SOFT-SHELL CLAM, *MYA ARENARIA* STUDY

TECHNICAL REPORT XI-1

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

In New Hampshire, recreational harvesting of soft-shell clams, *Mya arenaria*, focuses on Hampton-Seabrook estuary (Hampton Harbor). To put potential impact of Seabrook Station's cooling water system on this resource in perspective, some understanding of ecological problems currently facing the species is essential. For this purpose, Normandeau Associates, Inc. has investigated the population dynamics of the soft-shell clam in the vicinity of Hampton-Seabrook estuary for the past eleven years. Data collected have contributed to knowledge of: 1) larval spatial and temporal distribution, 2) temporal fluctuations in abundance of spat, juveniles and adults, 3) growth and mortality rates, 4) predation and harvesting pressures and 5) reproductive activity cycles.

The immediately preceding report (NAI, 1979) documented partial recovery of standing stock, to an estimated 7000 bushels by November 1978, after several years of clam scarcity. Further increases in standing stock were projected as the highly successful 1976 and 1977 clam sets attain harvestable size.

Most of the products of spawning in Hampton-Seabrook estuary are probably carried out along the open coast, there to congregate with larvae from nearby estuaries. Such larval aggregations, or swarms, appear influenced by hydrographic conditions (the coastal boundary layer); during swarms, larval densities typically range from (200 to 3000 larvae per m^3 within a mile of shore, and may occur in densities of several hundred larvae per m^3 even two miles offshore.

Over the years, planktonic larval densities have proved to be poorly correlated with spatfall (clam settling) success. The highest larval densities on record preceded the heaviest spat fall by a year, and the poorest year for larval density, 1977, recorded the second heaviest spat fall since 1972.

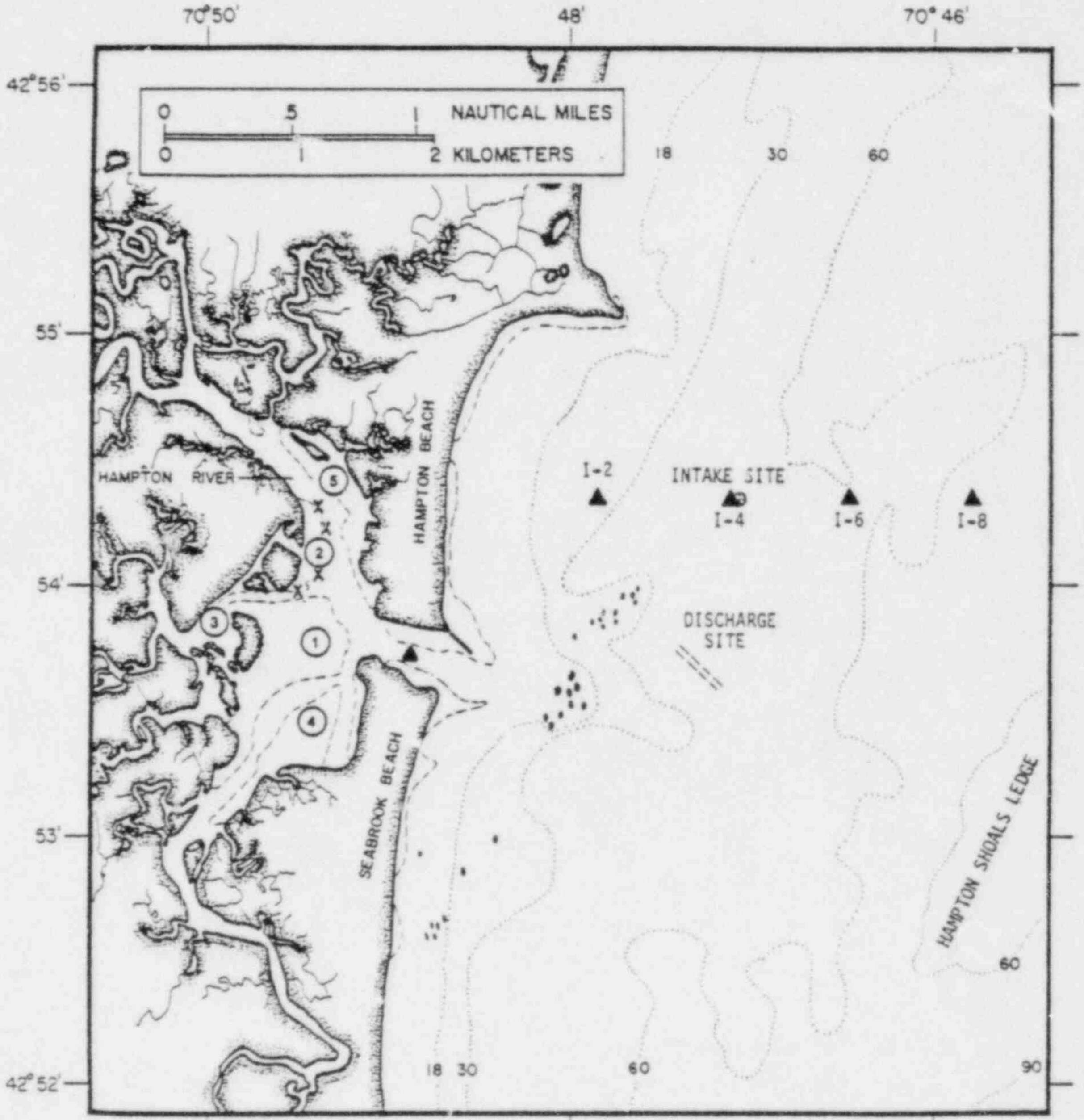
Continuing along previously established investigatory lines, this report contains 1979 results, and interpretations thereof, for: 1) oblique plankton tows off Hampton Beach and in the inlet to Hampton Harbor, monitoring seasonal and offshore-onshore clam larvae distributions, 2) population surveys of young clams, up to 47 mm shell length, on flats in six estuaries, from Ipswich, Massachusetts, to Ogunquit Beach, Maine, 3) surveys of juvenile and adult clams, over 24 mm shell length, in Hampton-Seabrook estuary, 4) histological examination of the gonadal development cycle in Hampton Harbor clams, and 5) a green crab, *Carcinus maenas*, trapping program, monitoring the relative pressure of these major predators on the Hampton Harbor clam population.

2.0 METHODS AND MATERIALS

2.1 LARVAE TOWS

To monitor temporal distribution of *Mya arenaria* larvae in the vicinity of the Seabrook Station cooling water intake (Figure 1), duplicate, two minute, oblique net tows were made approximately twice weekly, from 11 June to 22 O... ... weekly tows were taken from 16 April through 4 June and during the last week of October when larvae were found to be scarce or absent. A 0.5 m diameter No. 20 (73 μm) mesh net, with a 10 lb. depressor attached, was towed at approximately 1/2 knot. The net was lowered to a depth of approximately 13 m (43 feet), in the first minute and returned to the surface after a second minute had elapsed ending the tow. A General Oceanics flow meter was used to record the volume of water passing through the net; in practice, this volume ranged from 4 to 11 m^3 per tow, typically averaging 7 m^3 per tow. Upon recovery, net contents were thoroughly rinsed into a 1/2-gallon glass jar. The live material was transported immediately to the Piscataqua Marine Laboratory, Portsmouth for analysis.

To separate the live bivalve larvae from the bulk of the plankton, the sample was transferred to 1000 ml dispensing burettes and the contents allowed to settle for 5-12 minutes. The relatively high density of the shells allowed the bivalves to rapidly accumulate at the bottom of the burette column, and to be withdrawn for identification and enumeration. The entire sample concentrate containing the bivalves was enumerated for umboned (length 145-320 μm) *Mya arenaria* larvae except when this species was particularly abundant. In this event, the bivalve larvae were concentrated by a swirling motion, into the center of a round, 100 mm diameter, plastic culture dish. The resulting concentration of larvae was carefully divided into visually equal quadrants using a camel's hair probe, viewing the operation through a dissecting microscope at approximately 30x; two diagonally opposed quadrants were then enumerated.



▲ Larvae tow stations

① Clam flats

x Green crab trap stations

Figure 1. Soft-shell clam, *Mya arenaria*, and green crab, *Carcinus maenus* sampling stations. Seabrook *Mya arenaria* Study, 1979.

The same splitting technique was also used to reduce the amount of larvae, representing other bivalve species, to sample fractions containing a total of 200 to 600 individuals. Depending on original (i.e., field) population densities, this required from one to four successive operations consisting of concentrating the larvae into the center of the dish and then separating and extracting a quadrant. In all cases, two sample fractions were enumerated from each sample, each fraction having originated as one of two diagonally opposite quadrants in the initial (whole sample) larvae concentration.

Principal references used as aids in identifying larvae to species were: Sullivan (1948), de Schwenitz and Lutz (1976) and Savage and Goldberg (1976). With few exceptions, only umboned veligers were identified and enumerated. Abundances of *M. arenaria* straight hinge veligers were noted only when their identity was reasonably obvious because of the large numbers involved and the paucity of straight hinge veligers of other species.

On those dates when the *M. arenaria* umbone veliger population density was found to exceed 50 per m^3, a special towing program was carried out to: 1) define the onshore/offshore distribution of *M. arenaria* larvae in the intake vicinity and 2) compare open coastal and Hampton Harbor larval population densities. Oblique tows were made at 1/2-nautical mile intervals along a transect running east to west through the intake site; in Hampton Harbor inlet, oblique tows were made on both high and low slack tides (Figure 1). Sample analysis procedures were made as described above.

Inshore/offshore transect, and Hampton Harbor inlet high/low slack tide, sample data were submitted to a 2-way fixed effect analysis of variance (Sokal and Rohlf, 1969) with two observations per cell. A square root transformation was used to make sample variation more homogeneous. Tukey's procedure for pairwise comparisons (Guenther, 1964) was used to determine the significance of station differences within and across sample dates.

2.2 SPAT SURVEYS

To compare population densities of spat and seed clams, periodic surveys were conducted on Hampton Harbor Flats (Figure 1 and Table 1) and on flats in five adjacent estuaries, in New Hampshire, northern Massachusetts and southern Maine (Figure 2 and Table 1). With the exception of the November survey, the stations were fixed; once established (on the basis of preliminary evidence of high productivity), the same general locality was resampled with each survey. Using a section of PVC plastic pipe, three sediment cores four inches in diameter, and four inches deep, were extracted at each fixed collection site. Sediments from these core samples were washed through a 1 mm mesh screen and the *M. arenaria* spat picked from the screen with forceps. After transfer to small fingerbowls, the spat from each core sample were enumerated and measured to the nearest 1 mm.

Spat samples were also obtained, as described above, during the annual Hampton-Seabrook clam flat survey in November; however, the stations (Table 1) were chosen at random from a larger set of stations designated for sampling adult clam populations. While the fixed station program, with emphasis on high yield locations, gave relative estimates of temporal and geographical distribution, the random sampling program in November provided the best estimate of actual spat density over a particular flat, including portions less favorable for spat settlement.

2.3 ADULT SURVEYS

As in past years, the five largest harbor flats were each surveyed in November for adult clams; additional surveys were conducted on Flat #2 in April and August (Figure 1 and Table 2).

TABLE 1. CLAM SPAT SAMPLING EFFORT. SEABROOK *MYA ARENARIA* STUDY, 1979.

a. FIXED STATIONS

LOCATION	NO. OF STATIONS	DATES
Plum Island Sound, MA		
Middle Ground	5	3 Apr, 17 Jul, 12 Oct
Lufkin's Flat	3	
Nut Shoal	2	
Merrimack River, MA		
Salisbury Flat 3	5	2 Apr, 12 Jul, 13 Oct
Ball's Flat 1	5	
Hampton Harbor, NH		
Flat 2	5	5 Apr, 11 Jul, 9 Oct
Flat 4	5	
Little Harbor Channel, NH		
Clam Pit Island	5	6 Apr, 13 Jul, 8 Oct
Flat, opposite shore	1	
Southern Maine		
York River @ Rt. 103 bridge	5	4 Apr, 18 Jul, 11 Oct
Ogunquit Beach	6	

b. RANDOM STATIONS

LOCATION	NO. OF STATIONS	DATES
Hampton Harbor, NH		
Flat 1	20	1, 8, 21 Nov
Flat 2	9	8 Nov
Flat 3	4	8 Nov
Flat 4	17	9, 21 Nov
Flat 5	8	1, 21 Nov

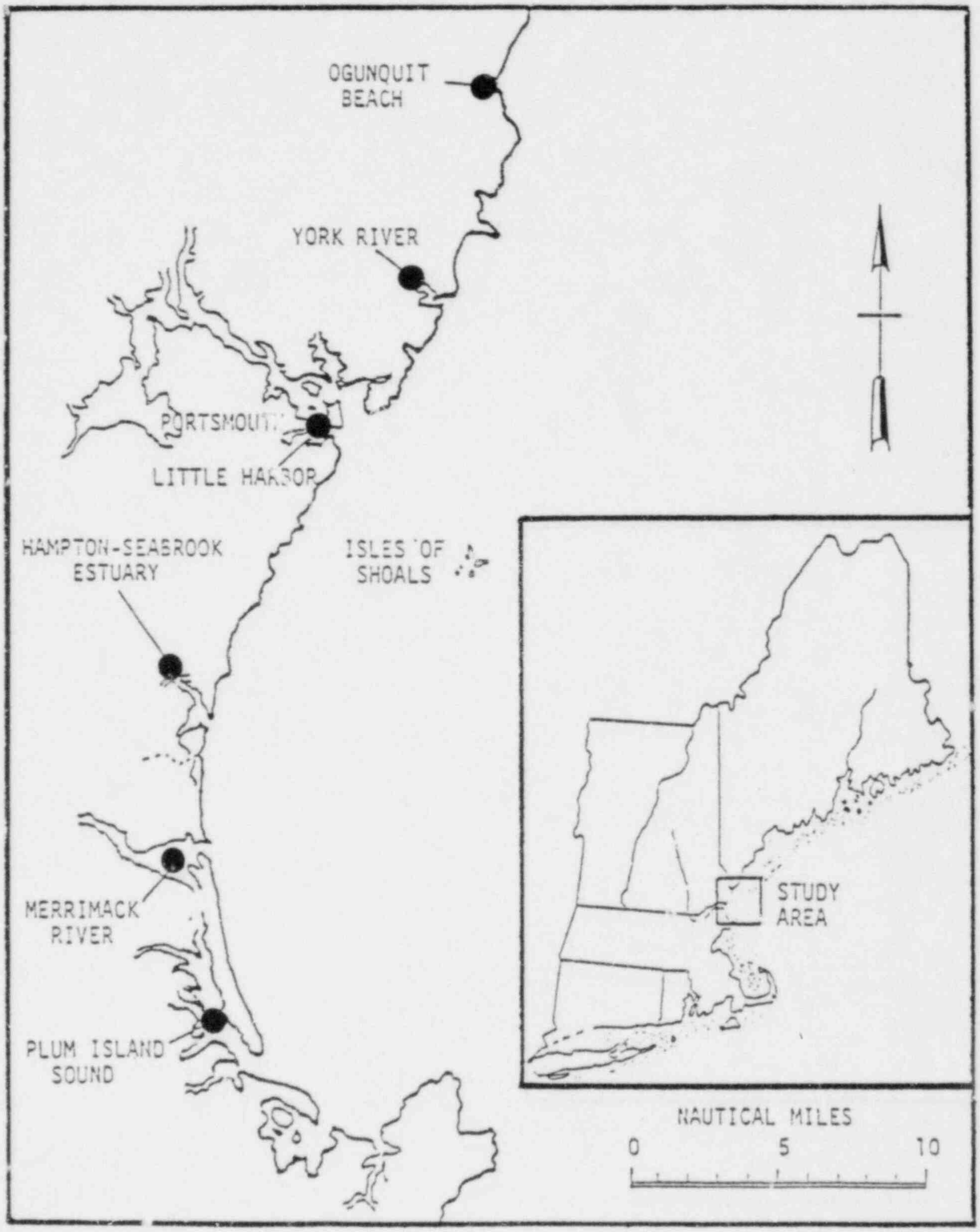


Figure 2. Location of spat study sites. Seabrook *Mya arenaria* Study, 1979.

Aerial photographs, taken on 11 August 1978 at mean low water, were used to construct sampling charts as in previous (1977, 1978) surveys. Acreage measurements were provided by the aerial survey contractor, employing the "stereotemplate laydown" procedure which is standard for the preparation of tax base maps. The maximum error in computed flat acreage has been estimated by the contractor to be approximately 2-3%.

Sampling procedures were employed which minimized unproductive digging in extremely depopulated areas of the flats. Evidence of breathing or siphon holes was used as an indicator of the presence, and conversely the absence, of clams. If, after determining the position of a sampling station, the investigator observed what was thought to be clam siphon holes, a two-square-foot area was dug thoroughly for clams. On the other hand, if no sign of siphon holes was detected within the two square foot sampling area, the investigator in most cases simply noted this fact on a field card and proceeded to the next sampling station. Several stations on each flat which showed no sign of clam holes were randomly selected and dug thoroughly to estimate clam abundance and standing crop for those areas exhibiting no visible evidence of clams. Previous experience (NAI 1977, 1978, 1979) has shown that large, deeply burrowed clams are occasionally present in such areas and can substantially influence overall estimates of standing crop.

To establish the location of sampling stations, rectangular (x,y) coordinates were plotted on charts of each flat and nodes, or intersecting points, chosen at random (using a table of random numbers) until the final quota of stations (Table 2) was attained. In the field, stations were located by compass bearing and distance from a predetermined central reference point. To delineate the sample area, a two-square-foot frame was placed on the substrate, with the left-hand corner of the frame at the investigator's right foot. The substrate surface outlined by the inner edges of the frame was carefully inspected for evidence of siphon holes. If a sample was to be taken because siphon holes were evident, or if a random subsample of a "no-hole" station was required, the sediment outlined by the frame was dug to a depth of about 16 inches.

TABLE 2. ADULT CLAM SAMPLING EFFORT, HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1979.

LOCATION	DATE	SURFACE AREA (ACRES)	TOTAL NO. SAMPLE STATIONS OBSERVED	NO. OF POTENTIALLY BARREN STATIONS (NUMBER SUBSAMPLED IN PARENTHESIS)	NO. OF POTENTIALLY PRODUCTIVE STATIONS DUG
Flat 1	1,8,21 Nov	54.91	72	44 (11)	28
Flat 2	8 Nov	24.96	33	14 (5)	19
	25 Apr		35	18 (6)	17
	23 [illegible]g		56	23 (6)	33
Flat 3	8 Nov	10.54	24	19 (2)	5
Flat 4	9,21 Nov	51.05	51	12 (7)	39
Flat 5	1,21 Nov	23.69	38	18 (4)	20
All flats	1-21 Nov	165.15	218	107 (29)	111

Juvenile and adult soft-shell clams (shell length $\geq$ 25 mm) found during excavation, or in the spoil, were picked out and placed in a plastic bag along with a tag identifying the station and flat number. In the laboratory, clams were tallied and measured for shell length to the nearest 1 mm.

Individual sample counts and shell measurements were converted to biomass estimates (bushels per acre) using a table of clam volumes provided in Belding (1930). The overall biomass estimate for each flat was obtained using the following formula:

$$\bar{X} = \frac{n_1}{n} X_1 + \frac{n_2}{n} X_2'$$

where: n = total number of sampling stations observed

n_1 = number of stations where siphon holes were observed

$n_2 = n-n_1$ = number of stations where no siphon holes were observed

X = average biomass (bushels per acre) estimate for the entire flat

X_1 = average biomass from n_1 samples

X_2' = average biomass from a subset of samples (n_2') representing stations where no siphon holes were observed

To express results in terms of standing crop (bushels of harvestable clams on the entire flat), the biomass estimate was multiplied by flat surface area (acres). Variance and standard error of biomass estimates were calculated approximately using formulae given in Hanson *et al.*, 1953. To obtain a rough approximation of 95 percent confidence intervals, standard errors were multiplied by two, as suggested by Hanson *et al.*, 1953.

2.4 GREEN CRAB (*CARCINUS MAENAS*) TRAPPING

Carcinus maenas were trapped twice a month at four stations around the perimeter of Flat #2 (Figure 1). Two 13 mm mesh, baited traps were set at each station so that they were awash at MLW. After fishing for 24 hours they were pulled in and the catch enumerated, sized and sexed. Total weight of *Carcinus maenas* from each trap was also recorded.

2.5 HISTOLOGICAL STUDY OF GONADAL CONDITION

On the dates shown in Table 3 at least 20 *M. arenaria* with a minimum shell length of 51 mm were collected by clam fork from Hampton Harbor flats. The visceral mass (gonad, liver, gastrointestinal tract, etc.) was taken out and fixed in 10% buffered formalin. Blocks of gonadal tissue were dissected from each specimen and sent to the University of New Hampshire Department of Animal Sciences Veterinary Diagnostic Laboratory where the blocks were: 1) dehydrated in alcohol and infiltrated (Armed Forces Institute of Pathology, 1949), 2) embedded in paraplast, 3) sectioned at 7 μm and 4) stained in hematoxylin and eosin.

TABLE 3. GONADAL SAMPLE COLLECTIONS, 1979.
SEABROOK *MYA ARENARIA* STUDY, 1979.

21 March	5 July
2 April	20 July
18 April	31 July
2 May	15 August
16 May	30 August
29 May	10 September
4 June	25 September
19 June	

Slide preparations were then returned to Normandeau Associates for evaluation of reproductive development. Recognition of the phases

of gonadal condition: indifferent, developing, ripe, spawning and spent, was based on the same characteristics as those used by other investigators (Ropes and Stickney, 1965; Porter, 1974; Brousseau, 1978a). Sections analyzed were from the dorsal, posterior quadrant below the heart, where Coe and Turner (1938) have claimed that maturation begins.

3.0 RESULTS

3.1 PLANKTONIC LARVAE

3.1.1 Spatial Distribution

Three factorial analyses of variance (Appendix 7.1) were run on *M. arenaria* larval density data (Table 4); all indicated significant station variation ($\alpha = .05$). Date of collection was also significant, but station-date interaction was not ($\alpha = .05$). Tukey's procedure for pairwise comparisons (Appendix 7.1) determined that, in general, inshore stations, I_2 and I_4, had significantly greater abundances of larvae than Station I_8 farthest offshore; these procedures also showed that *M. arenaria* larvae were significantly more abundant during high slack tide than at low slack in Hampton Harbor inlet, or at any of the open coastal ("I") stations.

3.1.2 Temporal Distribution

In 1979, a sparse population of *Mya arenaria* umboned veligers was first recorded off Hampton Beach on 21 May; then, three weeks passed until the species reoccurred in plankton samples taken on 11 June (Table 5). With the next three sample collections, *M. arenaria* larval population densities progressively increased, peaking at approximately 480 larvae per m^3 on 2 July (Figure 3 and Table 5). A gradual decline followed the early July peak, with mid-summer population levels generally fluctuating between 2 and 20 larvae per m^3.

The end of August marked the commencement of the late summer larval peak (Figure 3). Larval swarming was particularly intense, from 1000 to 3000 larvae per m^3, during the second week of September (Table 5). After mid October, larvae populations declined below midsummer levels (Figure 3). Evidence from current-meter records (Appendix 7.2) suggest that the most prominent *M. arenaria* swarms follow a period of northerly drifting surface water.

TABLE 4. DENSITY DISTRIBUTION (INDIVIDUALS PER m^3) OF UMBONED *MYA ARENARIA* VELIGERS ALONG THE ONSHORE-OFFSHORE INTAKE (I) TRANSECT, AND AT SELECTED TIDAL STAGES, IN THE INLET TO HAMPTON HARBOR (HH). SEABROOK *MYA ARENARIA* STUDY, 1979.

DATE	STATION I_2 (1/2 NAUT. MILE OFFSHORE)[b]		STATION I_4 (1 NAUT. MILE OFFSHORE)[b]		STATION I_6 (1-1/2 NAUT. MILES OFFSHORE)		STATION I_8 (2 NAUT. MILES OFFSHORE)		HH @ HIGH SLACK		HH @ OTHER TIDAL STAGE	
	TOW #1	TOW #2	TOW #1	TOW #2	TOW #1	TOW #2	TOW #1	TOW #2	TOW #1	TOW #2	TOW #1	TOW #2
											1-1/2 HRS AFTER HIGH SLACK	
2 Jul	362	393	316	194	26	52	10	10	552	361	792	626
											@ LOW SLACK[c]	
7 Sep	268	332	197	202	177	174	130	283	5[a]	14	<1	<1[a]
11 Sep	764	1954	830	1451	346	765	322	543	746	398	72	88
17 Sep	918	437	546	580	398	248	145	249	616	551	52	92
25 Sep	108	64	222	154	132	144	128	78	9	13	4	9

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[a] Sample heavily contaminated with suspended solid matter

[b] In July, larvae significantly more abundant at I_2 and I_4 than at I_6 and I_8; in September, larvae significantly more abundant at I_2 and I_4 than at I_8 (Tukey's test, α=.05).

[c] Significantly less abundant than at any "I" station or during high slack (Tukey's test, α=.05)

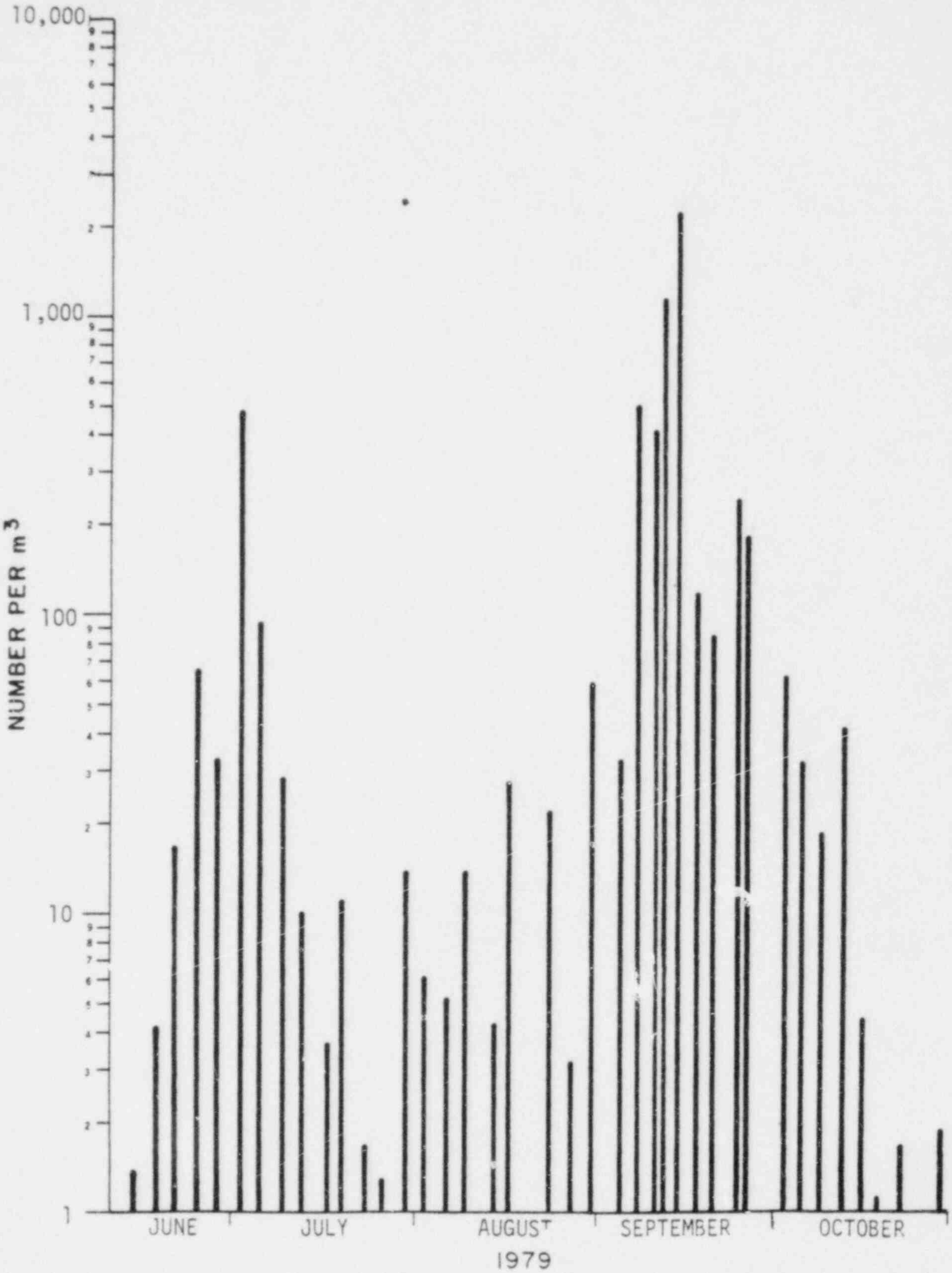

Figure 3. Temporal distribution of umboned *Mya arenaria* veligers at the intake site (I4) off Hampton Beach, New Hampshire. Seabrook *Mya* Study, 1979.

TABLE 5. DENSITIES (PER m^3) OF UMBONED *M. ARENARIA* VELIGERS COLLECTED AT I_4 (INTAKE SITE). SEABROOK *MYA ARENARIA* STUDY, 1979.

DATE	REPLICATE 1	REPLICATE 2	MEAN[a]	REMARKS
16 Apr	0	0	0	
24 Apr	0	0	0	
30 Apr	0	0	0	
7 May	0	0	0	
14 May	0	0	0	
21 May	0	0.6	0.3	
29 May	0	0	0	
4 Jun	0	0	0	
11 Jun	0.4	0	0.2	
14 Jun	0.7	2.0	1.4	
18 Jun	0.6	7.7	4.2	
21 Jun	13	20	17	
25 Jun	100	30	67	
28 Jun	44	23	33	
2 Jul	423	534	481	See also Intensive Survey
5 Jul	85	105	95	
9 Jul	20	39	29	
12 Jul	7.4	14	10	
17 Jul	1.7	5.6	3.7	
19 Jul	15	6.7	11	
23 Jul	2.5	0.6	1.7	
26 Jul	1.2	1.4	1.3	
30 Jul	13	15	14	
2 Aug	5.3	7.1	6.2	
6 Aug	4.0	6.6	5.3	
9 Aug	15	14	14	
14 Aug	3.0	5.5	4.4	
16 Aug	24	33	28	
20 Aug	0.3	1.4	0.8	
23 Aug	24	20	22	Straight hinge larvae swarming
27 Aug	3.0	3.6	3.3	Late straight hinge larvae ≈45per m^3
30 Aug	61	60	61	
4 Sep	51	16	33	Straight hinge larvae ≈122 m^{-3}
7 Sep	368	618	500	See also Intensive Survey
10 Sep	425	446	428	
11 Sep	831	1450	1160	Intensive Survey
14 Sep	2950	1850	2290	
17 Sep	120	124	122	See also Intensive Survey
20 Sep	76	96	86	
24 Sep	235	260	247	
25 Sep	223	154	185	Intensive Survey
27 Sep	4.0	7.0	5.5	

(Continued)

TABLE 5. (CONTINUED)

DATE	REPLICATE 1	REPLICATE 2	MEAN	REMARKS
2 Oct	57	73	64	
5 Oct	27	38	33	
8 Oct	19	*	*	* no second replicate
12 Oct	48	38	43	
15 Oct	4.4	4.5	4.5	
18 Oct	1.6	0.5	1.1	
22 Oct	2.4	1.1	1.7	
29 Oct	2.2	1.5	1.9	

Average density: 21 May to 29 Oct: 136 larvae per m^3

[a]Adjusted for differences in replicate volumes filtered.

3.1.3 Species Composition

Mya arenaria umbone veligers dc⁻inated the bivalve veliger assemblage only on 24 September (Tabl.). In general, mussels were the dominant species, with *Mytilus edulis* predominating in early summer and in the fall, and *Modiolus modiolus* predominating in mid to late summer. *Hiatella* sp. overwhelmingly dominated the bivalve assemblage in spring. Other bivalve mollusc species which exhibited seasonal prominence included: *Mya truncata* (?) (late May), *Anomia* sp. and *Spisula solidissima* (mid September) and *Macoma balthica* (October). Varying quantities of *Ensis directus* and *Placopecten magellanicus* larvae were also recorded (Table 6).

3.2 AREAWIDE SPAT AND JUVENILE CLAM SURVEYS

Compared to previous years, clam sets in 1979 were generally modest in the six estuaries investigated (Appendix 7.3). In the April survey, Hampton Harbor flats contained the largest concentration of small clams. By October, however, Plum Island Sound flats had overtaken the Hampton Harbor flats in terms of settling of small clams (Table 7). Flats in both the Merrimack and Ogunquit Rivers retained modest spat and juvenile clam resources throughout 1979; flats in the York River and Little Harbor Channel, on the other hand, were relatively unsuccessful in sustaining young soft-shell clams (Table 7).

3.3 HAMPTON HARBOR SOFTSHELL CLAM SURVEYS

3.3.1 Survivorship and Growth

A prominent gap in the 1-mm class length-frequency distribution (Figure 4) for 1979, clearly segregates clams less than 8-mm from those over 10-mm. Assuming this gap to represent the separation between young-of-the-year spat and older clams, the average number of clams one year and older is approximately 79 per ft^2. In November 1978 the average

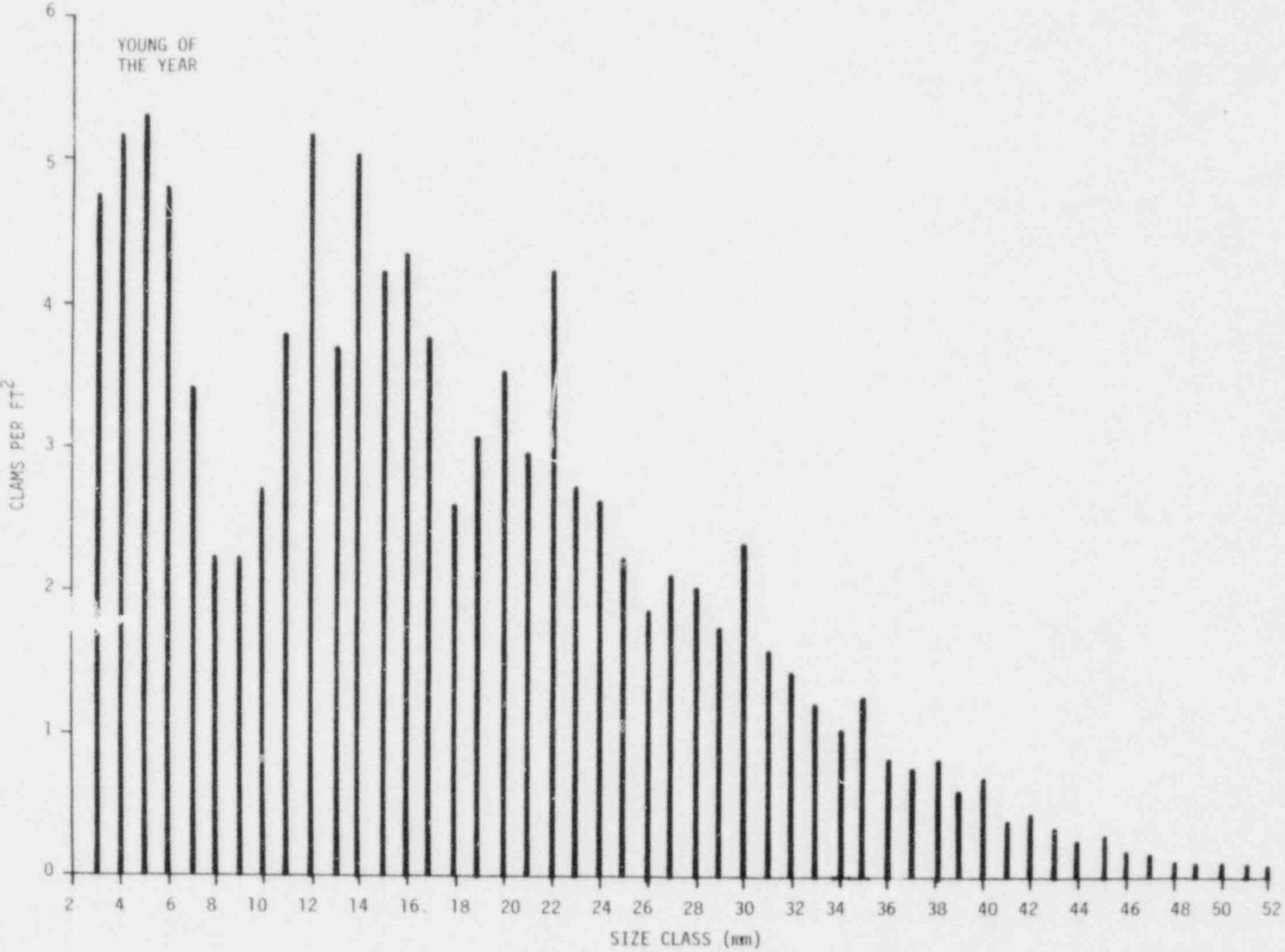

Figure 4. 1 mm class length-frequency distribution of *Mya arenaria* collected in November 1979, Seabrook *Mya arenaria* study, 1979.

TABLE 6. PERCENT COMPOSITION OF BIVALVE UMBONED VELIGERS IN OBLIQUE NET TOWS AT I_4 (INTAKE SITE). SEABROOK *MYA ARENARIA* STUDY, 1979.

	M. MODIOLUS	*M. EDULIS*	*HIATELLA SP.*	*ANOMIA SPP.*	*E. DIRECTUS*	*M. ARENARIA*	*P. MAGELLANICUS*	*M. TRUNCATA (?)*	*M. BALTHICA*	*S. SOLIDISSIMA*	ALL OTHERS	AVERAGE DENSITY ALL BIVALVES (NO. PER M^3)
16 April	0.0	2.8	76.0	21.1	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0	4
24 April	0.0	0.2	97.0	2.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	21
30 April	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42
7 May	0.0	0.1	99.8	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	2,720
14 May	0.0	0.0	96.2	0.0	3.8	0.0	0.0	0.0	0.0	0.0	<0.1	230
21 May	0.1	2.6	93.0	0.0	1.6	<0.1	0.9	0.6	0.0	0.0	1.1	594
28 May	0.0	10.7	58.9	0.0	0.1	0.0	0.1	27.6	0.1	0.0	2.6	671
4 June	0.0	46.7	42.4	0.0	0.8	0.0	<0.1	8.1	<0.1	0.0	1.9	3,000
11 June	1.7	88.4	7.4	0.1	0.1	<0.1	<0.1	1.4	<0.1	0.0	0.8	38,700
18 June	31.9	54.2	11.4	0.3	0.6	<0.1	<0.1	0.1	<0.1	0.0	1.4	89,800
25 June	21.8	62.2	14.6	0.4	<0.1	<0.1	0.0	0.1	0.0	0.0	0.9	523,000
2 July	30.5	54.5	11.1	2.2	0.1	0.2	0.0	0.1	0.0	0.0	1.4	235,000
9 July	18.9	64.3	11.7	2.4	0.9	0.1	<0.1	0.1	0.0	<0.1	1.6	26,600
17 July	74.8	15.5	2.5	4.9	0.1	0.1	0.0	0.1	0.0	0.0	2.2	17,100
23 July	42.1	32.5	5.6	15.6	<0.1	<0.1	<0.1	<0.1	0.0	0.0	3.3	45,700
30 July	45.1	28.1	11.7	11.1	0.2	<0.1	0.1	<0.1	0.1	0.6	2.8	19,400
6 August	32.2	40.8	1.7	16.0	1.0	<0.1	<0.1	<0.1	0.9	0.9	6.4	10,200
14 August	60.7	23.5	6.8	5.3	<0.1	<0.1	0.9	<0.1	0.6	0.3	1.8	20,100
20 August	71.7	10.0	3.1	12.5	0.0	<0.1	0.3	<0.1	1.2	0.2	0.9	1,760
27 August	30.9	34.8	13.8	12.8	0.1	0.3	0.4	<0.1	4.4	0.1	3.3	1,020
4 September	53.0	11.4	1.8	10.2	3.9	2.2	<0.1	0.0	2.6	13.5	1.3	1,520
10 September	6.7	12.0	1.8	26.7	9.9	16.5	<0.1	<0.1	6.7	16.7	2.9	2,600
17 September	5.1	27.9	2.1	37.1	6.4	3.5	<0.1	<0.1	2.2	14.8	0.8	3,470
24 September	2.6	14.4	0.3	2.8	11.0	36.8	0.2	0.0	2.7	27.0	2.1	672
2 October	10.4	13.3	3.5	11.4	6.5	7.5	0.1	0.0	31.8	13.1	2.4	860
8 October	30.9	34.3	2.5	19.0	2.3	5.0	<0.1	0.0	2.4	2.3	1.2	380
15 October	3.0	28.4	1.0	6.1	7.5	0.3	2.3	<0.1	38.4	11.0	1.9	1,310
22 October	2.6	26.8	4.2	11.7	5.4	0.1	2.3	<0.1	37.3	6.1	3.4	1,520
29 October	1.0	50.1	2.0	6.9	5.2	<0.1	1.1	0.0	25.7	5.4	2.5	4,450

TABLE 7. YOUNG-OF-THE-YEAR (1-12 mm) AND JUVENILE (13 TO 43 mm) SOFT-SHELL CLAM DENSITIES (PER FT^2) IN POTENTIALLY PRODUCTIVE AREAS OF SIX NORTHERN NEW ENGLAND ESTUARIES. SEABROOK *MYA ARENARIA* STUDY, 1979.

ESTUARY	APRIL YOUNG-OF-THE YEAR	APRIL JUVENILES	JULY YOUNG-OF-THE-YEAR	JULY JUVENILES	OCTOBER YOUNG-OF THE-YEAR	OCTOBER JUVENILES
Plum Island Sound (Ipswich, MA)	96	84	79	75	152	72
Merrimack River (Newburyport & Salisbury, MA)	16	23	11	33	27	34
Hampton Harbor (Hampton & Seabrook, NH)	220	198	139	154	148	107
Little Harbor Channel (Portsmouth, NH)	13	1.3	26	1.3	14	0.0
York River (York, ME)	31	5.[illegible]	33	2.2	18	0.0
Ogunquit River (Ogunquit Beach, ME)	26	13	27	29	33	10

density for clams of all ages was 213 per ft^2 indicating an apparent survivorship of 37%. Actual survivorship is almost certainly somewhat lower as spat settling late in the fall of 1978 would have been less than 1 mm wide (the screen mesh size), and, therefore, would not have been counted.

The median shell size of clams one year and older was 20 mm, compared to 15 mm in 1978. In 1978, fewer than 0.2 clams per ft^2 had a shell size greater than 42 mm (a category designated as "harvestable"; see Section 3.3.3). By 1979, however, an average of 1.8 clams per ft^2 had attained a length of at least 43 mm, representing an order of magnitude increase in number of harvestable clams. Because of the variety of physical and biological variables at work, individual clam growth is difficult to infer from size-frequency distribution comparisons and impossible to verify. The leading edge of the length-frequency slope, however, appears to have moved ("grown out") approximately 16 mm from an inflection point in the vicinity of 39-40 mm in 1978 to a comparable slope break in the vicinity of 55-56 mm in 1979 (Appendix Tables 7.3 and 7.4).

3.3.2 Population Density Trends by Shell Size Category

Size categories delineated in Table 8 are retained for continuity with earlier surveys. The 50 mm limit refers to the former minimum legally harvestable size (51 mm = 2 inches) abolished in 1976. The 25 mm limit may have been a convenient partitioning of previously sublegal shell sizes, but also relates to the size at which clams generally establish their first permanent burrows (Dow and Wallace, 1957).

On three of the five Hampton Harbor flats surveyed, population densities of young clams, 26 to 50 mm, increased for the second year in a row; population gains on Flats 1 and 4 broke all previous survey records (Table 8). Clams over 50 mm exhibited modest increases in density on all flats except Flat 5; while, a decline in clams less than 26 mm, continued in 1979 on all flats except Flat 2 (Table 8). Similar

TABLE 8. SUMMARY OF *MYA ARENARIA* POPULATION DENSITIES, ANNUAL NOVEMBER SURVEY. SEABROOK *MYA ARENARIA* STUDY, 1979.

LOCATION	YEAR	NUMBER OF SAMPLES COLLECTED		POPULATION DENSITY (#/SQ. FT.)		
		ADULTS	SPAT	SPAT (>1 TO 25 mm)	JUVENILES (26 TO 50 mm)	ADULTS (>50 mm)
Flat 1	1971	18	18	48	6.8	2.1
	1972	18	18	110	8.1	3.3
	1973	36	18	44	2.5	1.3
	1974	40	18	2.6	2.8	3.0
	1975	35	18	56	0.4	1.2
	1976	63	18	1084	0.12	0.53
	1977	66	14	819	0.04	0.15
	1978	66	14	372	0.62	0.15
	1979	*72*	*20*	*72*	*31.0*	*0.24*
Flat 2	1971	9	9	91	4.8	[illegible].8
	1972	9	9	152	2.2	[illegible].4
	1973	9	9	136	3.8	1.1
	1974	21	9	0.0	2.1	1.9
	1975	21	9	9.1	0.0	0.5
	1976	24	9	351	0.0	0.21
	1977	33	7	86	0.0	0.08
	1978	33	7	15	2.1	0.16
	1979	*33*	*9*	*57*	*3.6*	*0.29*
Flat 3	1971	6	6	74	4.7	4.6
	1972	6	6	39	1.6	0.4
	1973	12	6	8	3.6	2.2
	1974	12	6	0.6	0.7	1.7
	1975	12	6	1.1	0.0	0.6
	1976	24	5	560	0.07	0.23
	1977	24	6	75	0.12	0.04
	1978	24	6	50	1.2	0.14
	1979	*14*	*4*	*10*	*1.0*	*0.15*
Flat 4	1971	12	12	106	17.6	2.8
	1972	12	12	138	10.6	2.3
	1973	24	12	18	3.8	0.6
	1974	29	12	1.1	2.8	1.8
	1975	29	12	68	0.3	0.7
	1976	81	18	843	0.04	0.16
	1977	51	11	436	0.09	0.01
	1978	51	11	309	12.4	0.05
	1979	*67*	*17*	*175*	*39.0*	*0.52*

(Continued)

TABLE 8. (Continued)

LOCATION	YEAR	NUMBER OF SAMPLES COLLECTED		POPULATION DENSITY (#/SQ. FT.)		
		ADULTS	SPAT	SPAT (>1 TO 25 mm)	JUVENILES (26 TO 50 mm)	ADULTS (>50 mm)
Flat 5	1971	9	9	176	1.3	1.6
	1972	9	9	196	3.8	2.3
	1973	21	11	23	1.0	0.4
	1974	17	11	2.4	0.0	0.1
	1975	9	11	7.5	0.0	0.01
	1976	24	12	549	0.0	0.14
	1977	38	9	114	0.08	0.03
	1978	38	7	56	4.1	0.07
	1979	*32*	*8*	*14*	*1.8*	*0.03*
All Flats	1971	54	54	92	7.7	2.7
	1972	54	54	130	6.2	2.2
	1973	111	56	47	2.8	1.0
	1974	119	56	2.1	2.1	2.0
	1975	106	56	37	0.2	0.8
	1976	216	62	762	0.06	0.2
	1977	212	47	388	0.05	0.07
	1978	212	45	208	4.4	0.09
	1979	*218*	*58*	*86*	*24.0*	*0.3*

population trends were evident from 5 mm size class comparisons of present and past survey data (Appendix 7.6).

3.3.3 Biomass and Standing Crop

Substantial growth in the population of mid-sized clams, between November 1978 and November 1979 (Figure 5), produced comparable increases in estimates of biomass and standing crop (Figure 6 and Table 9). In NAI (1979), the term "marketable" (here replaced by the term "harvestable") was chosen to distinguish clams larger than 42 mm from smaller clams. In November 1978 only 940 bushels (5.7 bushels per acre) was estimated to be "harvestable"; by November 1979, harvestable biomass had increased by a factor of six (Figure 6). Similarly, biomass of soft-shell clams of all sizes had quadrupled over the 12-month period.

Virtually all of the substantial 1979 gains in biomass and standing crop occurred on Flats 1 and 4 (Tables 9 and 10). Only these two flats held small aggregations of clams exceeding the equivalent of 250 bushels per acre (Table 10). Such high yields (equivalent to more than ten 2-inch clams per ft^2) are typical of commercially valuable clamming areas in Maine and Massachusetts (based on examination of Maine Department of Marine Resources and Massachusetts Division of Marine Fisheries shellfish survey records). Sample yields equivalent to 40 bushels per acre (the equivalent of slightly less than two 2-inch clams per ft^2) may be regarded as the threshold between a marginal fishery and one with healthy potential for recreational digging. According to this criterion, approximately 24% of the clam flat area in Hampton-Seabrook estuary could readily support recreational digging as of November 1979. An additional 38% of the flat area possessed marginal capacity to sustain recreational digging (cf. Tables 10 and 11). Only 38% of the total flat area in Hampton Harbor was devoid of clams larger than 24 mm, an improvement over the years 1975 through 1978 (Table 11).

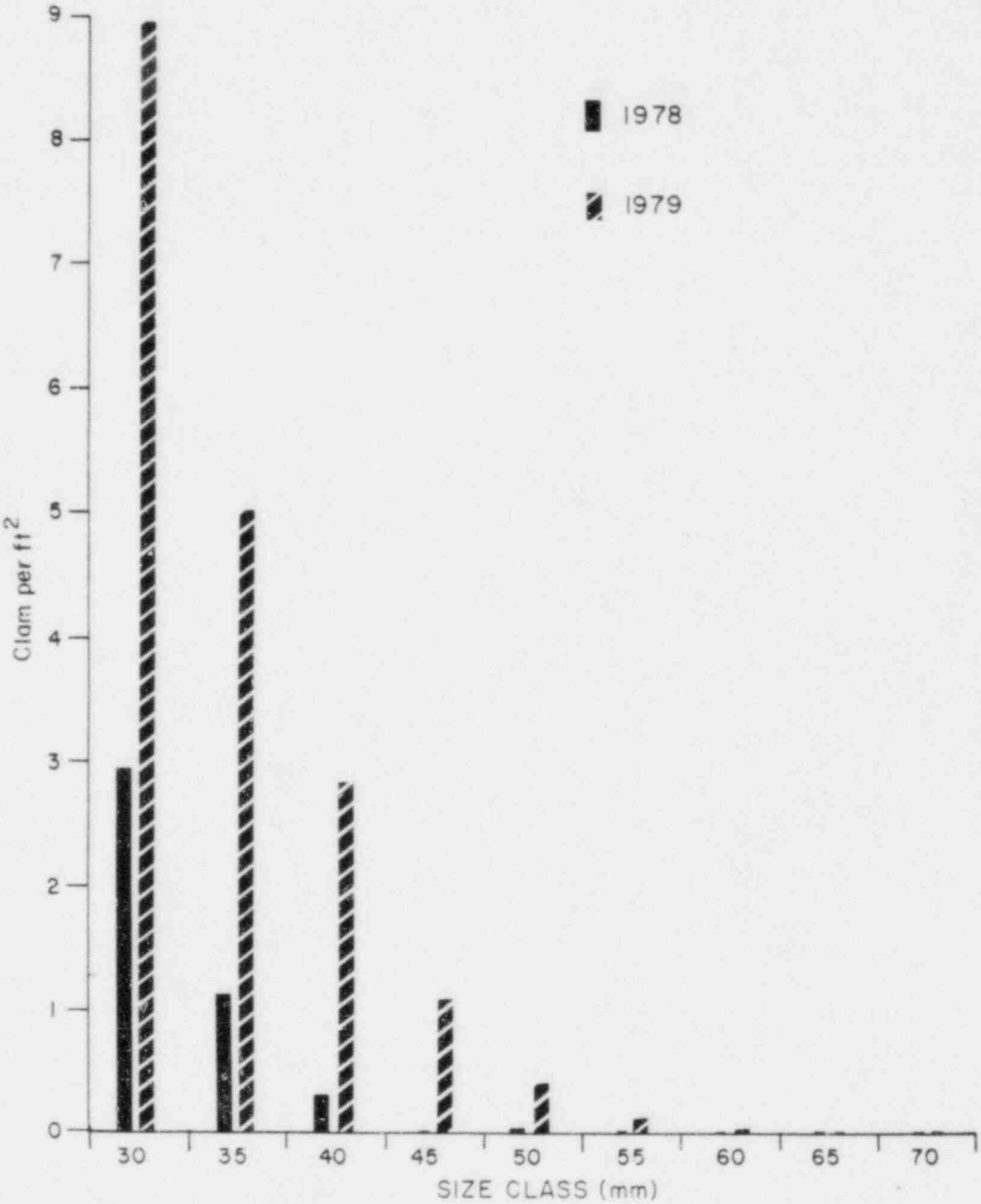

Figure 5. 5 mm class length-frequency distribution of *Mya arenaria* juveniles and adults in Hampton Harbor comparing November 1978 and 1979 surveys. Seabrook *Mya arenaria* Study, 1979.

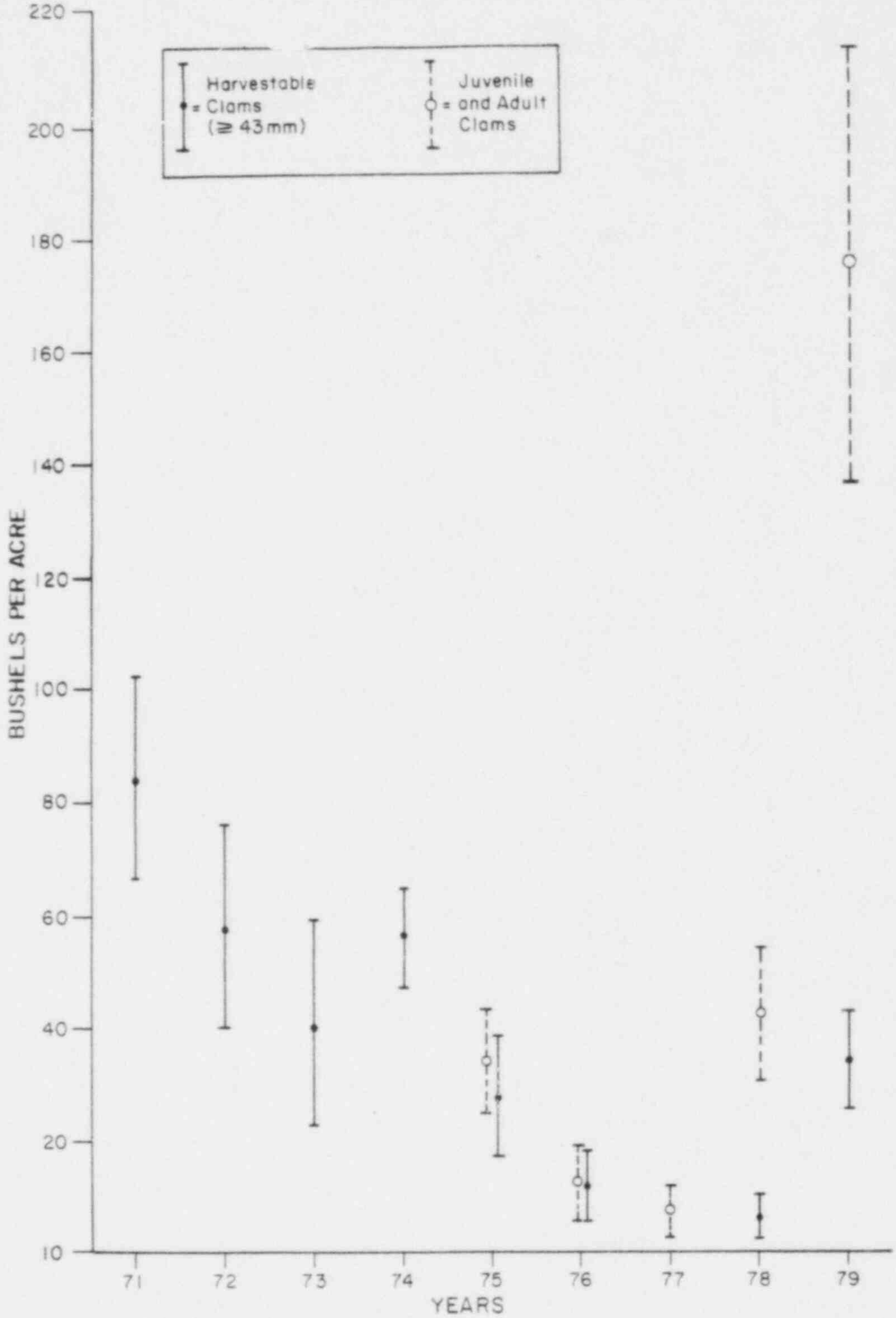

Figure 6. Estimates of *M. arenaria* biomass, 1971 through 1979, on five tidal flats in Hampton Harbor, with approximate 95% confidence intervals. Seabrook *Mya arenaria* Study, 1979.

TABLE 9. RESULTS OF SOFT-SHELL CLAM STANDING STOCK ESTIMATES, HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1979.

LOCATION	DATE	SURFACE AREA (ACRES)	TOTAL NUMBER OF SAMPLING UNITS (n)	NUMBER UNITS WITH BURROWS (n_1)	NUMBER BURROWLESS UNITS SUBSAMPLED (n_2')	MEAN BIOMASS (BUSHELS PER ACRE) BURROWS $(\bar{x}_1)$	NO BURROWS $(\bar{x}_2)$	COMBINED ESTIMATE $\bar{x}$ STD DEV.	STANDING CROP (BUSHELS) $\bar{x}$ STD DEV
Flat 1	1,8,21 Nov	54.91	72	28	11	462.9	92.7	236.6±40.9	13,000±2240
Flat 2	8 Nov	24.96	33	19	5	54.8	9.5	35.6± 8.9	888± 222
	25 Apr		35	17	6	23.0	19.6	22.2± 6.6	530± 164
	23 Aug		56	33	6	177.4	0.0	104.6±31.0	2,610± 774
Flat 3	8 Nov	10.54	14	5	2	48.9	0.0	17.5± 7.0	184± 74
Flat 4	9&21 Nov	51.05	67	39	7	496.3	8.3	292.4±29.6	14,900±1510
Flat 5	1&21 Nov	23.69	32	20	4	25.6	1.2	16.4± 9.7	390± 230
All Flats	1-21 Nov	165.15	218	111	29	307.3	40.3	175.7±19.2	29,000±3180
			Harvestable clams		(≥43 mm)	58.4	8.9	34.3± 4.4	5,670± 736

TABLE 10. ESTIMATES OF "HARVESTABLE"[1] STANDING CROP. SEABROOK *MYA ARENARIA* STUDY, 1979.

FLAT	TOTAL ESTIMATED HARVESTABLE CROP (BUSHELS) NOV 1978	NOV 1979	% OF SAMPLES YIELDING HARVESTABLE CLAMS, NOV 1979	% OF SAMPLES YIELDING EQUIVALENT OF > 40 BUSHELS PER AČRE, NOV 1979	% OF SAMPLES YIELDING EQUIVALENT OF >250 BUSHELS PER AČRE, NOV 1979
1	383	1890	44	21	1.4
2	185	350	44	18	0.0
3	113	126	29	14	0.0
4	126	3160	52	40	3.0
5	74	143	22	6	0.0
All	940	5670	43	24	1.4

1 Defined as clams with shells ≥ 43 mm long

TABLE 11. ESTIMATES OF CLAM FLAT PRODUCTIVE AREA[1] (%) IN HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1979.

	YEAR OF SURVEY					
LOCATION	1979	1978	1977	1976	1975	1974
Flat 1	72	60	17	35	53	80
Flat 2	62	36	15	17	44	63
Flat 3	29	42	32	48	39	67
Flat 4	76	62	20	19	57	88
Flat 5	22	43	22	27	4	20
All Flats	62	52	19	26	45	66

[1] Includes all clams $\geq$ 25 mm

The rapidity with which harvesting pressure can alter conditions, however, is illustrated in Figure 7. Flat 2 is a relatively small flat (25 acres) essentially accessible only by boat, but close to docking facilities in the town of Hampton. In recent years this flat has apparently received a disproportionate share of clam digger attention.

3.4 GREEN CRAB, *CARCINUS MAENAS*, TRAP CATCHES

For comparison, data from surveys in 1977 and 1978 have been presented in Table 12 along with 1979 catch data; also, size frequency distribution data from both the 1978 and 1979 catch data are presented in Figure 8.

After having generally declined to a range of 6 to 9 crabs per trap per day (excluding the mid winter lull), green crab catch per unit effort returned abruptly, to summer 1977 levels, in October through December 1979. The cause of this high value was a record catch of 468 crabs (58.5 crabs per trap) on 10 October 1979 (Appendix 7.5). Sex ratios, on the other hand, have remained about the same since July through September 1978, with slightly more females in the catch than males (Table 12). Few gravid females were caught in 1979, but, as in 1978, the main period of fecundity was April through June.

The smallest crab taken in 1979 was 2.9 cm at the widest part of the carapace; the largest was 7.5 cm wide. Approximately 98.5% of the crabs caught had carapaces between 3.0 and 7.0 cm at the widest point. Crabs which were 6.5 cm in carapace width tended to be males (Appendix 7.7).

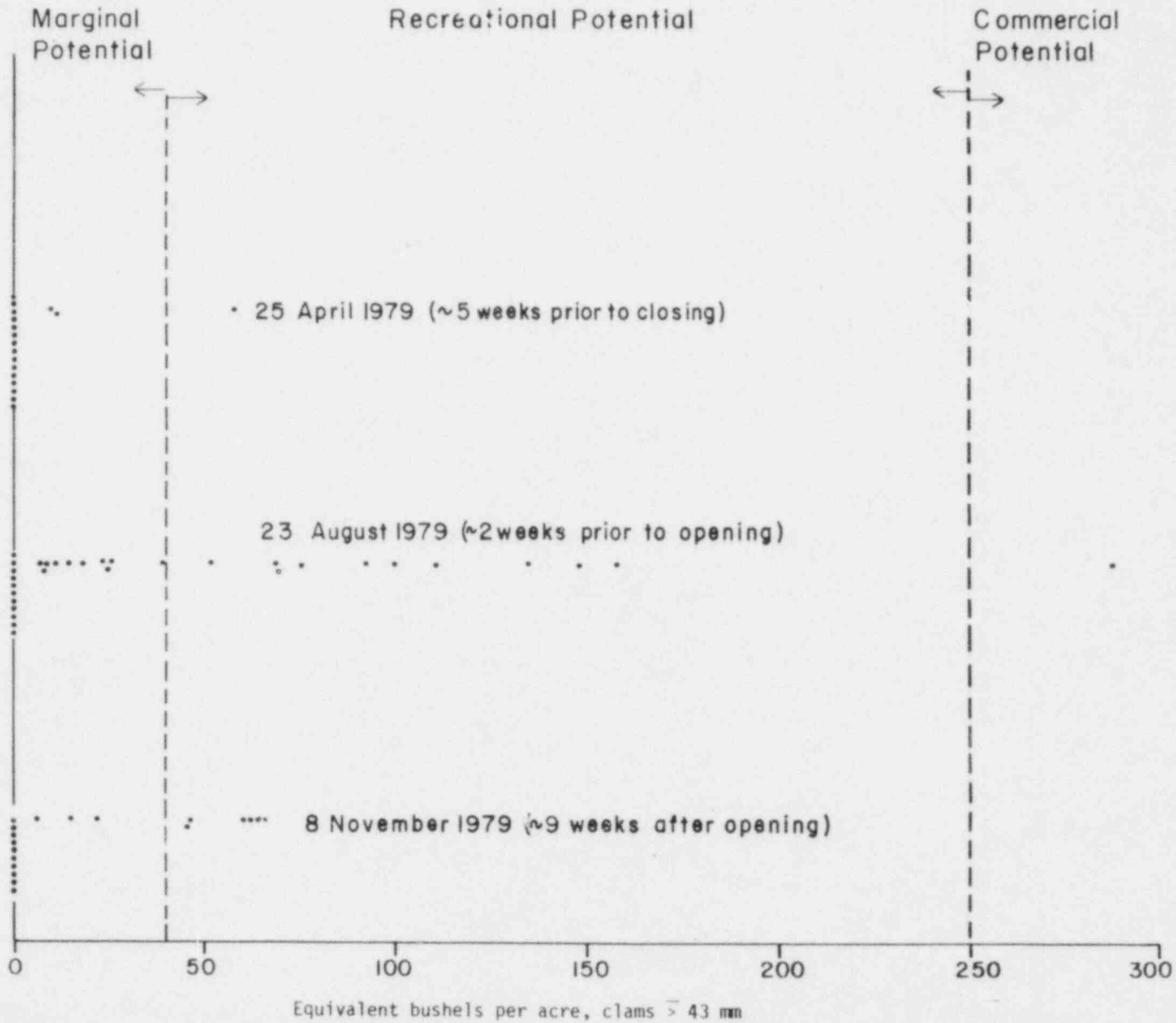

Figure 7. Scattergram of Flat 2 survey results illustrating harvesting impact on harvestable biomass (each dot represents a sample plot dug). Hampton Harbor flats were closed to clam digging from the first week in June to the first week in September 1979. Seabrook *Mya arenaria* Study, 1979.

TABLE 12. SELECTED *C. MAENAS* CATCH STATISTICS 1977-1979. SEABROOK *MYA ARENARIA* STUDY, 1979.

SAMPLE PERIOD	CATCH PER UNIT EFFORT[a]	SEX RATIO (M:F)	FECUNDITY (% GRAVID FEMALES)
Summer 1977[b]			
July	24.6	1:4.9	6.2
August	10.3	1:3.5	9.4
September	21.6	1:2.2	0.9
Oct-Dec 1977[c]	17.5	1:0.9	0.3
Jan-Mar 1978	0.1	Females only	0.0
Apr-Jun 1978	7.5	1:3.3	7.0
Jul-Sep 1978	8.6	1:1.5	3.2
Oct-Dec 1978	7.2	1:1.3	0.5
Jan-Mar 1979	2.7	1:1.7	0.0
Apr-Jun 1979	6.4	1:1.0	6.0
Jul-Sep 1979	6.0	1:1.5	0.6
Oct-Dec 1979	22.1	1:1.5	0.0

[a] Number of *C. maenas* per trap per day

[b] Two "prism" traps, fishing for 2 to 5 days at a time

[c] From Oct 1977 to Dec 1979, eight "box" traps, fishing for 24 hours twice per month.

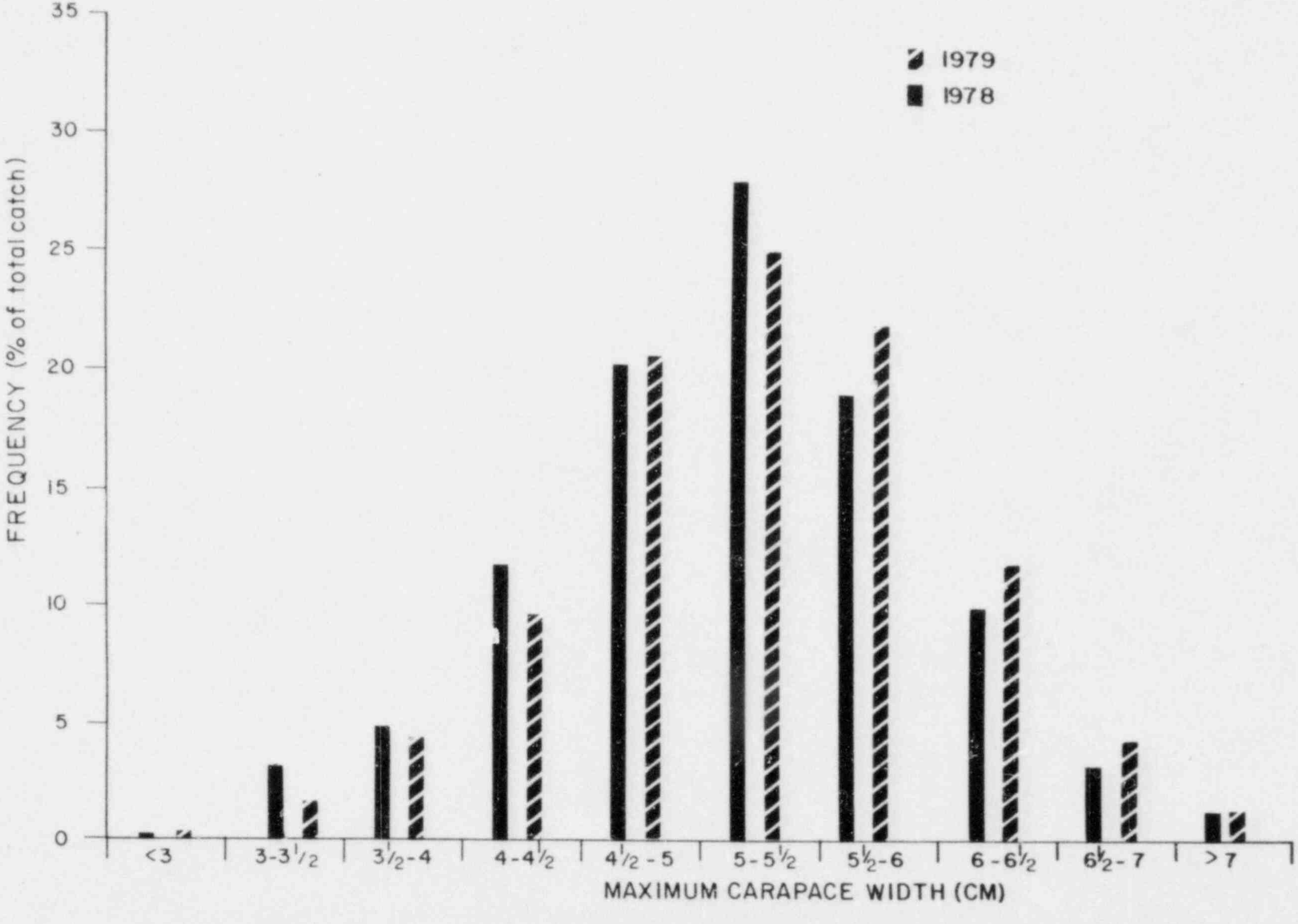

Figure 8. Size-frequency distribution of *Carcinus maenas* catch at Flat 2, Hampton Harbor. Seabrook *Mya arenaria* Study, 1979.

TABLE 13. COMPARISON OF *M. ARENARIA* UMBONED LARVAL ABUNDANCE OFF HAMPTON BEACH WITH YOUNG-OF-THE-YEAR SPAT DENSITIES IN HAMPTON HARBOR. SEABROOK *MYA ARENARIA* STUDY, 1979.

YEAR	PERIOD OVER WHICH LARVAE WERE COLLECTED	LARVAL DENSITY MEAN (per m^3/day)	LARVAL DENSITY DAILY MEAN x SEASON LENGTH (per m^3)	DENSITY OF YOUNG-OF-THE-YEAR (Spat per ft^2)
1974	16 Jul to 5 Sep (51 days)	69	3,520	2
1975	16 Aug to 14 Oct (59 days)	532	31,400	37
1976	28 Jan to 17 Oct (113 days)	158	17,800	762
1977	27 Jun to 6 Oct (102 days)	7	714	179
1978	22 May to 31 Oct (163 days)	83	13,600	56
1979	21 May to 29 Oct (162 days)	136	22,000	30

3.5 TEMPORAL PATTERN OF GONAD DEVELOPMENT

Histological determinations in 1979 indicated a single annual spawning cycle in Hampton Harbor soft-shell clam populations (Figure 9). In what appears to be the typical pattern, gametogenesis had already begun in the majority of females by mid March; while, all or most males remained indifferent until late May. Throughout the late spring, however, gonad development proceeded rapidly in both sexes, with the first evidence of active spawning coming in mid to late June. The peak of spawning activity appeared to be in July through early August, at a time when *M. arenaria* larvae were not very abundant off the coast of Hampton Beach (cf. Figures 3 and 9). A few spawning females were found in late September suggesting that small quantities of eggs may have continued to be released after that date. No spawning males were found in late September, however, a surprisingly large proportion of the sample appeared to be in the early stages of gametogenesis, reminiscent of mid-spring conditions.

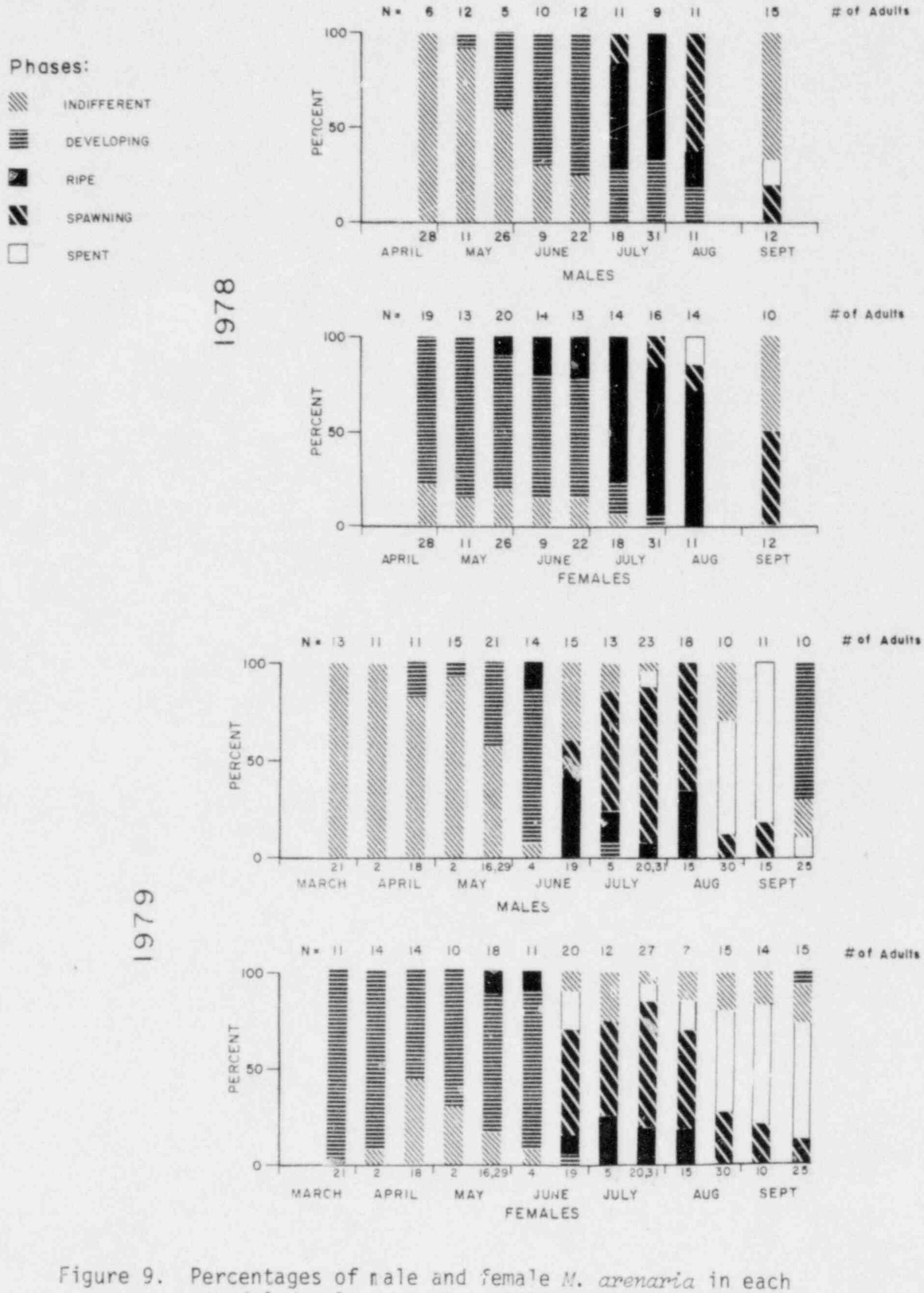

Figure 9. Percentages of male and female *M. arenaria* in each gonadal development phase 1978 and 1979. Seabrook *Mya arenaria* Study, 1979.

4.0 DISCUSSION

4.1 PLANKTONIC LARVAE SPATIAL DISTRIBUTION

As in previous years, *M. arenaria* larvae were present in substantial quantities up to two nautical miles from shore, when swarms occurred along the New Hampshire coast. Previous findings of a statistically significant onshore-offshore gradient received further support from the 1979 data. Apparently, however, the "neritic band" may be more than two nautical miles wide during periods of intense swarming, such as occurred on 11 September 1979.

For the first time the relationship between *M. arenaria* larval swarms along the open coast and inside Hampton Harbor was examined. Generally, 1979 results were consistent with the favored hypothesis that the bulk of the larvae enter Hampton Harbor on the flood tide and empty out of the Harbor on the subsequent ebbing tide. In two instances, 7 September and 25 September, however, there appears to have been little exchange between larvae-poor Harbor waters and larvae-rich coastal waters. Possibly, coastal water masses subducted into Hampton Harbor can occasionally be faunistically distinct from water masses in the vicinity of the Seabrook Station cooling water intake (Station I_4).

4.2 TEMPORAL RELATIONSHIPS: LARVAL SWARMING AND GONAD DEVELOPMENT

As in 1978, plankton tow collections clearly demonstrated bimodal temporal distribution of *M. arenaria* larvae. In 1978, peak densities in early to mid June characterized the spring-early summer node; however, in 1979, the early summer peak occurred later in June and into early July. The late summer-early fall peak was similar for both years, except that densities in excess of 100 larvae per m^3 were sustained for a longer time in September 1979.

Prior to 1978, densities in excess of 100 larvae per m^3 had not been recorded in July. Onset of larval swarming appears subject to year-to-year shifts, although environmental influences are not completely understood. Biologically, these shifts are probably related to the timing of spring spawning in northern Massachusetts soft-shell clam populations which may be a source of the majority of *M. arenaria* larvae present off Hampton Beach (NAI, 1979).

In contrast to the recent tendency for larvae to swarm later in summer, Hampton Harbor soft-shell clams appear to have spawned slightly earlier in 1979 than in 1978. Timing of spawning in Hampton Harbor and larval swarming off Hampton Beach was such that, in 1979, Hampton Harbor reproductive activity could have contributed to both early summer and late summer-early fall peaks. This was not the case in 1978, when spawning did not begin until the latter half of July in Hampton Harbor (NAI, 1979).

Evidence to support speculation, that the apparent increase in midsummer "background" larval abundance, from 1978 to 1979, could be due partly to larger Hampton Harbor breeding populations, comes from gonad samples indicating spawning in Hampton Harbor throughout the interval between swarms, both in 1978 (NAI, 1979) and in 1979 (Section 3.5). In the interval between major swarms, from mid-July until the end of August 1978, larval densities at Station I_4 averaged approximately 1.1 per m^3; whereas densities during a comparable period in 1979 averaged 8.9 larvae per m^3. Coincidentally, in 1979, there was a marked increase in the abundance of clams with shell sizes larger than 40 mm, which Brousseau (1978a, 1978b) determined to be the threshold of sexual maturity.

4.3 LARVAL ABUNDANCE AND SPAT FALL

In general, *M. arenaria* larvae were relatively abundant during the 1979 season; however, the ensuing spat fall in Hampton Harbor was relatively light (Table 13). Thus, further support is given to the argument that year-to-year trends in larval abundance have little direct

influence on the success of clam sets. Apparently crucial are the little understood physical and biological forces occurring during the period between larval swarming and spat settlement.

4.4 BIVALVE MOLLUSC LARVAE SPECIES COMPOSITION

General trends in species composition, described in previous reports (NAI, 1978, 1979) continued to prevail during 1979. A difference perhaps worth mentioning was that larvae of the sea scallop, *Placopecten magellanicus*, was scarce throughout 1978, but fairly common in the latter half of October 1979.

Beginning in 1979, a bivalve mollusc veliger, identical in size, shape and general appearance to *M. arenaria* at comparable stages of development, has been identified and enumerated separately as *M. truncata*. Despite a close resemblance with *M. arenaria*, experienced planktologists at Normandeau Associates readily distinguished *M. truncata* using fresh or very recently preserved plankton samples and illuminating the microscope stage by diffused light. Living or carefully preserved specimens of *M. arenaria* are easily recognizable by distinctive pigment characteristics described by several workers (Sullivan, 1948; Loosanoff and Davis, 1963; Savage and Goldberg, 1976). In *M. truncata*, the only strongly pigmented area is the visceral mass under the peak of the umbone, which, as in *M. arenaria*, ranges in color from burnt orange to brown-black. The rest of *M. truncata* appears chalky-gray at lower magnifications (25 to 30x); at slightly high magnification (40 to 60x) the chalky effect is seen to be due to a network of fine gray-black lines. This animal was designated as *M. truncata* in recognition of the physical resemblance with *M. arenaria* and because specimens of adult *M. truncata* have been collected by Normandeau Associates divers, in close proximity to bivalve larvae sampling stations off Hampton Beach. These *M. truncata* colonies had nestled, along with *Hiatella* sp., under clusters of *Modiolus modiolus*.

Except for one or two weeks in late spring, *M. truncata* larvae comprise a very small proportion of the total bivalve larvae assemblage. Conseqently, any effect on previous quantitative *Mya* data can be considered negligible, especially since, prior to 1978, collections typically began in late June, following the principal swarming period of *M. truncata*.

4.5 PREDATION IN HAMPTON HARBOR BY *CARCINUS MAENAS*

The previous report (NAI, 1979) considered the probability of declining abundance of the chief non-human clam predator, *Carcinus maenas*, based on trends in trap catches and winter water temperatures. Winter temperatures appear to correlate well with relative abundance of certain marine and estuarine species such as soft-shell clams and green crabs (Welsh, 1969; Dow, 1977). Until 1979, winter water temperatures had been declining (Figure 10), consistent with the assumption of declining green crab abundance. The 1979 trap data, however, showed a return, in October, to green crab catches reminiscent of summer 1977 levels. Correspondingly, water temperature minima during the previous winter showed the beginnings of an upward trend (Figure 10). Such signs, combined with expected renewed public interest in clam digging, suggest that intermediate sized soft-shell clams (lengths: 10-40mm) may become increasingly scarce, eventually affecting the standing crop of harvestable clams (Table 14).

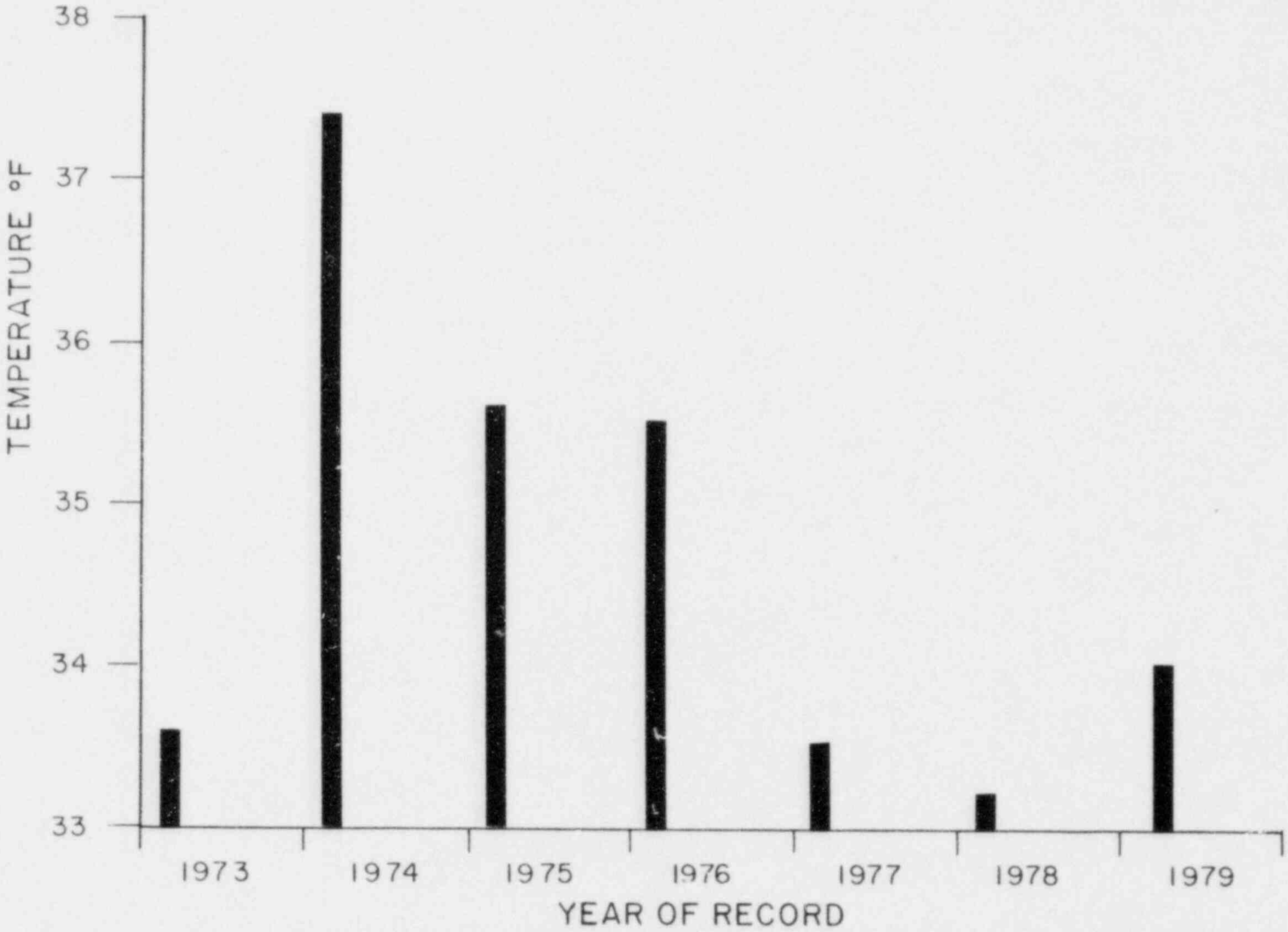

Figure 10. Means of daily minimum winter (February and March) water temperature off Hampton Beach, New Hampshire. Seabrook *Mya arenaria* study, 1979.

TABLE 14. RECENT HISTORY OF THE STANDING CROP OF HARVESTABLE SIZE ADULT[a] *MYA ARENARIA* IN HAMPTON HARBOR. SEABROOK *MYA ARENARIA* STUDY, 1979.

DATE	ESTIMATED BUSHEL PER ACRE	TOTAL ESTIMATED NUMBER OF BUSHELS
November 1967	152.0[b]	23,400
July 1969	103.0	15,840
November 1971	84.0	13,020
November 1972	58.0	8,920
November 1973	41.0	6,310
November 1974	56.0	8,690
November 1975	29.0	4,945
November 1976	11.0	1,350
November 1977	6.4	1,060
November 1978	5.7	940
November 1979	34.3	5,670

[a] 1967-1975, shell length = 50 mm and up; 1976-1978, shell length = 43 mm and up

[b] from Ayer (1968)

5.0 SUMMARY

For the second consecutive year, plankton tows produced evidence of bimodal temporal distribution of *Mya arenaria* larvae, with major abundance peaks occurring in early July and mid September. Several years of current-meter records have indicated northerly drift immediately preceding or during these abundance peaks, suggesting an important contribution of larvae from clam breeding areas to the south of Hampton-Seabrook estuary.

As has often occurred in previous years, *M. arenaria* larvae were significantly more abundant ($p \geq .05$) within one nautical mile (1.85 kilometers) of the New Hampshire coastline than at two nautical miles. During periods of peak abundance, *M. arenaria* larvae were generally more abundant inside Hampton Harbor following flood tide than after ebb tide. On at least two occasions in September, however, *M. arenaria* larvae were found in the Harbor in low numbers on both tides, although abundance was at or near peak offshore.

Despite an approximately 60% increase in overall larval abundance over the previous year, the 1979 spat set was relatively light, down 30% from that of the previous year. Further support was thus given to the argument that year-to-year trends in larval abundance have little direct impact on spat fall intensity.

The second consecutive study of gonad development in *M. arenaria* corroborated the earlier study in showing a single annual spawning cycle for Hampton Harbor populations. In 1979, spawning activity peaked from early July through early August, when 40 to 80% of clams, over 50 mm long, showed histological evidence of active spawning. This range represented a marked increase over the previous year and coincided with an approximately six-fold increase in biomass of sexually mature clams in Hampton Harbor, primarily recruited from a heavy spat set in 1976.

The total standing crop, in November 1979, was estimated at 29,000 bushels, of which 5670 bushels were of "harvestable" size (i.e., $\geq$ 43 mm).

Natural predation and human clam digging have an impact on *M. arenaria* standing stocks in Hampton Harbor. From April 1978 through September 1979, green crab, *Carcinus maenas*, trap catches were reasonably stable, averaging 6 to 9 crabs per trap per day. In October 1979, however, trap catches increased sharply to an average of 22 crabs per trap per day, thereby rivaling records established in the summer and fall of 1977. A virtually parallel pattern of winter water temperature fluctuation was noted from temperature-recording buoys off Hampton Beach. Along with renewed public interest in clam digging, such trends suggest that *M. arenaria* standing crop may peak during 1980 and could decline unless existing seed stocks are replenished.

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APPENDICES

APPENDIX 7.1. ANALYSIS OF VARIANCE TABLES. *MYA ARENARIA* LARVAE.

I. SEPTEMBER 1979: "I" STATIONS ONLY USING SQUARE ROOT TRANSFORMATION

	D.F.	S.S.	M.S.	F
Station	3	307.010	102.337	5.09*
Day	3	1335.974	445.324	22.15***
Sta x Day	9	249.266	27.696	1.38
Error	16	321.704	20.106	
Total	31	2213.954		

II. SEPTEMBER 1979: "I" AND "HH" STATIONS USING SQUARE ROOT (9/7/79 DELETED)

	D.F.	S.S.	M.S.	F.
Station	5	1196.259	239.252	12.76***
Day	2	1558.406	779.202	41.56***
Sta x Day	10	411.143	41.114	2.19 N.S.
Error	18	337.484	18.749	
Total	35	3503.291		

III. JULY 1979: "I" STATIONS ONLY USING SQUARE ROOT

	D.F.	S.S.	M.S.	F
Station	3	349.284	116.428	46.047 ***
Error	4	10.114	2.528	

I = Intake

II = Hampton Harbor Inlet

APPENDIX 7.1 (Continued)

RESULTS OF TUKEY'S PROCEDURES FOR PAIRWISE MULTIPLE COMPARISONS

I. SEPTEMBER DATA: STATIONS "I" ONLY: ALL DATES

(a) Station comparisons

I2, I4 > I8

(b) Date comparisons

9-11-79 > 9-7-79, 9-17-79, 9-25-79
9-17-79 > 9-25-79

II. SEPTEMBER DATA: STATIONS "I" AND "HH": 9/7/79 DELETED

(a) Station comparisons

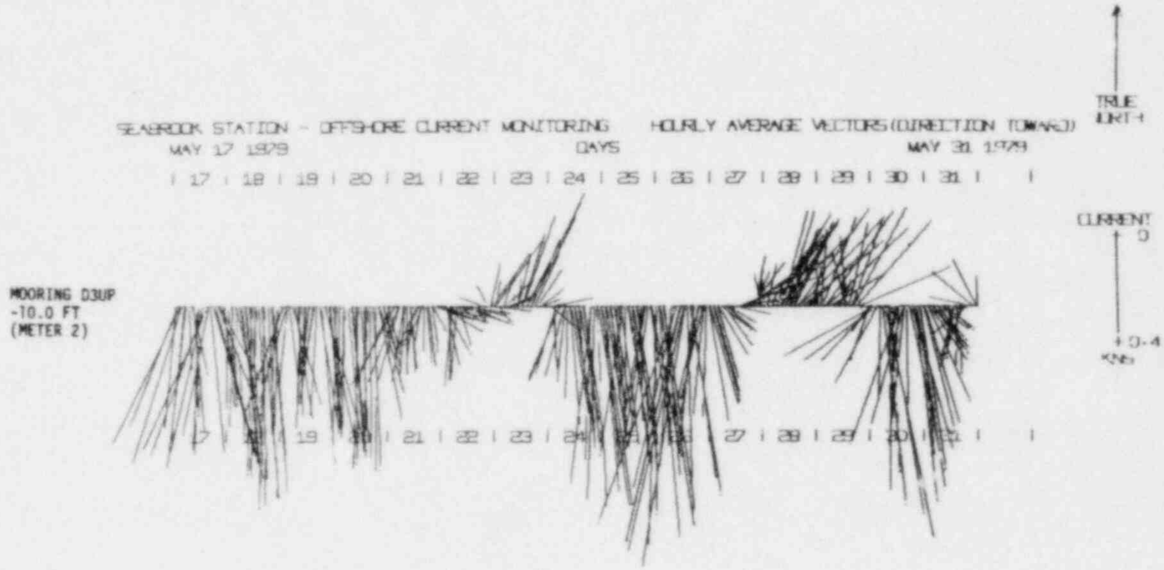
HH-Flood >I2, I4, I6, I8, HH-Ebb
I2, I4 > I8

(b) Dates not tested for this group - see above (I)

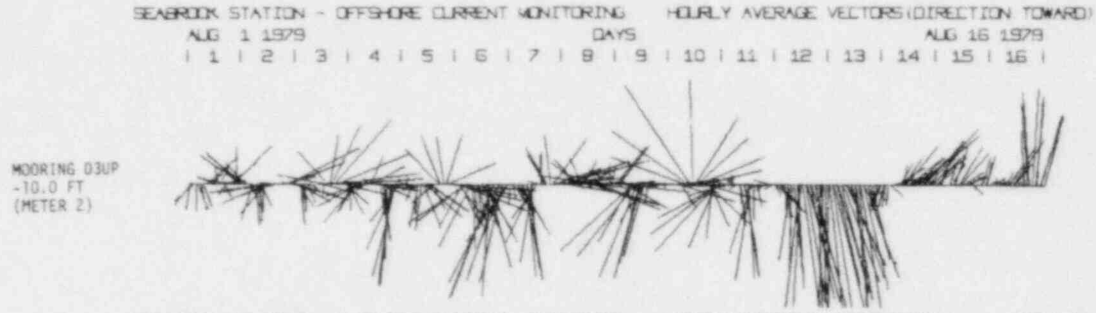
III. JULY DATA: STATIONS "I" ONLY

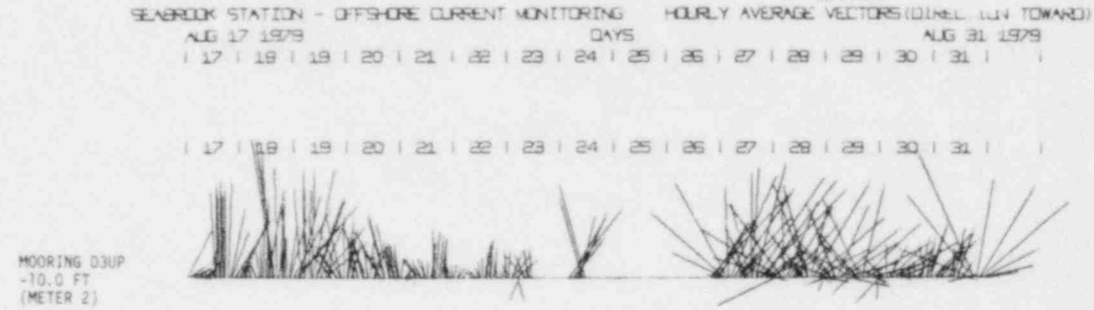
(a) Station comparisons

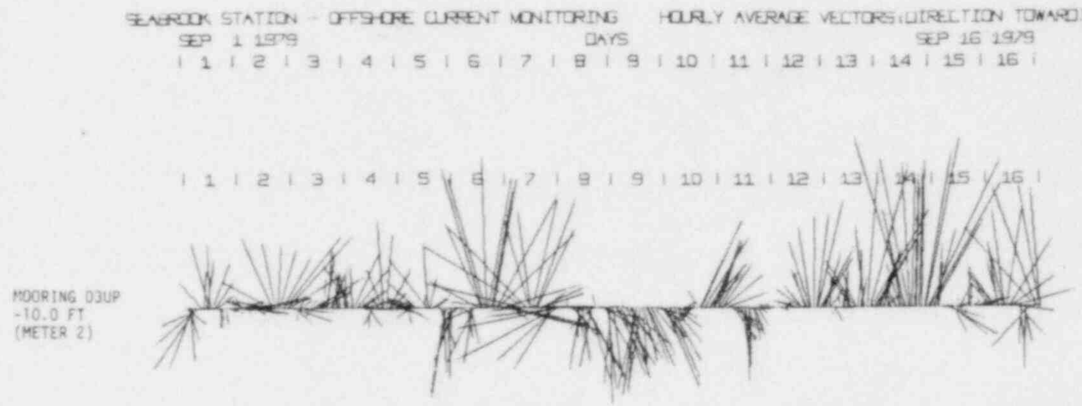
I2, I4 > I6, I8

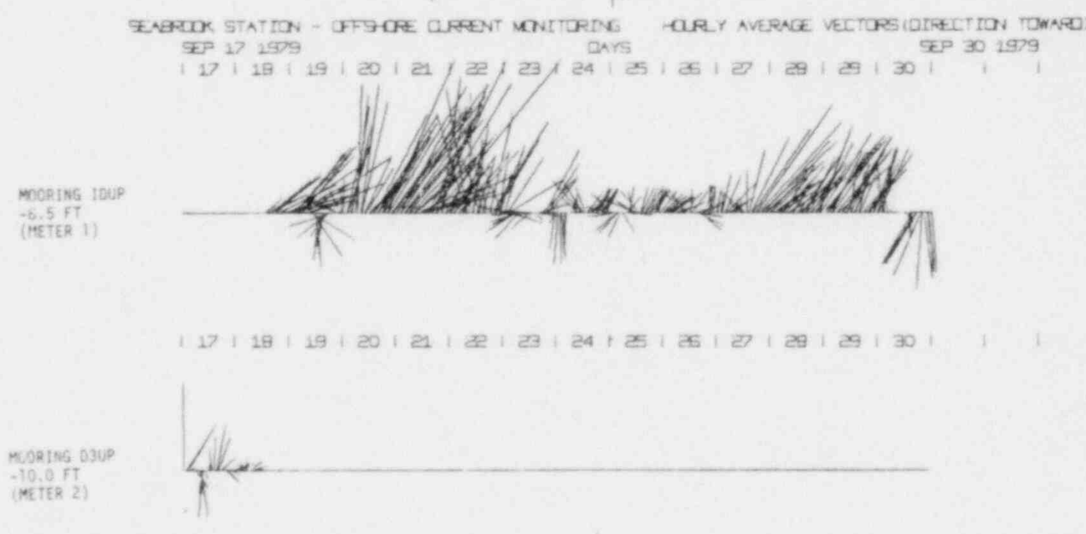

SEABROOK STATION - OFFSHORE CURRENT MONITORING HOURLY AVERAGE VECTORS (DIRECTION TOWARD)
MAY 17 1979
DAYS
MAY 31 1979
TRUE NORTH
17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
CURRENT 0
0.4 KNS
MOORING D3UP
-10.0 FT
(METER 2)

Appendix 7.2.

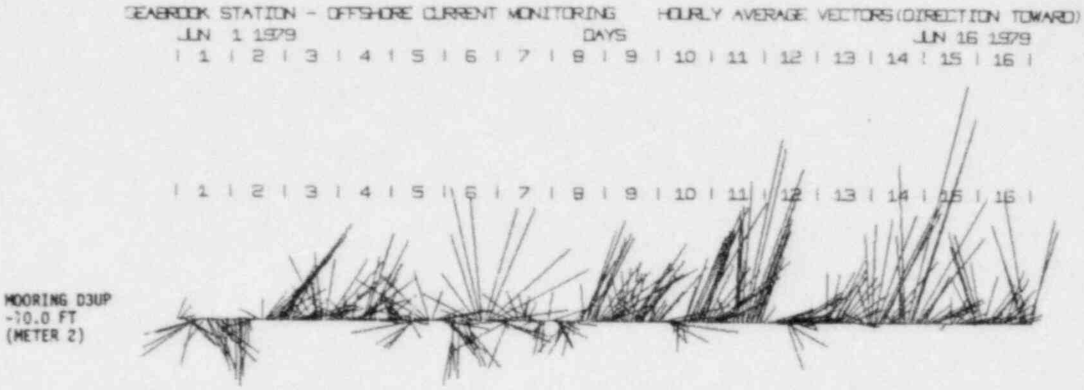


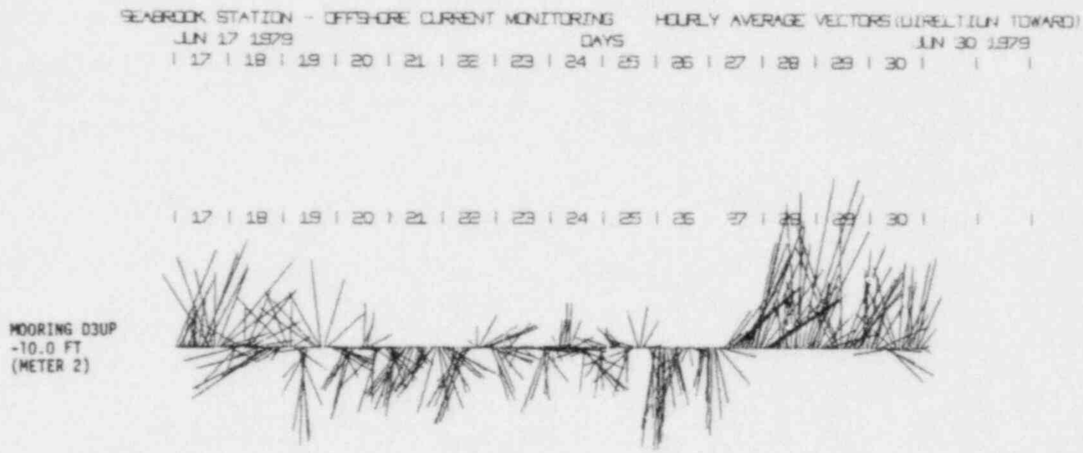


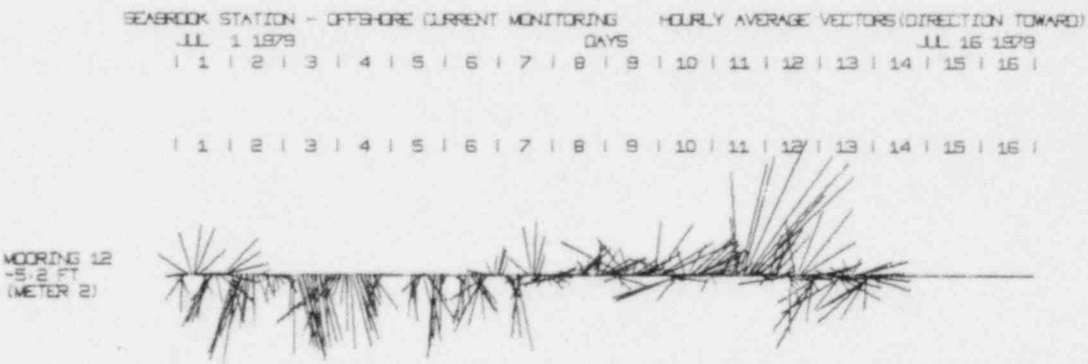


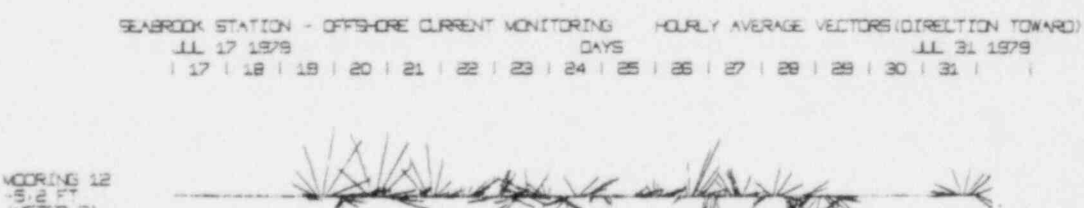


Appendix 7.2 (Continued)

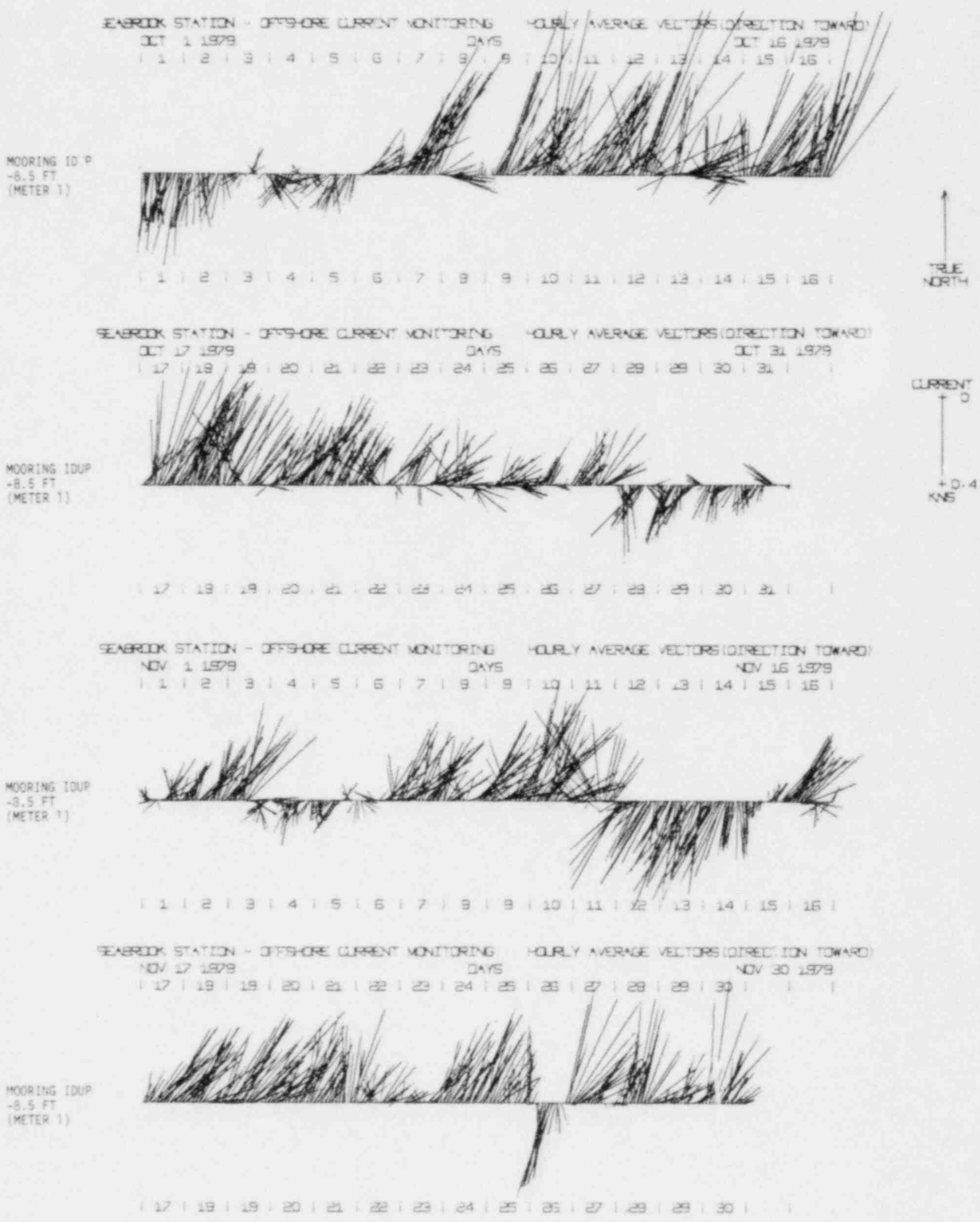








Appendix 7.2 (Continued)



Appendix 7.2 (Continued)

APPENDIX 7.3. SHELL SIZE DISTRIBUTION (NUMBER PER FT^2) OF YOUNG *MYA ARENARIA* COLLECTED FROM FIXED STATIONS IN SELECTED NORTHERN NEW ENGLAND ESTUARIES, 1976 THROUGH 1979. SEABROOK *MYA ARENARIA* STUDY, 1979.

PLUM ISLAND SOUND
MIDDLE GROUND

SIZE CLASS (mm)	19 APR 1976	21 JUN 1976	17 AUG 1976	28 OCT 1976	11 [illegible]B 1[illegible]	11 APR 1977	8 JUN 1977	5 AUG 1977	19 OCT 1977	6 JAN 1978	4 APR 1978	13 JUN 1978	11 AUG 1978	12 OCT 1978	3 APR 1979	17 JUL 1979	11 OCT 1979
5	5	2	11	208	101	149	127	7	625	91	127	31	19	114	44	24	18
10	7			8	10	44	132	5	46	22	20	69	27	29	7	93	14
15	1			1	1	6	98	49	29	7	6	32	112	94	13	33	48
20						1	29	87	45	35	23	7	61	28	12	6	14
25							15	38	37	41	33	8	14	9	17	8	3
30								9	21	24	26	13	15	12	17	14	6
35								2	4	5	7	6	14	12	17	12	8
40										2	3	2	9	10	12	11	14
45												1	8	9	4	13	16

APPENDIX 7.3 (Continued)

PLUM ISLAND SOUND
LUFKIN'S FLAT

SIZE CLASS (mm)	11 APR 1977	8 JUN 1977	5 AUG 1977	19 OCT 1977	6 JAN 1978	4 APR 1978	13 JUN 1978	11 AUG 1978	12 OCT 1978	3 APR 1979	17 JUL 1979	11 OCT 1979
5	165	169	10	171	60	87	5	16	8	29	2	41
10	43	79	1		15	15	31	3	6	3	8	46
15	32	13			1	1	9	13	10	3	2	8
20	5	4	5	6	3	3	3	10	25	11	3	9
25	3	1	14	8		3	1	19	17	15	1	5
30		4	8	23	3	11		13	5	8	2	8
35			3	15	4	9	1	3	5	13	5	9
40				1	1	4	5	1	4	8	3	2
45				1		1	1	1	1	1	2	2

APPENDIX 7.3. (Continued)

PLUM ISLAND SOUND
EAGLE HILL RIVER AT NUT SHOAL

SIZE CLASS (mm)	11 APR 1977	8 JUN 1977	5 AUG 1977	19 OCT 1977	6 JAN 1978	4 APR 1978	13 JUN 1978	11 AUG 1978	12 OCT 1978	3 APR 1979	17 JUL 1979	11 OCT 1979
5	142	23	68	912	199	182	50	97	80	292	13	534
10	28	58		12	36	27	143		13	10	59	10
15	11	110	28		4	2	38	55	74	10	61	4
20	2	26	66	8	6	6	15	59	63	25	17	8
25			49	30	19	23	4	32	38	32	19	8
30			10	27	27	15	4	6	4	6	11	10
35				8	25	19	8	8	4	11	11	13
40				8	6	11	10	11	15	23	13	17
45				2		4	4	8	8	23	8	6

APPENDIX 7.3. (Continued)

MERRIMACK RIVER ESTUARY
BALL'S FLAT #1

SIZE CLASS (mm)	23 APR 1976	17 JUN 1976	18 AUG 1976	26 OCT 1976	27 JAN 1977	13 APR 1977	6 JUN 1977	2 AUG 1977	18 OCT 1977	4 JAN 1978	5 APR 1978	19 JUN 1978	9 AUG 1978	13 OCT 1978	2 APR 1979	12 JUL 1979	10 OCT 1979
5	44	6	22	353	244	368	265	15	81	364	131	116			10	5	29
10	2	7				2				1	1	84	3		9	4	12
15		3								1		3	24	3	4	5	7
20			1										37	27	14	16	4
25													5	36	18	21	7
30													2	5	5	19	10
35														1	2	2	16
40																1	14
45																1	8

APPENDIX 7.3. (Continued)

MERRIMACK RIVER ESTUARY
SALISBURY FLAT #3

SIZE CLASS (mm)	23 APR 1976	17 JUN 1976	18 AUG 1976	26 OCT 1976	28 JAN 1977	13 APR 1977	6 JUN 1977	2 AUG 1977	18 OCT 1977	5 JAN 1978	6 APR 1978	19 JUN 1978	9 AUG 1978	13 OCT 1978	2 APR 1979	12 JUL 1979	10 OCT 1979
5	18	7	12	102	82	86	28	31	22	15	27	2	30	15	8	8	8
10	1	4	5			1	1	2	1	1	1	4		4	4	4	2
15		2	1				2					1	2	2	1	2	2
20			4										2	1			1
25			1										1	1			
30														1			
35																	
40																	
45																	

APPENDIX 7.3. (Continued)

HAMPTON HARBOR
FLAT #2

SIZE CLASS (mm)	12 MAR 1976	21 APR 1976	18 JUN 1976	16 AUG 1976	21 OCT 1976	11 JAN 1977	14 APR 1977	[illegible] JUN 1977	1 AUG 1977	17 OCT 1977	4 JAN 1978	5 APR 1978	9 JUN 1978	14 AUG 1978	9 OCT 1978	5 APR 1979	11 JUL 1979	9 OCT 1979
5	168	112	18	80	1284	612	691	593	219	118	78	157	42	24	106	97	93	103
10		1	2				1	10	104	119	58	29	38	43	5	9	40	10
15									39	89	87	69	8	77	29	10	17	3
20									2	4	15	21	3	64	61	39	12	9
25												2		46	51	29	17	20
30														18	20	22	21	10
35														2	5	8	12	11
40														2	1	4	12	14
45																	2	12

APPENDIX 7.3. (Continued)

HAMPTON HARBOR
FLAT #4 (MIDDLE GROUND)

SIZE CLASS (mm)	5 APR 1978	9 JUN 1978	14 AUG 1978	5 OCT 1978	5 APR 1979	11 JUL 1979	9 OCT 1979
5	282	70	170	529	268	30	144
10	306	85	47	137	80	141	46
15	394	96	56	145	77	62	36
20	68	56	75	140	86	64	30
25	5	5	26	60	59	43	37
30		1	16	21	17	25	29
35			3	5	14	13	12
40					7	7	7
45			1			5	4

APPENDIX 7.3. (Continued)

LITTLE HARBOR CHANNEL
FLATS

SIZE CLASS (mm)	24 FEB 1976	22 APR 1976	23 JUN 1976	19 AUG 1976	25 OCT 1976	12 JAN 1977	15 APR 1977	13 JUN 1977	10 AUG 1977	10 OCT 1977	13 JAN 1978	10 APR 1978	16 JUN 1978	8 AUG 1978	6 OCT 1978	6 APR 1979	13 JUL 1979	8 OCT 1979
5	15	66	13	6	114	84	175	182	56	29	9	11	12		22	11	26	16
10		3	1					13	4	2		4	4	1		2		1
15								2	1	1				1			1	
20										1				1	1			
25																		
30																		
35																		
40																		
45																1	1	

APPENDIX 7.3 (Continued)

YORK RIVER
FLAT AT ROUTE 103 BRIDGE

SIZE CLASS (mm)	20 APR 1976	22 JUN 1976	20 AUG 1976	29 OCT 1976	14 JAN 1977	12 APR 1977	9 JUN 1977	9 AUG 1977	21 OCT 1977	17 JAN 1978	3 APR 1978	14 JUN 1978	10 AUG 1978	11 OCT 1978	4 APR 1979	18 JUL 1979	12 OCT 1979
5	180	267	91	103	119	90	395	89	70	76	29	31	9	28	29	24	18
10		9	1	2		2	20	16	5	12	19	15	12	2	2	2	1
15			2				2	4			2	5	5	2		1	
20											3		2	2	2		
25							1				1			1	2	1	
30													2		2	1	
35														1			
40														1			1
45																	

APPENDIX 7.3 (Continued)

OGUNQUIT BEACH
FLAT

SIZE CLASS (mm)	20 APR 1976	22 JUN 1976	20 AUG 1976	29 OCT 1976	14 JAN 1977	12 APR 1977	9 JUN 1977	9 AUG 1977	21 OCT 1977	17 JAN 1978	3 APR 1978	14 JUN 1978	10 AUG 1978	11 OCT 1978	4 APR 1979	18 JUL 1979	OCT 1979
5	35	2	8	57	100	64	48	19	26	18	9	20	18	40	22	11	89
10	2	1			1		50	4		2	3	13	1		4	15	
15							5	33	2	1	1	4	12	1		11	
20								66	12	6	10	1	9	2	2	1	1
25								8	6	11	5	5	4	4	1		2
30									4	4	10	10	5	3	2	5	2
35											2	2	6	2	2	6	2
40											1	1	8	3	4	3	2
45													4	4	4	5	4

APPENDIX 7.4. 1 MM SIZE CLASS LENGTH-DENSITY DATA FROM THE NOVEMBER 1978 SURVEY.

LENGTH [mm]	DENSITY [#/ft^2	%-AGE	%-AGE CUM	LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	%-AGE CUM	LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	%-AGE CUM
1	0.45	0.211	100.000	26	1.19	0.559	3.185	43	0.02	0.009	0.073
2	4.38	2.056	99.789	27	1.07	0.502	2.627	44	0.005	0.002	0.063
3	7.39	3.469	97.732	28	0.66	0.310	2.124	45	0.005	0.002	0.061
4	11.47	5.385	94.233	29	0.74	0.347	1.815	46	0.002	0.001	0.059
5	9.20	4.319	88.878	30	0.74	0.347	1.467	47	0.005	0.002	0.058
6	9.51	4.465	84.559	31	0.38	0.178	1.120	48	0.02	0.009	0.655
7	10.41	4.887	80.094	32	0.41	0.192	0.941	49	0.007	0.003	0.046
8	10.56	4.958	75.207	33	0.30	0.141	0.749	50	0.002	0.001	0.043
9	10.11	4.746	70.249	34	0.23	0.108	0.608	51	0.002	0.001	0.042
10	11.92	5.596	65.503	35	0.30	0.141	0.500	52	0.007	0.003	0.041
11	11.32	5.314	59.907	36	0.15	0.070	0.359	53	0.	0.0	0.038
12	10.26	4.817	54.593	37	0.15	0.070	0.289	54	0.	0.0	0.038
13	10.11	4.746	49.176	38	0.10	0.047	0.218	55	0.019	0.009	0.038
14	12.22	5.737	45.072	39	0.08	0.038	0.171	60	0.014	0.007	0.029
15	11.32	5.314	39.292	40	0.06	0.028	0.134	65	0.023	0.011	0.022
16	12.00	5.634	33.978	41	0.04	0.019	0.106	70	0.005	0.002	0.011
17	12.55	5.892	28.344	42	0.03	0.014	0.087	75	0.012	0.006	0.009
18	11.27	5.291	22.452					80	0.005	0.002	0.003
19	8.06	3.784	17.161					85	0.002	0.0009	0.0009
20	7.09	3.329	13.378					Σ	213.005		
21	4.83	2.268	10.049								
22	4.93	2.314	7.782								
23	1.92	0.901	5.467								
24	1.54	0.723	4.566								
25	1.40	0.657	3.843								

APPENDIX 7.5. 1 MM SIZE CLASS DATA FROM THE NOVEMBER LENGTH-DENSITY 1979 SURVEY.

LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	%-AGE CUM	LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	%-AGE CUM	LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	%-AGE CUM
1	0.12	0.107	100.000	26	1.83	1.626	19.984	43	0.32	0.284	1.623
2	4.11	3.651	99.893	27	2.08	1.848	18.358	44	0.22	0.195	1.339
3	4.69	4.166	96.243	28	1.99	1.768	16.510	45	0.27	0.240	1.143
4	5.16	4.584	92.077	29	1.70	1.510	14.743	46	0.14	0.124	0.903
5	5.28	4.690	87.493	30	2.28	2.025	13.232	47	0.14	0.124	0.779
6	4.81	4.273	82.803	31	1.55	1.377	11.207	48	0.116	0.103	0.655
7	4.56	4.051	78.530	32	1.41	1.252	9.831	49	0.107	0.095	0.552
8	2.31	2.052	74.480	33	1.19	1.057	8.578	50	0.192	0.171	0.457
9	2.52	2.238	72.428	34	1.03	0.915	7.521	51	0.061	0.054	0.286
10	2.81	2.496	70.189	35	1.22	1.083	6.606	52	0.041	0.036	0.232
11	3.75	3.331	67.693	36	0.81	0.720	5.522	53	0.034	0.030	0.195
12	5.16	4.584	64.362	37	0.75	0.666	4.803	54	0.023	0.020	0.165
13	3.64	3.233	59.779	38	0.81	0.720	4.137	55	0.025	0.022	0.145
14	5.04	4.477	56.545	39	0.59	0.524	3.417	56	0.040	0.036	0.123
15	4.22	3.749	52.068	40	0.67	0.595	2.893	57	0.005	0.004	0.087
16	4.34	3.855	48.320	41	0.35	0.311	2.298	58	0.014	0.012	0.083
17	3.75	3.331	44.465	42	0.41	0.364	1.987	59	0.013	0.012	0.070
18	2.58	2.292	41.134					60	0.007	0.006	0.059
19	3.05	2.709	38.842					61	0.002	0.002	0.052
20	3.40	3.020	36.133					62	0.002	0.002	0.051
21	2.93	2.603	33.112					63	0.	0.0	0.047
22	4.22	3.749	30.510					64	0.	0.0	0.049
23	2.70	2.398	26.761					65	0.009	0.008	0.049
24	2.58	2.292	24.363					70	0.013	0.012	0.041
25	2.35	2.087	22.071					75	0.008	0.007	0.029
								80	0.008	0.007	0.022
								85	0.017	0.015	0.015
								90			
								Σ	112.577		

APPENDIX 7.6.

TABLE A. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 1 FOR THE NOVEMBER SURVEYS, 1971-1979. SEABROOK *MYA ARENARIA* STUDY, 1979.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979
5	19.00	74.00	30.00	2.50	55.00	1031.00	283.00	38.00	16.98
10	11.00	9.00	6.00		1.14	52.00	413.00	100.00	8.15
15	11.00	15.00	3.00			0.75	117.00	148.00	14.26
20	7.00	11.00	5.00		0.02		5.82	76.00	20.00
25	0.47	2.50	0.16	0.11			0.48	9.20	19.50
30	1.30	2.30	0.51	0.17	0.02	0.02		0.56	13.57
35	1.50	1.20	0.60	0.48	0.04			0.03	6.10
40	1.80	1.40	0.67	0.89	0.23		0.01	0.03	3.33
45	1.80	0.61	0.49	1.10	0.14	0.10	0.01		0.94
50	1.00	0.83	0.42	1.20	0.36	0.03	0.02	0.03	0.31
55	0.64	1.60	0.30	0.82	0.25	0.04	0.03	0.03	0.06
60	0.36	0.33	0.29	0.42	0.28	0.23	0.02	0.03	0.03
65	0.08	0.19	0.18	0.31	0.14	0.13	0.01	0.04	
70	0.03	0.19	0.11	0.10	0.11	0.06	0.04		0.01
75	0.03	0.08	0.05	0.10	0.03	0.03	0.02	0.02	0.03
80				0.02	0.07		0.02		0.03
85						0.01	0.01	0.01	0.05
90						0.01			0.01

APPENDIX 7.6 (Continued)

TABLE B. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT #2, NOVEMBER 1971-NOVEMBER 1979. SEABROCK *MYA ARENARIA* STUDY, 1979.

SIZE CLASS (mm)	NOV 1971	APR 1972	JUL 1972	NOV 1972	FEB 1973	MAY 1973	AUG 1973	NOV 1973	JAN 1974	MAY 1974	AUG 1974	NOV 1974
5	37.00	1.60	2.90	116.00	138.00	199.00	15.00	114.00	4.20	7.60	5.90	
10	35.00	9.70	8.70	26.00	34.00	110.00	20.00	8.00	2.00	2.50		
15	11.00	0.91	5.50	2.40	2.40	13.00	28.00	2.60	0.36			
20	9.00	1.50	4.40	0.91	1.00	1.00	42.00	10.00	2.00			
25	0.89	0.11	4.70	0.11	0.38	0.42	0.56	0.67	0.91	0.97	0.11	0.50
30	0.44	0.14	4.20	0.44	0.44	0.63	0.27	0.80	0.58	1.40	0.27	0.22
35	0.67	0.19	2.80	0.50	0.38	0.80	0.08	0.66	0.44	1.40	0.61	0.30
40	1.20	0.33	1.60	0.83	0.38	0.97	0.08	0.61	0.38	0.91	0.75	0.40
45	1.60	0.61	0.80	0.27	0.27	0.72	0.08	0.39	0.55	0.83	0.38	0.65
50	1.10	0.53	0.69	0.22	0.22	0.55	0.14	0.36	0.50	0.58	0.56	0.75
55	0.89	0.67	0.56	0.33	0.17	0.32	0.19	0.33	0.19	0.17	0.33	0.32
60	0.94	0.68	0.28	0.27	0.22	0.18	0.08	0.08	0.17	0.25	0.17	0.34
65	0.44	0.36	0.22	0.22	0.08	0.16	0.19	0.14	0.14	0.08	0.06	0.15
70	0.33	0.30	0.19	0.11	0.17	0.12	0.03	0.11	0.14	0.08	0.06	0.19
75		0.08	0.06	0.11	0.06	0.09		0.08	0.14	0.03	0.03	0.06
80	0.06	0.17	0.03	0.06	0.06	0.08	0.06	0.06		0.03		0.06
85	0.06	0.03		0.06	0.03	0.04	0.11		0.06			0.02
90						0.04	0.06	0.11				0.02
95						0.01		0.06				
100							0.03					
105												
110												

(Continued)

APPENDIX 7.6 (Continued)

TABLE B. (Continued)

SIZE CLASS (mm)	FEB 1975	MAY 1975	AUG 1975	NOV 1975	FEB 1976	MAY 1976	AUG 1976	NOV 1976	FEB 1977	MAY 1977	AUG 1977	NOV 1977	APR 1978	NOV 1978	APR 1979	AUG 1979	NOV 1979
5	5.90	9.80	3.40	9.10	---	---	---	351.00	---	---	---	83.00	---	11.00	---	---	32.44
10					---	---	---		---	---	---	2.90	---		---	---	10.56
15					---	---	---		---	---	---		---		---	---	10.56
20					---	---	---		---	---	---		---	1.94	---	---	2.26
25													0.04	2.61	2.03	2.50	1.04
30														1.58	4.13	o.82	1.03
35	0.13	0.06									0.02			0.29	1.03	8.30	0.88
40	0.32	0.18	0.02			0.11				0.02				0.15	0.70	5.25	0.90
45	0.37	0.28	0.13			0.02					0.02			0.04	0.06	1.73	0.35
50	0.67	0.32	0.06		0.02	0.02		0.02		0.04			0.08	0.06	0.06	[illegible]	0.21
55	0.72	0.52	0.09	0.02	0.02								0.02	0.02		0.09	0.10
60	0.24	0.44	0.02	0.07		0.04		0.02		0.02				0.03		0.04	0.05
65	0.18	0.18	0.06	0.02	0.02	0.11				0.06				0.03		0.05	[illegible]
70	0.20	0.11	0.02	0.09		0.02					0.02		0.03			[illegible]	
75	0.04	0.02	0.07	0.04		0.11		0.02		0.02	0.04		0.02	0.02			
80	0.06	0.04	0.02	0.07	0.02		0.04	0.02			0.09		0.02	0.02			
85	0.06	0.02		0.02	0.04						0.04		0.03		0.03		
90	0.02	0.02	0.02	0.04	0.09							0.06	0.02			0.02	
95	0.02	0.02		0.06							0.09						
100		0.04		0.04				0.02		0.02		0.02	0.02				
105																	
110		0.02	0.02														

--- = Not randomly sampled; see Appendix 7.2 for fixed station results

APPENDIX 7.6 (Continued)

TABLE C. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 3 FOR NOVEMBER SURVEYS, 1971-1979. SEABROOK *MYA ARENARIA* STUDY, 1979.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979
5	35.00	28.00	6.00	0.63	1.14	556.00	67.00	38.00	10.18
10	29.00	4.70	1.00			4.10	3.40	1.10	
15	5.20	4.00					3.40	3.00	
20	4.80	2.00					1.13	3.71	
25	0.17	0.42	1.00			0.05		3.74	0.18
30	0.92	0.25	1.00	0.14				0.85	0.14
35	0.67	0.17	0.38	0.12		0.02	0.10	0.27	0.14
40	1.50	0.33	0.62	0.11				0.02	0.29
45	1.40	0.42	0.50	0.30		0.02		0.04	0.14
50	1.30	0.17	0.29	0.11	0.03		0.02	0.02	0.07
55	1.10	0.17	0.79	0.08	0.03	0.02		0.04	0.04
60	0.83	0.08	0.54	0.18	0.08		0.02		
65	0.58		0.46	0.38	0.08	0.04		0.02	0.07
70	0.33		0.08	0.42	0.14	0.02		0.04	
75	0.25		0.08	0.22	0.03	0.06	0.02	0.02	
80	0.08		0.08	0.14	0.03	0.06			
85			0.04	0.03	0.08				
90	0.08			0.06	0.08				0.04

APPENDIX 7.6. (Continued)

TABLE D. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 4 FOR NOVEMBER SURVEYS, 1971-1979. SEABROOK *MYA ARENARIA* STUDY, 1979.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979
5	[illegible]	116.00	12.00	2.50	66.00	830.00	117.00	113.00	49.13
10	[illegible]	31.00	1.00		1.80	13.20	183.00	91.00	38.34
15	7.00	20.00	3.00				115.00	48.00	49.13
20	4.00	18.00	2.00	0.64			20.40	45.10	30.75
25	2.80	1.10	0.52	0.05		0.01	0.62	12.38	16.77
30	3.50	3.00	1.40	0.26	0.01	0.02		8.29	13.46
35	4.60	2.80	0.62	0.58	0.01	0.01		3.19	8.98
40	4.00	1.70	0.46	0.96	0.16			0.85	4.98
45	2.60	2.00	0.35	0.92	0.16		0.09	0.02	2.21
50	1.30	1.00	0.38	0.80	0.18			0.03	0.85
55	1.10	0.79	0.14	0.50	0.21	0.13		0.01	0.27
60	0.25	0.21	0.08	0.29	0.12				0.07
65	0.17	0.04	0.14	0.21	0.14		0.01	0.01	0.02
70	0.12	0.08	0.06	0.03	0.04				0.01
75			0.02		0.01	0.01			
80		0.04		0.01		0.01			
85				0.01	0.01	0.01			

APPENDIX 7.6 (Continued)

TABLE E. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 5 FOR NOVEMBER SURVEYS, 1971-1979. SEABROOK *MYA ARENARIA* STUDY, 1979.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979
5	67.00	136.00	22.00	2.40	7.50	546.00	92.00	44.00	11.03
10	38.00	94.00	1.00			2.80	8.30	4.80	2.55
15	12.00	16.00					7.50		
20	3.00	6.00					5.30	4.80	
25	0.06	0.55	0.10				0.75	2.28	0.05
30	0.11	0.89	0.31					2.17	0.31
35	0.33	0.61	0.14	0.01			0.01	1.41	0.73
40	0.44	1.00	0.28				0.07	0.41	0.33
45	0.44	0.77	0.12					0.10	0.22
50	0.94	0.94	0.10			0.02		0.04	0.12
55	0.39	0.61	0.12	0.01					0.03
60	0.28	0.50	0.12						
65		0.11	0.05	0.08			0.01		
70		0.11	0.05	0.04					
75			0.05		0.01		0.01	0.01	
80		0.06						0.01	
85									
90									

APPENDIX 7.7 *CARCINUS MAENAS* CATCH RECORD JANUARY THROUGH DECEMBER 1979, EIGHT TRAPS. SEABROOK *MYA ARENARIA* STUDY, 1979.

TRAPPING DATES	MAXIMUM CARAPACE WIDTHS (cm) <3	3-3 1/2	3 1/2-4	4-4 1/2	4 1/2-5	5-5 1/2	5 1/2-6	6-6 1/2	6 1/2-7	>7	*CANCER* SPP.	TOTAL *CARCINUS MAENAS*
8-9 Jan		4M 2F	2M 3F	6M 16F	9M 19F	9M 28F	5M 10F	6M 4F	1M	2M	207	126
18-19 Jan				1M							1	1
31 Jan-1 Feb			1M								1	1
27-28 Feb		No catch									0	0
15-16 Mar		No catch									3	0
27-28 Mar									1M		5	1
9-10 Mar		1M 1F		1F		1M					75	4
25-26 Apr		1M 2F	2M 4F	7M 9F(1g)	21M 3F	35M 6F	32M 4F	12M 8F	3M		185	149
9-10 May		1M	3M 2F	5M 3F	1M 3F(1g)	7M 6F(2g)	8M 1F	3M 1F	2M		81	46
23-24 May		No catch									54	0
5-6 Jun			1F	8F	5F(1g)	13F	1M 4F				176	32
20-21 Jun				1F	1M 13F(2g)	20F	3M 24F(2g)	3M 9F	3M 1F		195	78

(Continued)

APPENDIX 7.7 (Continued)

TRAPPING DATES	MAXIMUM CARAPACE WIDTHS (cm) >3	3-3 1/2	3 1/2-4	4-4 1/2	4 1/2-5	5-5 1/2	5 1/2-6	6-6 1/2	6 1/2-7	>7	TOTAL *CANCER* SPP.	TOTAL *CARCINUS MAENAS*
5-6 Jul				3F	3M 9F	4M 17F	[illegible]M 20F	8M 5F	15M	6M	133	93
18-19 Jul			1M	1F		2F				1M	122	5
1-2 Aug	1F	5F	2M 6F	6M 2F	10M 7F	1M 3F	6M 4F	4M 1F	2M	1M	60	61
15-16 Aug			4M 2F	2M 3F	5M 11F(1g)	3M 2F	3M 3F	1F			145	39
6-7 Sep[1]		1F	1F		3M 15F	3M 11F	3M 15F	5M 9F	2M 1F		30+	69
19-20 Sep[1]				1M	1M 1F	1F	1M 1F	2M 1F	1M		180	10
9-10 Oct	1M 1F	3F	3M 9F	9M 39F	18M 102F	28M 108F	34M 65F	20M 17F	5M 3F	3M	57	468
27-28 Oct			2M 1F	1M 3F	2M 7F	13M 11F	15M 7F	15M 6F	4M	2M	138	89
7-8 Nov	1M	2F	3M 4F	3M 5F	3M 7F	8M 3F	5M 5F	7M 5F	6M 1F		34	68
24-25 Nov		1M 1F	3M 7F	2M 12F	5M 21F	7M 23F	17M 14F	12M 1F	1M 2F	2M	46	131
11-12 Dec	1F		2M 3F	1M 2F	12M 10F	12M 13F	26M 6F	20M 2F	14M	3M	103	126

[1]One trap missing