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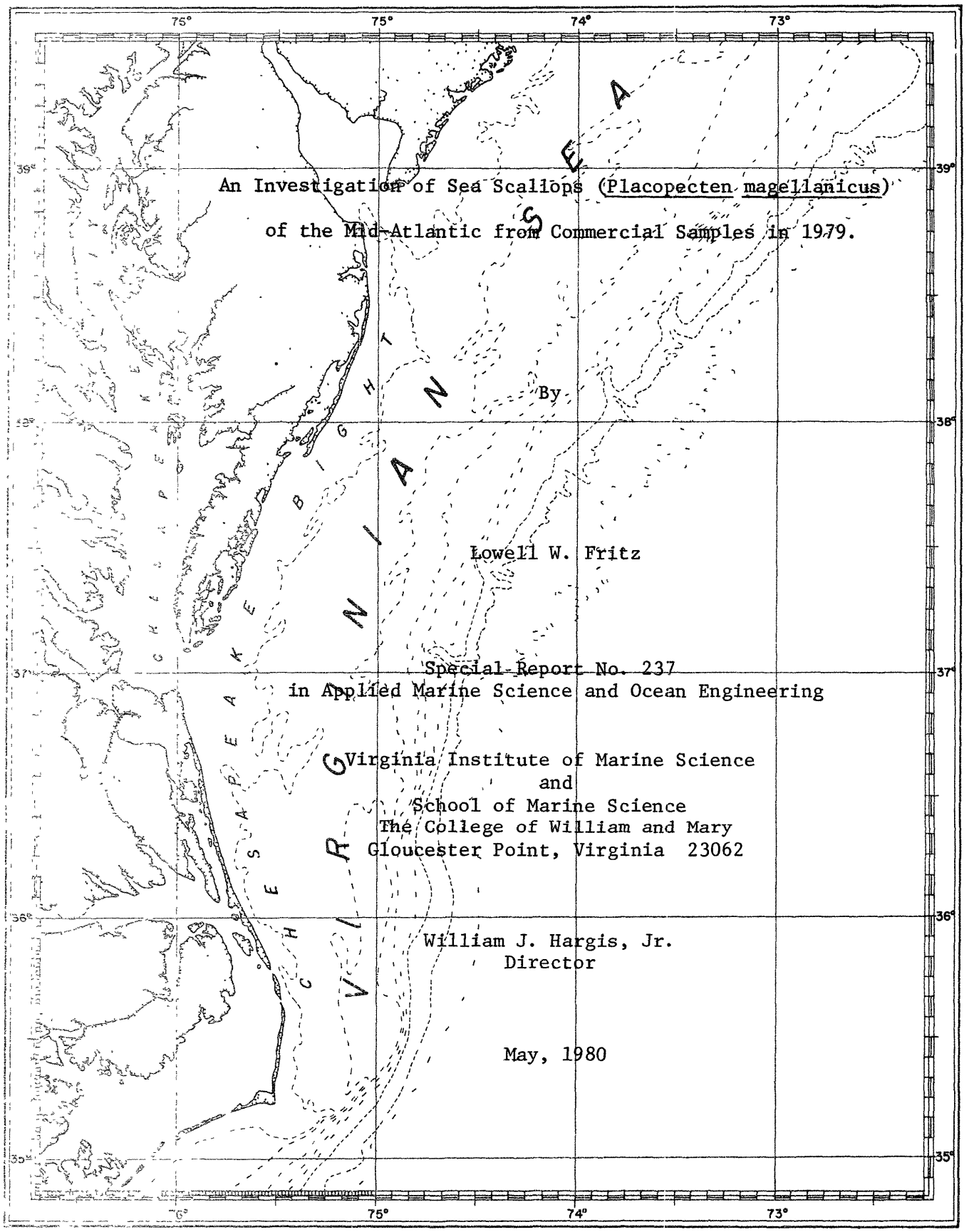

An Investigation of Sea Scallops (Placopecten magellanicus) of the Mid-Atlantic from Commercial Samples in 1979.

By

Lowell W. Fritz

Special Report No. 237
in Applied Marine Science and Ocean Engineering

Virginia Institute of Marine Science
and
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ABSTRACT

Bushel samples of sea scallops (Placopecten magellanicus) for height-frequency analysis were obtained aboard the commercial scalloper, VIRGINIA SURF, from the mid-Atlantic region on two trips during the summer of 1979. Fishing effort was concentrated in three areas of the shelf: 1) Sixty miles east of the Virginia-North Carolina border, 2) Seventy miles east of the coast from Cape Henlopen, Delaware to Atlantic City, New Jersey, and 3) Forty-five miles south of Long Island from Moriches Bay to Bridgehampton. Individuals (212) were retained for age analysis from the catches of the two northern areas.

The mean size of scallops caught in the southern region of the mid-Atlantic was smaller than in the north. Ninety percent of the southern scallops measured were between 75-119 mm shell height with a peak occurring at between 95-99 mm. A peak in height-frequency for the two northern samples occurred at 110-114 mm and ninety percent of the scallops measured ranged between 95-134 mm. Most of the scallops represented by the peak in the southern samples are of the 1975 year class, while the northern sample peak is composed of the 1972-1974 year classes. Smaller, younger scallops appeared more frequently in the southern area, possibly indicating more successful recruitment since 1975 than in the northern areas sampled.

Catch per unit of effort (pounds per paired 15-foot dredge tow) was higher in the southern (41.3) than either of the two northern areas (20 and 30.8, respectively).

ACKNOWLEDGMENTS

This work is the product of many people who share an interest in the study and preservation of sea scallop resources. The following are recognized for their contributions to this report:

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Sea scallops (Placopecten magellanicus) occur in the northwestern Atlantic Ocean from the northern shore of the Gulf of St. Lawrence to Cape Hatteras (Posgay, 1957). Although it is primarily an inhabitant of the continental shelf, scallops may be found near the coast in the northern part of its range, but are restricted to cooler offshore waters in the mid-Atlantic.

Sea scallop beds in U.S. waters which are dense enough for commercial exploitation occur on Georges Bank, in the New York Bight, off Delmarva, and near the Virginia Capes. Before 1965, the Georges Bank fishery accounted for most of the U.S. scallop landings. However, as a result of the successful recruitment of a year-class to the mid-Atlantic fishery the U.S. fishery has concentrated south of Long Island since 1965 (Serchuk, et al., 1979).

Surveys of sea scallops have been conducted in the mid-Atlantic by National Marine Fisheries Service (NMFS) and Canadian research vessels since 1960 (Serchuk, et al., 1979). Data on the commercial catch, however, has been limited to pounds landed and areas fished. The Virginia Institute of Marine Science (VIMS) began the study of sea scallops in the mid-Atlantic aboard commercial vessels in July, 1979. Our preliminary objectives were:

1. To determine the height-frequency distribution of the scallops caught by commercial vessels in the areas fished;
2. To determine the age composition of the catch;
3. To determine the catch per unit of effort by area;
4. To obtain information on the gear and its deployment,

and methods and intensity of fishing on the grounds visited;

5. To determine age at recruitment to the gear (fishery).

This report summarizes the results of two trips, both conducted aboard the VIRGINIA SURF in July-September 1979.

I. Vessel and Trip Descriptions

The VIRGINIA SURF is a 100-foot stern trawler equipped with dual outriggers. It is a relatively new boat (1-year) in the Fass Bros. (Hampton, VA) fleet. Fass Bros. prefers trips to extend no more than 12 days dock-to-dock. A successful trip would yield 350-400 bags, at 40 pounds of scallop meats per bag.

The first trip was conducted from 17-20 July 1979. Due to electrical problems aboard the ship, the trip was concluded after four days. Fishing operations during Trip 1 were concentrated on hard sand bottoms 60 miles off the Virginia-North Carolina border. The area sampled was approximately 20 miles long (NE to SW) and 10 miles wide and centered near $36^{o}35'N$, $74^{o}50'W$ (see Figure 1). Throughout the rest of this report, this area will be referred to as VA-NC. In the southern portion (sampled in tows 1-12), the depths ranged between 36-50 meters while deeper waters up to 56 meters were fished in the northern portion and sampled in tows 13-20 (see Table 2A).

The second trip lasted from 24 August to 4 September 1979. Fishing operations were not concentrated on a single grounds but scattered along the 56-80 meter band from Cape Henlopen, Delaware to Eastern Long Island. The tows can be conveniently grouped into two areas: 1) NJ - This region extends from Cape Henlopen to Atlantic City, NJ approximately 65-75 miles

offshore and was sampled during tows 1-9 and 38-43. The approximate coordinates of the northern and southern boundaries are 38°35'N, 73°5'W, respectively. In the southern portion of this region, the depths ranged between 60-78 meters and tows were generally made in a northeasterly or southwesterly direction. In the northern portion, depths fished ranged between 64-80 meters with tows made generally due north or south. Dragging operations were often conducted in sight of offshore oil drilling rigs here. 2) LI - This region is located between 40-50 miles due south of central Long Island between Moriches Bay and Bridgehampton. It was sampled in tows 10-37 and was the predominant grounds fished on this trip. Depths ranged between 56-74 meters. The approximate coordinates of the eastern and western boundaries of this region are 40°15'N, 72°20'W and 40°10'N, 72°50'W, respectively.

Bottom type during Trip 2 varied from soft sand and crushed shell to hard sand, gravel, and rock. Catches did not appear to be affected by bottom stability but areas of large, loose rocks (which were caught in the bag) yielded poor catches.

II. Gear Description and Deployment

The two dredges deployed were each 15 feet (4.5 meters) wide and approximately 1 foot high at the mouth. The dredge slides over the bottom on a pair of metal plates (shoes) which are tapered (in thickness) toward the mouth. Attached to the dredge mouth by numerous 10-link-chains, is the bag. It is composed of a series of 3-inch (76 mm) rings, and is 48 rings across at the mouth. To decrease the weight of the bag and insure that the mouth remains open, a twine section is woven into the top of the

bag and is approximately 12 feet wide by 10 feet long. A tickler chain is stretched across the mouth.

When the drags are ready to be fished, the boat speeds up. Upon a downward roll of the boat, the dredges are released one at a time with adequate tension on the cables maintained to prevent the dredges from flipping over. The dredge is released by knocking out the "knock-out-block" which allows the dredge to rest upon the rail of the boat by a chain attached to the deck.

The ratio of warp length to water depth is between three and three and one-half to one. Tows generally range between 30-50 minutes in duration and are conducted at a ship speed of approximately 6 knots. Consequently, in a single tow, 3-5 nautical miles of bottom are generally fished by the pair of dredges.

The dredges are raised at the end of the drag by a pair of large winches which return the dredges amidship. Hooks are placed on the bullrings and the dredges moved astern and raised by a pair of smaller winches located on the captain's deck. Once the dredges are on board, the clubsticks are lifted emptying the catch out of the mouth. When the dredges are secure over the side and ready to be dropped again, the catch is culled and shucked. The scallops to be cut (shucked) are placed in wire bushel baskets and carried to bins located in various positions on the deck. Small scallops (discards) were left with the rest of the catch to be shovelled overboard, usually within 10-15 minutes of being landed.

Dragging operations are conducted 24 hours a day once the grounds are reached. The crew is divided into two, four or five man watches, con-

sisting of two winch operators and two 'hookers' (who must place the hooks on the dredge and guide it onto the boat). The schedule on the SURF was 6 hours on and 6 hours off, which resulted in two shifts per day per man.

III. Fishing Operations

1. Catch and Effort

A summary of the catch and effort for both Trips 1 and 2 appears in Table 1. During one six-hour watch, almost seven tows could be completed. Consequently, an average of 1.1 tows/hour is used to compute the number of tows for complete watches in column 3 in Table 1. On Trip 1, two watches were incomplete (3 and 4 tows each) which is considered in the number of tows.

The catch/effort (denoted in Table 1 as bags/tow, pounds/tow or pounds/hour) was considerably lower during Trip 2 than Trip 1. However, other boats in the same fleet completed 350-400 bag trips in the NJ-LI region during August-September, 1979. The low catch/effort during Trip 2 may have been due to one or more of the following factors: 1) Differences in deployment and design of the dredges between boats; 2) Relative inexperience of the crew in the scalloping of this area; or 3) Actual low densities of scallops on the bottoms dredged.

During Trip 2, the effort was divided between the two regions, LI and NJ, at two-thirds and one-third of the total time, respectively. However, three-fourths of the catch was caught in LI; only one-fourth was caught in NJ. Consequently, the catch/effort was 50% better in LI than NJ.

Trips 1 and 2 were both considered poor in terms of total catch and the number of bags per watch by the crew. An excellent watch usually

yields between 10-15 bags, whereas the largest watch on either trip yielded only 9.

2. Yields and Meat Weights

In a given area, individual meat (muscle) weight is generally related to scallop height (Serchuk, et al., 1979). However, when comparing meat weights from two areas, scallops of similar shell height may have meats of different weight and volume. When a trip's catch is sold, the buyer samples the catch throughout the unloading process, checking the count per pound, and using this information along with the total landed meat weight, determines the rate at which the catch will be bought.

Yields, as referred to in this report, are defined as the number of bushels of unshucked scallops, that when shucked, will fill a 40 pound bag. This is essentially the live volume/meat weight-volume ratio. Filled bags varied somewhat in weight, with most weighing between 40-43 pounds. Yield estimates for the areas sampled were obtained primarily through interviews with crew members and observations of shucking. However, on the first trip, bushel samples of scallops were shucked and the resultant volume of meats noted. Crew estimates of yield from these areas were in good agreement with my results.

Data for yields and average meat weights for VA-NC, NJ and LI regions appear in Table 1A. The smaller average meat weight in the VA-NC area is due to the smaller average scallop size in the southern catches as compared with the northern mid-Atlantic catches (Figure 2B and Table 2C).

The average number of scallops per bushel was similar in the NJ (101.7) and LI (106.5) regions (Table 2C). However, the average meat weight

in the NJ region is more than twice the average meat weight of the VA-NC region.

In the LI area, the meat quality varied considerably. During one series of tows in the western LI area (Tows 10-13, Table 2B), the scallops appeared abnormal, the meats being grayish-green in color and the body flaccid and pale. A greater number of these poorer meats were required to fill a bag than in the eastern LI region where the scallops appeared more normal. As can be seen from Table 2B, the scallops from Tows 10-13 were not signicantly smaller than those from other tows in the LI area.

3. Discards

There are no state or federal regulations designating a minimum size of sea scallop which can be legally captured. This policy, however, is set by individual captains. Through investigations of the small, discarded scallops from commercial catches, individuals which set two or three years previously can be detected. These year-classes are not fully recruited into the fishery, but will contribute to it in the future. The dredge employed is not 100% efficient for the capture of scallops smaller than 100 mm shell height, but qualitative results can be obtained by their presence or absence in the catch (Caddy, 1968).

a) Trip 1

Scallops less than 70 mm in shell height were discarded by the crew on Trip 1. This policy was set despite the relatively small size of the average scallop on this trip compared with Trip 2

(Table 2C, # scallops/bu). The percentage of discards in the total catch, however, was small. In the 20 total samples analyzed, small scallops accounted for only 3% of the total number of scallops measured (90/2931).

A brief investigation of the physical state of the discarded scallops when landed was conducted during Trip 1. Only one small scallop (out of the 90 measured) was lethally damaged when landed, both valves being broken. Medcof and Bourne (1964) regarded between 11-26% of the discards (between 65-100 mm shell height) as lethally damaged when returned. These figures are much higher than observed during Trip 1 and may be due to the rocks caught in the dredge bag during their studies.

b) Trip 2

All scallops landed and culled on Trip 2 were shucked, regardless of size. Some scallops were undoubtedly overlooked and discarded, but this was a random and inconsequential occurrence.

The catch from many tows in the NJ and LI regions consisted primarily of sand dollars approximately 50 mm in diameter. However, few 50 mm scallops were captured. This is due either to their absence or dredge avoidance rather than their release through the rings, noting the ability of the gear at retaining 50 mm sand dollars.

IV. Methods

1. Height-Frequency Samples

Height-frequency analysis was performed by measuring one bushel of scallops randomly handpicked from one-half of the catch obtained in a single dredge haul. If the catch of a particular tow was small, the sample size was proportionally reduced (Tables 2A and 2B).

2. Samples for Age Analysis

Shell samples for age analysis were obtained either from a single tow or a series of tows in the same area. One crew member was asked to save the left (top) valve of about one hundred scallops and from these, three or four representatives from each 5 mm shell height interval were randomly chosen. The shells were scrubbed and dried on board and stored in the hold for the duration of the trip. Shell samples during Trip 1 were not collected in the same manner and are not discussed in this report. Consequently, data on age and growth rates apply only to the NJ and LI areas.

3. Calculation of Growth Equation

Age determinations were conducted according to the methods of Merrill, Posgay and Nichy (1966) and L. O'Brien (personal communication). The Von Bertalanffy growth curve (Table 3 and Figure 3) was fit by the Allen method.

V. Results

1. Height-Frequency of Catch

a) Entire Mid-Atlantic Area

The height-frequency of market and discards are tabulated for analysis in four categories:

1) The VA-NC catch (Table 2A; Figure 2B);

2) The NJ catch (Table 2B; Figure 2B);

3) The LI catch (Table 2B; Figure 2B);

4) The combined mid-Atlantic catch (Table 2C; Figure 2A).

The data for all areas are combined since the mid-Atlantic area has been treated as a unit by researchers. Therefore, these data may be compared to other studies made in the same region. However, data presented here for each area reveals differences between the northern and southern scallop populations.

The modal height-frequency category for the entire mid-Atlantic is 95-99 mm, but a significant shoulder appears at 110-114 mm and a small peak at 55-59 mm (Figure 2A). Due to the occurrence of this peak at 55-59 mm, the scarcity of scallops caught between 65-74 mm shell height may be real and not due to gear selectivity.

b) Catch Subdivided by Area

In Figure 2A, the peak at 95-99 mm is due to the large number of this size in the VA-NC samples (Figure 2B). The shoulder at 110-114 mm (Figure 2A) is the modal height-frequency of both the NJ and LI samples (Figure 2B).

Scallops from samples taken in the VA-NC region ranged from 40-159 mm with ninety percent of the measurements between 75-119 mm. Scallops from the NJ region ranged from 70-149 mm. Ninety percent limits for both northern regions were 95-134 mm. Despite the smaller size range in the northern scallop samples, the mean, median and modal heights are larger.

The small peak at 55-59 mm in the VA-NC region was not observed in the NJ and LI samples. Ninety-four percent (90/96) of all scallops smaller than 70 mm shell height were caught in the southern mid-Atlantic area. Larger scallops 140 mm or greater were also more plentiful in the VA-NC catch samples. Sixty-nine percent (51/74) of all scallops larger than 140 mm were captured in the south.

2. Growth and Age Structure

a) Growth

Data on growth of scallops from the northern mid-Atlantic samples (NJ and LI) appear in Table 3 and Figure 3. Annuli are numbered sequentially, counting the first as 0, the second as 1 and so on. Since spawning occurs in late summer and the first annulus is formed in late winter, scallops are approximately six months old at the time of first annulus formation (Merrill, Posgay and Nichy, 1966; L. O'Brien (pers. comm.). Thus, to convert from annulus number to age 0.5 years must be added to the former. For instance, at annulus number 2, an individual is 2.5 years old.

The Von Bertalanffy growth equation describing the growth of the VIRGINIA SURF NJ and LI scallop samples appears in Table 3.

The L_∞ is only slightly larger than the largest scallop measured on Trip 2, but several measured on Trip 1 exceeded the L_∞ value (Tables 2A and 2B). However, the plot of $\ln(L_\infty - l_t)$ vs. age had an $r^2 = -0.99$ for $L_\infty = 151.00$.

b) Age Structure

The peaks in height-frequency distribution in Figure 2B of the NJ and LI samples at 110-114 mm shell height are composed of primarily 5-7 ring scallops (1972-1974 year classes). The shell samples taken from this area spanned the ages from 3 (64 mm) to 14 (144 mm). The peak in height-frequency in the VA-NC sample at 95-99 mm shell height is composed almost entirely of 4 ring (1975 year class) scallops. Two ring scallops of the 1977 year class comprise the small peak at 55-59 mm (personal observation).

VI. Discussion

There are several difficulties confronted when attempting to interpret data collected on commercial vessels. Initially, the non-random selection of sampling sites prevents extrapolation to the entire mid-Atlantic. This can be overcome (at least for the segment of the population subject to exploitation) by repeated sampling in the areas. However, differences in the deployment and design of the gear between vessels may bias the results and prevent comparisons between trips. A different set of dredges was used on each trip reported here. There undoubtedly were differences in their behavior on the bottom types encountered. Since most of the crew was the same for both trips, data from the two have been combined and compared although with reservation.

Scallop dredges are not 100% efficient for all scallop size groups. Caddy (1968) found an overall efficiency of 2.1% for an eight-foot dredge towed at 2 knots. Small scallops (less than 100 mm shell height) were better able to avoid capture than larger ones due to their greater mobility and perception of the approaching dredge. If the ring bag is not too full of debris, scallops less than three inches (76 mm) in height may also be released through the rings or twine bag. Presumably, a fifteen foot dredge towed at 6 knots would capture a larger percentage of the small scallops, but size selection is also dependent on the dredge behavior on the bottom type. Absence of certain sizes or the relative proportion of sizes within the catch does not necessarily reflect the population structure on the bottom (Caddy, 1968). Scallops between 95-99 mm shell height are available to the gear on the hard sand bottom of the VA-NC area and constituted a large percentage of the catch. Scallops down to 40 mm shell height were captured here as well. The size distribution in the VA-NC catch samples may reflect the greater efficiency of dredges on hard sand bottoms. Age at recruitment, although impossible to determine from these data, may be younger in the VA-NC area than in the NJ-LI areas due to bottom type differences. However, this is purely speculative at this point and requires further study.

Predicted heights at annuli from Serchuk, et al (1979) and MacKenzie (1979) were derived by substituting age at annuli into the reported growth equation (Table 3). This allows direct comparison with the results from the NJ and LI areas. As can be seen, the two growth equations are very similar. This is surprising for two reasons: 1) the

size of the NJ-LI samples was small and collected on only one trip, and 2) the samples on which the equation of Serchuk, et al. (1979) and MacKenzie (1979) was based were collected on many trips several years ago (Serchuk, pers. comm.). This may indicate a consistency in growth rate of sea scallops in the mid-Atlantic over time. From either equation, scallops will reach 70 mm (the minimum size of the market scallops on trip 1) in three years and 100 mm in five years.

With the results of only two sea sampling trips in the mid-Atlantic, the results reported here are preliminary. If drag selection differences on various bottom types are discounted, the height-frequency distributions and age structures of the NJ-LI and VA-NC beds could be a reflection of differences in the recruitment patterns of the northern and southern mid-Atlantic populations. Scallop beds of commercial density appear to be based on fewer year classes in the south than in the north. This may indicate that years of successful recruitment occur less frequently in the south than the north. This is consistent with the fact that the VA-NC beds sampled are near the southern limit of scallop distribution.

Factors affecting recruitment success which have been investigated and discussed include temperature and circulation patterns. Dickie (1955) found a positive correlation between high fall bottom temperatures and recruitment success in the Bay of Fundy. Presumably, when bottom temperatures during the summer and fall are low, the spawning threshold may not be reached resulting in the complete failure of a year-class (Medcof and Bourne, 1964). Low temperatures can also retard larval development prolonging the planktonic phase, increasing larval mortality and the likelihood of transport to sub-optimum areas (Medcof and Bourne, 1964).

The location of a successful set of sea scallop larvae is dependent on surface circulation patterns during the dispersal stage. On the mid-Atlantic shelf, a surface current flows southwesterly from Nova Scotia to Cape Hatteras with semi-persistant gyres existing on Georges Bank and in the Gulf of Maine (Serchuk, et al. 1979). Consequently, settlement of larvae is unlikely to occur in the same area as the spawning aggregation except in those areas with gyres. Larvae settling off the Virginia Capes are assumed to have been spawned by the populations off Delmarva or in the New York Bight (Serchuk, et al. 1979). If fall temperatures in these northern areas were warm and a low temperature differential between the north and south existed (indicating a strong southwesterly current), recruitment could be expected to the Virginia Capes population. However, this is purely speculative at this point and could only be supported by a time series of temperatures, surface current data and age structure of scallop populations on the mid-Atlantic shelf.

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Table 1. Summary of Catch and Effort on Scalloper, VIRGINIA SURF, for Trips 1 (VA-NC) and 2 (NJ and LI).

	# Bags	Hours Fished	Computed # Tows*	Bags/ Tow	Pounds/ Tow	Pounds/ Dredge	Pounds/ Hour
VA-NC	62	58	60	1.03	41.3	20.7	42.8
NJ	36	65	72	0.50	20	10	22.2
LI	114	135	149	0.77	30.8	15.4	33.8
TOTAL (NJ&LI)	150	200	221	0.68	27.1	13.6	30

*At 1.1 tows/hour (Trip 2).

Table 1A. Yields and Average Meat Weights from the VA-NC, NJ, and LI Areas of the Mid-Atlantic.

Location	# Scallops[1] Per Bushel	# Bushels Per Bag	# Individuals Per Bag	Average Meat Wt.[2] (grams)
VA-NC	172.4	6-8	1034-1379	13.2-17.5
NJ	101.7	4-5	407- 508	35.7-44.6
LI (West)	106.5	7-8	746- 852	21.3-24.3
(East)	106.5	5-6	532- 639	28.4-34.1

[1] From Table 2C.

[2] 18.14 Kg (40 pounds) divided by upper and lower estimate of number individuals per bag.

Table 2A. Sea Scallop Height-Frequency by Tow on Trip 1 (VA-NC Region).

		TOW #																			
	mm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20B	Total
DISCARDED	20- 24																					
	25- 29																					
	30- 34																					
	35- 39																					
	40- 44										1											1
	45- 49						1		1													2
	50- 54	1			2		3	5	2		3	1								1	1	19
	55- 59				1		11	14	4	3	1	1		2	1			1	1		1	41
	60- 64						6	5	2				1	1	1			3	1	3	3	26
	65- 69							1														1
	70- 74														1						1	2
	75- 79		1		1					1	3	2	1	2	2	2		1		3		19
	80- 84	1	1	3	9	1	3	3	3	1	10	10	2	3	5	4	7	3	8	9	13	99
	85- 89	8	21	7	15	16	13	14	9	21	46	43	10	28	30	35	27	29	34	36	37	479
	90- 94	23	30	20	37	20	33	24	19	34	50	52	21	27	49	34	29	40	44	47	39	672
	95- 99	29	47	16	37	31	52	21	35	64	51	44	29	33	32	35	28	39	52	29	49	753
	100-104	23	33	15	32	29	40	10	18	40	34	20	12	25	14	12	12	26	11	11	15	432
SHUCKED	105-109	8	7	5	11	7	7	5	1	13	11	13	3	4		6	1	6	1	2	1	112
	110-114	1	4		3	1	3	3	4	5	4	2	1			2	2	1		1		37
	115-119		5		2	1	5	5	1	7	1	5	1	1		1	2					37
	120-124	2	1			1	3	1		5	2	1	1	2	1	3	1	2	2	1	1	30
	125-129	1	1		2	1	2	2		2		1	1	2	4	8	2	1	2	6	5	43
	130-134						3	4	2					3	1	5	4	2	4	3	1	32
	135-139						2	6	3				1	2		4	3	3	8	4	7	43
	140-144						3	4	5					3	2	4	2	4	6	3	1	37
	145-149												1						3		1	5
	150-154						1						1	3		2		1				8
	155-159																				1	1
	TOTAL	97	151	66	152	108	191	127	109	196	217	195	86	141	143	157	120	162	177	159	177	2931
	Sample size (Bushels of Scallops)	½	1	½	1	2/3	1	2/3	2/3	1	1	1	½	2/3	3/4	1	1	1	1	1	1	17
	Depth (Meters)	36	36	40	40	40	50	40	40-46	40-46	50	40-50	40-50	40-50	52	--	--	--	--	--	56	
	Time on Bottom (Min)	30	45	35-40	35-40	35-40	40	35	40	45	40	40	40	45	40	50	40	--	--	--	40	
	Date	7/17	7/17	7/18	7/18	7/18	7/18	7/18	7/18	7/18	7/18	7/18	7/18	7/19	7/19	7/19	7/19	7/19	7/17	7/19	7/19	

Table 2B. Sea Scallop Height-Frequency by Tow on Trip 2 (NJ and LI Regions).

	TOW #																					
mm	1	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
60- 64																					1	
65- 69																	1	2		2		
70- 74		1															1					
75- 79	2	2													1	2					1	
80- 84	1	2					2	1		3	1	1				1	2			3	2	2
85- 89	5	1							1	1				1	1		2		1	1	1	2
90- 94	7	2	2	2	2	2	3	1	2	3			1	2			1	2	3		1	2
95- 99	6		1	3	2	2	8	10	6	12	4	5	2	3	3	2	3	4	10	7	6	15
100-104	4		1	6	4	7	14	16	11	33	9	8	14	9	14	12	10	7	12	17	21	26
105-109	4	4	7	7	16	14	18	24	15	31	20	23	13	9	14	14	20	17	16	23	15	19
110-114	8	4	8	9	24	23	21	28	17	25	24	20	11	21	14	15	17	19	22	16	12	21
115-119	19	12	9	18	20	17	20	13	15	13	5	13	12	23	18	7	18	19	13	8	11	14
120-124	15	21	8	15	18	11	10	8	10	3	7	16	9	13	15	6	15	11	13	10	20	8
125-129	7	14	7	16	10	9	7	4	4	2	1	17	7	15	10	9	9	9	8	13	9	4
130-134	5	9	6	7	4	6	2	2	3		2	7	7	8	6	3	3	7		7	5	6
135-139	10	6	1	3	1	3	1		1			3	2		3		3	1	1	2	5	1
140-144	3	2	1		2	1	1		1			1		1			1			1	1	1
145-149		1			1	1																
TOTAL	96	81	51	86	104	96	107	107	86	126	73	114	78	105	99	71	106	98	99	110	111	121
Sample Size (bu)	1	1	2/3	1	1	1	1	1	3/4	1	3/4	1-1/4	3/4	1	1	2/3	1	1	1	1	1	1
# Clackers per sample	5		0	6	5	3	5	1	3	1	0	4	2	3		3	1	3	2	0	0	0
Total Scallop Catch (Bu)	6	4		7				4	4	6	4	7	5.5	7	5.5	5	8	5		7	7	
Depth (Meters)	60-68	60-68	60-68	66	64	70	70	60	64	64	64		68		60	58	58	60	62	58	56	58
Time on Bottom (Min.)	30	40	35	40	30	30	35	45	40	35	35	30	30	30	30	40	40	40	40	40	40	40
Location	NJ	NJ	NJ	NJ	NJ	NJ	NJ	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI
Date	8/25	8/25	8/25	8/25	8/26	8/26	8/26	8/27	8/27	8/27	8/27	8/28	8/28	8/28	8/28	8/28	8/28	8/29	8/29	8/29	8/29	8/29

Table 2B (Contd.)

mm	TOW # 25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	1-43 Grand Total
60- 64																				1
65- 69																				5
70- 74									2	1	1	1		1			1			9
75- 79	1													8		1		5		23
80- 84	2	2	1	3		2			1	2	1			5	1			11	4	56
85- 89	1	2		4	2	1		2	1		2			5	4	4		35	14	94
90- 94	4	1	6	3	5	3	1		1		1	1	2	4	2	3	3	13	3	94
95- 99	7	2	4	6	7	7	7	6	2	6	1	4	7	4	2	1	3	11	7	208
100-104	15	21	8	10	19	16	10	21	19	31	8	13	12	4	2	6	2	9	22	503
105-109	12	18	22	14	24	31	23	23	22	25	5	33	11	14	5	7	5	23	30	690
110-114	23	21	32	16	22	21	21	19	15	19	6	38	15	30	10	14	13	26	33	773
115-119	13	24	13	18	12	10	15	22	23	18	7	18	20	16	6	19	13	9	12	605
120-124	12	6	15	17	18	13	9	9	7	10	3	5	17	11	15	21	12	5	2	469
125-129	3	8	3	9	4	5	5	5	7	3	4	4	12	7	5	7	9	5	2	298
130-134	3	3	3				1	1	1	1	1		2		2	2	9	1		135
135-139	2	1	1							2			4	1	1	1	2	3		65
140-144			1									1		1						20
145-149																				3
TOTAL	98	109	109	100	113	109	92	108	101	118	40	118	102	111	55	86	72	156	129	4,051
Sample Size (bu)	1	1	1	1	1	1	1	1	1	1	1/3	1	1	1	3/4	1	2/3	1	1	38.6
# Clackers per sample	2	4	0	1	2	2	10*	2	4	2	5	3	4	11*	5*	12*	13*	1	2	132
Total Scallop Catch (Bu)	8	7	6	7	11	8	9	4		5	3.5	5	4.5	4	3	4.5	3	6	4	
Depth (Meters)	66	64	60	64	64	68	60	58	58	54	50	62	74	74	80	78	64	78	78	
Time on Bottom (Min.)	35	35	40	30	30	45	35	40	35	35	35	35	35	25	20	40	35	35	40	
Location	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	NJ	NJ	NJ	NJ	NJ	NJ	
Date	8/30	8/30	8/30	8/30	8/30	8/30	8/31	8/31	8/31	8/31	8/31	9/1	9/1	9/1	9/2	9/2	9/3	9/3	9/3	

Table 2C. Summary of Sea Scallop Height-Frequency Distributions by Region.

mm	VA-NC #	VA-NC %	NJ #	NJ %	LI #	LI %	TOTAL #	TOTAL %
40- 44	1	0.03					1	0.01
45- 49	2	0.07					2	0.03
50- 54	19	0.65					19	0.27
55- 59	41	1.40					41	0.59
60- 64	26	0.89			1	0.04	27	0.39
65- 69	1	0.03			5	0.18	6	0.09
70- 74	2	0.07	3	0.24	6	0.21	11	0.16
75- 79	19	0.65	18	1.46	5	0.18	42	0.60
80- 84	99	3.38	26	2.11	30	1.06	155	2.22
85- 89	479	16.34	68	5.53	26	0.92	573	8.21
90- 94	672	22.93	48	3.90	46	1.63	766	10.97
95- 99	753	25.69	50	4.07	158	5.60	961	13.76
100-104	432	14.74	81	6.59	422	14.96	935	13.39
105-109	112	3.82	154	12.52	536	19.00	802	11.49
110-114	37	1.26	223	18.13	550	19.50	810	11.60
115-119	37	1.26	190	15.45	415	14.71	642	9.20
120-124	30	1.02	164	13.33	305	10.81	499	7.15
125-129	43	1.47	105	8.54	193	6.84	341	4.88
130-134	32	1.09	53	4.31	82	2.91	167	2.39
135-139	43	1.47	33	2.68	32	1.13	108	1.55
140-144	37	1.26	11	0.89	9	0.32	57	0.82
145-149	5	0.17	3	0.24			8	0.11
150-154	8	0.27					8	0.11
155-159	1	0.03					1	0.01
TOTAL	2931	100%	1230	100%	2821	100%	6982	100%
Sample Size (Bu)	17		12.1		26.5		55.6	
Mean	96.39		111.97		111.40		105.20	
Median	95-99		110-114		110-114		100-104	
Mode	95-99		110-114		110-114		95-99	
# Scallops/Bu	172.4		101.7		106.5		125.6	

Table 3. Mean Heights at Annuli For Scallops From NJ and LI Areas.

N	# of Annuli	Year Class	ANNULUS NUMBER[1] 2	3	4	5	6	7	8	9	10
25	3	1976	56.60								
17	4	1975	51.35	74.47							
50	5	1974	53.12	78.08	95.54						
44	6	1973	50.48	73.64	92.29	104.50					
35	7	1972	50.20	72.60	94.43	108.86	116.66				
18	8	1971	53.28	77.22	96.11	109.50	119.28	125.72			
13	9	1970	47.08	68.69	92.08	107.31	117.77	124.54	128.46		
5	10	1969	51.20	74.40	91.20	102.40	112.00	120.60	128.00	133.40	
5	11	1968	58.60	78.60	99.60	111.80	120.40	125.60	130.20	134.80	137.80
Weighted Mean			52.09	74.86	94.26	107.04	117.41	124.71	128.74	134.10	137.80
N			212	187	170	120	76	41	23	10	5
Std. Error of Means			0.6103	0.7454	0.6189	0.7225	0.7649	1.0788	1.2064	1.4642	2.0593
Predicted Heights[2]			55.23	76.42	92.93	105.78	115.79	123.58	129.65	134.37	138.05
Serchuk, et al (1979) MacKenzie (1979)[3]			51.26	77.31	96.61	110.91	121.51	129.36	135.18	139.50	142.69

Notes:

1. To convert to age, add 0.5 years to annulus number.
2. Growth according to the equation: $L_t = 151.00\ (1-e^{-0.2501\ (t-0.6799)})$.
3. Growth according to the equation: $L_t = 151.84\ (1-e^{-0.2997\ (t-1.1256)})$.

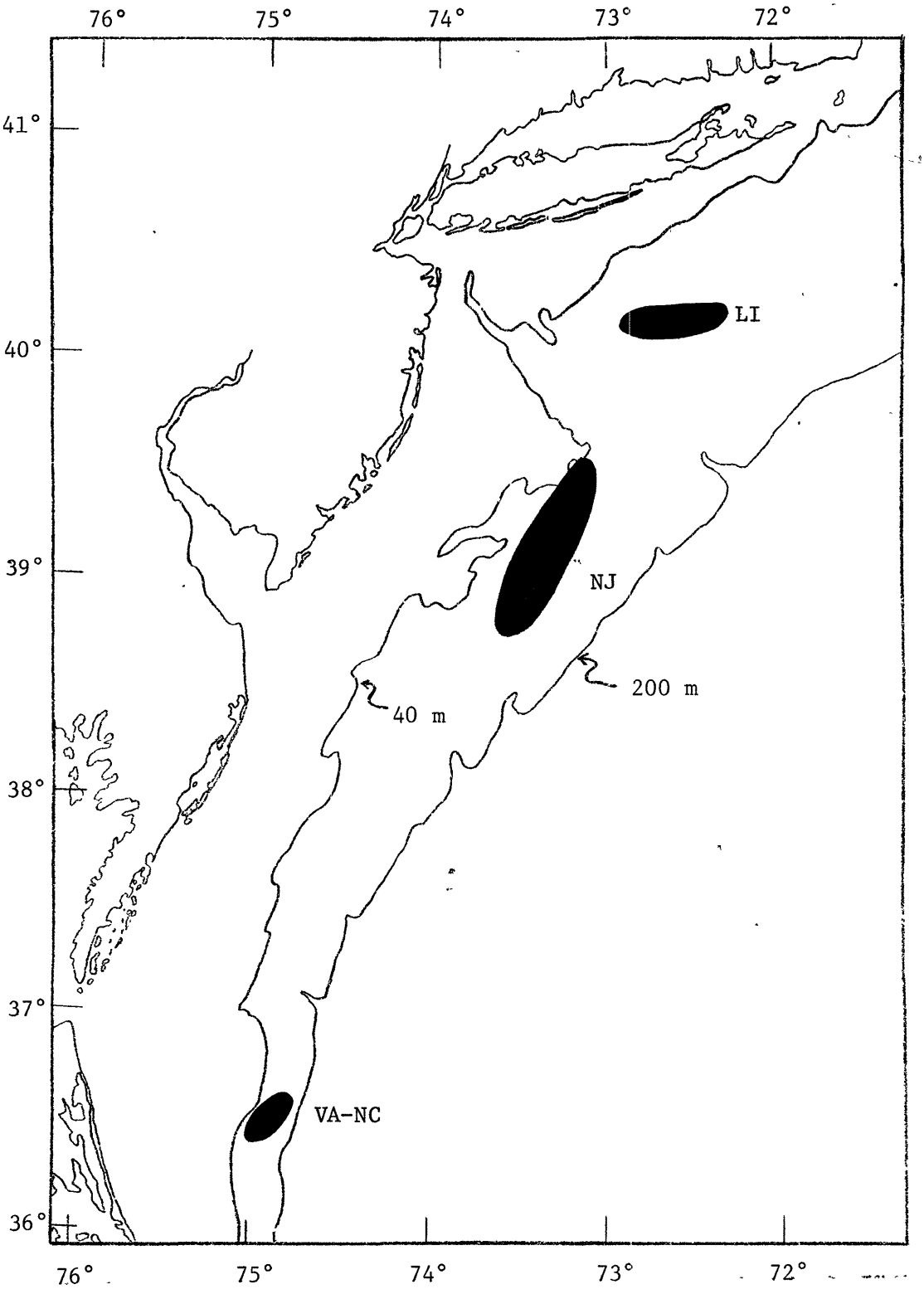

Figure 1. Map of Middle Atlantic Showing Areas Sampled.

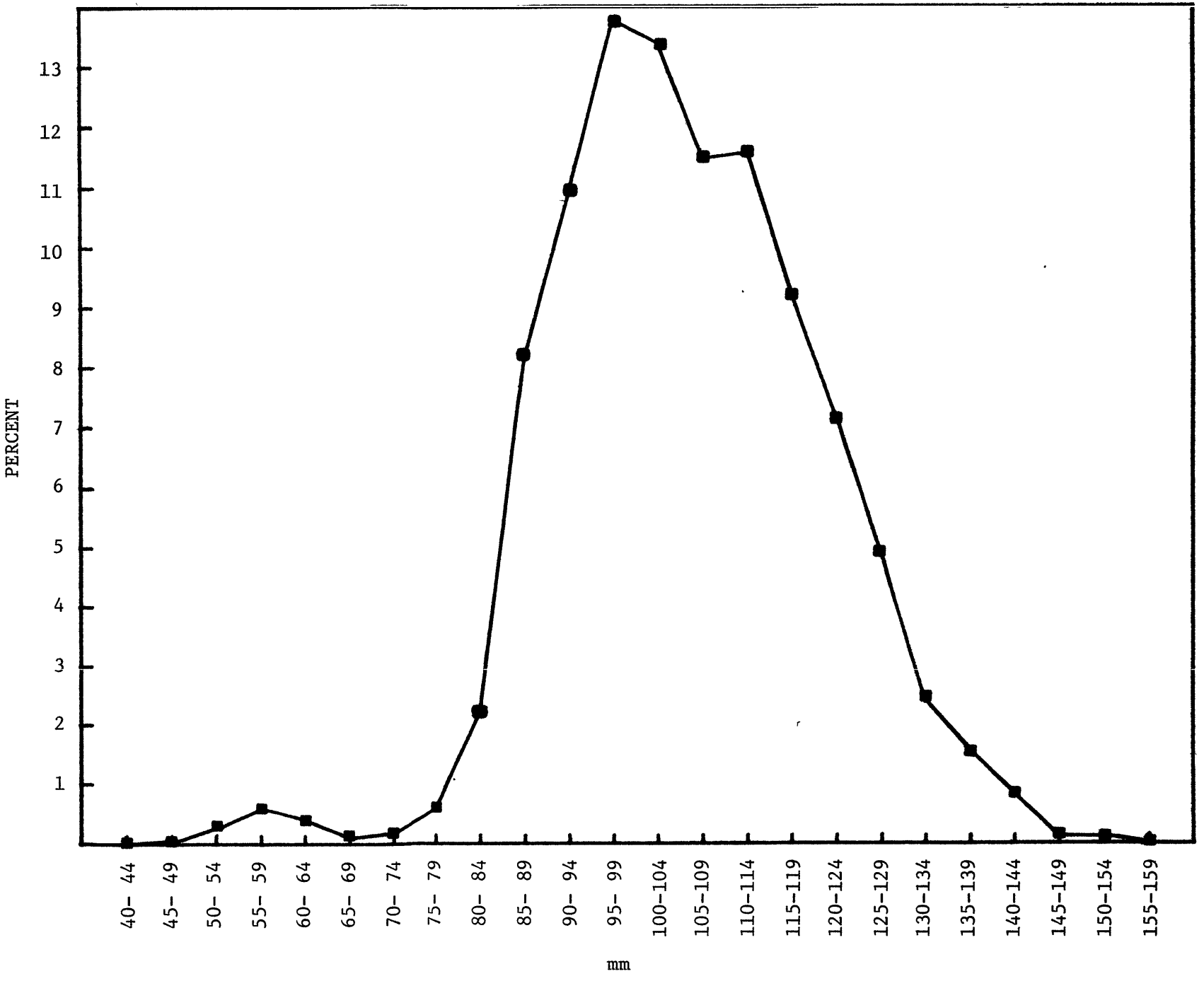

Figure 2A. Sea Scallop Height Frequency Distribution, Long Island to VA-NC Border. (n = 6,982).

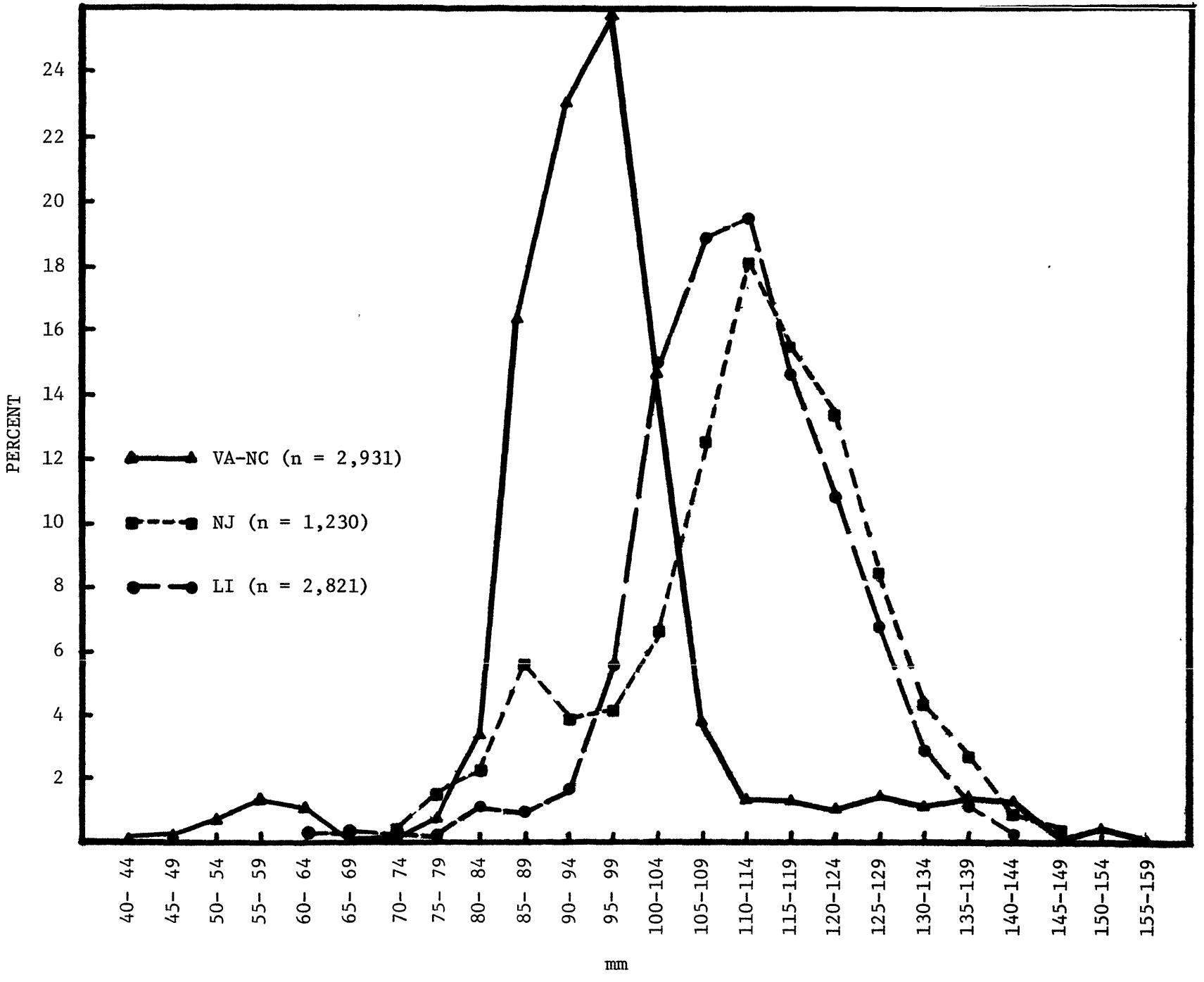

Figure 2B. Sea Scallop Height-Frequency Distribution by Area, Long Island to VA-NC Border.

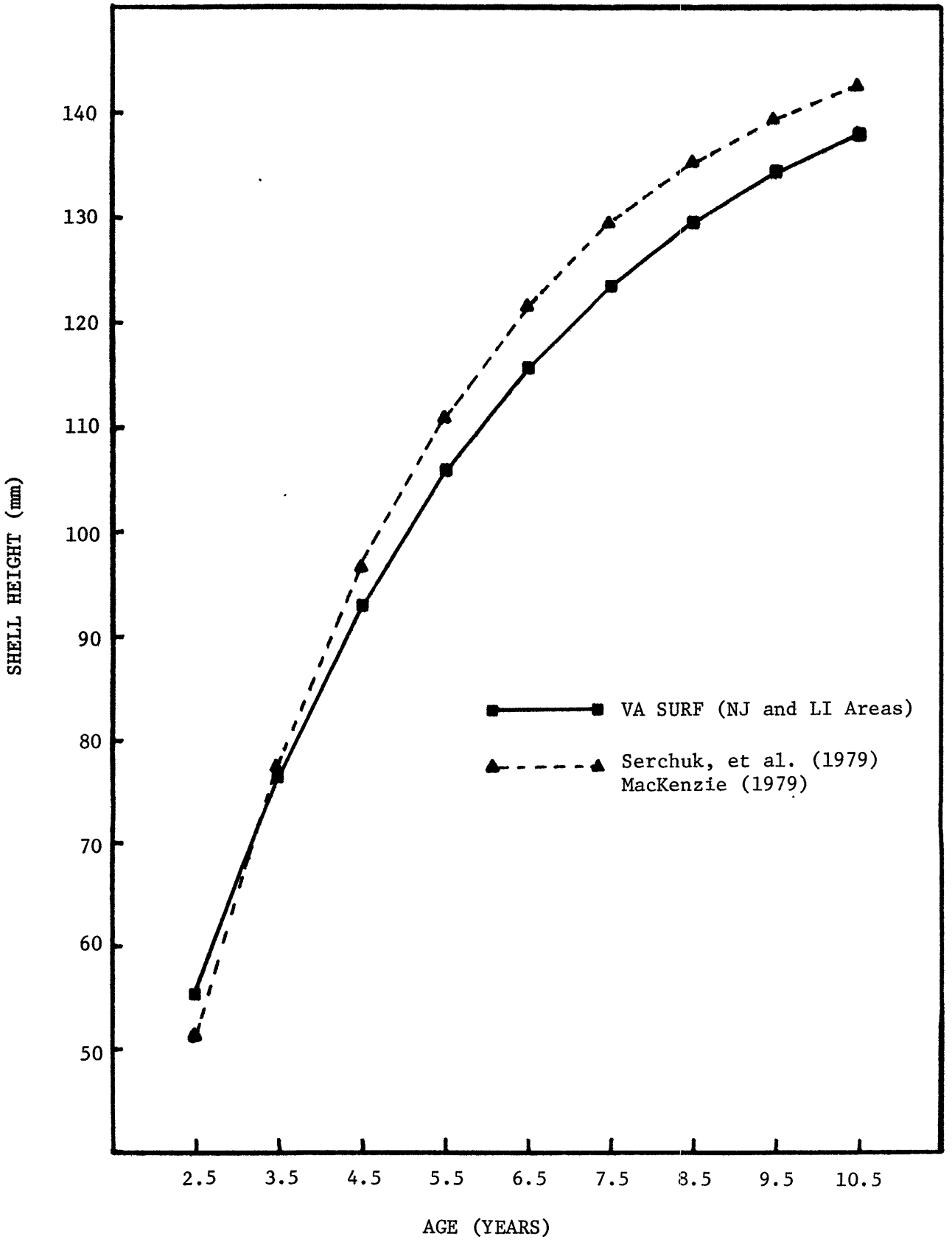

Figure 3. Age vs. Height for Sea Scallops in the NJ and LI Areas.