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Results from the 2004 Cooperative Survey of Atlantic Surfclams

by

James R. Weinberg, Eric N. Powell,
Chris Pickett, Victor A. Nordahl, Jr.,
and Larry D. Jacobson

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ABSTRACT

A cooperative survey of the Atlantic surfclam EEZ resource was successfully carried out in 2004. The survey area included the Mid-Atlantic coast from the Hudson Canyon, off northern New Jersey (NNJ), to southern Virginia (SVA). Fieldwork was conducted from the *FV Lisa Kim*, a commercial clamming vessel. A stratified random sampling design was used, and dredge efficiency was measured with depletion experiments. The survey covered the full depth range of the species, to 50 m. Of the four regions surveyed in 2004, the greatest biomass was in NNJ. Fully recruited biomass in NNJ has remained fairly stable from 1997 – 2004 at about 500,000 mt. The region with second highest biomass in 2004 was Delmarva (DMV), with approximately 143,000 mt. There was a large decline in the resource in this region between 1999 and 2002. No change in biomass in DMV was detected from 2002 to 2004. Neither Southern New Jersey (SNJ) nor SVA had significant biomass (<20,000 mt combined) in 2004, and biomass appears to have declined in those regions since 2002. Fully-recruited surfclam biomass is more concentrated in the NNJ region than in the past. Most of the NNJ resource is located in deeper water now. At the large regional scale, the fully recruited clams in NNJ have increased in shell size over time. Strong recruitment occurred recently in the two NNJ mid-depth strata, but not in shallower strata of NNJ or DMV.

INTRODUCTION

The Atlantic surfclam (*Spisula solidissima*) supports a multimillion dollar annual fishery along the Mid-Atlantic coast of the USA. The history of the Atlantic EEZ clam fishery is described in Murawski and Serchuk (1989), Weinberg (1999), NEFSC (2000, 2003) and Weinberg et al (2002a). Federal surveys of the Atlantic surfclam resource in the EEZ are conducted by NOAA/NMFS Northeast Fisheries Science Center (NEFSC) every 3 years. The next federal clam survey on the *RV Delaware-II* (i.e., *DE-II*) is scheduled for spring of 2005. Due to concerns about the status of the surfclam stock in the Mid-Atlantic region, a cooperative survey of the EEZ was planned and then successfully carried out in late June - early July 2004 with contributions from the surfclam industry, Rutgers University and the NEFSC. The survey area included the Mid-Atlantic coast from the Hudson Canyon, off northern New Jersey, to Virginia. All fieldwork was conducted from the *FV Lisa Kim*, a commercial clamming vessel operated by a professional captain and crew and equipped with a commercial ocean quahog dredge. A stratified random sampling design, utilizing NEFSC clam strata, was used during the survey, and dredge efficiency was measured with depletion experiments.

The 2004 cooperative survey was preceded by a brief shakedown leg, April 6-9, 2004 off the coast of New Jersey to determine the appropriate tow duration to use during the upcoming survey. Results indicated that 5-min was the optimal tow duration for capturing 5-10 bushels of surfclams at locations which had low-moderate clam densities in 2002. In addition, two depletion experiments (sc04-1, sc04-2) were completed during the shakedown to estimate dredge efficiency.

This report presents results from the 2004 cooperative surfclam survey and three dredge efficiency experiments (2 during the shakedown; 1 during the survey). The report describes catches at each station as well as regional and stratum-based analyses of population size-structure and biomass. Results from 2004 are compared with historical survey data, when appropriate. Particular attention is given to changes in the depth distribution of surfclams and to the surfclam resource in the Delmarva region, where a temperature-related die-off was detected in 2002 (NEFSC 2003; Kim and Powell 2004).

In this report, some abbreviations and terms are used repeatedly. Region names are: Northern New Jersey (NNJ), Southern New Jersey (SNJ), Delmarva (DMV), Southern Virginia (SVA) and Georges Bank (GBK). Reference is made to 3 depth zones: shallow (9 – 28 m), mid (29 – 46 m), and deep (47 – 55 m). Surfclams are grouped into three length classes: large (120 mm+), medium (88 – 119 mm), and small (1 – 87 mm).

METHODS

The 2004 surfclam survey was conducted from the *FV Lisa Kim*, a commercial clamming boat equipped with an ocean quahog dredge (Table 1). The dredge is constructed of metal bars with 1.25” spaces, although in some places, spaces as large as 2” were noted. Commercial ocean quahog dredges have smaller openings than surfclam dredges. The openings on this dredge were similar in size to those on the NEFSC clam dredge, which was used in previous NMFS surfclam surveys with the *RV Delaware-II*.

The 2004 survey used a stratified random sampling design (Fig. 1) based on NEFSC clam strata, and the number of samples per stratum was the same as in the 2002 clam survey with the *RV Delaware-II* (NEFSC, 2003). Station locations (Fig. 2) were selected by the NEFSC Ecosystems Survey Branch using a standard computer program. In addition to sampling at randomly chosen sites within strata, nonrandom tows were made to monitor dredge efficiency.

The sampling procedure at random stations was similar to that on *RV Delaware-II* clam surveys. Total number of surfclams per tow was determined and the maximum shell lengths of a subset of surfclams were measured to the nearest mm with manual measuring boards. In general, tows were made in the direction of the next station. The boat arrived at each station doing 4-6 knots, but quickly slowed down to make the 5-minute timed tow at 3 knots, once the gear hit the bottom and started fishing. The fast winches and heavy dredge on the *FV Lisa Kim* made the time to set and haul back the dredge very short compared to the *RV Delaware-II* (Weinberg, et al. 2002b).

When the dredge was hauled aboard the vessel, the catch was passed over a mechanical shaker to retain whole and broken clams. Spacing of the bars on the shaker was set at 1.25 inches, although some spaces up to 1.5 inches were present. Surfclams were then moved on a conveyor belt and collected in bushel baskets, each of which could hold about 50-60 adult surfclams. Total number of full, level baskets was recorded. For small catches (i.e., 0 - 3 bushels), all clams were counted and measured. For medium catches (i.e., 4 - 5 bushels), the number of clams in each bushel was recorded separately, and 3 of those bushels were selected at random for shell measurements. For large catches (>5 bushels), the total number of level bushels was recorded, the number of clams in each of 5 randomly selected bushels was recorded separately, and 3 of those bushels were randomly selected for shell measurements. For large catches, the total number caught was estimated by multiplying the average number per bushel times the total number of bushels. At every station, partial bushels were counted and added in separately. Broken clams were counted, but not measured.

Due to the small number of scientists on the *FV Lisa Kim*, compared to the *RV Delaware II,* some standard sampling was not done. Surfclam shells were not collected for age analysis and counts, but no measurements, were made of ocean quahogs (*Arctica islandica*), southern quahogs (*Mercenaria campechiensis*), surfclam clappers, and ocean quahog clappers. Data were not collected on other by-catch species, such as crabs, starfish or gastropods. Data were not collected on the amount of shell hash or sediment in the dredge. Sediment samples were not collected from the bottom.

At many stations, scientists from Rutgers University collected surfclams to examine the relationship between shell length and meat weight. These results are not available yet.

Dredge performance on the *FV Lisa Kim* was monitored with the NMFS Survey Sensor Package (SSP). In addition, Rutgers provided WindPlot GPS software and Vemco pressure-temperature sensors. The SSP measured dredge angle, depth, temperature, manifold pressure and ship's position. SSP sampling frequency was 1-sec for all variables except for position, which was every 2-sec. There was an SSP equipment failure after Station 20. During subsequent survey stations, WindPlot was set to sample ship's position every 10 sec, and the Vemco sensor on the dredge sampled every 5-sec. Due to the timing of message packets, the actual GPS times from WindPlot were 9-12 seconds apart. The dredge sensor data from each station were used to determine the starting and ending position of each tow. Distance sampled was determined from the GPS latitudes and longitudes along each tow track. The GPS measured the boat's position, which was assumed to be representative of the position of the dredge. Additional details about the survey are given in Table 1.

Audited SSP sensor data from the shakedown leg and 2004 surfclam survey were loaded into the NEFSC database with Oracle table names LK_200415 and LK_200416, respectively. Audited biological and station data from the 2004 Surfclam Survey were assigned Cruise code 200416 and loaded into the NEFSC survey database. Original survey log sheets are stored with the Ecosystem Survey Branch of the NEFSC.

RESULTS

DREDGE EFFICIENCY

Depletion Experiments

Three depletion experiments were conducted to estimate the *FV Lisa Kim*'s dredge efficiency in capturing surfclams (Fig. 3; Tables 2-4). The tables give information on the location of each experiment, bottom depth, dates of operation, number of tows per experiment, and sensors that were used to monitor dredge behavior and vessel location. The first two experiments were done during the shakedown leg, in NMFS Strata 21 and 88. The third was carried out during the survey leg, in NMFS Stratum 13.

Each experiment consisted of making repeated tows in a rectangular area, counting the catch per tow, monitoring size composition, and logging the location of the vessel during each tow (Fig. 4).

The Rago Patch model, described in NEFSC (2003) and NEFSC (2004), was used to analyze the depletion experiments. The model estimates dredge efficiency and clam density. The model was run using a cell size of 20 feet, which is twice the width of the *FV Lisa Kim* dredge (10 feet). Gamma was fixed at 0.5, which assumes no "indirect" effects. In analyzing sc04-3, it was necessary to interpolate positions to every 10 feet to match the scale of the location data to dredge and cell size (Table 4). No interpolation was needed for the sc04-1 and sc04-2 experiments, because the position of the ship had been measured every 10 feet.

Based on the likelihood profiles, the Patch model was able to estimate dredge efficiency and surfclam density in all three experiments (Fig. 5; Table 5). The mean of the three estimates of dredge efficiency was 0.792 (SD=0.036, CV=4.6%). There was little variation among the three efficiency estimates even though the surfclam density varied among experiments by an order of magnitude and the experiments were done at different depths and in two regions (Tables 5 and 6).

For comparison, estimates of commercial dredge efficiency from 2004 are listed along with estimates from earlier experiments involving surfclams and ocean quahogs (Table 6). Those values range from 0.46 to 0.95. Estimates from 2004 are well within the range of these earlier estimates.

"Repeat" Lisa Kim Stations to Examine Dredge Efficiency

At six stations, tows were repeated to check for gross changes in efficiency between the start and end of the 2004 cooperative survey. Pairs of catches were similar at the two times, with no consistent bias, suggesting that dredge efficiency did not change during the survey (Table 7, Fig. 6). To test for a gross change in the catches between the two times, a one-sample T-test was run on the six differences, testing the null hypothesis that the mean difference = 0. This null hypothesis could not be rejected ($T = 0.98$, $Pr > 0.1$). Although the correlation between catch at time 1 and time 2 was positive, it was not statistically significant ($r = 0.577$, $Pr > 0.1$, $n=6$). This test probably had low statistical power owing to the small sample size. Overall, the statistical tests do not indicate gross changes in gear efficiency between the start and end of the survey.

DREDGE SELECTIVITY

Selectivity of the dredge was examined by pushing surfclams of known sizes through the bars on the dredge (Table 8). Although clams of all sizes tested could fit through the grate directly behind the blade, this is not likely to be a place where many clams are lost because the clams are being scooped up and quickly pass over this grate. Both the floor of the dredge and the mechanical shaker probably have a large effect on size selectivity. The data, shown in the table, suggest that at least some clams as large as 89 mm in shell length could pass through the shaker; this could vary depending on the thickness of the shell. Overall, the data suggest that clams 90 mm and larger in shell length were retained by the gear used during the 2004 survey. Depending on their size and shell shape, a fraction of surfclams, smaller than 90 mm in length, was not retained.

TOW DISTANCE

Summary statistics on tow distances are given in Table 9. The average distance sampled at random survey stations was 0.244 nmi. Tow distance did not vary appreciably with depth or from the start to the end of the survey (Fig. 7). The few cases where tows had exceptionally short distances were the result of retrieving the dredge early when it was full or had encountered bad bottom.

SURVEY RESULTS

Geographical Patterns

Catch per tow was standardized to a tow distance of 0.15 nmi, the distance used in recent surfclam assessment reports (NEFSC 2000, 2003). Standardizing catch to a common distance allows for a better comparison of the catches from stations at various locations within a survey. We note, however, that these standardized catches per tow for 2004 are not directly comparable to those reported for earlier surveys (NEFSC 2000, 2003) because the dredge on the *FV Lisa Kim* sampled a larger area per tow and had a higher efficiency than the *RV DE-II*.

Surfclam catch per tow, standardized for tow distance, is shown for three length classes: large (120 mm+) (Fig. 8), medium (88 – 119 mm) (Fig. 9), and small (1 – 87 mm) (Fig. 10). As mentioned earlier, the smallest length class was not retained consistently by the survey dredge.

In NNJ, large clams were most abundant in the shallow (Strata 88 and 89) and mid-depth strata (Strata 21 and 25). There were large catches of surfclams in the deeper portions of Strata 21 and 25, a pattern that occurred very rarely in the 1980's and early 1990's (see Fig. C42 in NEFSC 2003).

In DMV, large clams were most abundant in mid-depth strata (Strata 9 and 13). Within Stratum 9, larger catches occurred in deeper water. This pattern was also seen in 2002 (see Fig. C36 in NEFSC 2003).

In 2004, mid-sized clams were most abundant in mid-depth strata of both NNJ (Strata 21 and 25) and DMV (Strata 9 and 13) (Fig. 9). Larger catches occurred in deeper water. Mid-sized clams were not captured in high numbers in shallow strata of NNJ in 2004 (Fig. 9) or in 2002 (see Fig. C37 in NEFSC 2003).

Efficiency Corrected Swept Area Biomass (ESB)

Methods used here for calculating ESB and 80% confidence intervals for ESB are described in two recent laboratory reference documents in this series: NEFSC (2003, pages 299-301) and NEFSC (2004, pages 27-30). Terms in the ESB calculation include survey-specific dredge efficiency (e), sensor tow distances (d_s), area swept per standard tow (a), total area of region (A), percent suitable habitat (u), and catch. The CVs for area swept per tow and habitat area in each region, given in Table A17 of NEFSC (2003), were also assumed in this report when computing region specific ESBs for 2004.

Fully-recruited ESB estimates and confidence intervals were computed for four Mid-Atlantic EEZ regions, by year (Table 10, Figs. 11 - 12). The ESB time series begins with 1997, the first year with a dredge efficiency estimate. Only those regions that were surveyed in 2004 are listed in the table. Other regions that may have considerable surfclam biomass, such as GBK, are not shown.

Of the four regions surveyed in 2004, the greatest biomass was in NNJ. Considering the confidence intervals, fully recruited biomass in NNJ has remained fairly stable from 1997 to 2004 at about 500,000 mt (Fig. 11). There may have been a dip in biomass between 2000 and 2004. It is difficult to pinpoint when changes occur because surveys have not been conducted annually.

The region with second highest biomass in 2004 was DMV, with approximately 143,000 mt (Table 10, Fig. 12). This biomass has held steady since 2002, after the large decline that took place between 1999 and 2002.

Neither SNJ nor SVA had significant biomass (<20,000 mt combined; Table 10) in 2004, and biomass appears to have declined in both regions since 2002.

For the regions surveyed in 2004, NNJ and DMV had 77% and 21% of the biomass, respectively (Fig. 13). The biomass is concentrated in the NNJ region, and the degree of concentration has increased since 1997 (Fig. 14).

Population Structure

Changes have occurred in population size-structure within each region over time, based on the time series going back to 1982 (Figs. 15-16). Surveys were conducted before 1982, but they used different collecting gear (see Table C6 in NEFSC 2003), and are not directly comparable to more recent data. We also note that a different dredge was used in 2004 than in previous surveys. Though the two dredges probably have similar selectivity of surfclams >100 mm in length, there may be some differences in retention of smaller clams.

At the large regional scale, surfclams in NNJ increased in shell size over time, through growth. The mode in NNJ shifted from 140-145 mm in 1997 to 150-155 mm in 2004 (Fig. 15). Furthermore, the NNJ size structure was bimodal in 2002 and 2004, suggesting a pulse of recruitment. Relative to NNJ, surfclams in the DMV region were smaller (Fig. 16). DMV clams were commonly in the 110 – 140 mm length interval. Based on the size-frequency distribution, there was some evidence of recruitment in 2002.

Although there was both recruitment of small clams and growth of large clams in NNJ, these processes did not occur uniformly throughout that region. This is evident from data from certain strata in NNJ. Strata 88 and 89, two of the main shallow NNJ strata, show the increase in body size of large surfclams over time, but little or no evidence of recruitment (Figs. 17 and 18). The modal size in 2004 in these shallow strata was 155-160 mm. In contrast, there was evidence of growth of large clams over time and recent strong recruitment in the two NNJ mid-depth strata, 21 and especially 25 (Figs. 19 - 20). Stratum 25 is the most northern large stratum in NNJ, located on the edge of the Hudson Canyon. The large clams in the mid-depth strata were approximately 140 – 155 mm in length in 2004, making them smaller than the large clams in shallow Strata 88 and 89.

A detailed examination of the catch per tow data from strata in the NNJ region in 2004 was made to determine where biomass per tow and density per tow were highest (Tables 11 and 12). For the analysis, strata within the region were classified into three depth zones: shallow, mid, deep (Table 11).

For large (>= 120 mm) clams, shallow Stratum 89 had the highest catch per tow (Table 12A). The two mid-depth strata (21 and 25) ranked second and third, ahead of shallow Stratum 88. This latter result is significant because historically, the commercial surfclam fishery was active in and around Stratum 88.

For recruiting (88 – 119 mm) clams, the two mid-depth strata (25 and 21) ranked first and second in catch per tow (Table 12B). Stratum 25 had much greater catches than Stratum 21. Thus, catches of recruiting surfclams in 2004 were higher in both of the mid-depth NNJ strata than in the shallow NNJ strata.

Few surfclams of any size were captured in the deepest NNJ strata sampled in 2004, Strata 22 and 26 (Table 12).

A robust index for monitoring gross changes in the DMV population, where thermal stress may have killed off surfclams recently, is the percentage of random tows that captured no surfclams (Table 13). This index was high in 1999 and 2002, 0.3 and 0.39 respectively. The index in 2004 (0.24) must be interpreted cautiously because in 2004 the probability of capturing a clam in a tow was greater than in earlier surveys, irrespective of sufclam density. The 2004 survey was conducted with a wider dredge and a dredge which has much greater catching efficiency. Thus, the value for 2004 is a lower bound estimate for that year.

Depth Distribution

Several signals in the data suggested a shift in the surfclam population over time to deeper water. For example, in 2004 in NNJ more recruit-size surfclams were captured per tow in mid-depth strata than in shallow strata. Also, there was evidence of a die-off in the shallow portion of DMV.

To examine this more directly, we computed the proportion of surfclam biomass in three depth zones (shallow, mid, deep) for each combination of region and year (Tables 14 – 16, Fig. 21). This calculation could not be made for the NJ region in 1984, because random samples were not taken from the deep zone in that year (Table 15). For NNJ and

SNJ, the values shown in Fig. 21 for 1984 are the averages of the values from 1983 and 1986.

In NNJ, there was a clear change over time in the distribution of surfclam biomass with respect to water depth. In the 1980's, over 70% of the biomass was in the shallow zone. This percentage declined continuously throughout the late 1980's and the 1990's to its historical low value of 29% in 2004. In 2004, 71% of the NNJ biomass was in the mid-depth zone. The other regions did not show clear trends regarding depth.

Future analyses, with finer partitioning of depth zones and taking into account the locations of commercial landings, might yield additional results.

SUMMARY AND CONCLUSIONS

1. The 2004 Cooperative surfclam survey sampled from the Hudson Canyon to approximately 36.5 degrees latitude. The survey collected data from 4 regions: NNJ, SNJ, DMV, and SVA. The survey covered the full depth range of the species. Most stations were at depths of 10 to 50 m.

2. Of the four regions surveyed in 2004, the greatest biomass was in NNJ. Considering the confidence intervals, fully recruited biomass in NNJ has remained fairly stable from 1997 – 2004 at about 500,000 mt.

3. The region with second highest biomass in 2004 was DMV, with approximately 143,000 mt. There was a large decline in the resource in this region between 1999 and 2002. No change in biomass was detected from 2002 to 2004.

4. Neither SNJ nor SVA had significant biomass (<20,000 mt combined) in 2004, and biomass appears to have declined in both regions since 2002.

5. Fully-recruited surfclam biomass is concentrated in the NNJ region. The degree of concentration in 2004 was greater than in the recent past.

6. The biomass of surfclams in NNJ has not changed greatly since 1997; however, most of the NNJ resource is located in deeper water now.

7. At the large regional scale, the fully recruited clams in NNJ have increased in shell size over time. Surfclams in NNJ are larger than those in the DMV region.

8. Strong recruitment occurred recently in the two NNJ mid-depth strata (21 and 25). Strong recruitment did not occur in the shallower strata of NNJ or DMV.

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ACKNOWLEDGMENTS

We are grateful to the clam industry for their strong support of this survey. In particular we thank the captain and crew of the *F/V Lisa Kim* for their professional work. This successful project was carried out cooperatively by the clam industry, Rutgers University, and NOAA's National Marine Fisheries Service (NMFS).

Table 1. List of cruise and gear information for the Cooperative surfclam survey in 2004.

Cruise code	200416
Cruise dates	June 26 – July 6, 2004
Total stations (Survey leg)	242
Survey area	NNJ, Hudson Canyon to as far south as 36.5 degrees (NMFS Surfclam strata)
Statistical design	Stratified random sampling in NMFS clam strata
Vessel name and length	*FV Lisa Kim* (115 feet)
Dredge width	120" (stern mounted dredge)
Dredge length	185"
Blade depth	3.5"
Pump type	Surface
Manifold nipples (outer diameter)	1"
Bar spacing	1.25" (up to 2" in some places)
Tow speed	3 knots
Tow duration	5 min
Differential Pump Pressure (at depth)	70 – 80 psi
Captain and Crew	Eddie Platter, Jeff, Seth, Alex
Scientists	Jim Weinberg, Eric Powell
	Chris Pickett, Vic Nordahl, Sara King
	Becky Marzec, Yungkul Kim, Jeff

Table 2. Surfclam depletion experiments conducted with the *FV Lisa Kim*. Table lists general location, date, station numbers and number of tows per experiment.

Experiment	Location	Date	Cruise or leg, stations	Total tows
sc04-1	NJ (mid-depth)	April 8, 2004	Shakedown, 15-38	24
sc04-2	NJ (shallow)	April 9, 2004	Shakedown, 49-68	20
sc04-3	DMV (mid-depth)	July 3, 2004	Survey, 146-165	20

Table 3. Specific locations (decimal degrees) and depths of three surfclam depletion experiments conducted by the *FV Lisa Kim* in 2004.

Experiment	Latitude	Longitude	Depth (m)
sc04-1	39.28611	73.87778	35
sc04-2	39.58278	74.02778	21
sc04-3	38.27075	74.37920	38

Table 4. Sensor information related to the three surfclam depletion experiments carried out by the *FV Lisa Kim* in 2004. "SSP" = NMFS survey sensor package. "WindPlot" = a GPS-based program, used by the Rutgers scientists, which collected vessel location information.

Experiment	Primary Lat/Lon Sensor	Sensor Logging Rate	Positions Interpolated for Patch Model?
sc04-1	SSP	2-sec (8-11 ft)	N
sc04-2	SSP	2-sec (8-11 ft)	N
sc04-3	WindPlot	10-sec (52-57 ft)	Y, to 10 ft

Table 5. Point estimates of dredge efficiency and surfclam density for three depletion experiments carried out by the *FV Lisa Kim* in 2004. Results are from the Rago model, assuming no indirect effects (as defined in Table 6 legend).

Experiment	*Lisa Kim* DredgeEfficiency	Surfclam density per square ft
sc04-1	0.797	0.104
sc04-2	0.825	0.026
sc04-3	0.753	0.165

Table 6. List of commercial clam dredge efficiency estimates from 2002 and 2004. Table also gives the region, bivalve species, and number of tows in each experiment. Estimates of efficiency are from the Rago model, assuming no "indirect" effects (i.e, a loss or addition of clams from/to the depletion site during the experiment caused by the repeated sampling of the area).

Efficiency of Commercial Clamming Vessels

Year	Vessel	Species	Experiment	Region	Depth (m)	# Tows	**Efficiency**
2004	Lisa Kim	SC	sc04-1	NJ	35	24	**0.80**
			sc04-2	NJ	21	20	**0.83**
			sc04-3	DMV	38	20	**0.75**
2002	Jersey Girl	SC	sc02-2	NNJ	37	16	**0.93**
			sc02-3	SNJ	31	20	**0.46**
			sc02-4	DMV	31	18	**0.95**
2002	Lisa Kim	OQ	oq02-1	LI-E	59	24	**0.65**
			oq02-2	LI-W	44	22	**0.81**
			oq02-3	SNJ	46	20	**0.82**
			oq02-4	DMV	43	24	**0.60**

Table 7. List of surfclam catches at six stations that were sampled at the beginning and near the end of the 2004 surfclam survey. This was done to check for gross changes in gear efficiency over time within the survey.

Station #, NMFS Stratum #		# Surfclams/Tow	
Time 1	Time 2	Time 1	Time 2
16, 21	209, 21	708	348
14, 21	211, 21	1161	1041
13, 25	212, 25	731	952
12, 25	217, 25	1265	1112
15, 21	218, 21	637	806
11, 25	219, 25	1089	724

Table 8. Gear selectivity data for Atlantic surfclams captured with the dredge on the FV *Lisa Kim* in 2004. See Table 1 for information on bar spacing. The table states whether individual surfclams could pass (yes/no) through the bars at three locations.

Shell Length	Grate behind blade	Floor of Cage	Shaker
80	yes (easy)	no (almost)	--
80	yes	yes	no (fat clam)
82	yes (easy)	no	no
85	yes (easy)	no	--
86	yes	yes	yes
87	yes	no (almost)	yes (sometimes)
89	yes	no (almost)	yes (sometimes)
90	yes (sometimes)	no	--
93	yes	no	no
94	yes	no	no
96	yes	no	no
97	yes	no	no
98	yes	no	no
99	yes	no	no
117	yes	no	no

-- = no data

Table 9. Summary statistics for distance (nmi) sampled per tow by the FV *Lisa Kim* during the 2004 surfclam survey. Distances were calculated from sensor data (see text). Data only include the random survey stations.

Distance (nmi)	
Mean	0.244
Standard Error	0.003
Median	0.248
Mode	0.252
Standard Deviation	0.0404
Sample Variance	0.0016
Kurtosis	5.8853
Skewness	-1.8461
Range	0.288
Minimum	0.05
Maximum	0.338
Sum	48.216
Count	198
Largest(1)	0.338
Smallest(1)	0.05
Confidence Level(95.0%)	0.0057

Table 10. Efficiency corrected biomass estimates ('000s mt meats), and confidence intervals, for fully recruited surfclams, by region and year. Catch per tow was standardized to 0.15 nmi based on computed tow distances (SENDIST_2004). Only good, random tows were included (RANDLIKE = 1 or 2).

SC Recruited Biomass (1000 MT)
by Region/Time, with 80% CI's.

Year	NNJ	LL	UL	SNJ	LL	UL	DMV	LL	UL	SVA	LL	UL
1997	**485**	256	922	**37**	18	79	**292**	150	570	**6**	3	13
1999	**487**	256	924	**116**	44	311	**317**	162	618	**10**	5	20
2002	**313**	163	607	**42**	19	93	**143**	74	275	**18**	8	43
2004	**522**	397	687	**13**	6	28	**143**	97	210	**0.3**	0.1	0.9

Notes:

1 **2004 Results are for 100+mm in DMV, SVA, and for 120+mm in NNJ,SNJ.**
2 **2004 Results are based on LW parameters from the 2002 NMFS Clam survey (i.e., REV_DATE_FOR_LW = 2003).**
3 **Pre-2004 Results are copied from the SARC37 Report, Table C21.**
4 **Offshore strata 18, 22, 26 are NOT included for any survey (i.e., for 2004 and other years, REV_DATE_FOR_AREAS=2002).**

Table 11. List of strata in the NNJ region, their areas, and the number of random stations sampled in the 2004 survey.

Region of NNJ	Stratum	Area (sq. nmi.)	Approx. Depth (meters)	N (# of tows)
shallow	88	484	9 to 28	20
	89	343	9 to 28	17
	90	117	9 to 28	2
mid	21	1693	29 to 46	29
	25	647	29 to 46	10
deep	22	305	47 to 55	3
	26	190	47 to 55	4

Table 12. Surfclam abundance per tow and meat weight per tow by stratum, for two size classes: A. 120mm + shell length, B. 88 – 119 mm. Catch per tow was standardized to 0.15 nmi based on computed tow distances (SENDIST_2004). Only good, random tows were included (RANDLIKE = 1 or 2). Meat weight – shell length parameters were based on data collected during the 2002 clam survey (LWSARCYR= 2003). Rank indicates which strata had the most clams per tow, on average.

A. **Length Range: 120 mm + Fully Recruited**

Region of NNJ	Stratum	Abundance / Tow	CV_numbers	Biomass (kg) / Tow	CV_biomass	Rank
Inshore (Shallow)	88	169.1	0.16	25.45	0.168	
	89	317.9	0.15	51.15	0.149	1
	90	85.1	--	14.71	--	
Mid	21	191.6	0.19	28.41	0.192	3
	25	257.4	0.32	34.48	0.343	2
Offshore (Deep)	22	2.4	0.75	0.32	0.73	
	26	0.1	--	0.01	--	

B. **Length Range: 88 - 119 mm Pre-Recruits**

Region of NNJ	Stratum	Abundance / Tow	CV_numbers	Biomass (kg) / Tow	CV_biomass	Rank
Inshore	88	7.2	0.34	0.46	0.358	3
	89	7.5	0.17	0.44	0.18	3
	90	0	--	0.00	--	
Mid	21	33.7	0.29	1.96	0.289	2
	25	128.5	0.42	7.26	0.412	1
Offshore	22	1.2	--	0.06	--	
	26	0	--	0.00	--	

Table 13. The percentage of random stations in Stratum # 9, off DMV, that captured no surfclams, by survey.

NMFS Survey	1982	1983	1984	1986	1989	1992	1994	1997	1999	2002	2004*
Total # of Station in Strata 9	30	26	35	29	37	37	39	39	37	38	37
# of Stations w/one or more clams	24	18	26	25	27	29	35	34	26	23	28
# of Stations w/zero clams	6	8	9	4	10	8	4	5	11	15	9
p= Proportion of Zeros	**0.20**	**0.31**	**0.26**	**0.14**	**0.27**	**0.22**	**0.10**	**0.13**	**0.30**	**0.39**	**0.24**
Var(p)	0.005	0.008	0.005	0.004	0.005	0.005	0.002	0.003	0.006	0.006	0.005

*= The proportion of zeros in 2004 is biased low relative to other values in the time series. Data from 1982 – 2002 were collected with the *RV DE-II.* In 2004, data were collected with the *FV Lisa Kim* commercial dredge, which is 2x the width of the dredge on the *RV DE-II*. The commercial dredge also has much higher clam capture efficiency than the dredge on the *RV DE-II*.

Table 14. List of survey strata, by region and depth zone. These zones were used to examine the proportion of surfclam biomass at depth over time. Strata are shown in Figure 1.

Region	Shallow (9-28 m)	Mid (29-46 m)	Deep (47-55 m)
NNJ	88-90	21, 25	26, 22
SNJ	87	17	18
DMV	82-86	9, 13	10,14

Table 15. Number of clam survey tows by region, depth category and year in the NEFSC clam survey during 1982-2002 and in the 2004 cooperative clam survey. Only successful, random tows were counted.

Region	Depth Category	1982	1983	1984	1986	1989	1992	1994	1997	1999	2002	2004
DMV	Shallow	15	13	13	15	15	14	15	14	15	16	14
	Mid	49	44	60	49	57	57	60	61	57	59	57
	Deep	4	4	6	6	6	6	8	6	6	6	6
	DMV Total	68	61	79	70	78	77	83	81	78	81	77
NNJ	Shallow	32	32	48	34	40	39	39	42	42	40	39
	Mid	27	27	35	27	29	29	32	38	47	38	39
	Deep	5	5	0	6	6	6	8	6	6	6	7
	NNJ Total	64	64	83	67	75	74	79	86	95	84	85
SNJ	Shallow	8	7	10	9	9	9	9	9	9	16	14
	Mid	11	11	18	12	12	12	12	14	12	12	12
	Deep	3	3	0	3	3	3	3	3	3	3	3
	SNJ Total	22	21	28	24	24	24	24	26	24	31	29

Table 16. Percent of surfclam biomass by region, depth category and year, based on the NEFSC clam survey during 1982-2002 and the 2004 cooperative clam survey. Data are from random tows completed successfully. Blank cells in the table are due to no (0) tows taken in "deep" depths (as defined in Tables 14 and 15) in the NNJ and SNJ regions during 1984.

Region	Depth Category	1982	1983	1984	1986	1989	1992	1994	1997	1999	2002	2004
DMV	Shallow	38%	1%	0%	11%	0%	3%	1%	1%	1%	2%	0%
	Mid	62%	99%	99%	89%	99%	97%	99%	98%	99%	94%	100%
	Deep	0%	0%	0%	0%	1%	0%	0%	1%	0%	4%	0%
NNJ	Shallow	75%	83%		75%	56%	57%	52%	39%	35%	33%	29%
	Mid	25%	17%		25%	44%	43%	48%	61%	65%	67%	71%
	Deep	0%	0%		0%	0%	0%	0%	0%	0%	0%	0%
SNJ	Shallow	42%	36%		21%	75%	35%	86%	75%	84%	43%	30%
	Mid	58%	64%		79%	25%	65%	12%	25%	16%	57%	68%
	Deep	0%	0%		0%	0%	0%	3%	0%	0%	0%	2%

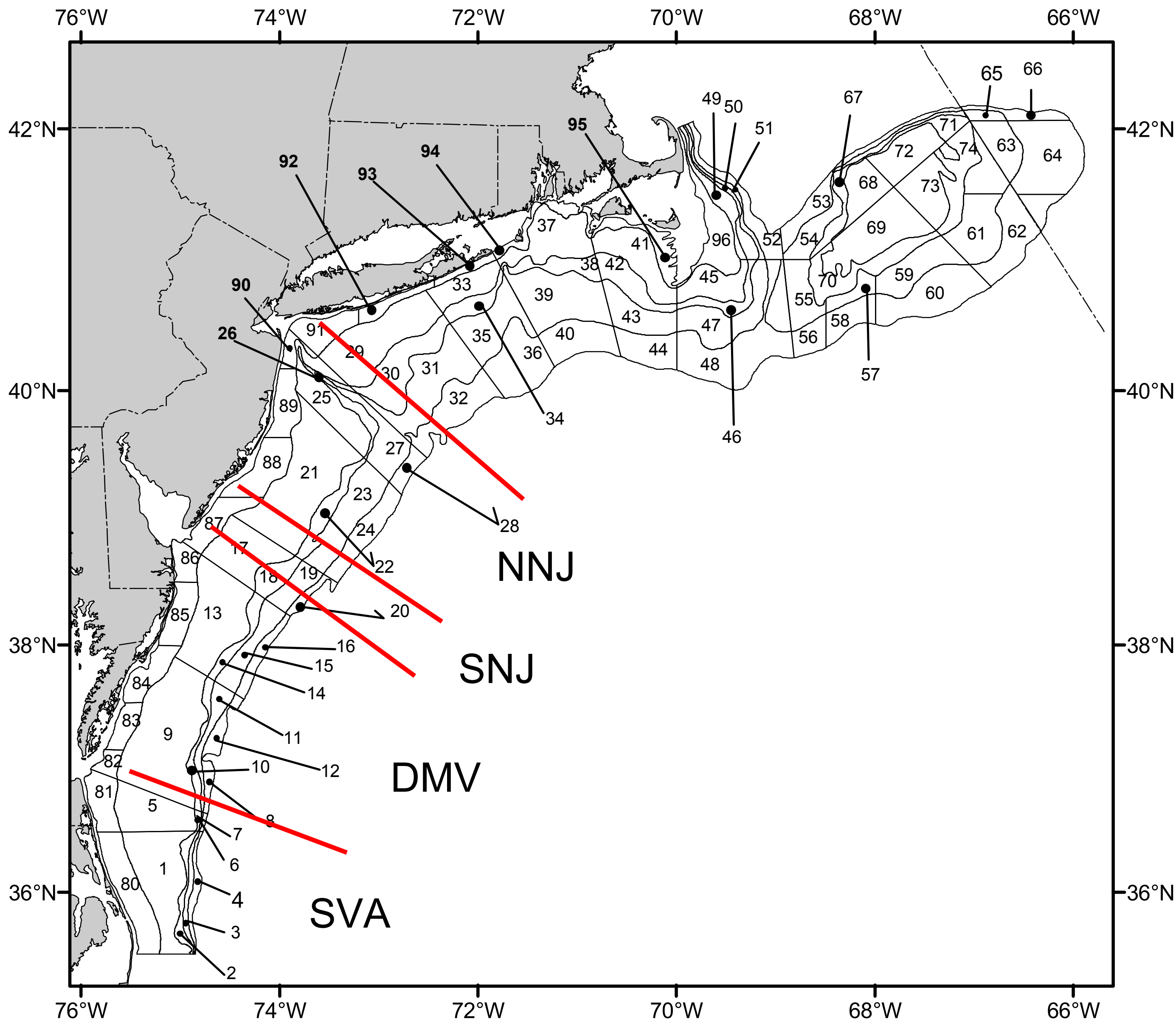


Figure 1. Map showing regions and strata along the northeast coast of the US. This is the standard set of strata used for stratified random sampling during NMFS clam surveys.

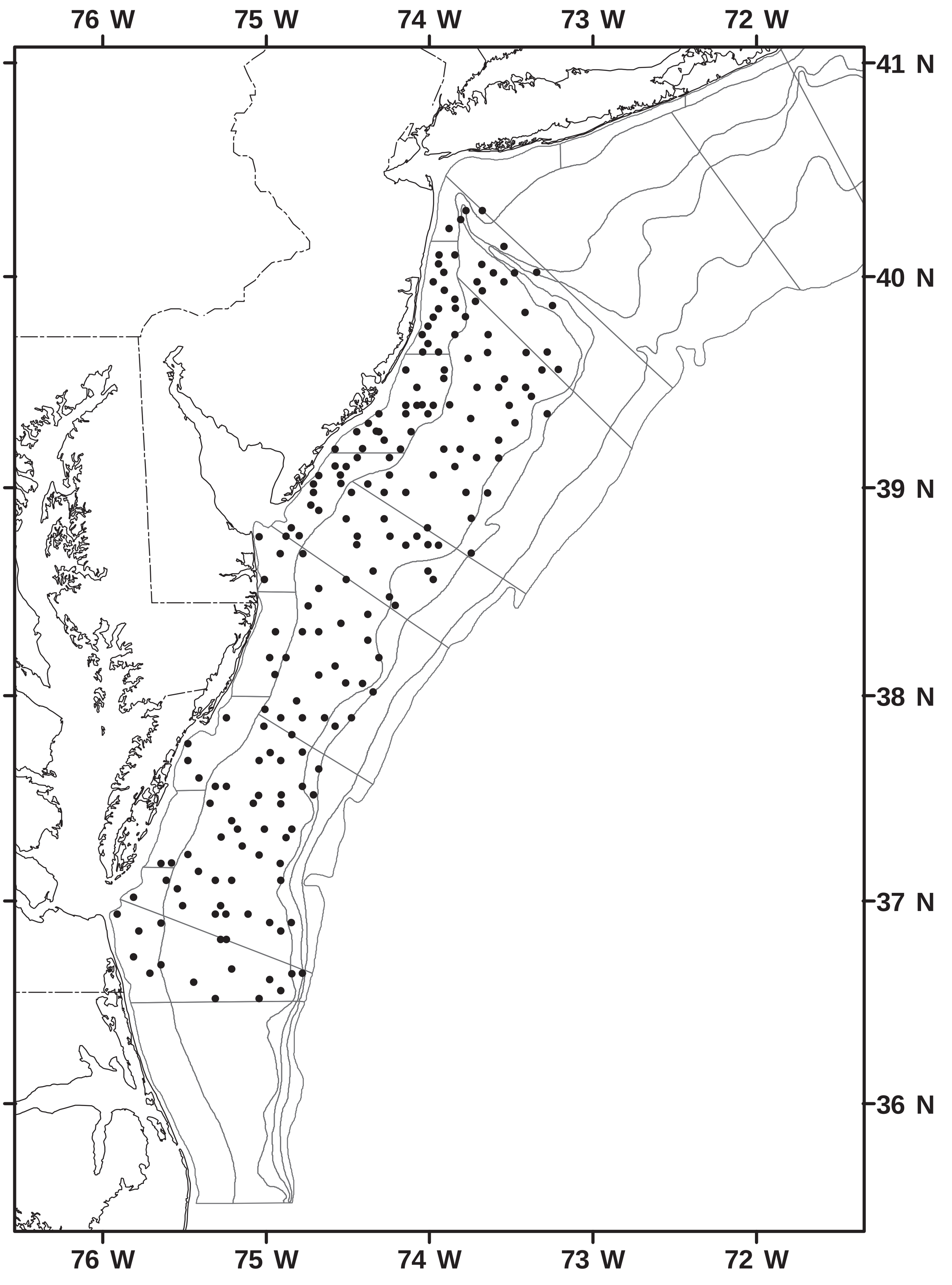


Figure 2. Locations of random stations sampled by the *FV Lisa Kim* during the 2004 cooperative surfclam survey.

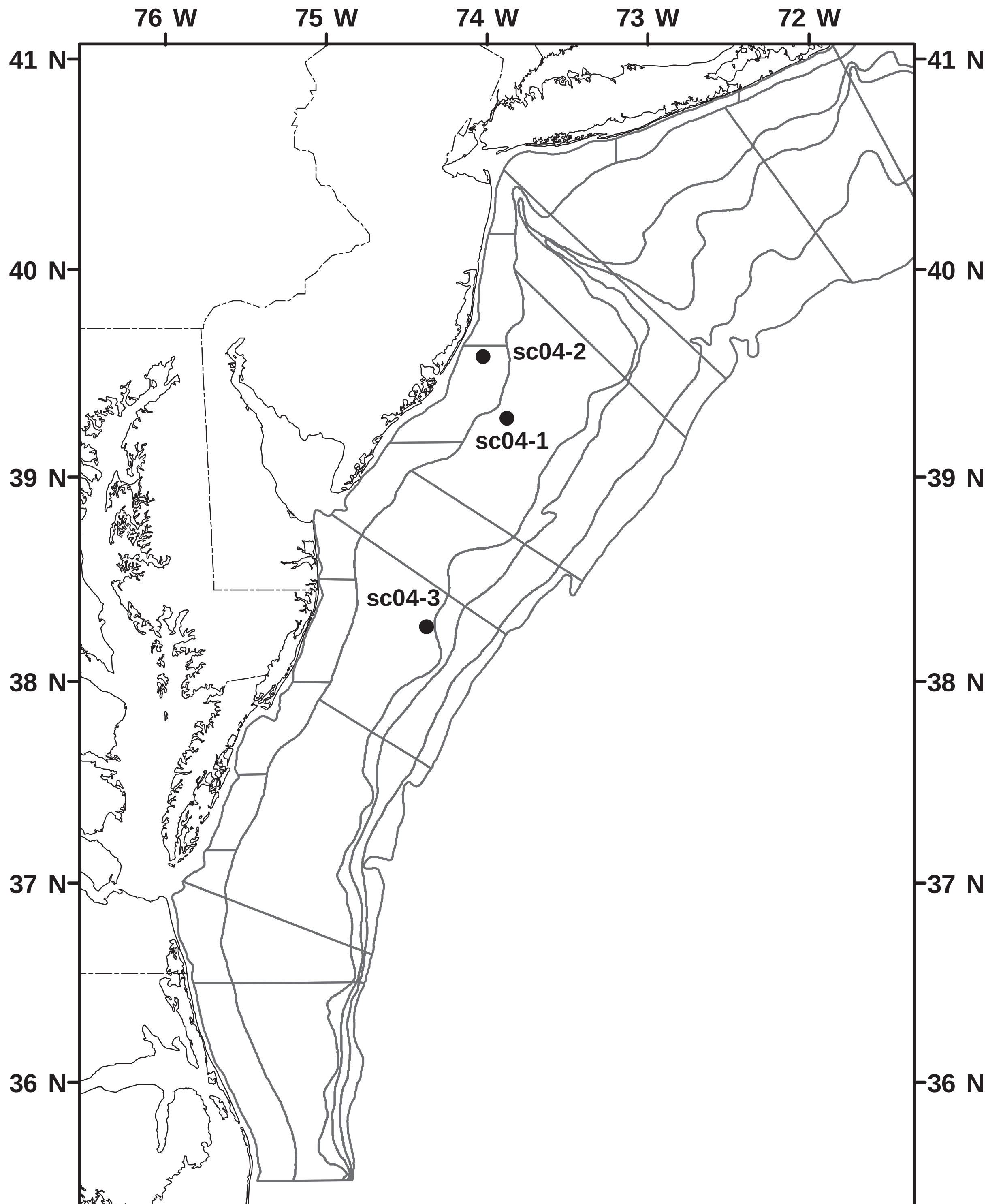


Figure 3. Locations of three gear efficiency ("depletion") experiments with the *FV Lisa Kim* for the 2004 cooperative surfclam survey.

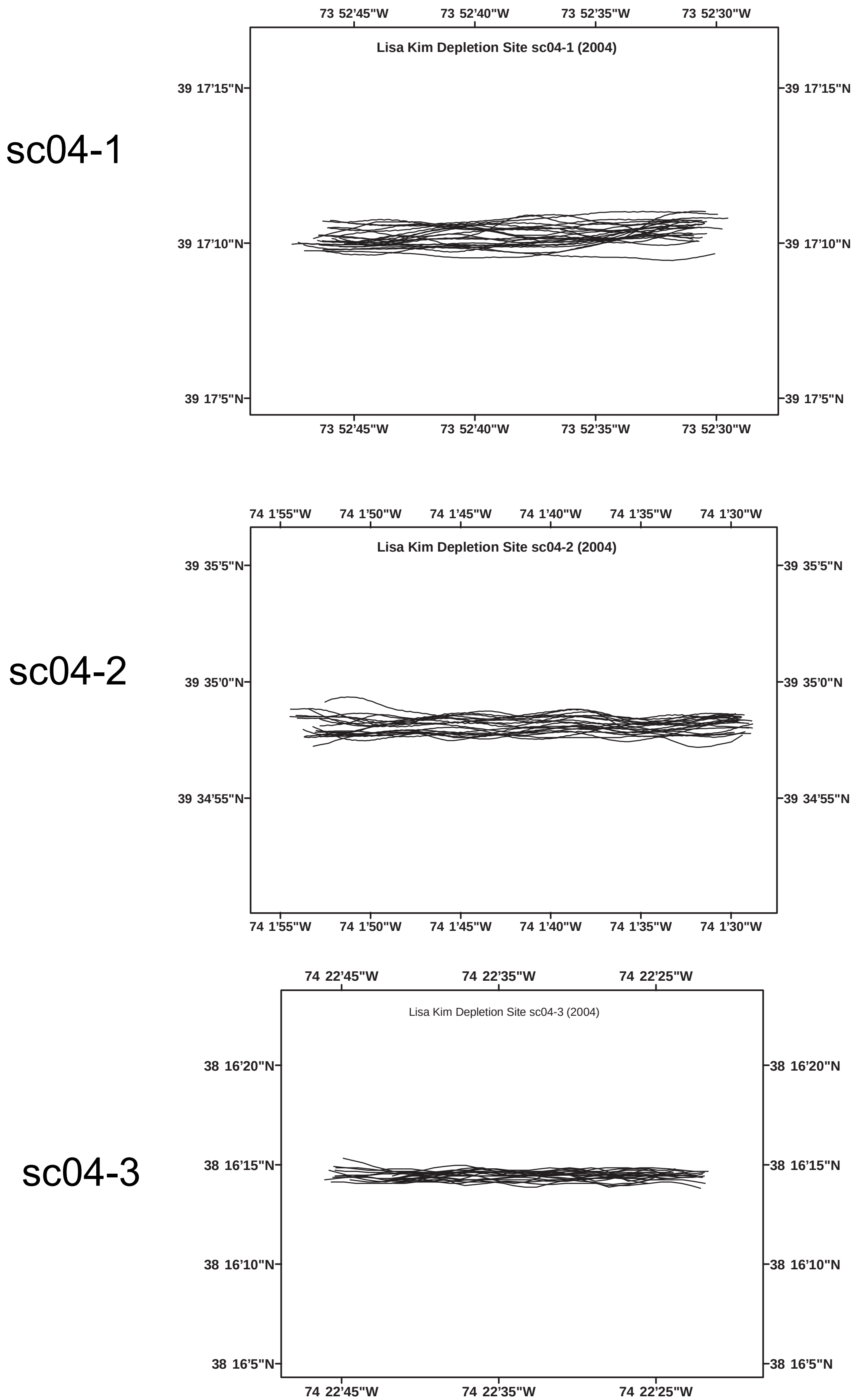


Figure 4. Tow tracks of the *FV Lisa Kim* during three gear efficiency ("depletion") experiments for the 2004 cooperative surfclam survey.

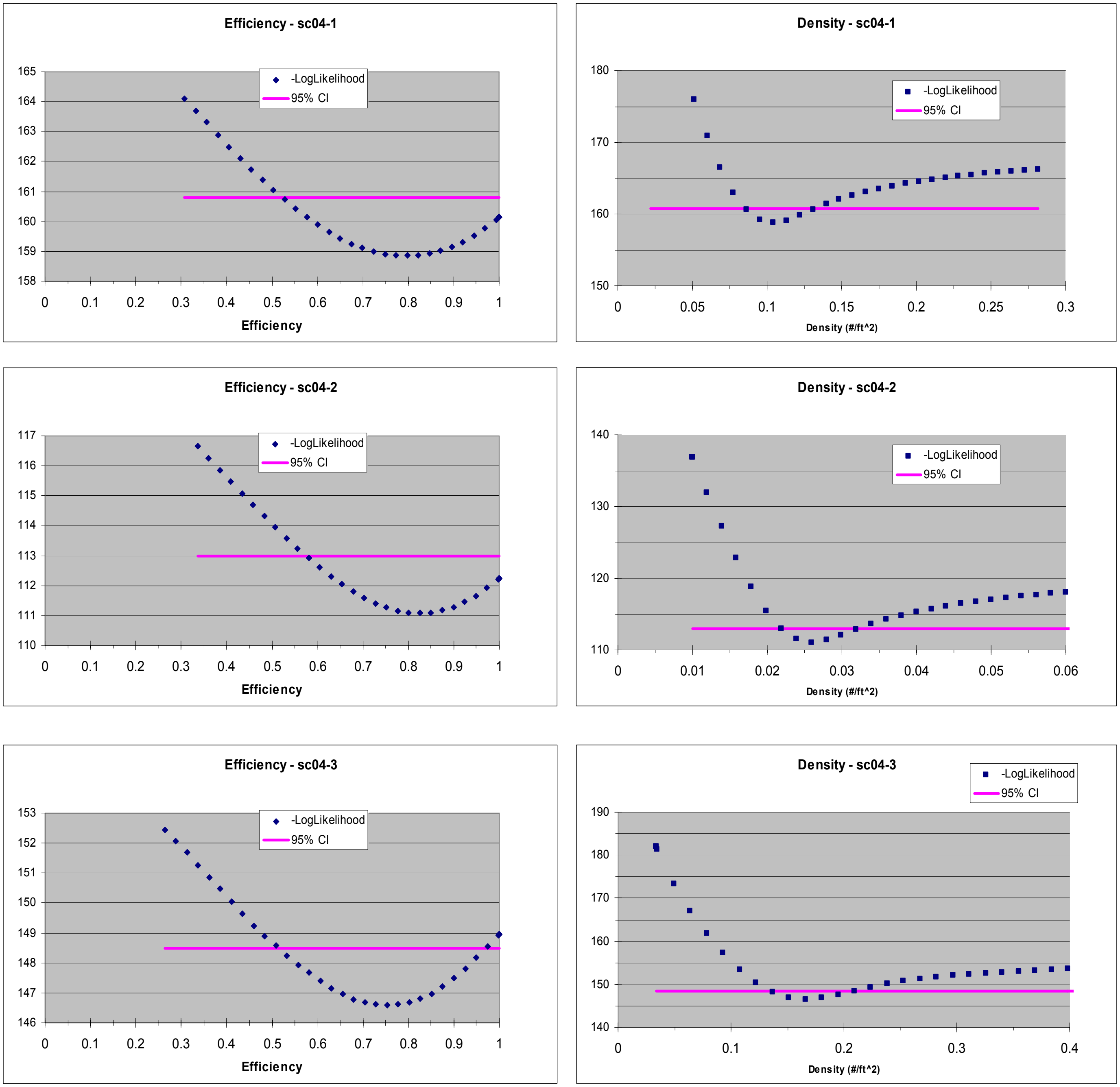


Figure 5. Results from the three surfclam depletion experiments by the *FV Lisa Kim* in 2004. Figures show the likelihoods of dredge efficiency and clam density for each experiment. In each figure, the intersections of the horizontal line with the likelihood curve represent the 95% confidence limits. Results are from the Rago Patch model, with no “indirect” effects.

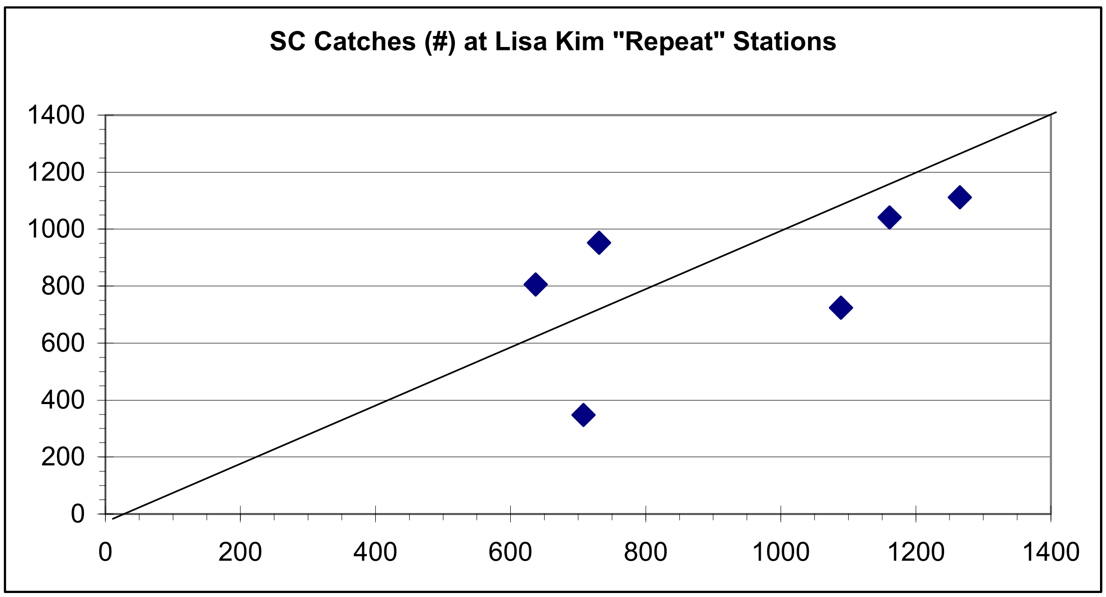
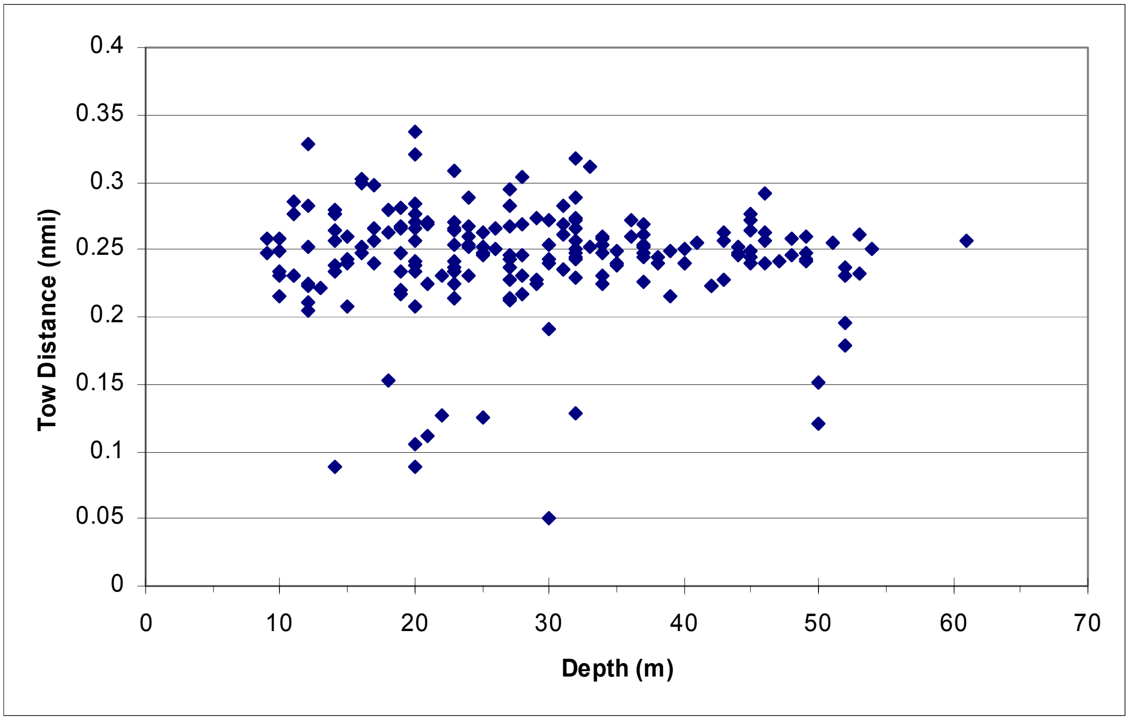


Figure 6. Catch of surfclams (#) per tow at 6 stations that were sampled twice during the survey. The slanted line shows what the catch would be if there was no change over time and no error variance. Data are given in Table 7.



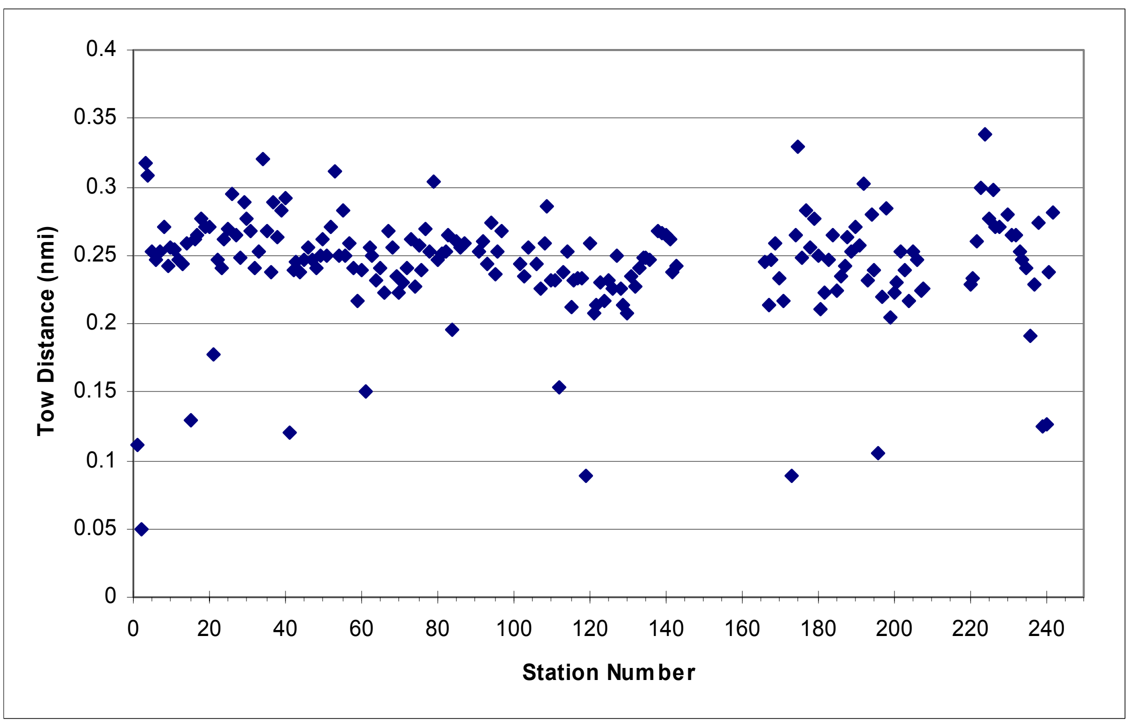


Figure 7. Graphs showing the relationship between *FV Lisa Kim* tow distance and station depth and station number in 2004.

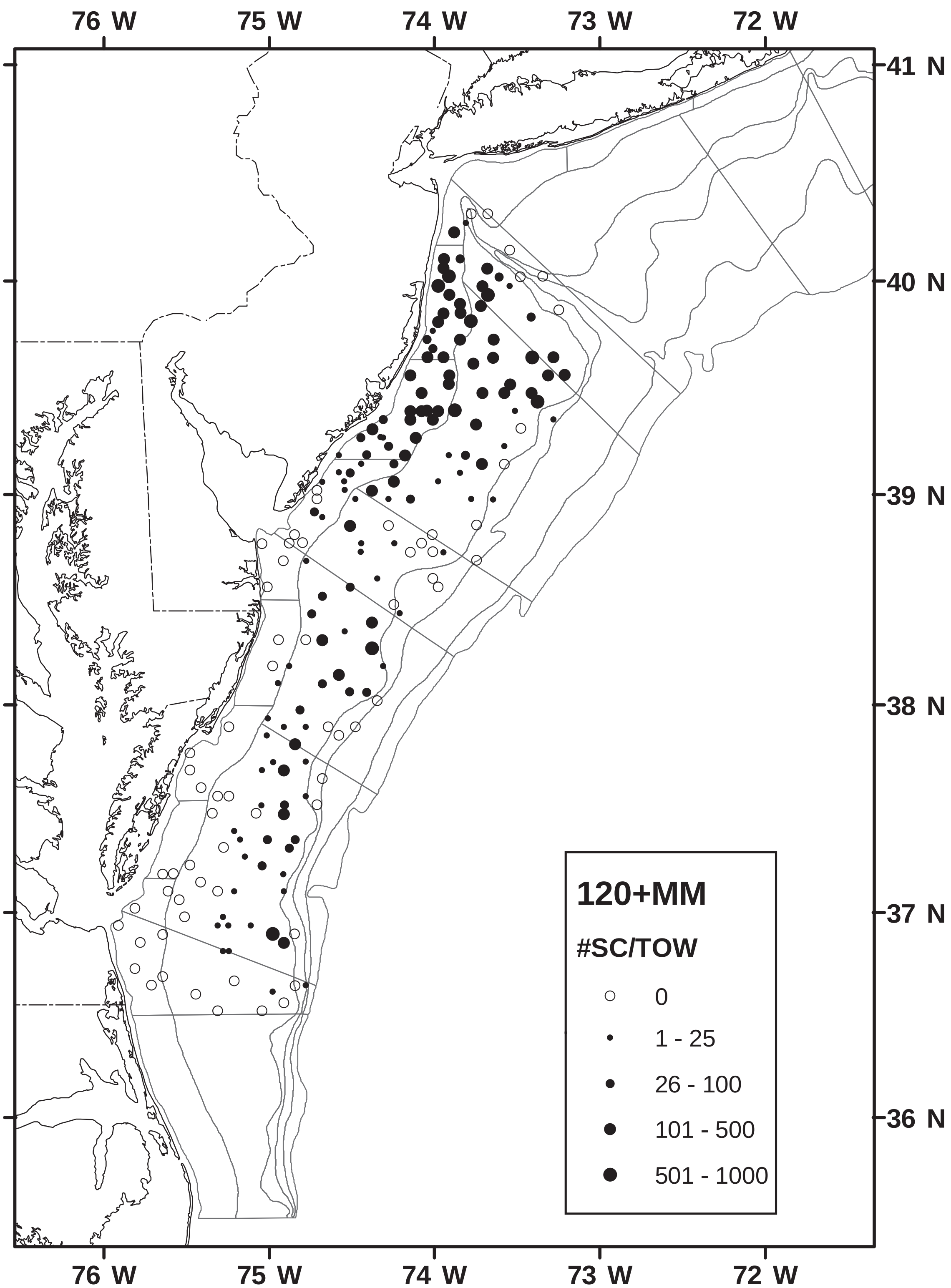


Figure 8. Map of catch per tow of large surfclams (**120 mm**+ shell length) at random survey stations in 2004. Catches were standardized to a distance of 0.15 nmi.

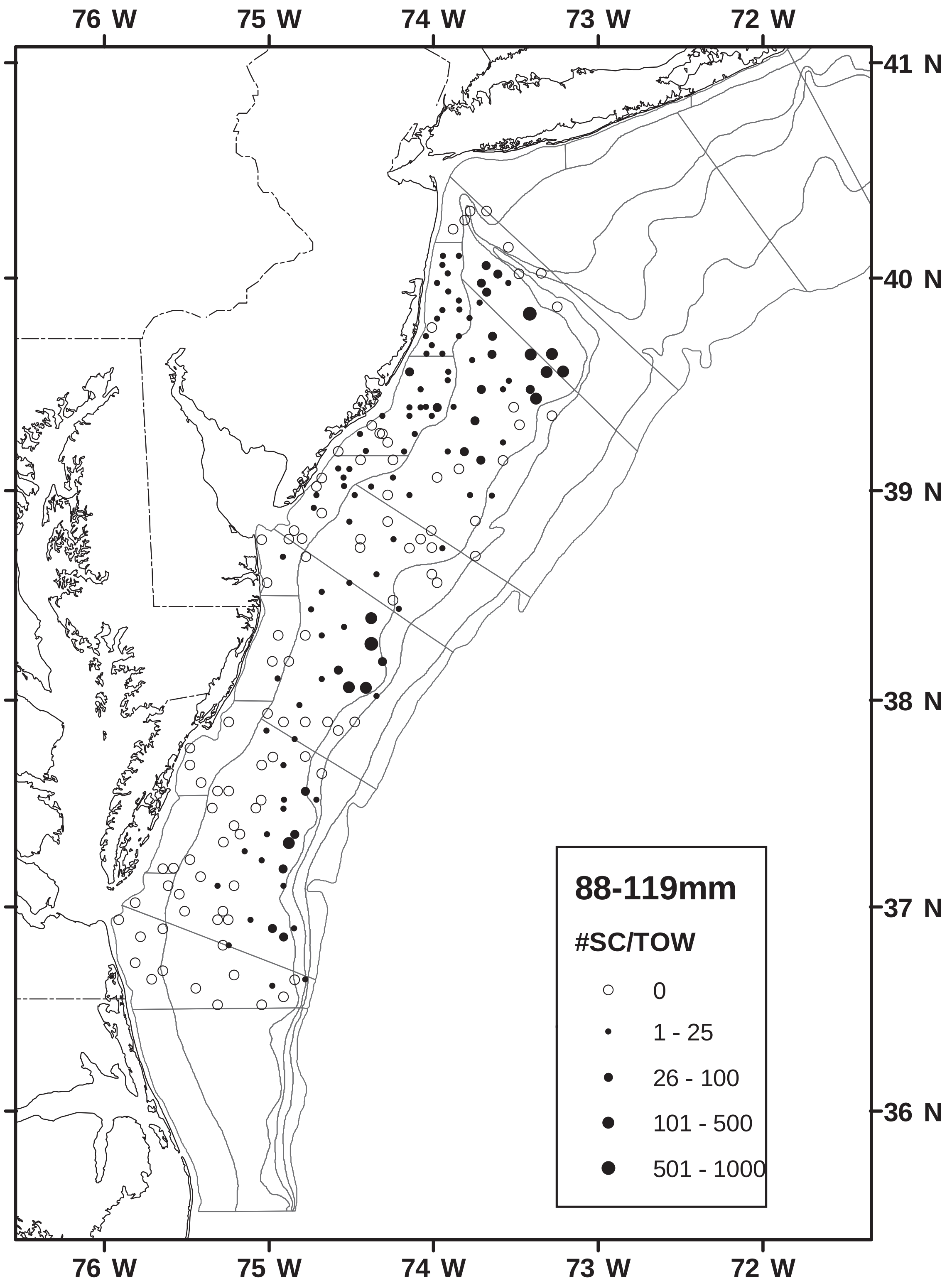


Figure 9. Map of catch per tow of medium surfclams (**88-119 mm** shell length) at random survey stations in 2004. Catches were standardized to a distance of 0.15 nmi.

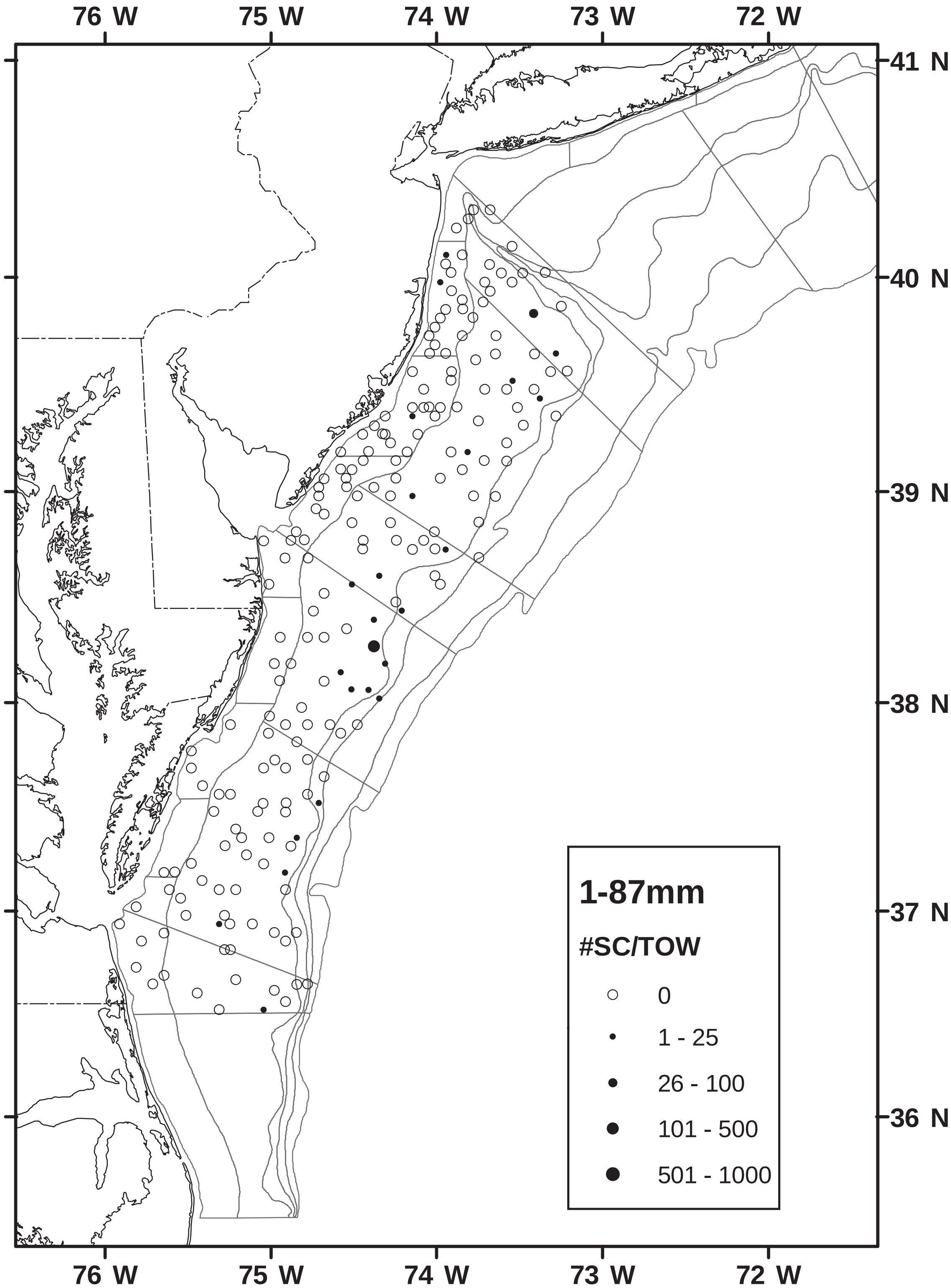
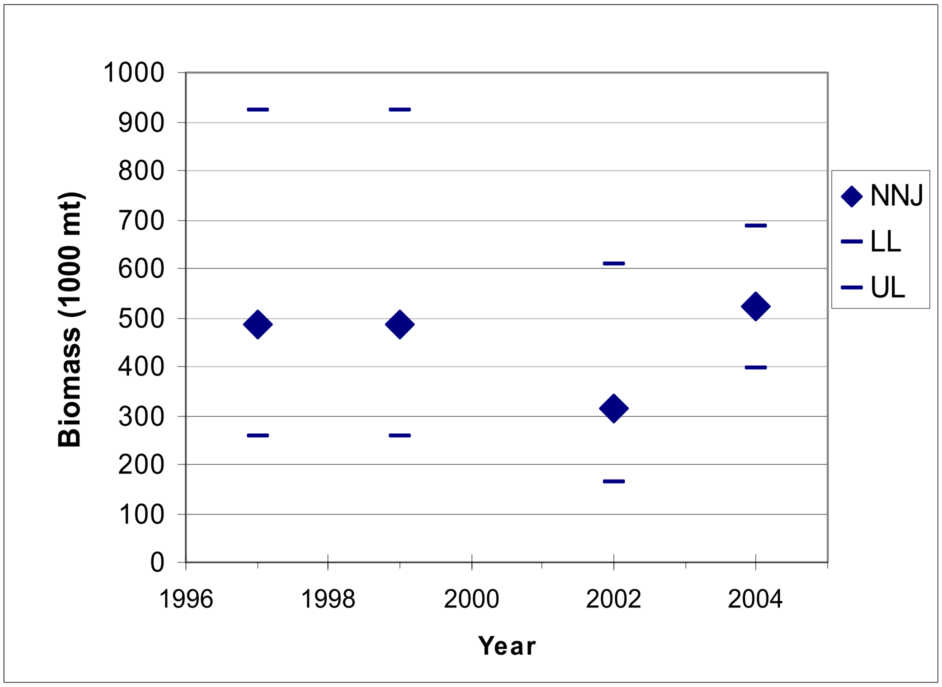


Figure 10. Map of catch per tow of small surfclams (**<88 mm** shell length) at random survey stations in 2004. Catches were standardized to a distance of 0.15 nmi. The dredge did not retain this size class consistently.



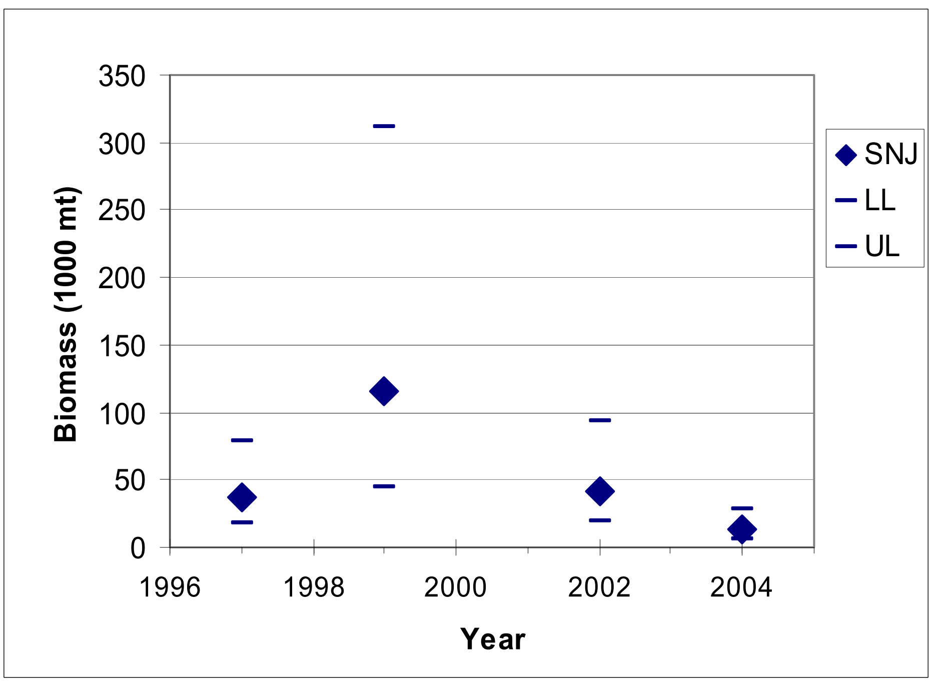
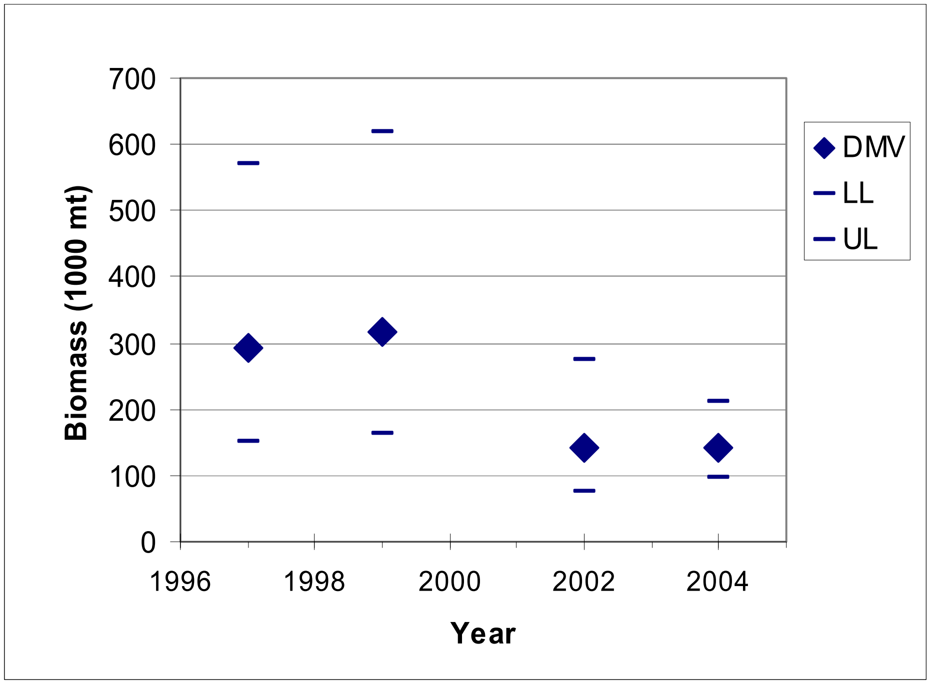


Figure 11. Efficiency corrected biomass estimates (‘000s mt meats), and 80% confidence intervals, for fully recruited surfclams, by region (**NNJ**, **SNJ**) and year. Catch per tow was standardized to 0.15 nmi based on computed tow distances (SENDIST_2004). Only good, random tows were included (RANDLIKE = 1 or 2). For NNJ and SNJ, full recruits were defined as those 120 mm and greater.



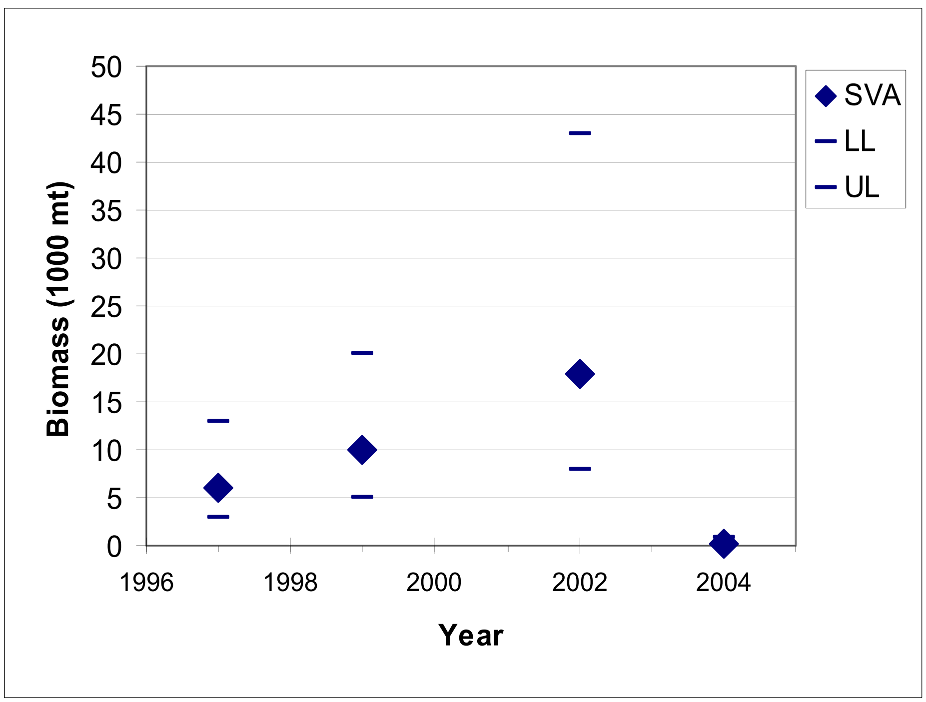


Figure 12. Efficiency corrected biomass estimates ('000s mt meats), and 80% confidence intervals, for fully recruited surfclams, by region (**DMV**, **SVA**) and year. Catch per tow was standardized to 0.15 nmi based on computed tow distances (SENDIST_2004). Only good, random tows were included (RANDLIKE = 1 or 2). For DMV and SVA, full recruits were defined as those 100 mm and greater.

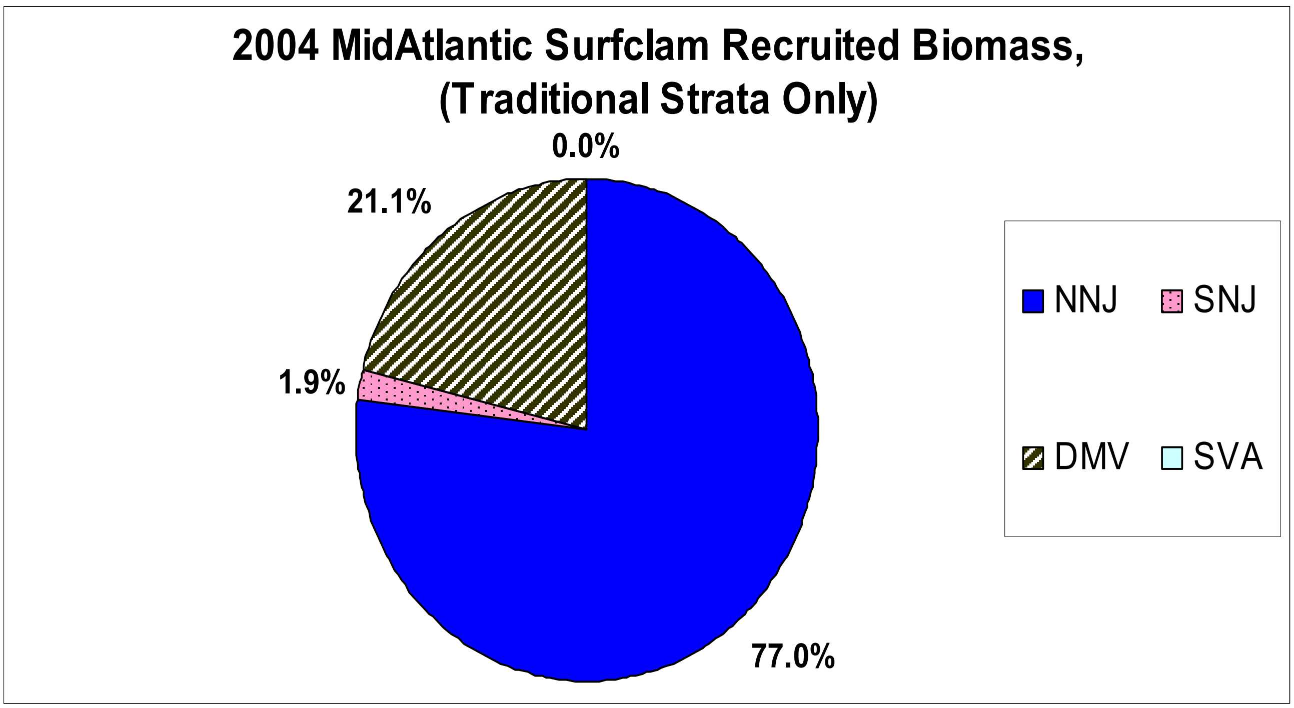
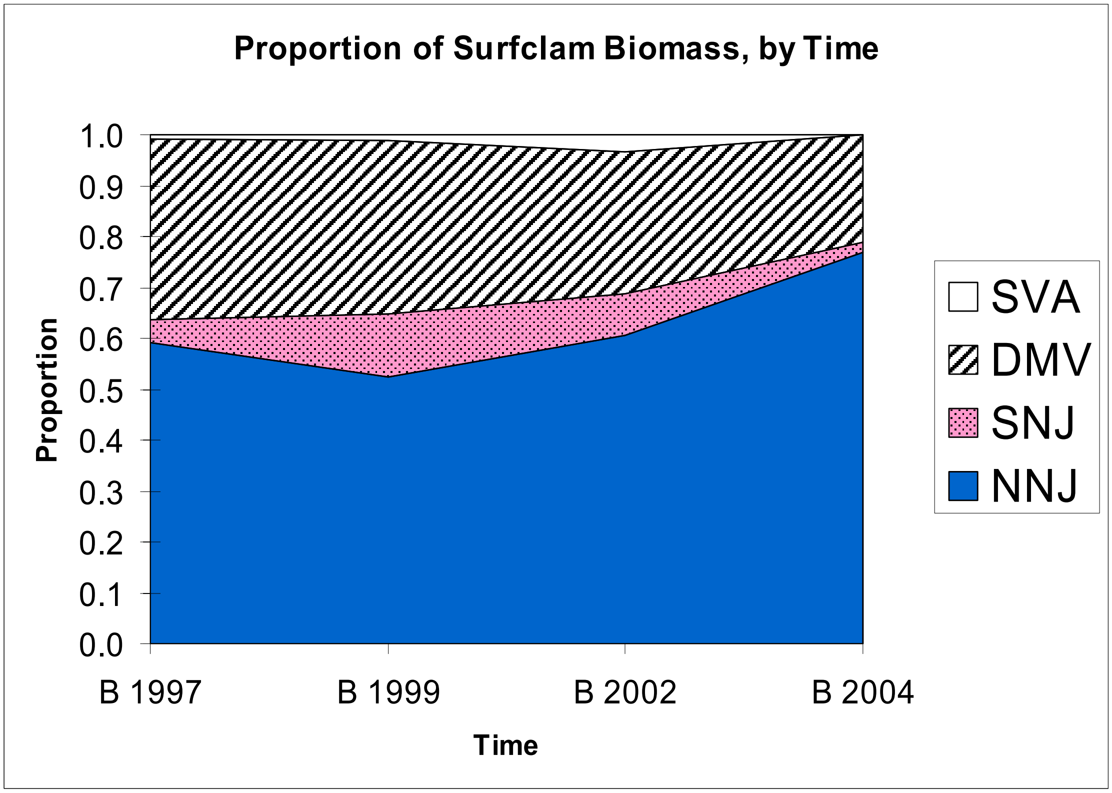


Figure 13. Percentage of fully recruited surfclam biomass in each Mid-Atlantic region in 2004. SVA had too little biomass to appear in the chart.



Region	B 1997	B 1999	B 2002	B 2004
NNJ	0.59	0.52	0.61	0.77
SNJ	0.05	0.12	0.08	0.02
DMV	0.36	0.34	0.28	0.21
SVA	0.01	0.01	0.03	0.00

Figure 14. Changes over time in the proportion of fully recruited surfclam biomass in each Mid-Atlantic region. There are data points for 1997, 1999, 2002, and 2004.

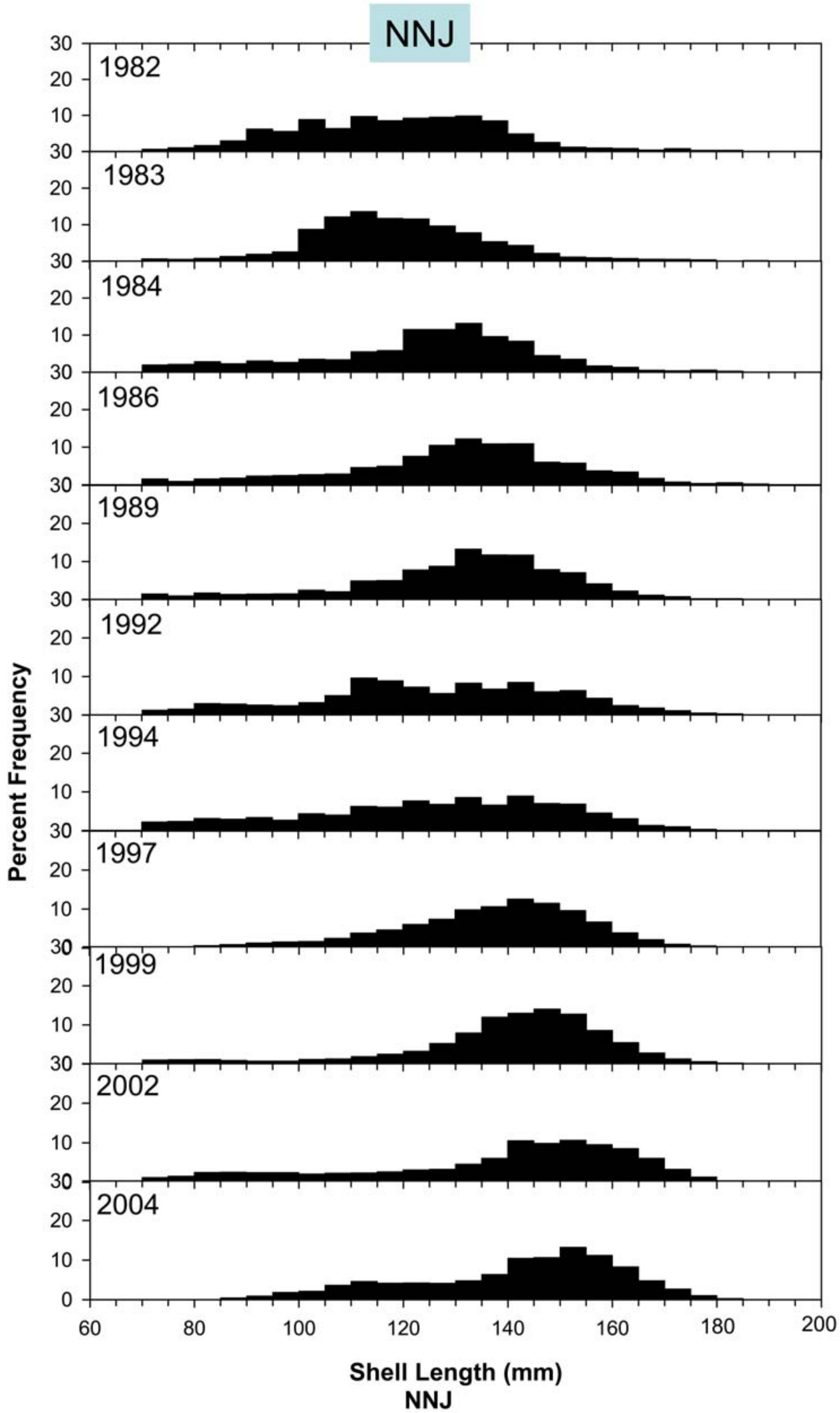


Figure 15. Surfclam length-frequency distributions over time in the **NNJ** region. Clams were sampled from 1982 – 2002 with the NMFS clam dredge on the *RV DE-II*. In 2004, samples were made with the commercial dredge on the *FV Lisa Kim*, which might have lower retention of small clams (<90 mm) compared with the NMFS dredge.

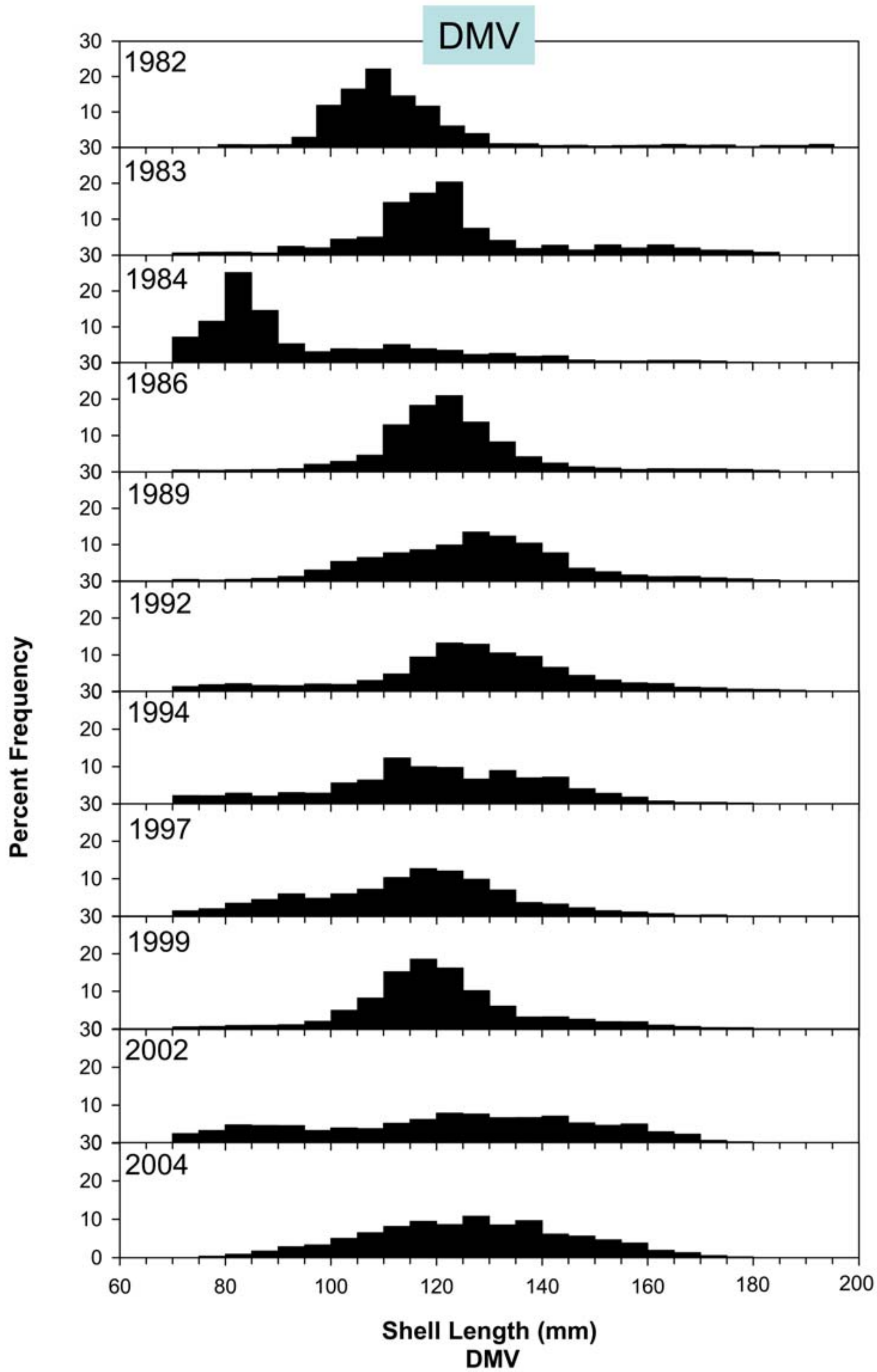


Figure 16. Surfclam length-frequency distributions over time in the **DMV** region. Clams were sampled from 1982 – 2002 with the NMFS clam dredge on the *RV DE-II*. In 2004, samples were made with the commercial dredge on the *FV Lisa Kim*, which might have lower retention of small clams (<90 mm) compared with the NMFS dredge.

NNJ Inshore : Stratum 88

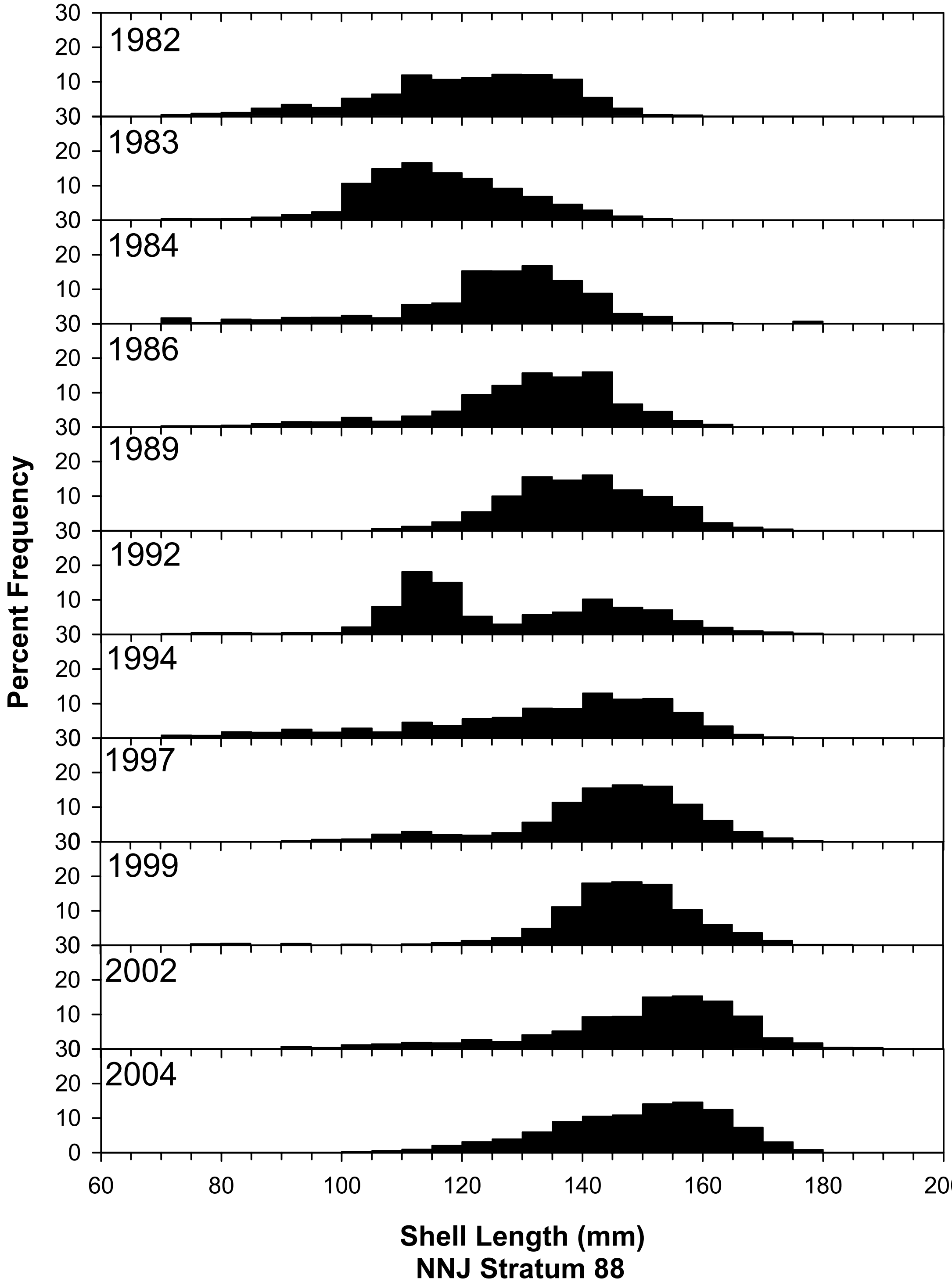


Figure 17. Surfclam length-frequency distributions over time in the **shallow NNJ Stratum 88**. Clams were sampled from 1982 – 2002 with the NMFS clam dredge on the *RV DE-II*. In 2004, samples were made with the commercial dredge on the *FV Lisa Kim*, which might have lower retention of small clams (<90 mm) compared with the NMFS dredge.

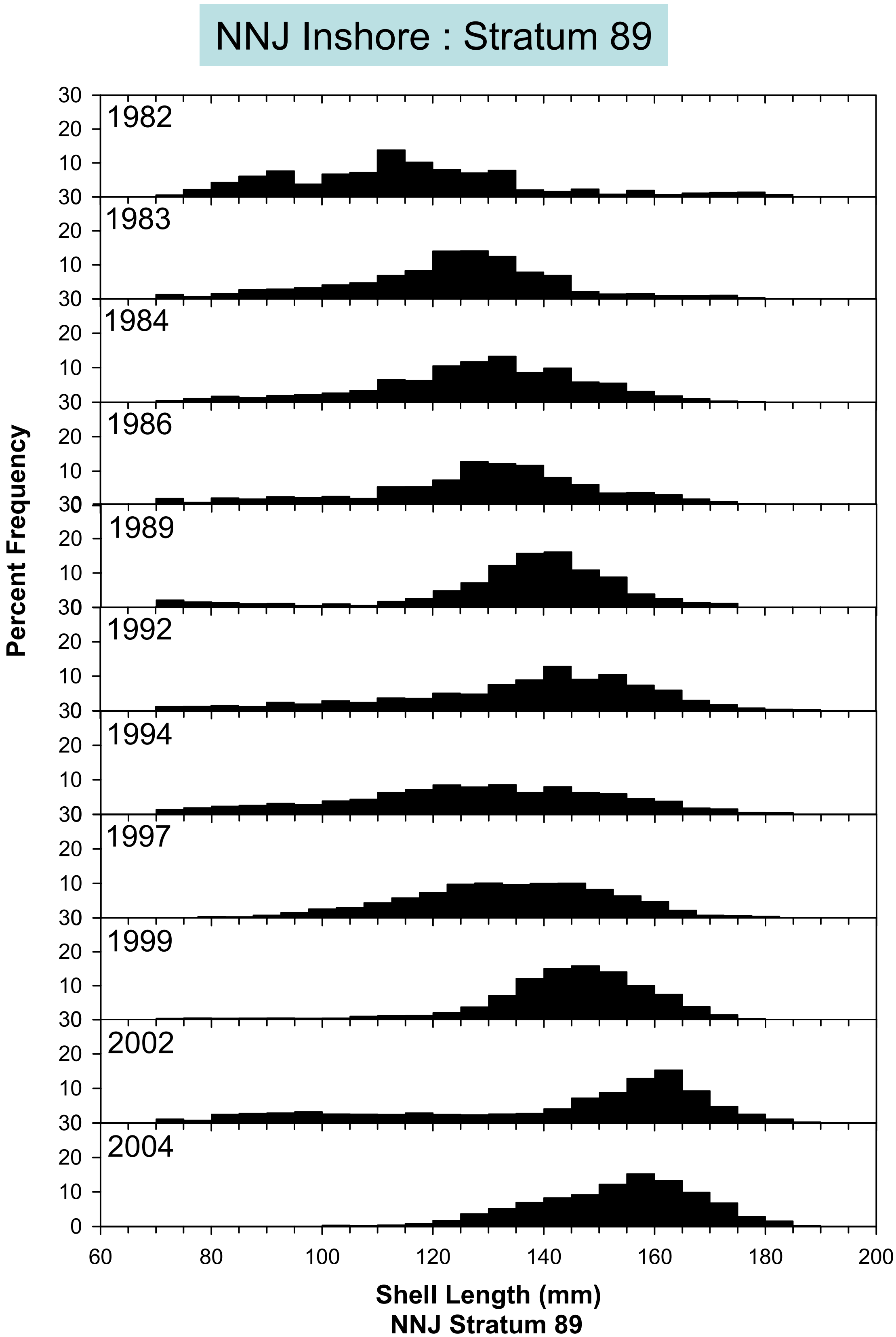


Figure 18. Surfclam length-frequency distributions over time in the **shallow NNJ Stratum 89**. Clams were sampled from 1982 – 2002 with the NMFS clam dredge on the *RV DE-II*. In 2004, samples were made with the commercial dredge on the *FV Lisa Kim*, which might have lower retention of small clams (<90 mm) compared with the NMFS dredge.

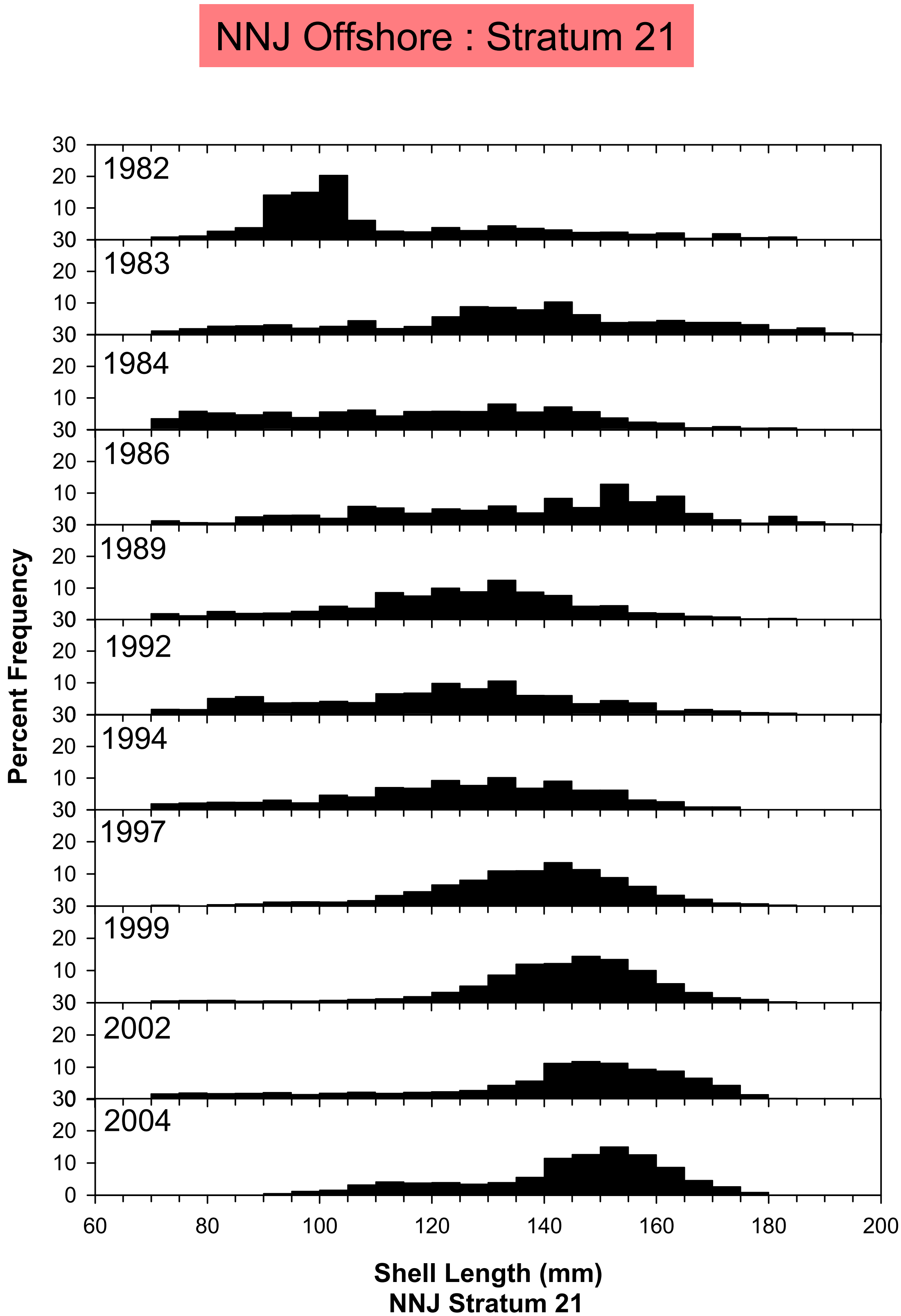


Figure 19. Surfclam length-frequency distributions over time in the **mid-depth NNJ Stratum 21**. Clams were sampled from 1982 – 2002 with the NMFS clam dredge on the *RV DE-II*. In 2004, samples were made with the commercial dredge on the *FV Lisa Kim*, which might have lower retention of small clams (<90 mm) compared with the NMFS dredge.

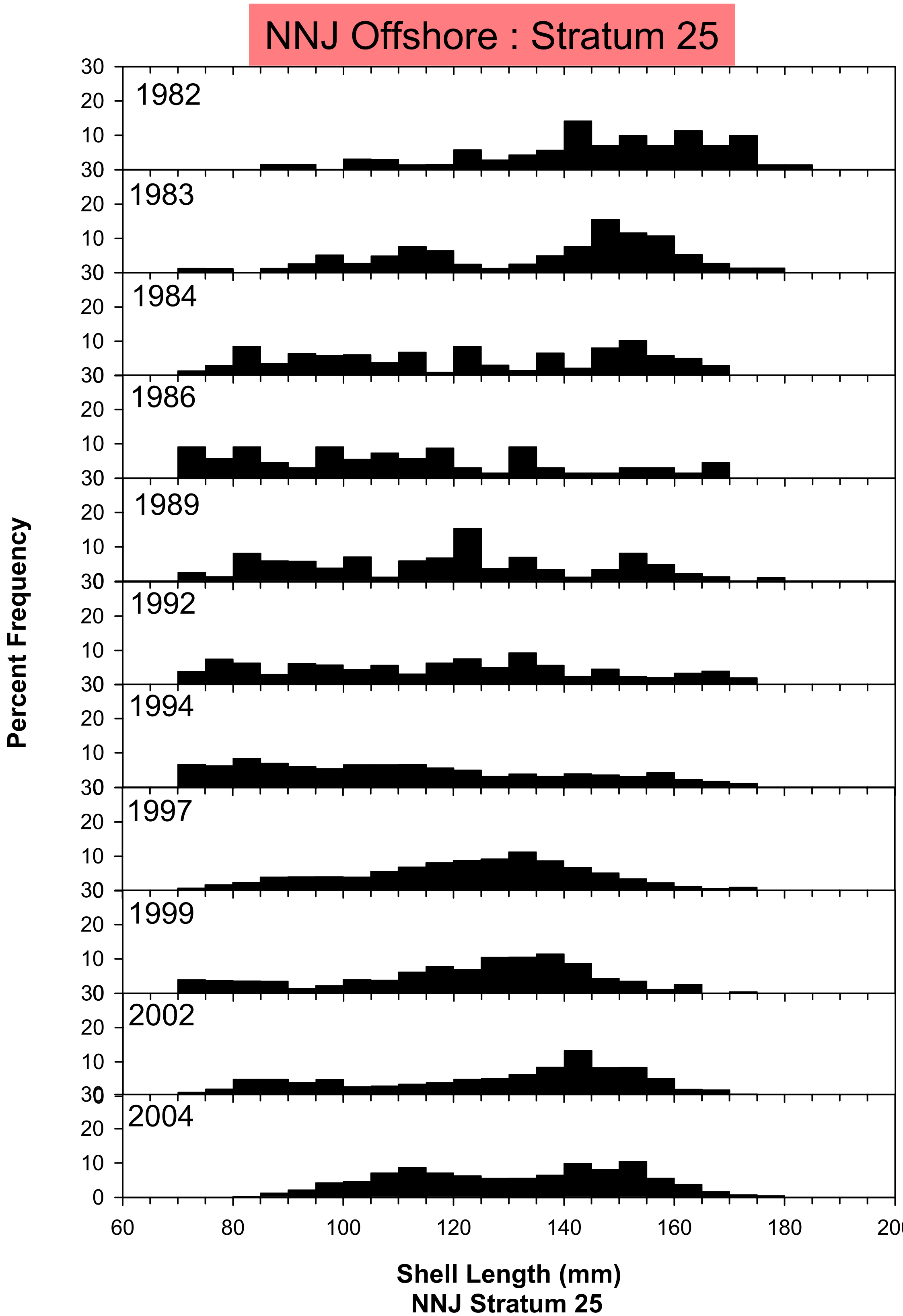


Figure 20. Surfclam length-frequency distributions over time in the **mid-depth NNJ Stratum 25**. Clams were sampled from 1982 – 2002 with the NMFS clam dredge on the *RV DE-II*. In 2004, samples were made with the commercial dredge on the *FV Lisa Kim*, which might have lower retention of small clams (<90 mm) compared with the NMFS dredge.

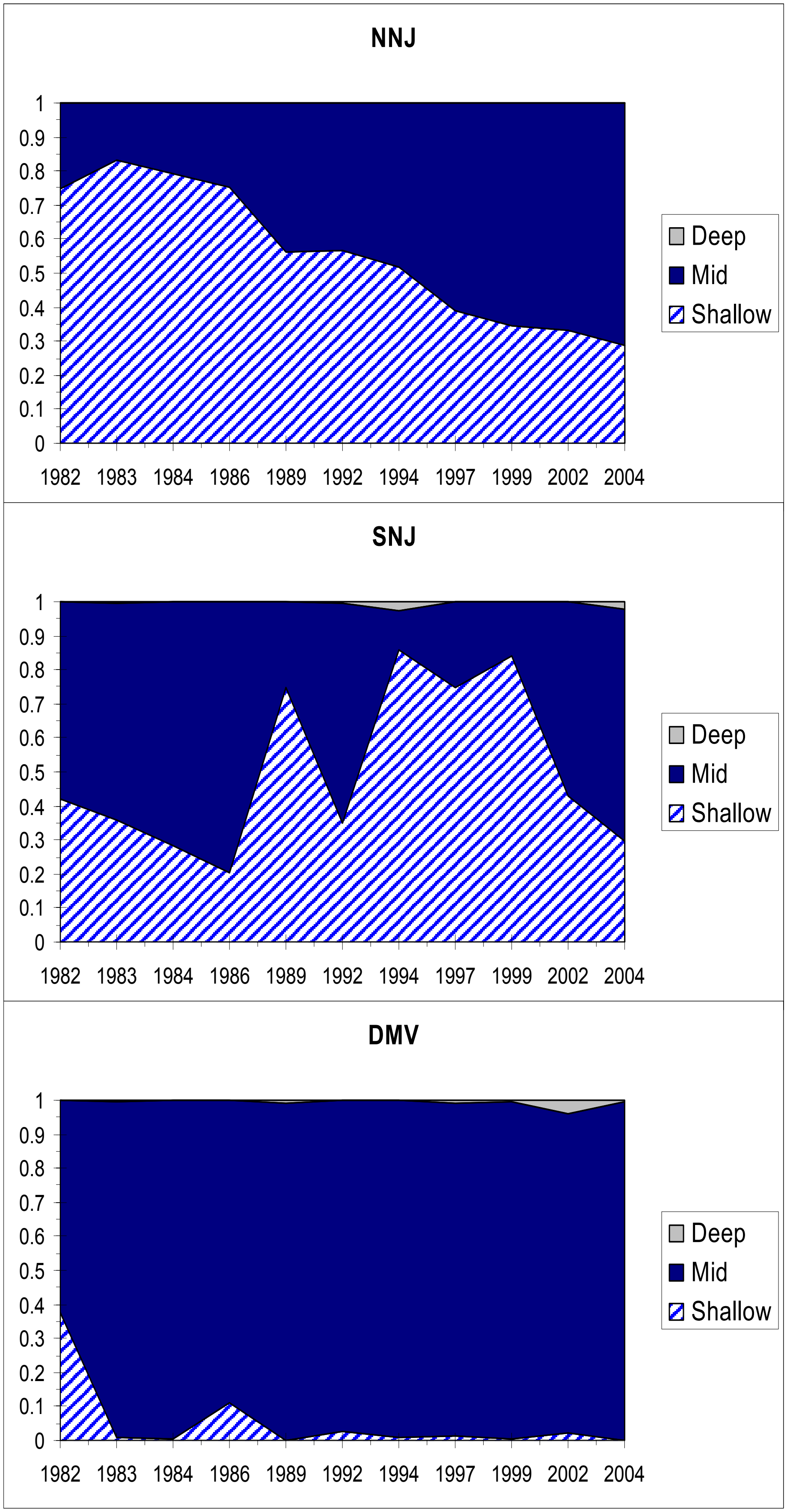


Figure 21. Percent of surfclam biomass in 3 depth zones (see Table 14) by year, for the **NNJ, SNJ** and **DMV** regions. See Table 16 for values plotted in figure.

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