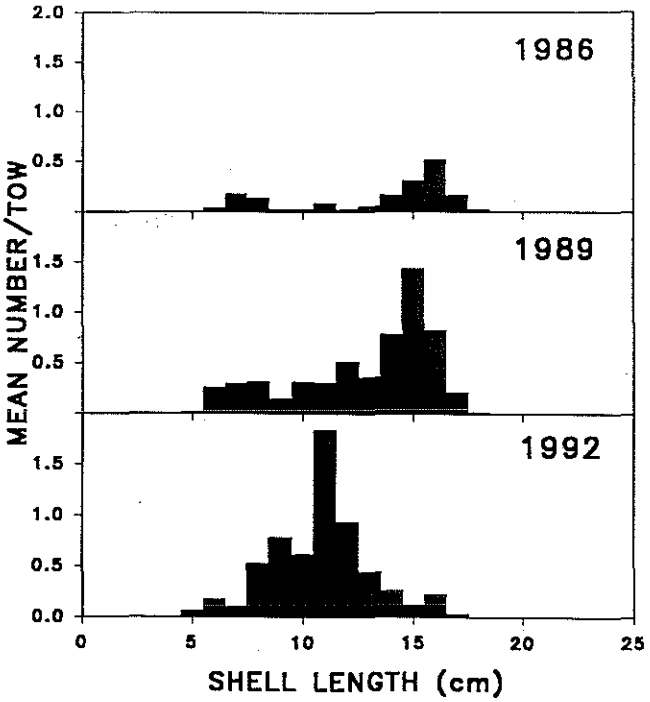

Figure 13. Stratified mean number of surfclams per standardized survey tow at each 1 cm length group in NMFS hydraulic dredge surveys off Long Island, 1986-1992.

Table 13. Summary statistics for surfclam abundance by region and year[1]

Region	Year	Stratified Mean per Tow	SD[2]	N[3]	Minimum 95% CI	Upper Limit	Lower Limit
SVA	1986	16.75	12.41	25	25.61	42.18	-9.04
	1989	11.69	10.46	32	21.36	33.05	-9.67
	1992	22.67	14.60	32	29.81	52.48	-7.14
DMV	1986	104.61	39.77	69	79.54	184.15	25.07
	1989	48.86	13.43	78	26.73	75.59	22.13
	1992	36.31	11.08	78	22.05	58.36	14.26
SNJ	1986	18.95	7.46	21	15.56	34.51	3.39
	1989	13.20	5.35	20	11.20	24.40	2.00
	1992	10.51	4.13	21	8.62	19.13	1.89
NNJ	1986	45.57	8.01	63	16.02	61.59	29.55
	1989	55.89	9.83	70	17.77	73.66	38.12
	1992	47.44	9.33	68	18.57	66.01	28.87
LI	1986	1.78	0.78	29	1.56	3.34	0.22
	1989	5.87	2.79	27	5.74	11.61	0.13
	1992	6.20	2.36	28	4.84	11.04	1.36
SNE	1986	6.34	4.11	26	8.43	14.77	-2.09
	1989	7.15	4.13	23	8.57	15.72	-1.42
	1992	3.75	1.68	31	3.43	7.18	0.32
GBK	1986	19.77	11.27	63	22.54	42.31	-2.77
	1989	29.33	21.75	40	43.96	73.29	-14.63
	1992	23.72	7.58	68	15.16	38.88	8.56

[1] **Computations made using untransformed data from three research vessel surveys**
[2] **SD = standard deviation of the stratified mean (see text for formula)**
[3] **N = the sum of all tows in the region**

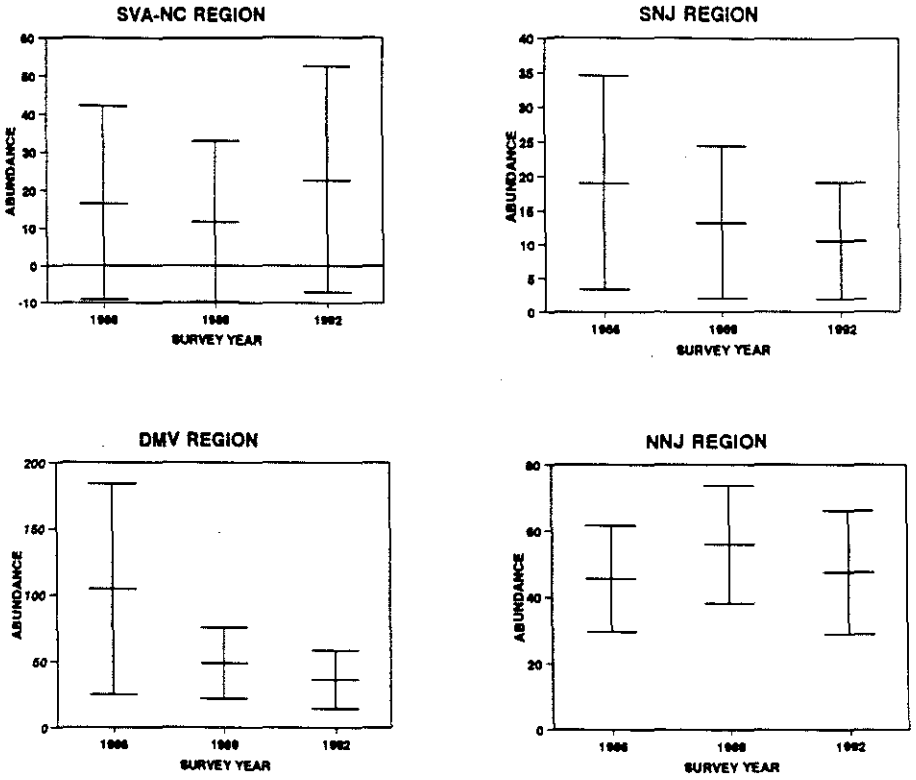

Figure 14. Minimum 95% confidence intervals for the stratified mean of surfclam abundance per tow for Southern regions. Computations were made on untransformed data from three research vessel surveys (1986, 1989, 1992).

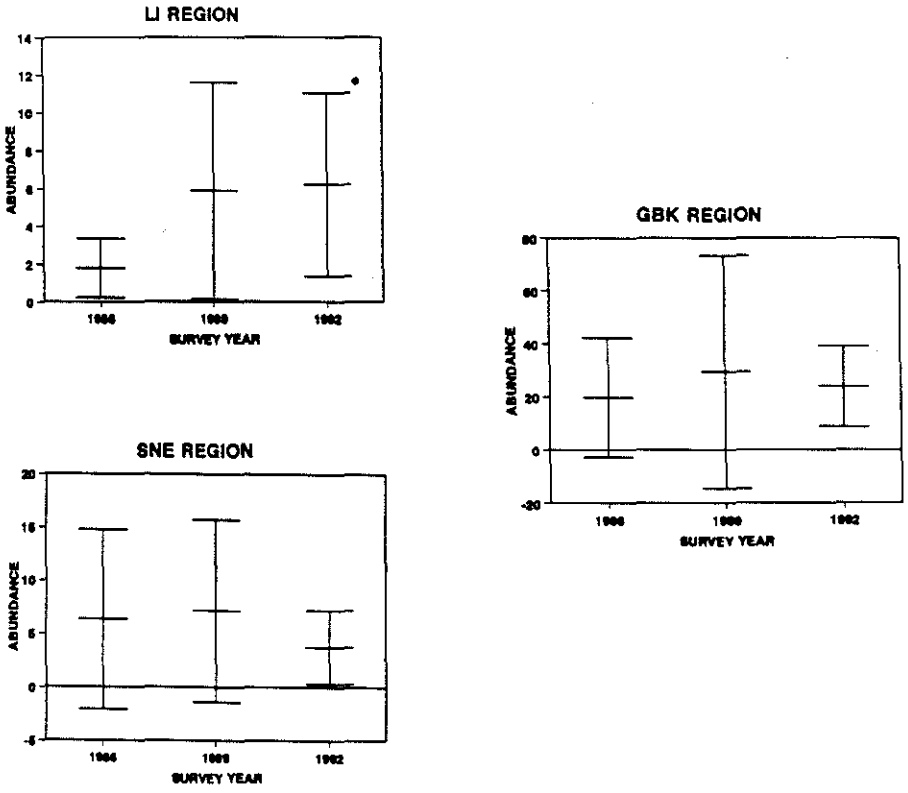

Figure 15. Minimum 95% confidence intervals for the stratified mean of surfclam abundance per tow for Northern regions. Computations were made on untransformed data from three research vessel surveys (1986, 1989, 1992).

Table 14. Landings, biomass (metric tons) and current supplies of surfclams, expressed in number of years, by geographical area

Geographical Area	1991 Landings	Minimum Stock[1] Biomass	Supply Years[2,3,4] m=0.02	m=0.06
Georges Bank	0	87,133	28[2]	20[2]
Southern New England	0	17,867	10[2]	9[2]
Long Island	0	12,590	7[2]	6[2]
Northern New Jersey	17,092	141,941	7	6
Southern New Jersey	1,234	16,344	11	9
Delmarva	1,625	133,745	48	30
Southern Virginia-North Carolina	0	35,261	18[2]	14[2]
Mid-Atlantic[5]	19,952	339,881	14	11
Total	19,952	444,881	18	14

[1] **Biomass values are derived from the research survey of 1992.**

[2] **"Supply years" are based on 1990 annual quotas. Hypothetical annual landings by region are assumed to be 2313 mt (Georges Bank), 1542 mt (Southern New England), 1542 mt (Long Island), and 1542 mt (Southern Virginia-North Carolina).**

[3] **Estimates of "supply years" are based on 1991 landing rates, unless there were no landings in 1991, and do not consider changes that might occur in the population in the future due to recruitment, growth, or catastrophic mortality.**

[4] **m = the instantaneous rate of natural mortality**

[5] **The Mid-Atlantic region includes Long Island, Northern New Jersey, Southern New Jersey, Delmarva, and Southern Virginia-North Carolina.**

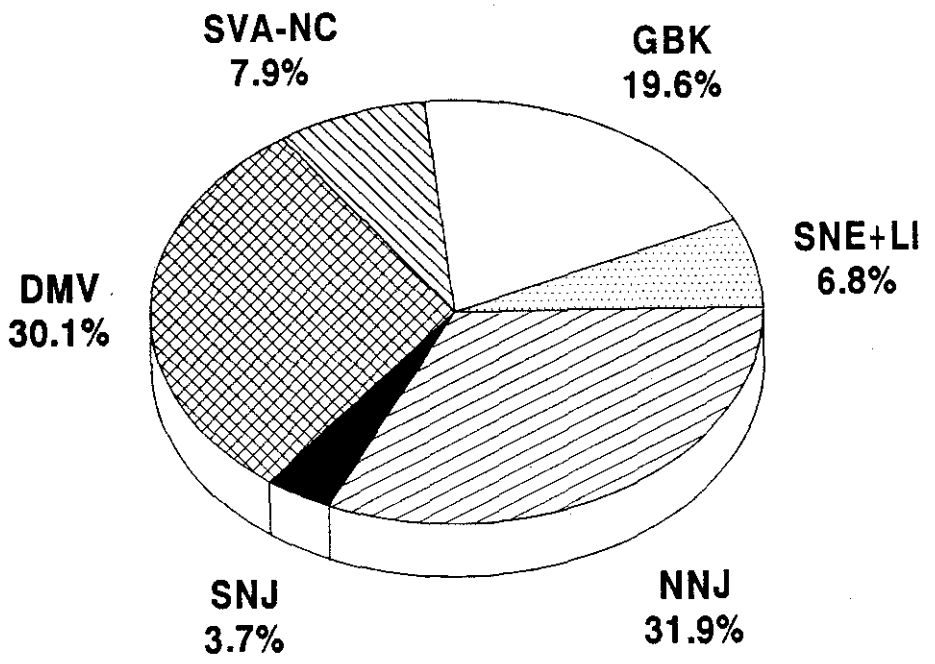

Figure 16. Relative distribution of surfclam biomass, based on 1992 research vessel survey data (Table 15). The total minimum swept-area biomass estimate for the entire region is 444,881 mt of shucked meats.

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