SOFT-SHELL CLAM, *MYA ARENARIA* STUDY

TECHNICAL REPORT X-3

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1.0 INTRODUCTION

Normandeau Associates began providing estimates of soft-shell clam (*Mya arenaria*) standing crop in Hampton-Seabrook estuary in July 1969. This effort succeeded an investigation of soft-shell clam resources by the State of New Hampshire Department of Fish and Game in 1967 (Ayer, 1968). Between 1967 and 1969, standing crop estimates fell from 23,400 to 15,840 bushels (NAI, 1978). This decline continued until November 1977, when slightly more than 1000 bushels remained on 167 acres of tidal flats (NAI, 1978). Stock depletion was credited to over harvesting by humans, abetted by the clams' principal natural enemies, waterfowl and the green crab (*Carcinus maenas*), the latter having experienced a population boom during the early 1970's (Welsh, 1975; Dow, 1977).

In the summer of 1976, juvenile clams (spat) settled on the Hampton-Seabrook flats in densities averaging almost 800 individuals per ft^2, and in some places approaching 8000 per ft^2. Approximately 25% of the spat survived the first year. This high survival, plus a subsequent spat fall (settlement) in 1977, (approximately one fifth as intense as the previous one), augured for substantial replenishment of local stocks.

Normandeau Associates had expanded the spat (i.e., sediment core) sampling program in the spring of 1976 to include five estuaries within a 50-mile radius of Hampton-Seabrook Estuary. Survey results indicated similar heavy spat settlement occurred throughout the study area. Traditional clamming grounds, such as those in Ipswich, Massachusetts and Ogunquit Beach, Maine, which had been depleted by years of commercial and recreational digging were recovering stock even faster than Hampton-Seabrook.

Normandeau Associates' investigations have been primarily concerned with the impact of Seabrook Station's cooling water system on soft-shell clam resources. While estimates of standing crop and spat settlement densities are crucial indicators of the welfare of this resource, the principal direct impact anticipated is entrainment of planktonic larvae in the intake off Hampton Beach. Normandeau Associates has investigated spatial and temporal distribution of the larvae since 1971, although *M. arenaria* larvae were not reliably distinguished from larvae of a look-alike clam relative, *Hiatella* sp., until 1973. Since then, findings have generally supported these hypotheses (NAI, 1976, 1977, 1978):

1. Clam flats along the Massachusetts coast, north of Cape Ann, supply the bulk of the larvae recruited into Hampton-Seabrook Estuary.

2. Larvae tend to aggregate close to shore, along the open coast, the aggregations becoming progressively sparser in the offshore direction.

3. The quantity of larvae at the intake site off Hampton Beach bears no relationship to the quantity of spat settling on Hampton-Seabrook flats.

This report is the eighth in a series on the status of *M. arenaria* resources in the vicinity of Hampton-Seabrook Estuary. The above mentioned hypotheses are evaluated based on these study elements:

1. oblique plankton tows monitoring seasonal and offshore-onshore larvae distributions off Hampton Beach

2. population surveys of spat (less than 26 mm shell length) and young adults (up to 50 mm shell length) on flats in six estuaries from Ipswich, Massachusetts to Ogunquit Beach, Maine

3. surveys of adult standing crop in Hampton-Seabrook estuary (= Hampton Harbor)

4. histological examination of gonadal tissue samples to determine the timing of reproductive development in the Hampton Harbor *M. arenaria* .

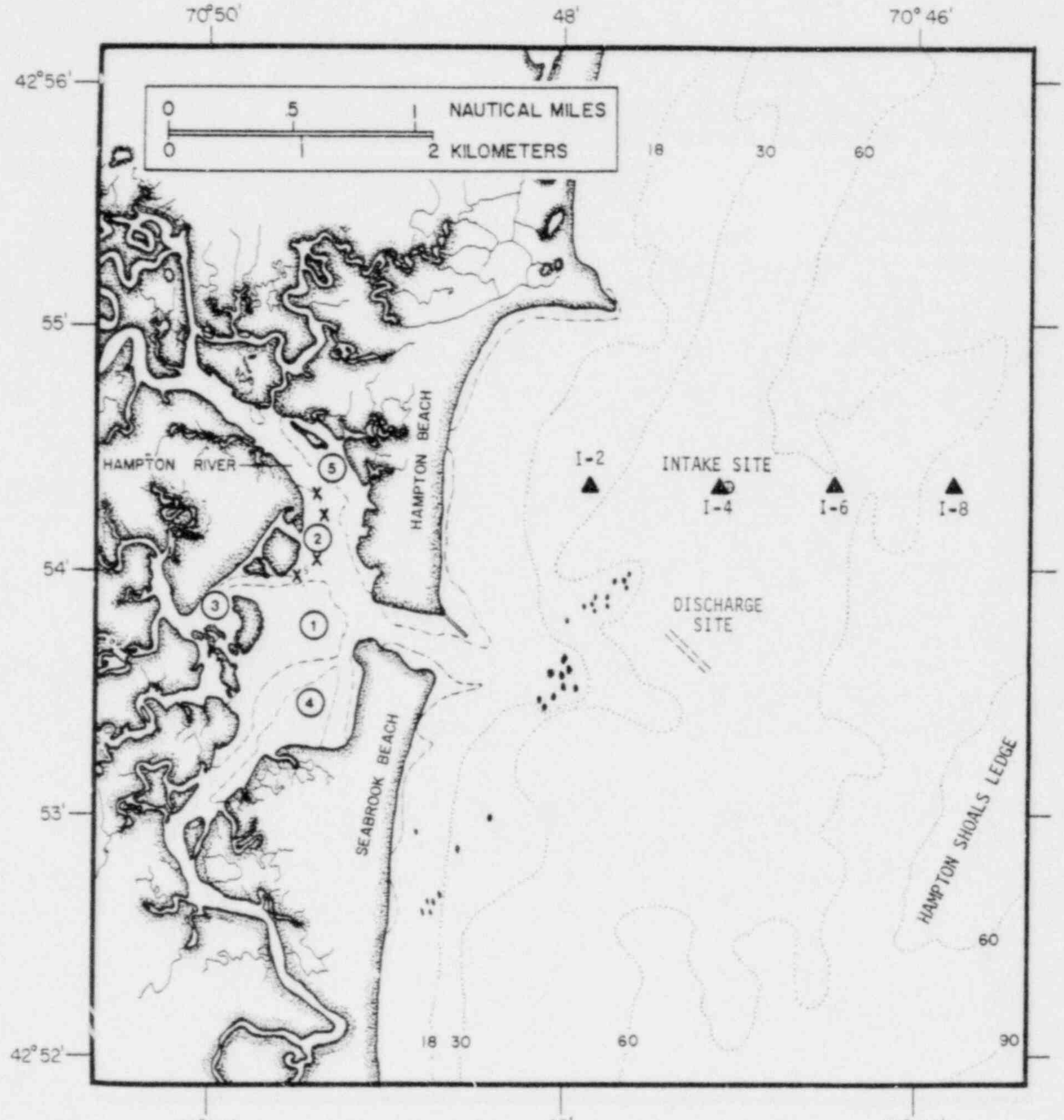
In addition, results are given for the first 18 months (July 1977 through December 1978) of a green crab trapping program designed to monitor relative predator pressure on *M. arenaria* in Hampton Harbor.

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 18 May to 19 October; weekly tows were taken from 25 April to 8 May, and from 19 to 31 October when larvae were generally 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 7m^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 s le concentrate containing the bivalves was enumerated for umboned (length 145-320 μm) *M. arenaria* larvae except when this species was particularly abundant; whereupon, 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 camels 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, 1978.

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. Enumeration of *M. arenaria* straight hinge veligers was carried out 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 define the onshore/offshore *M. arenaria* larval density distribution in the intake vicinity. Oblique tows were made at 1/2-nautical mile intervals along a transect running east to west through the intake site (Figure 1). Sample analysis procedures were as described above.

Inshore/offshore transect sample data were submitted to a 2-way fixed effect analysis of variance (Sokal and Rohlf, 1969) with two observations per cell. 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 in that once established (on the basis of preliminary evidence of high productivity), the same general locality was resampled with each survey. At each fixed collection site, sediment cores three or four inches in diameter, and four inches deep, were extracted in triplicate, using a section of PVC plastic pipe. 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 November 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 1978 for adult clams; additional surveys were conducted on Flat #2 in April 1978 (Figure 1 and Table 2).

TABLE 1. CLAM SPAT SAMPLING EFFORT. SEABROOK *MYA ARENARIA* STUDY, 1978.

a. FIXED STATIONS

LOCATION	NO. OF STATIONS	DATES
Plum Island Sound, MA		
Middle Ground	5	6 Jan 4 Apr 13 Jun 11 Aug 12 Oct
Lufin's Flat	3	6 Jan 4 Apr 13 Jun 11 Aug 12 Oct
Nut Shoal	2	6 Jan 4 Apr 13 Jun 11 Aug 12 Oct
Merrimack River, MA		
Salisbury Flat 3	5	5 Jan 6 Apr 19 Jun 9 Aug 13 Oct
Ball's Flat 1	5	4 Jan 5 Apr 19 Jun 9 Aug 13 Oct
Hampton Harbor, NH		
Flat 2	5	4 Jan 5 Apr 9 Jun 14 Aug 9 Oct
Flat 4	5	* 5 Apr 9 Jun 14 Aug 9 Oct
Little Harbor Channel, NH		
Clam Pit Island	5	13 Jan 10 Apr 16 Jun 8 Aug 6 Oct
Flat, opposite shore	1	13 Jan 10 Apr 16 Jun 8 Aug 6 Oct
Southern Maine		
York River	5	17 Jan 3 Apr 14 Jun 10 Aug 11 Oct
Ogunquit Beach	6	17 Jan 3 Apr 14 Jun 10 Aug 11 Oct

b. RANDOM STATIONS

LOCATION	NO. OF STATIONS	DATES
Hampton Harbor, NH		
Flat 1	14	6 Nov
Flat 2	7	7 Nov
Flat 3	6	6 Nov
Flat 4	11	10 Nov
Flat 5	7	7 Nov

* Not sampled

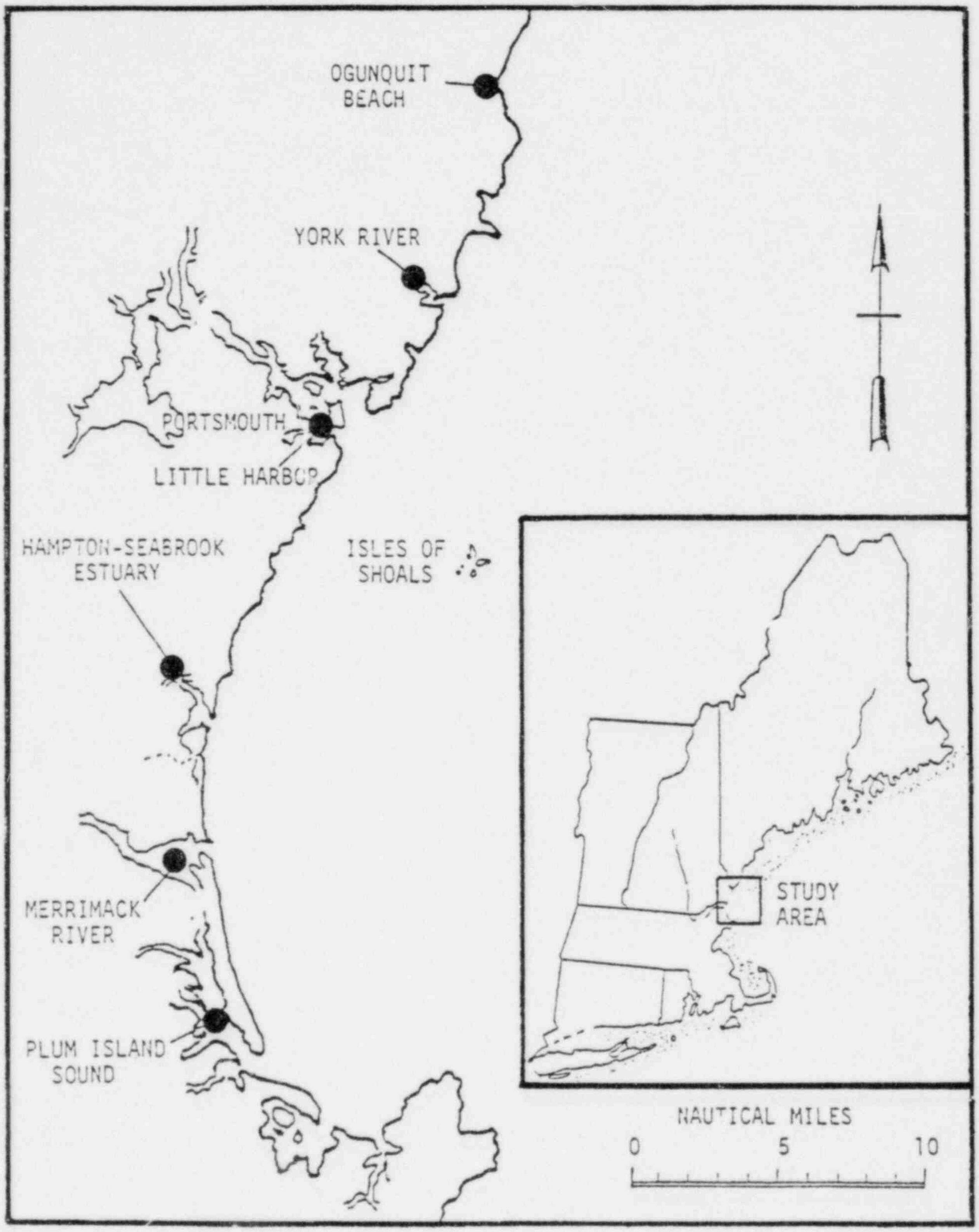


Figure 2. Location of spat study sites. Seabrook *Mya arenaria* Study, 1978.

TABLE 2. ADULT CLAM SAMPLING EFFORT, HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1978.

LOCATION	DATE	SURFACE AREA (ACRES)	TOTAL NO. SAMPLE STATIONS OBSERVED	NO. OF POTENTIALLY BARREN STATIONS SUBSAMPLED	NO. OF POTENTIALLY PRODUCTIVE STATIONS DUG
Flat 1	6 Nov	54.91	66	10	27
Flat 2	7 Nov (12 Apr)	24.96	33 (33)	4 (6)	14 (7)
Flat 3	6 Nov	10.54	24	3	12
Flat 4	10 Nov	51.05	51	9	22
Flat 5	7 Nov	23.69	38	4	16
All Flats	6-10 Nov	165.15	212	30	91

Aerial photographs were made on 11 August 1978 at mean low water and were used to construct sampling charts as they were in 1977 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%.

Random 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 as a check on the effectiveness of establishing the absence of clams by the absence of siphon holes (see Table 2).

Total number of samples to be observed for evidence of siphon holes was roughly determined by the surface area of the flat above mean low tide (Table 2). To establish sampling stations, randomly generated rectangular (x, y) coordinates were plotted on charts of each flat. Random coordinates were generated until the full quota of stations was attained for the flat. In the field, stations were located by compass bearing and distance from the central reference point established during the beach profile survey. 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.

Adult soft-shell clams 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 (1931). 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 MAENUS*) TRAPPING

From 8 July to 25 August 1977, two prism-shaped crab traps, loaned by Maine Department of Marine Resources, were hauled and reset on Flat 2 at 2 to 5 day intervals continuously, also, at least one of the two loaned traps was tended three times from 13 through 23 September.

Beginning in fall, 1977, *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 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.

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, 1978). Sections analyzed were from the dorsal, posterior quadrant below the heart, where Coe and Turner (1938) have claimed that maturation begins.

TABLE 3. GONADAL SAMPLE COLLECTIONS, 1978.

28 April	18 July
11 May	31 July
26 May	11 August
9 June	12 September
22 June	

3.0 RESULTS

3.1 PLANKTONIC LARVAE

3.1.1 Onshore-Offshore Distribution of *M. arenaria*

On some of the dates when *M. arenaria* larvae were most abundant, and on average, Station I-2 had significantly higher densities than Stations I-4, I-6 and I-8 (Table 4). Station I-8, on the other hand, had significantly lower densities than any of the other stations sampled. In addition to significant station differences, ANOVA results indicated significant differences between dates, and a significant station-date interaction; main effect differences and their interaction were significant at $p \leq .001$ (Appendix 7.1).

3.1.2 Temporal Distribution of *M. arenaria* Larvae

In 1978, *M. arenaria* umboned veligers first appeared off Hampton Beach at the end of May (Figure 3 and Table 5). Peak values of a few hundred individuals per m^3 were recorded during the second week of June; a rapid decline in population density followed in mid July. From mid July until the end of August there were never more than 5 larvae per m^3.

The second (late summer) larval peak began abruptly with up to 1800 larvae per m^3 recorded on 1 September (Table 4). Densities eventually declined to near the detection limit by the third week in October. The average larval density at I-4 from 22 May to 31 October was estimated as approximately 83 individuals per m^3.

3.1.3 Species Composition

Mya arenaria umbone veligers only occasionally dominated the bivalve veliger assemblage off Hampton Beach in late summer and early

TABLE 4. DENSITY DISTRIBUTION (INDIVIDUALS PER m^3) OF UMBONED *M. ARENARIA* VELIGERS ALONG THE EAST-WEST INTAKE TRANSECT. SEABROOK *MYA ARENARIA* STUDY, 1978.

DATE	STATION:	I_2		I_4		I_6		I_8		SIGNIFICANCE OF STATION DIFFERENCES
	REPLICATE:	1	2	1	2	1	2	1	2	(@ $p \leq .05$; TUKEY'S PAIRWISE COMPARISONS)
5 Jun		234	208	80	52	50	48	46	45	$I_2 > I_6$ and I_8
12 Jun		415	478	260	212	318	189	275	176	None
26 Jun		120	106	99	52	50	52	52	34	None
10 Jul		133	169	40	94	146	92	102	62	None
1 Sep		170	1770	210	118	111	71	3	4	$I_2 > I_4$ through I_8 $I_8 < I_2$ through I_6
5 Sep		56	28	0	17	12	24	9	9	None
21 Sep		612	520	458	307	180	175	36	49	$I_2 > I_6$ and I_8 $I_8 < I_2$ and I_4
Station Mean		430		143		108		64		$I_2 > I_4$ through I_8 $I_8 < I_2$ through I_6

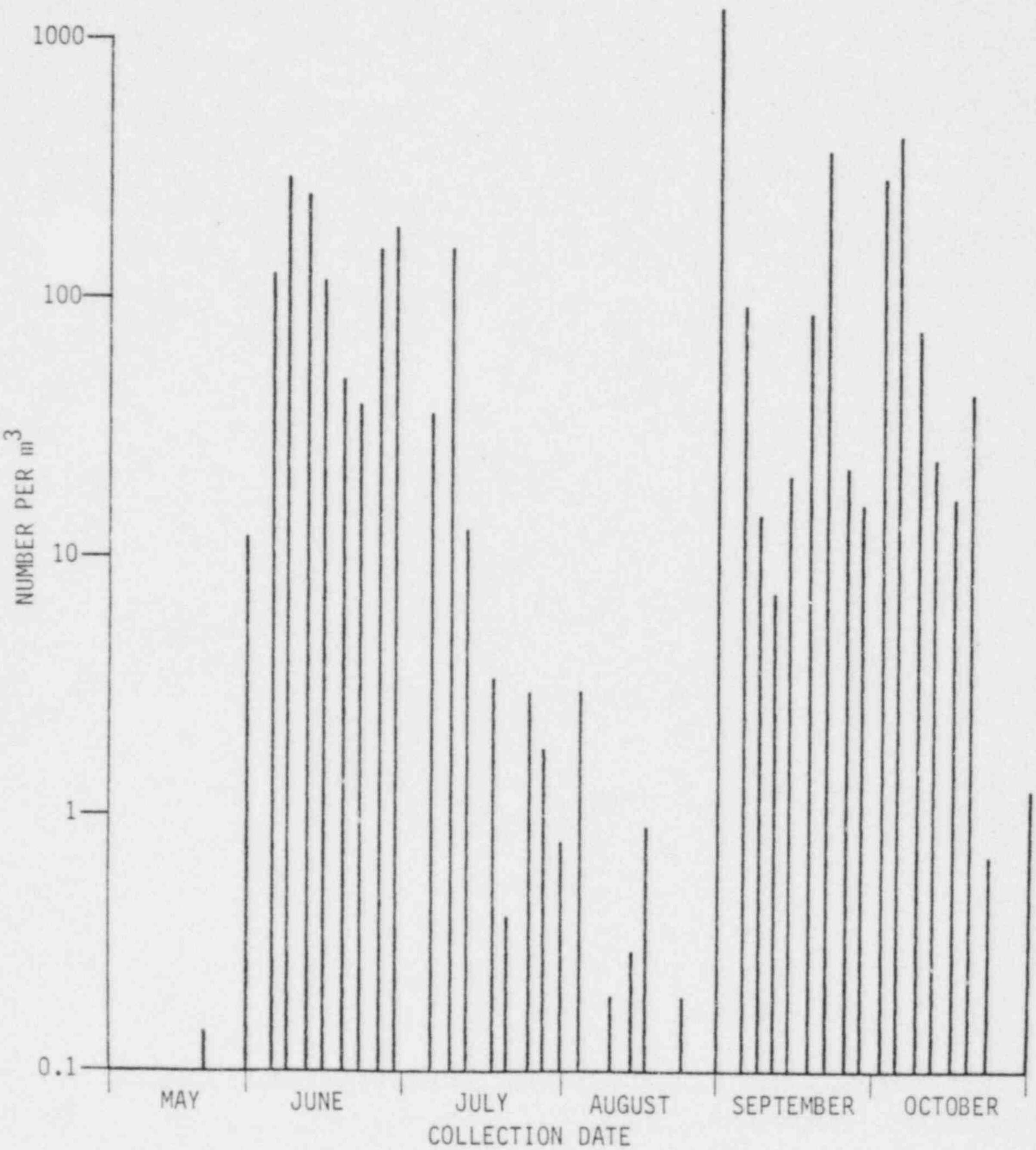


Figure 3. Temporal distribution of umboned *Mya arenaria* veligers at the intake site off Hampton Beach, New Hampshire. Seabrook *Mya arenaria* Study, 1978.

TABLE 5. DENSITIES (PER M^3) OF UMBONED *M. ARENARIA* VELIGERS COLLECTED AT THE COOLING WATER INTAKE SITE (I-4). SEABROOK *MYA ARENARIA* STUDY, 1978.

DATE	REPLICATE 1	REPLICATE 2	MEAN	REMARKS
25 Apr	0.0	0.0	0.0	
1 May	0.0	0.0	0.0	
8 May	0.0	0.0	0.0	
18 May	0.0	0.0	0.0	
22 May	0.3	0.0	0.1	
30 May	10.0	14.0	12.0	
5 Jun	125.0	*	125.0	See also Table 4
8 Jun	276.0	316.0	296.0	
12 Jun	260.0	*	260.0	See also Table 4
15 Jun	150.0	88.0	119.0	
19 Jun	48.0	39.0	44.0	
22 Jun	52.0	26.0	39.0	
26 Jun	211.0	100.0	156.0	See also Table 4
29 Jun	142.0	240.0	191.0	
6 Jul	41.0	32.0	36.0	
10 Jul	174.0	142.0	158.0	See also Table 4
13 Jul	17.0	15.0	16.0	
18 Jul	3.3	3.4	3.4	
21 Jul	0.3	0.5	0.4	
25 Jul	1.5	4.1	3.0	
28 Jul	2.4	1.0	1.8	
31 Jul	1.4	0.3	0.8	
4 Aug	1.1	5.3	3.1	
7 Aug	0.0	0.0	0.0	
10 Aug	0.0	0.5	0.2	
14 Aug	0.4	0.3	0.3	
17 Aug	0.0	1.8	0.9	
21 Aug	0.0	0.1	<0.1	
24 Aug	0.3	0.2	0.2	
28 Aug	0.0	0.0	0.0	
31 Aug	463.0	2250.0	1360.0	
1 Sep				See Table 4
5 Sep	118.0	69.0	94.0	See also Table 4
8 Sep	18.0	12.0	15.0	
11 Sep	9.5	5.2	7.4	
14 Sep	26.0	16.0	21.0	
18 Sep	76.0	105.0	90.0	
21 Sep				See Table 4
25 Sep	21.0	23.0	22.0	

(Continued)

*not enumerated

TABLE 5. (Continued)

DATE	REPLICATE 1	REPLICATE 2	MEAN	REMARKS
28 Sep	18.0	16.0	17.0	
2 Oct	281.0	326.0	306.0	
5 Oct	428.0	446.0	437.0	
9 Oct	50.0	105.0	75.0	
12 Oct	19.0	30.0	24.0	
16 Oct	14.0	20.0	17.0	
19 Oct	43.0	45.0	44.0	
23 Oct	0.8	0.5	0.7	
31 Oct	1.4	1.2	1.3	

Average density, 22 May to 31 October: 83.3 larvae per m^3

fall (Table 6). *Hiatella* sp. was virtually the only bivalve represented from the beginning of the 1978 tow program in late April, until early June. Mussels, *Modiolus modiolus* (horse mussel) and *Mytilus edulis* (blue mussel) predominated from June through the end of July. Thereafter, *Anomia* spp. (jingle shells) assumed dominance until the end of August. Throughout most of September, veligers of *Macoma balthica* and *Spisula solidissima* (surf clam) predominated. Very few larvae of *Placopecten magellanicus* (sea scallop) were collected this year.

3.2 SPAT AND YOUNG ADULTS

In Plum Island Sound, a substantial portion of the 1976 spat set had already attained "adulthood" by January 1978 (Table 7; Appendix 7.2), the threshold of sexual maturity having been defined as 26 mm shell length (Belding, 1930). At Ogunquit Beach, recruitment to adulthood followed at a slightly slower pace. Substantial recruitment to the over 25 mm category did not occur in Hampton Harbor until the summer of 1978. For the first time in over three years, clams 25 to 43 mm long were collected from the Merrimack River estuary late in 1978. Few young adults were evident at the York River flat, even in late 1978, while none were found in Little Harbor Channel.

The spat category was composed of individuals representing the 1976 and 1977 year classes during the first half of 1978; young of the year recruitment followed in late summer, but was modest at all study sites compared to 1977 and, particularly, 1976 spatfalls (Table 7; Appendix 7.2). This progressive decrease in young-of-the-year recruitment from 1976 through 1978, influenced size-frequency distributions for Hampton Harbor (Figure 4). Two and three mm size classes overwhelmingly dominated the 1976 size-frequency distribution, but the numerical importance of these size classes progressively diminished in succeeding November surveys. Meanwhile, frequency peaks representing the three most recent spat year classes became less and less distinct as growth of later settling individuals overtook some of the slower growing earlier settlers.

TABLE 6. PERCENT COMPOSITION OF BIVALVE UMBONED VELIGERS IN OBLIQUE NET TOWS IN THE VICINITY OF THE INTAKE SITE. SEABROOK *MYA ARENARIA* STUDY, 1978.

DATE	*Modiolus* .	*Mytilus* .	*Hiatella* .	*Anomia* .	*Ensis* .	*Mya* .	*Placopecten* .	Others .	AVERAGE DENSITY (NO. PER M^3)
25 Apr	0.0	0.0	99.8	0.0	0.0	0.0	0.0	0.2	112
1 May	0.0	0.0	100.0	0.0	0.0	0.0	0.0	<0.1	1,330
8 May	0.0	0.0	100.0	0.0	0.0	0.0	0.0	<0.1	77
18 May	0.0	0.0	99.9	0.0	0.0	0.0	0.0	<0.1	296
22 May	0.0	0.0	99.4	0.0	0.0	0.6	0.0	<0.1	16
30 May	0.0	0.0	94.6	0.0	0.0	5.4	0.0	0.1	224
8 Jun	61.5	24.9	10.3	0.0	1.8	0.3	<0.1	1.2	120,000
15 Jun	11.8	67.2	16.4	0.1	1.2	2.0	0.4	0.9	5,900
22 Jun	16.0	67.6	13.1	0.3	0.8	0.1	0.1	2.0	50,300
29 Jun	17.2	52.1	27.6	0.4	1.6	0.2	<0.1	0.8	88,200
6 Jul	9.8	68.1	4.8	1.8	11.1	3.4	0.0	0.9	1,070
13 Jul	0.6	84.4	6.9	2.6	2.5	0.2	0.0	2.8	7,180
18 Jul	2.0	77.0	1.8	3.4	7.4	0.2	0.0	8.2	2,210
25 Jul	1.0	92.1	0.8	1.9	0.7	<0.1	0.0	3.6	8,980
4 Aug	4.2	44.6	5.6	31.9	3.5	1.2	0.0	3.6	278
10 Aug	4.2	31.4	5.3	51.2	1.4	<0.1	0.0	6.5	1,520
17 Aug	0.2	32.6	2.5	45.5	1.1	1.5	0.2	16.4	60
24 Aug	0.3	17.3	1.8	54.8	2.1	0.8	0.0	22.8	28
31 Aug	0.0	2.6	<0.1	0.6	1.2	85.8	0.0	9.8	1,550
8 Sep	0.6	19.4	0.2	1.2	2.0	8.0	0.0	68.6*	199
14 Sep	0.5	4.1	0.4	1.2	18.0	4.2	0.0	71.6*	525
21 Sep	4.4	17.4	0.2	7.6	9.0	23.8	0.0	37.6*	1,430
28 Sep	45.8	6.6	0.2	9.2	9.2	11.2	0.0	17.8*	159
5 Oct	12.8	6.2	0.0	2.2	20.1	35.0	0.0	23.7*	1,240
12 Oct	14.8	7.5	3.4	14.0	19.3	23.7	0.0	17.3*	104
19 Oct	10.0	9.5	2.9	12.4	21.2	20.7	0.0	23.3*	214
31 Oct	4.4	20.6	5.7	32.9	9.3	4.9	0.0	22.2	28

*predominantly *Macoma balthica* and *Spisula solidissima*

TABLE 7. SPAT AND YOUNG ADULT DENSITIES (PER FT^2) FOR SIX NORTHERN NEW ENGLAND ESTUARIES (SPAT: >1 TO 25 mm; YOUNG ADULTS: 26 TO 50 mm). SEABROOK *MYA ARENARIA* STUDY, 1978.

LOCATION	SAMPLE DATE	JAN		APR		JUN		AUG		OCT	
	SIZE GROUP	SPAT	YOUNG ADULTS	SPAT	YOUNG ADULTS	SPAT	YOUNG ADULTS	SPAT	YOUNG ADULTS	SPAT	YOUNG ADULTS
Plum Island Sound, MA		156	36	183	40	133	24	176	47	183	52
Merrimack River Estuary, MA		190	0	80	0	105	0	51	1	80	9
Hampton Harbor, NH		287	0	525	2	192	1	311	21	604	55
Little Harbor Channel, NH		9	0	15	0	16	0	2	0	22	0
York River, ME		88	0	53	1	53	0	27	3	33	2
Ogunquit Beach, ME		34	8	33	21	39	17	43	25	45	18

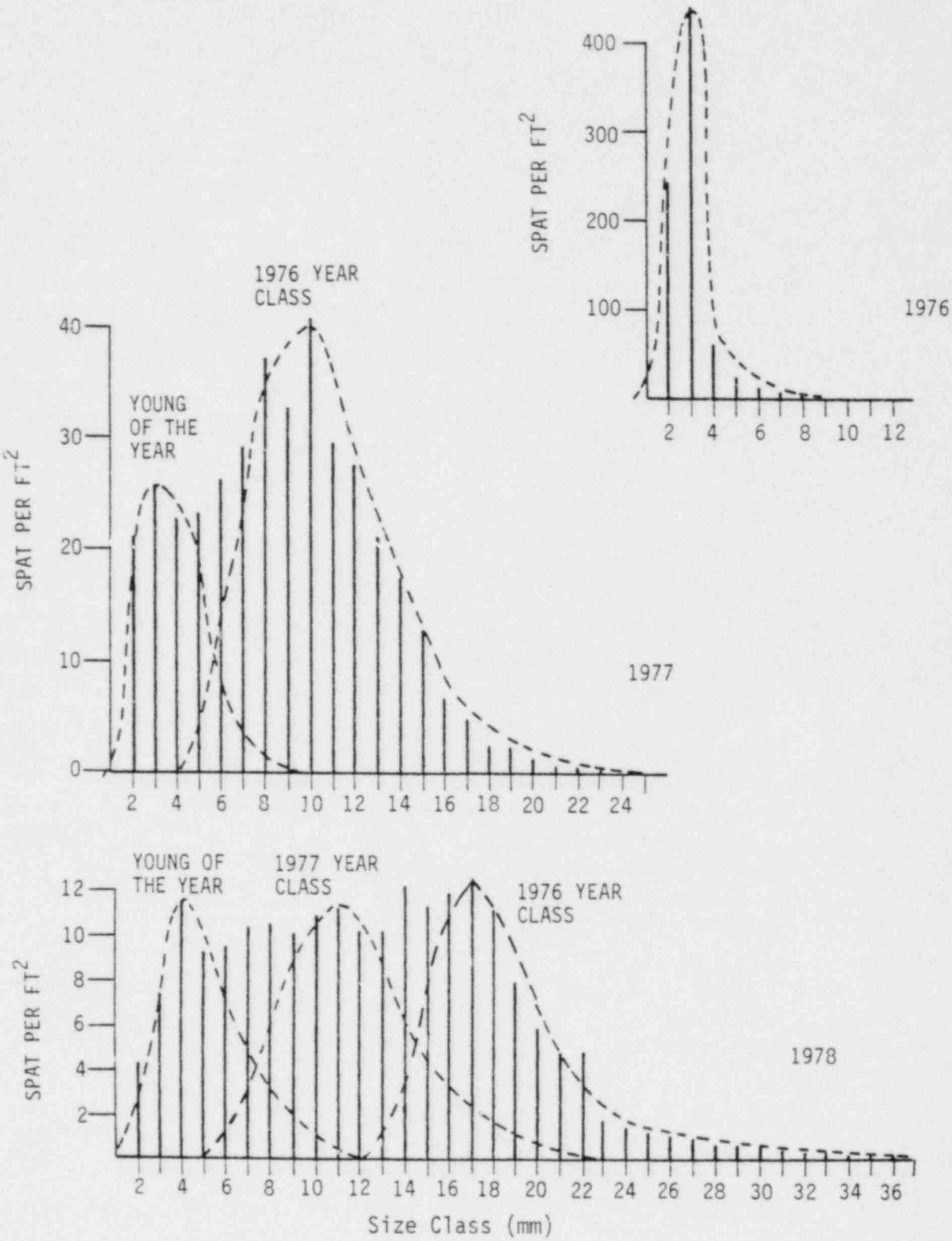


Figure 4. Size-frequency distributions of young *Mya arenaria* from November surveys in Hampton Harbor. Seabrook *Mya arenaria* Study, 1978.

By November 1978, a few of the fastest growing representatives of the 1976 year class in Hampton Harbor had attained a shell size of up to 42 mm. Most of these were found on Flats 4 and 5 (Appendix 7.3). All of the Hampton-Seabrook flats, however, showed substantial increases in young adult population, while the spat category declined from the previous two years (Table 8).

As inferred from size distribution data, presented in Appendix 7.2, a wide variation in shell growth was apparent within each of the estuaries investigated (Table 9). Average annual growth was highest in Plum Island Sound and lowest in Hampton Harbor and Little Harbor channel.

3.3 ADULT STANDING STOCKS IN HAMPTON HARBOR

For the first time since the earliest clam population surveys (Table 8) young adult clams (26 to 50 mm) completely outnumbered older clams (>50mm). In Table 10, clams larger than 42 mm were distinguished from smaller clams to compare 1978 data with previous results. The 42 mm cut off was chosen because the largest representatives of the 1976 year class appeared to be no more than 42 mm long. Clams considerably less than 42 mm are probably too small to be of value as human food; thus, the term "marketable" was given to the over 42 mm category.

The former minimum legal size, 51 mm (2 inches) is no longer used in New Hampshire; however, even if the 45 mm size class were added to the 50 mm and up category, biomass estimates would be increased only nominally. The influence of individual clams on biomass estimates increases exponentially with increase in body size; yet, smaller-bodied 1976 year-class clams succeeded in dominating older, larger-bodied clams because of almost two orders of magnitude numerical superiority (Figure 5).

At the end of 1978, biomass estimates of marketable sized clams were about the same as they had been one year earlier (Figure 6).

TABLE 8. SUMMARY OF *MYA ARENARIA* POPULATION DENSITIES, ANNUAL NOVEMBER SURVEY. SEABROOK *MYA ARENARIA* STUDY, 1978.

LOCATION	YEAR	NUMBER OF SAMPLES COLLECTED		POPULATION DENSITY (#/SQ. FT.)		
		ADULTS	SPAT	SPAT (>1 TO 25 mm)	YOUNG ADULTS (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
Flat 2	1971	9	9	91	4.8	3.8
	1972	9	9	152	2.2	1.4
	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
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	0	50	1.2	0.14
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

(Continued)

TABLE 8. (Continued)

LOCATION	YEAR	NUMBER OF SAMPLES COLLECTED		POPULATION DENSITY (#/SQ. FT.)		
		ADULTS	SPAT	SPAT (>1 TO 25 mm)	YOUNG ADULTS (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
All Flats	1971	54	54	92	7.7	2.7
	1972	54	54	130	6.2	2.2
	1973	111	56	47	[illegible].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	0.20
	1977	212	47	388	0.05	0.07
	1978	212	45	208	4.4	0.09

TABLE 9. COMPARISON OF *M. ARENARIA* SHELL GROWTH (MM) IN SIX NORTHERN NEW ENGLAND ESTUARIES. SEABROOK *MYA ARENARIA* STUDY, 1978.

LOCATION	1976 YEAR CLASS				1977 YEAR CLASS	
	1st YEAR		2nd YEAR		1st YEAR	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
Plum Island Sound						
Middle Ground	14-33	20	31-59	40	9-31	17
Lufkin's Flat	18-35	26	31-56	42	16-28	22
Nut Shoal	13-32	21	32-60	42	14-28	19
Merrimack River						
Salisbury Flat 3	*		*		16-26	18
Ball's Flat 1	*		*		11-30	13
Hampton Harbor						
Flat 2	9-16	12	16-39	22	8-18	14
Flat 4	+		14-36	19	8-15	12
Little Harbor Channel	9-16	11	*		12-21	16
York River	*		27-41	33	12-23	17
Ogunquit Beach	10-27	18	29-46	38	13-26	18

* Insufficient data due to heavy predation

\+ Not sampled in summer 1977

TABLE 10. RESULTS OF SOFT-SHELL CLAM STANDING STOCK ESTIMATES, HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1978.

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	6 Nov	54.91	66	10	27	29.4	7.3	16.3 ± 3.4	895 ± 185
Flat 2	7 Nov	24.96	33	4	14	65.5	0.0	27.8 ± 8.1	694 ± 203
	12 Apr		33	6	7	57.3	8.5	18.8 ± 7.5	470 ± 186
Flat 3	6 Nov	10.54	24	3	12	36.0	0.0	18.0 ± 5.6	190 ± 60
Flat 4	10 Nov	51.05	51	9	22	218.2	13.4	101.8 ± 15.5	5195 ± 790
Flat 5	7 Nov	23.69	38	4	16	74.3	4.0	33.6 ± 16.6	796 ± 392
All Flats	6-10 Nov	165.15	212	30	91				
All adult clams						89.4	7.0	42.4 ± 5.9	7000 ± 970
"marketable" size clams (>42 mm)						10.2	2.4	5.7 ± 1.3	940 ± 215

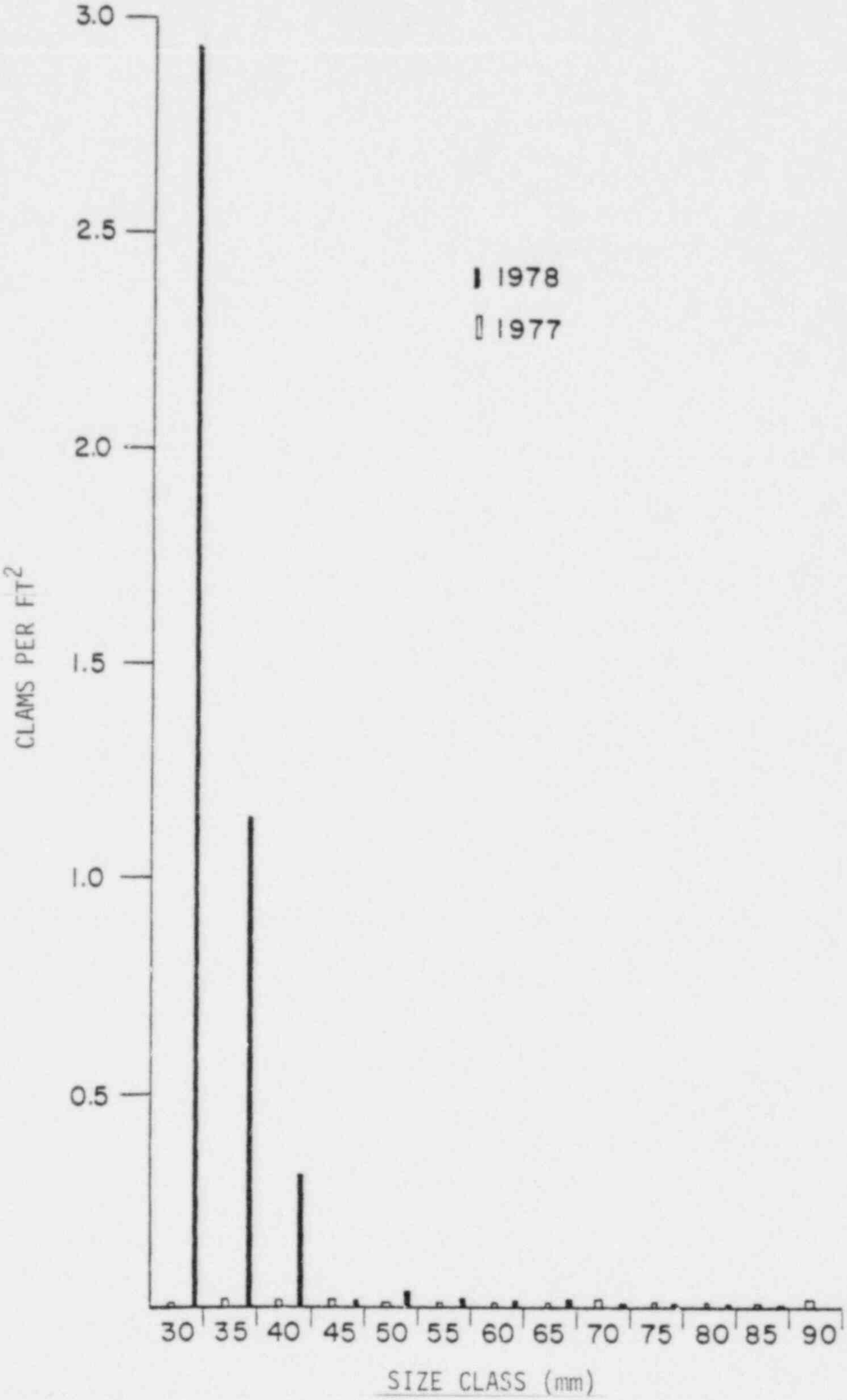


Figure 5. Length density distribution of adult clams collected in November surveys from five flats in Hampton Harbor. Seabrook *Mya arenaria* Study, 1978.

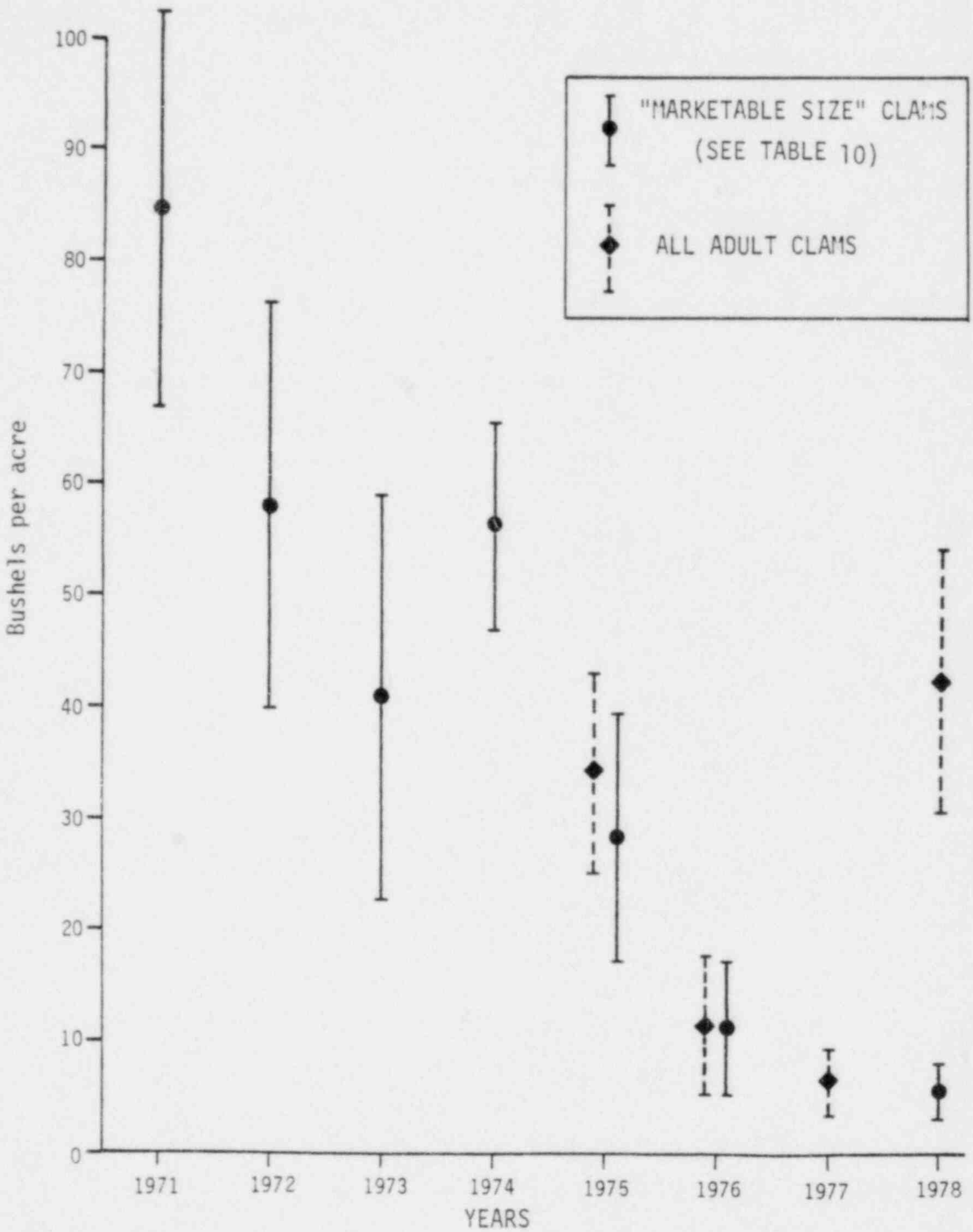


Figure 6. Estimate of *Mya arenaria* biomass for five tidal flats in Hampton Harbor, with approximately 95% confidence intervals. Seabrook *Mya arenaria* Study, 1978.

Flat 1, with one third of the total flat acreage, held approximately 41% of the total marketable crop; but, Flat 4, with approximately 74% of the total standing crop, appeared to hold the greatest potential for future yields (Tables 10 and 11). Due to the successful establishment of the 1976 year class, estimates of percent productive f at area took a sharp upward turn in 1978, halting the progressive decline that had characterized previous years (Table 12).

3.4 *CARCINUS MAENAS*

For comparison, data from the preliminary, summer 1977, effort has been presented in Figure 7, Table 13 and Appendix 7.5 along with the later, twice monthly, trapping data. It is unlikely that size frequency distribution (Figure 7), or sex ratio and fecundity (Table 13) has been appreciably affected by the difference in catch method. On the other hand, summer 1977 catch per effort values are probably not equivalent to similar values computed from subsequent trapping results.

The smallest crab taken during the study was 1.5 cm at the widest part of the carapace while the largest was 7.2 cm wide. From July 1977 through December 1978, approximately 99% of the crabs caught had carapaces between 3 and 7 cm wide. Although the majority of the captures were female (Table 13), males predominated at carapace widths greater than 6 cm (Appendix 7.5). In 1977, fecundity appeared to be highest from the third week in July through mid August (Appendix 7.5). In contrast, fecundity peaked in mid-May, 1978. In both years the egg bearing season virtually ended in mid September, although a single gravid female was caught in December in 1977 and 1978 (Appendix 7.5).

TABLE 11. COMPARISON OF "MARKETABLE" AND TOTAL STANDING CROP ESTIMATES, HAMPTON-SEABROOK ESTUARY, NOVEMBER SURVEY. SEABROOK *MYA ARENARIA* STUDY, 1978.

LOCATION	"MARKETABLE" BIOMASS (BUSHELS PER ACRE)	"MARKETABLE" STANDING CROP (BUSHELS)	TOTAL STANDING CROP (BUSHELS)	PERCENT "MARKETABLE" SIZE*
Flat 1	7.0	383	895	43
Flat 2	7.4	185	694	27
Flat 3	10.7	113	190	60
Flat 4	2.5	126	5195	2
Flat 5	3.1	74	796	9
All Flats	5.7	940	7000	13

* of total standing crop on flat in question

TABLE 12. ESTIMATES OF CLAM FLAT PRODUCTIVE AREA (%) IN HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1978.

LOCATION	YEAR OF SURVEY				
	1978	1977	1976	1975	1974
Flat 1	60	17	35	53	80
Flat 2	36	15	17	41	63
Flat 3	42	32	48	39	67
Flat 4	62	20	19	57	98
Flat 5	43	22	27	4	20
All Flats	52	19	26	45	66

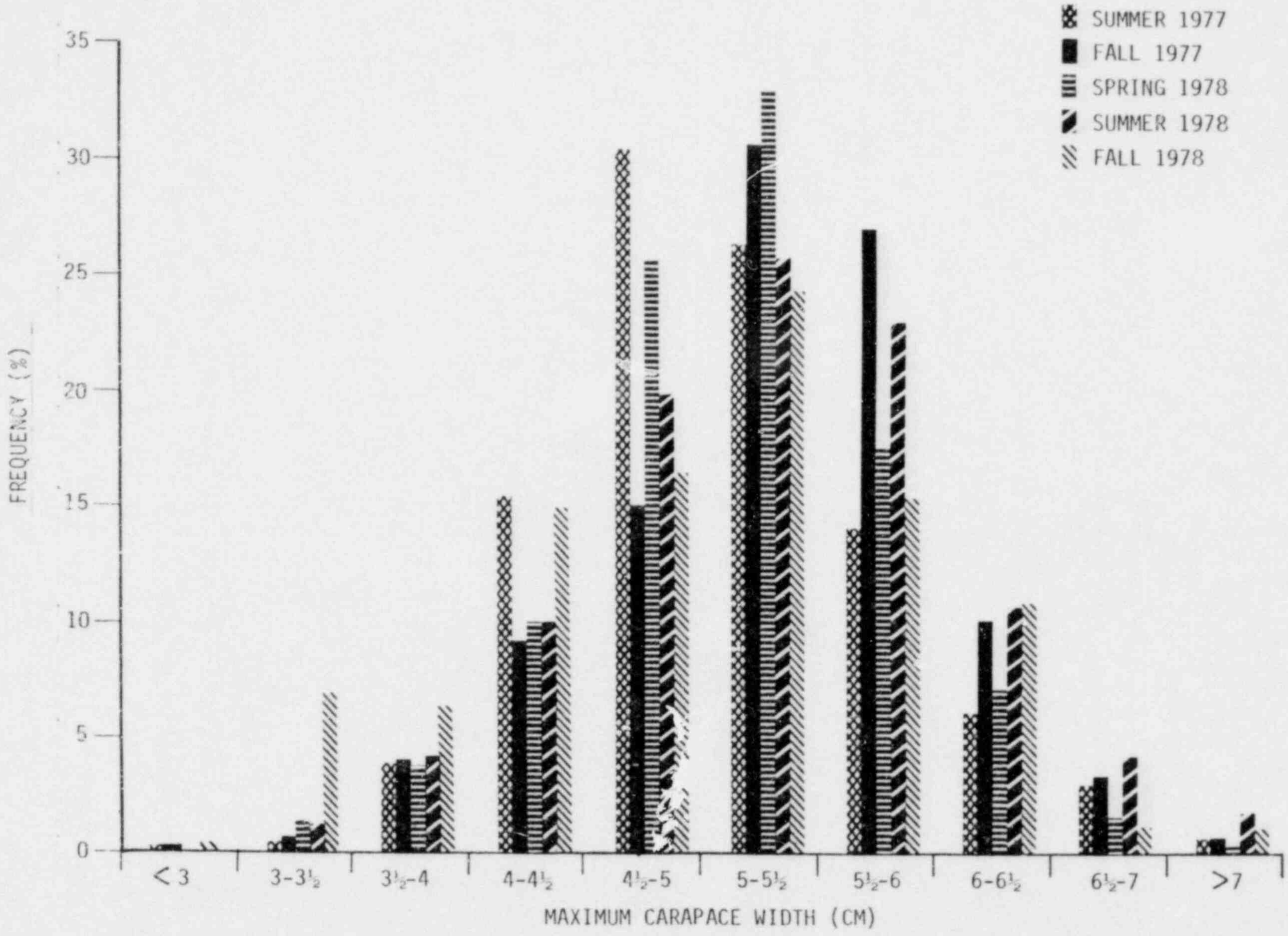


Figure 7. Size frequency distribution of *Carcinus maenas* from Hampton Harbor Flat 2. Seabrook *Mya arenaria* Study, 1978.

TABLE 13. SELECTED *C. MAENAS* CATCH STATISTICS 1977-1978. SEABROOK *MYA ARENARIA* STUDY, 1978.

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
Fall 1977[c]	17.5	1:0.9	0.3
Spring 1978[c]	7.5	1:3.3	7.0
Summer 1978[c]	8.6	1:1.5	3.2
Fall 1978[c]	7.2	1:1.3	0.5

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[a] No. of *C. maenas* per trap per day

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

[c] Eight "box" traps, fishing for 24 hours twice per month

3.5 *MYA ARENARIA* REPRODUCTIVE CYCLE

Examination of gonad condition in Hampton-Seabrook *M. arenaria* populations indicated a single annual spawning cycle in 1978 (Figure 8). Gametogenesis appeared to begin in females in late winter or early spring; whereas, male gametogenesis apparently did not begin until early May. Once started, however, male gonad development proceeded rapidly enough that both sexes were ready to spawn by July. Spawning activity peaked during August and September, with some activity probably continuing after the last gonad sample collection in mid September.

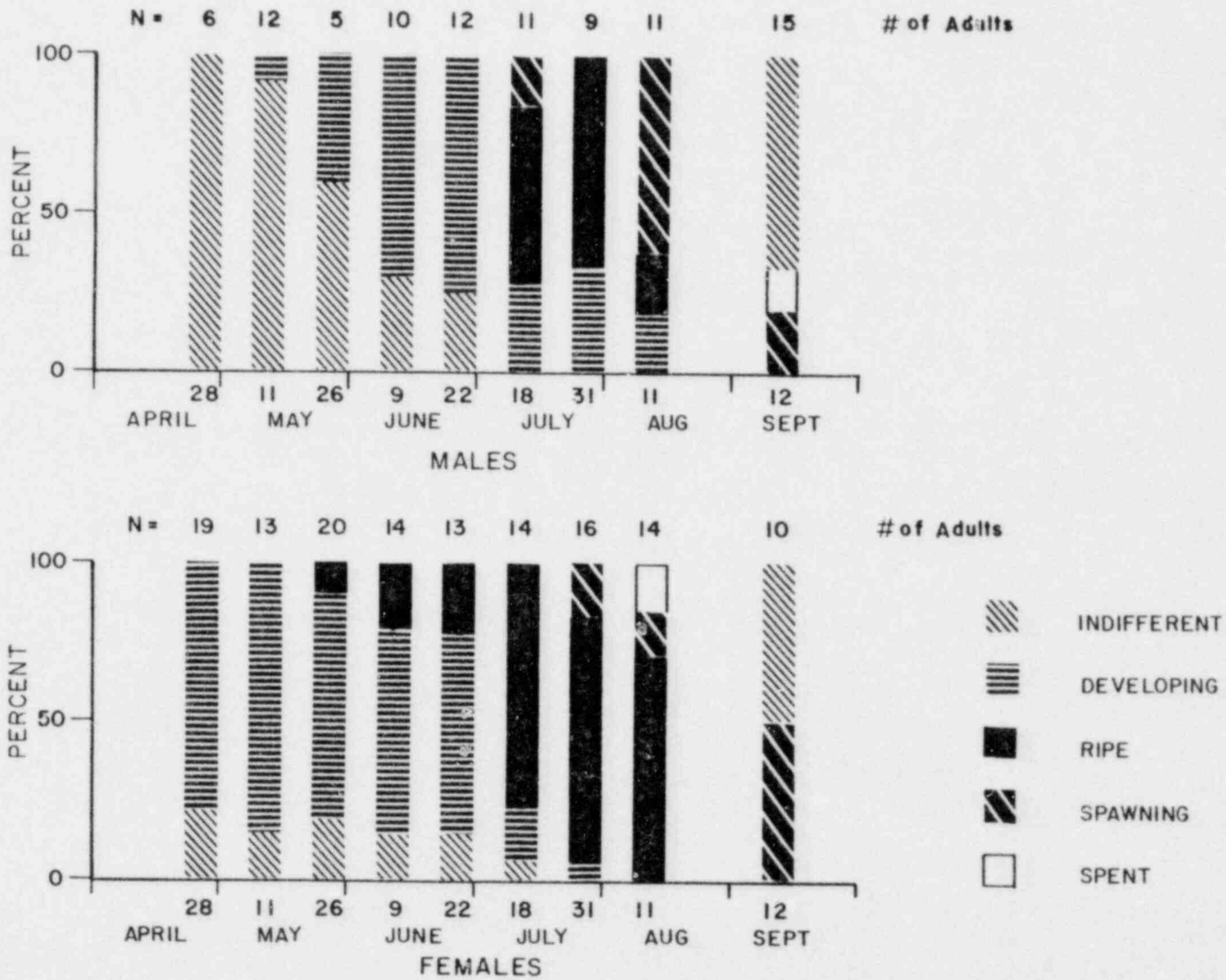

Figure 8 . Percentages of male and female *Mya arenaria* in each gonadel development phase during 1978.

4.0 DISCUSSION

4.1 ORIGIN, DISTRIBUTION AND RECRUITMENT OF *MYA ARENARIA* LARVAE

In 1978, plankton tows clearly indicated a bimodal temporal distribution of *M. arenaria* larvae, confirming earlier suspicions based on scant evidence (NAI, 1977) that a late spring, or early summer, abundance peak may, in some years at least, precede the well documented late summer peak. Examination of 1978 gonad samples, on the other hand, corroborated earlier NAI (1971) findings of a single, late summer, spawning cycle in Hampton-Seabrook Estuary. Presuming that these findings are representative of the entire estuary, this discrepancy can have only one logical explanation: larvae which appear in New Hampshire nearshore waters in early summer largely come from source(s) other than Hampton-Seabrook estuary.

Correlation between water currents flowing northward for several days and peaks in larvae abundance was first noted in 1975 (NAI, 1976) and led to the supposition that northern Massachusetts was the origin of much of the larvae entering New Hampshire waters. The credibility of this hypothesis has now been enhanced by present evidence of bimodal larvae peak abundance combined with Brousseau's (1978) claim that *M. arenaria* populations in the Jones River, Gloucester, Massachusetts spawn in spring, and again in late summer. Until Brousseau's histological examination of gonad tissue from Jones River *M. arenaria* bimodal spawning periodicity had been conclusively demonstrated only south of Cape Cod (Landers, 1954; Pfitzenmeyer, 1962; Ropes and Stickney, 1965).

In 1978, dense populations of *M. arenaria* larvae continued to be closely associated with onset of northerly wind drift, usually following a period of indeterminant or southerly current flow (Appendix 7.4). The heaviest concentration of larvae (31 August and 1 September) was associated with abrupt onset of high velocity northward flowing currents (30 and 31 August; Appendix 7.4).

Onset of strong northerly flow on 12 August did not produce an abundance of *M. arenaria* larvae probably because during this time clams were not spawning but recovering ("resting") from earlier (May-June) spawning efforts. In 1978, the summer larval peak was unusually late; observations during the past several years also indicate that a high larvae concentration in July is unusual (NAI 1975, 1976, 1977, 1978), suggesting that delayed timing of a spring peak, until early summer, may have offset the timing of the conventionally accepted summer peak.

The hypothesis that *M. arenaria* larvae are more densely distributed inshore along the New Hampshire coast requires no further elaboration. As explained in previous reports (NAI, 1977, 1978), the inshore-offshore gradient occurs as a statistically average condition, and is most fully expressed when the larvae are abundant.

Umboned veliger abundance off Hampton Beach continued to be poorly correlated with spat settlement density in Hampton Harbor (Table 14). Although larval abundance increased by a factor of nearly 20, from a five year low in 1977, spat settlement declined by a factor of approximately four between 1977 and 1978. A similar independence of *Crassostrea virginica* larval abundance and spatfall density has long been noted by commercial oystermen (pers. comm., Long Island Oyster Co. representatives).

4.2 OTHER BIVALVE MOLLUSC LARVAE

To the species, *Modiolus modiolus, Mytilus edulis, Hiatella* sp. and *Anomia* sp. which predominated in 1977 (NAI, 1978), 1978 results added *Macoma balthica* and *Spisula solidissima*. In both years, *M. modiolus* larvae populations peaked during June and exhibited concentrations in excess of 50,000 larvae per m^3. Also in both years, *Anomia* sp. comprised up to 54% of the total population in August. Generally, *Hiatella* sp. percent composition was relatively low in the summer of 1978 compared to 1977; there were no spring samples in 1977 to compare with 1978 findings.

TABLE 14 . COMPARISON OF *M. ARENARIA* UMBONED LARVAL ABUNDANCE OFF HAMPTON BEACH WITH YOUNG-OF-THE-YEAR SPAT DENSITIES IN HAMPTON HARBOR. SEABROOK *MYA ARENARIA* STUDY, 1978.

YEAR	PERIOD OVER WHICH LARVAE WERE COLLECTED	LARVAL DENSITY		DENSITY OF YOUNG-OF-THE-YEAR (Spat per ft^2)
		MEAN (per m^3/day)	DAILY MEAN x SEASON LENGTH (per m^3)	
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 Jun 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	46

Ensis directus occurred in concentrations of up to 2000 larvae per m^3 on 19 September 1977, but barely attained peak concentrations of 450 per m^3 on 5 October 1978. This difference may not be definitive since it is the nature of such planktonic populations to fluctuate widely even within a few hours. Absence of *Placopecten magellanicus* larvae from fall 1978 collections through the end of October may have been due to the same seasonal delay which appears to have affected the temporal distribution of other bivalve mollusc larvae as well.

4.3 SHELL GROWTH

Evidence presented in Table 9 and in Appendix 7.2 indicates that *M. arenaria* shell growth has been generally slower in New Hampshire waters than in adjacent areas of northern Massachusetts and southern Maine. Size frequency distribution graphs given by Brousseau (1978) show growth rates in the Jones River, Gloucester, Massachusetts, comparable to rates reported here for Lufkin's Flat in Plum Island Sound. Dow and Wallace (1951) reported the average 1 year old clam in the Scarboro River and in Doctor's Creek, Wells, Maine, to be approximately 20 mm, and the average 2 year old clam to be approximately 33 mm. These values are reasonably close to average values reported here for the York River and Ogunquit Beach, Maine (Table 9).

In Hampton-Seabrook estuary, Ayer (1968) reported growth rate of clams in "growth boxes" similar to the growth rate reported by Dow and Wallace (1951). Subsequently, NAI (1977) gave slightly higher growth rate estimates than those of Ayer (1968) for the 1968 through 1972 Hampton-Seabrook year classes. Thus, Hampton-Seabrook clams, in the 1976 and 1977 year classes, appear to be experiencing less than optimum growth.

Substratum was probably not an important factor in the observed shell growth differential although quantitative substrate sampling has been restricted to Hampton Harbor (NAI 1978) visual examination has shown no

distinctive differences between flats in the six estuaries studied. Fine sand predominated at all sampling sites, with some slightly more muddy or shelly areas also present.

Crowding is probably the main reason for the slower than expected growth in Hampton-Seabrook estuary. NAI (1978) presented data suggesting growth to be inversely proportional to population density. Earlier, Stickney (1964) found such a relationship between growth and population density in a small cove near Bremen, Maine. Laboratory experiments (Stickney, 1964) indicated the detrimental effects of crowding to be related to competition for food (i.e., unicellular microalgae). Food scarcity may be a particularly critical issue in estuaries like Hampton-Seabrook which have high flushing rates preventing endemic aggregation (build up) of algal populations.

4.4 SURVIVORSHIP AND PREDATION

Judging from the areas under the size density curves in Figure 5, approximately 25% of young clams in both the 1976 and 1977 year class have survived from one November survey to the next. It is estimated that approximately 6% of those clams which settled on Hampton Harbor flats in 1976 survived until November 1978. Earlier calculations of first-year survival (NAI, 1977) gave estimates ranging from 0.2% for the 1975 year class to 7% for the 1971 year class; data then available showed 25% survival occurring only in the second and subsequent years following settlement. Present estimates therefore suggest marked recent improvement in first year survival, a finding supported by observation of young adults (25 to 43 mm) in the Merrimack River estuary for the first time in three years (Section 3.2).

The apparent increase in first year survivorship, accompanying an increase in population density, suggests relaxation of predator pressure. If true, relaxation of predation could be due to increased abundance of the prey (i.e., small clams) or be compounded by a decrease

in predator (i.e., *Carcinus maenas*) abundance. Two factors which point to a possible reduction in *C. maenas* abundance are: 1) recent decline in winter water temperature (Figure 9), upon which Welch (1969, 1975) has shown *C. maenas* abundance to be directly dependent, and 2) the decrease in Flat 2 *C. maenas* catch-per-effort comparing fall 1977 with fall 1978. Pressure of human predators (clam diggers) has also decreased because of: 1) closing the flats in summer (see Section 4.5), and a general decline in interest in digging concurrent with the clam population decline (Table 15).

4.5 PRESENT AND FUTURE STATUS OF MARKETABLE *M. ARENARIA* STANDING CROP IN HAMPTON HARBOR

Between November 1977 and November 1978 the standing crop of marketable clams (shell size: 43 mm and up) essentially stabilized at approximately 940 bushels (Table 15). It appears that recruitment, probably of no more than 350 bushels, virtually compensated the amount harvested. In the future, however, the policy of closing the flats to digging, from Memorial Day to Labor Day, should help restore standing crop to a condition eventually approaching that which existed earlier in this decade (Table 15).

By November 1979, there could be at least 3000 bushels of "marketable" clams on the Hampton-Seabrook flats. This estimate has been derived primarily by considering the probable rate of recruitment of young adults (30 to 42 mm) to marketable size. In November 1978, there were approximately three clams per ft^2 in the 30 to 42 mm size range (Appendix 7); at a 25% survival rate and a 13 mm per year growth rate this yields 0.75 clams per ft^2 in the size range: 43 to 55 mm. Using Belding's (1930) tables this converts to approximately 14 bushels per acre and on 165 acres this gives a standing stock recruitment of approximately 2300 bushels, 74% of which will probably come from Flat 4 alone (cf. Table 11). An additional 700 bushels is expected to be composed of older clams overlooked by diggers.

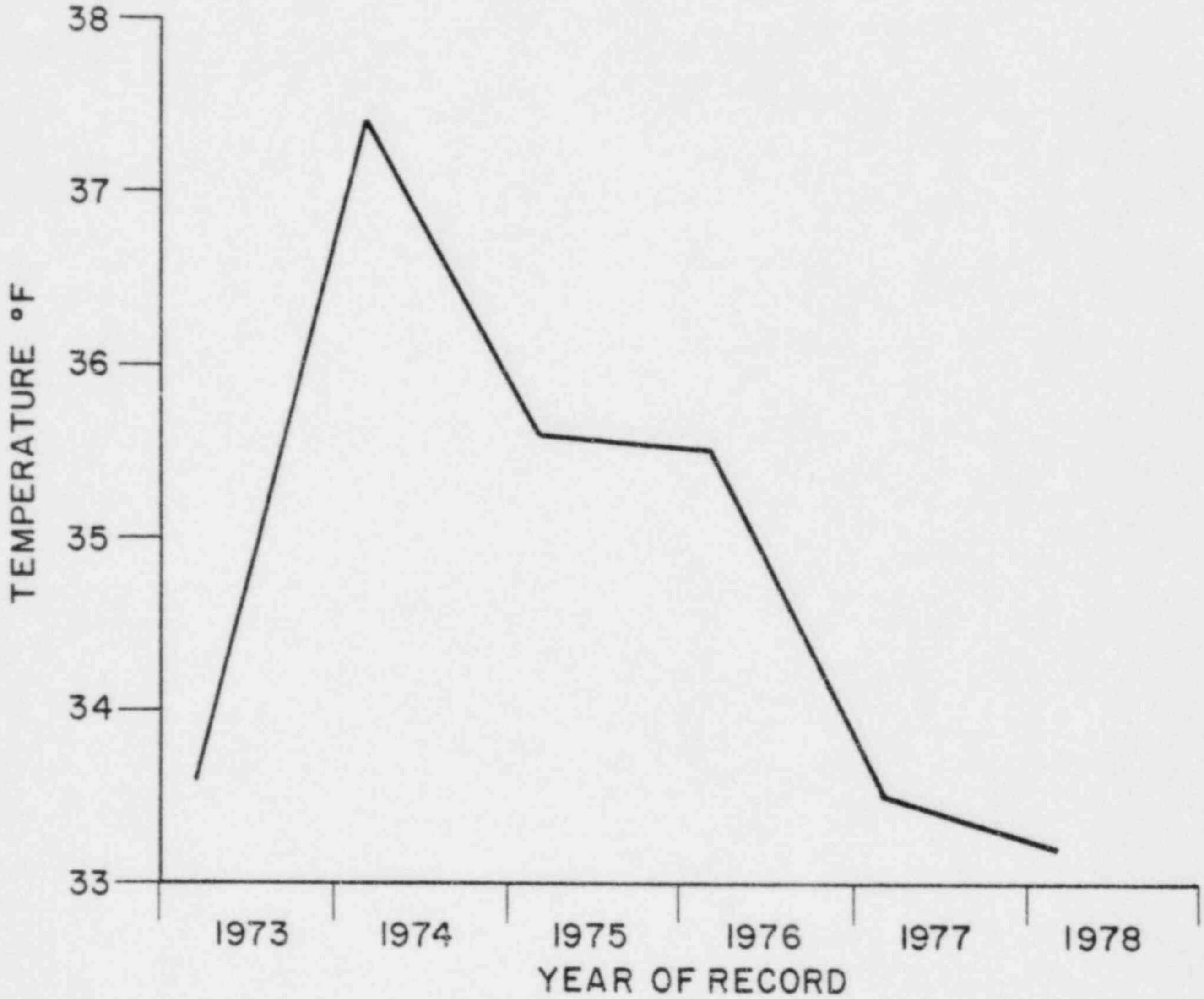

Figure 9. Means of daily minimum winter (February and March) winter temperature off Hampton Beach, New Hampshire. Seabrook *Mya arenaria* Study, 1978.

TABLE 15. RECENT HISTORY OF THE STANDING CROP OF "MARKETABLE" SIZE ADULT[a] *MYA ARENARIA* IN HAMPTON HARBOR. SEABROOK *MYA ARENARIA* STUDY, 1978.

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

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

[b] from Ayer (1968)

Between November 1979 and November 1980, four clams per ft^2 should be recruited to the 42 to 55 mm range if survival and growth continues at the present rate. This would provide an additional standing crop recruitment of over 6000 bushels. By the end of 1981, the 1976 and 1977 year classes together should have yielded at least 11,000 bushels of harvestable clams. These are conservative estimates; standing crop recruitment could be much higher if survival turns out to be better than projected, or if growth rate improves with the inevitable decline in population density.

5.0 SUMMARY

By November 1978, approximately 940 bushels of clams with a shell length greater than 42 mm remained on the five largest flats of Hampton Harbor (approx. 166 acres), representing a negligible net loss from November 1977. Successful establishment of the 1976 year class of spat (the strongest in more than 10 years) caused a sharp upturn in total standing crop estimates to approximately 7000 bushels, with a projected yield, after growth to a more "marketable" size, of at least 11,000 bushels.

The largest clams representing the 1976 year class had attained a shell size of 42 mm as of November 1978, although the mean size at Hampton Harbor was only 22 mm. Slower growth of the Hampton Harbor population, compared to adjacent areas of northern Massachusetts and southern Maine, was attributed to crowding, complicated by limited food resources available in a well flushed estuary.

Increased survivorship accompanied the increased abundance of young clams in Hampton Harbor; this was partly attributed to reduction in predation by the green crab, *Carcinus maenas*. Based on preliminary trapping data, plus a downward trend in winter water temperatures (to which fecundity in this crab is believed to be sensitive) since 1974, green crab numbers are suspected to be declining, or at least not keeping up with the increased availability of the prey. Summer closure of the Hampton and Seabrook flats to human diggers has also probably had a favorable effect on 1976 year class survival.

Over a 163 day monitoring period, *Mya arenaria* umboned larvae densities at the cooling water intake site averaged 83 per m^3. Peak densities of one to two hundred per m^3 were recorded throughout most of June and into early July, followed by a midsummer lull in which there were never more than 5 larvae per m^3. A second abundance peak began abruptly at the end of August, diminished through September, and surged for the final time to several hundred larvae per m^3 in early October.

Examination of gonad samples showed that Hampton Harbor clams first began to spawn in late July and early August. This evidence, together with data on non-tidal (net) current drift, supports a northern Massachusetts origin for a substantial proportion of the *M. arenaria* larvae entering New Hampshire coastal waters.

As in previous surveys, *M. arenaria* larvae were found more densely distributed along the coast within 0.5 to 1.0 nautical miles of the shore, especially during major spawnings. Larvae of several other bivalve mollusc species usually outnumber *M. arenaria* in the plankton. In order of decreasing abundance these include: *Modiolus modiolus*, *Mytilus edulis*, *Hiatella* spp., *Anomia* spp., *Macoma balthica*, *Spisula solidissima* and *Ensis directus*. Fewer larve of *Placopecten magellanicus* were collected than during 1977.

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APPENDICES

APPENDIX TABLE 7.1. ANALYSIS OF VARIANCE TABLE FOR TWO-WAY TREATMENT MODEL

PROJECT AND STUDY: Seabrook *Mya* Study

TRANSFORMATION: Square root

DATES OF DATA: June, July, September 1978

ALPHA LEVEL: .05

SUBJECT OF ANALYSIS: *Mya* larvae counts

NATURE OF DATA: #'s/m^3 *Mya*

FACTOR A: Dates (7) 6/5, 6/12, 6/26, 7/10, 9/1, 9/5, 9/21

FACTOR B: Stations (4) I2, I4, I6, I8

OBS/CELL: 2

SOURCE OF VARIATION		SUM OF SQUARES	D.F.	MEAN SQUARE	F-RATIO	P
Dates	A	1061.91	6	176.985	55.637	<.001
Stations	B	964.426	3	321.475	101.059	<.001
Dates x Stations	AB	1048.812	18	58.267	18.317	<.001
Error	E	89.070	28	3.181		
Total	T	3164.220	55			

COMMENTS: All main effects and interactions are highly significant

APPENDIX TABLE 7.2. SHELL SIZE DISTRIBUTION.

PLUM ISLAND SOUND
MIDDLE GROUND 1978

SIZE CLASS (mm)	6 JAN	4 APR	13 JUN	11 AUG	12 OCT
1		1.5			
2	19.9	32.8		10.7	1.5
3	16.0	40.5		4.6	29.0
4	18.3	19.1	1.5	1.5	34.4
5	11.5	16.0	4.6	0.8	22.9
6	15.3	8.4	9.2	0.8	19.1
7	9.9	8.4	15.3	0.8	6.9
8	6.9	6.1	13.0		0.8
9	3.8	3.1	13.0	3.8	3.1
10	6.1	4.6	17.6	7.6	3.1
11	3.1	3.8	15.3	6.1	6.9
12	2.3	2.3	9.9	9.2	15.3
13	2.3	0.8	10.7	17.6	11.5
14	1.5	0.8	2.3	22.9	29.8
15			7.6	29.0	20.6
16		1.5	7.6	23.7	22.9
17	3.1	3.1	3.8	18.3	9.2
18	4.6	2.3	3.1	11.5	12.2
19	5.3	3.1	0.8	14.5	7.6
20	5.3	5.3	0.8	17.6	2.3
21	6.1	6.1	1.5	7.6	2.3
22	13.8	6.1	0.8	9.2	3.8
23	13.8	6.1	1.5	2.3	
24	8.4	5.3	0.8	3.1	3.1
25	6.9	9.2	0.8	3.8	1.5
26	4.6	9.2	2.3	3.8	2.3
27	6.9	3.1	2.3	0.8	2.3
28	5.3	8.4	0.8	2.3	3.1
29	5.3	6.1	0.8	2.3	0.8
30	6.9	3.1	3.8	2.3	2.3
31	4.6	3.8	4.6	6.1	4.6
32	1.5	4.6	3.1	2.3	0.8
33	2.3	3.8	0.8	1.5	
34	0.8	1.5	1.5	0.8	3.1
35	1.5	1.5	0.8	5.3	3.1
36			1.5	3.1	3.1
37			1.5	3.8	3.1
38	0.8	1.5	0.8	3.1	1.5
39	0.8		0.8	2.3	2.3
40				1.5	2.3

(Continued)

APPENDIX TABLE 7.2 (Continued)

SIZE CLASS (mm)	6 JAN	4 APR	13 JUN	11 AUG	12 OCT
41	0.8	1.5	0.8	0.8	0.8
42				1.5	3.1
43			0.8	0.8	1.5
44				3.1	3.8
45				1.5	0.8
46				1.5	1.5
47				0.8	1.5
48				0.8	4.6
49				3.1	2.3
50				1.5	
51				0.8	1.5
52				0.8	1.5
53					0.8
54					
55					
56				0.8	0.8
57					
58					
59					0.8
60					

APPENDIX TABLE 7.2 (Continued)

PLUM ISLAND SOUND
LUFKIN'S FLAT 1978

SIZE CLASS (mm)	6 JAN	4 APR	13 JUN	11 AUG	12 OCT
1					
2	8.9	14.0		3.8	
3	11.5	25.5		8.9	
4	17.8	16.6	1.3	3.8	2.5
5	8.9	14.0			2.5
6	6.4	10.2	1.3		1.3
7	6.4	6.4	2.5		1.3
8	3.8	2.5	2.5		
9	6.4	5.1	6.4		2.5
10	2.5	6.4	1.3		1.3
11	2.5	1.3	14.0	1.3	1.3
12			6.4	1.3	1.3
13			5.1		
14		1.3	1.3	1.3	
15	1.3			2.5	
16				9.6	3.8
17			2.5		6.4
18	1.3		1.3		2.5
19		1.3		2.5	6.4
20		1.3	1.3	1.3	5.1
21				2.5	2.5
22	1.3			3.8	8.9
23				1.3	5.1
24				5.1	6.4
25				7.6	1.3
26		1.3	1.3	1.3	3.8
27		1.3		3.8	
28	1.3	1.3		3.8	3.8
29		1.3		3.8	
30	1.3	2.5		1.3	
31		2.5		3.8	1.3
32		3.8			
33	1.3	2.5	1.3		
34	2.5	1.3		1.3	3.8
35		1.3			1.3
36		2.5		1.3	
37		1.3			
38			2.5		
39	1.3	1.3			
40			1.3	1.3	1.3

(Continued)

APPENDIX TABLE 7.2 (Continued)

SIZE CLASS (mm)	6 JAN	4 APR	13 JUN	11 AUG	12 OCT
41		1.3	1.3		1.3
42		1.3			1.3
43				1.3	
44					
45					
46					1.3
47		1.3	1.3		
48		1.3			1.3
49		1.3	1.3		1.3
50					
51					1.3
52		1.3			1.3
53					
54					
55					1.3
56					1.3
57					
58					
59					
60					

APPENDIX TABLE 7.2 (Continued)

PLUM ISLAND SOUND
EAGLE HILL RIVER AT NUT SHOAL 1978

SIZE CLASS (mm)	6 JAN	4 APR	13 JUN	11 AUG	12 OCT
1		7.6			
2	40.1	72.6		59.2	3.8
3	43.9	49.7	1.9	32.5	30.6
4	51.6	22.9	1.9	3.8	17.2
5	26.7	11.5	19.1		13.4
6	19.1	11.5	9.6	1.9	5.7
7	17.2	5.7	17.2		9.6
8	19.1	5.7	21.0		5.7
9	5.7	9.6	28.6		3.8
10	5.7	5.7	36.3		3.8
11	1.9	3.8	26.7		
12	3.8	1.9	30.6		
13	1.9	1.9	15.3		7.6
14	1.9		13.4	5.7	21.0
15			9.6	7.6	11.5
16				17.2	21.0
17				24.8	13.4
18				13.4	21.0
19			3.8	17.2	13.4
20	1.9		5.7	5.7	7.6
21	1.9	1.9	5.7	11.5	7.6
22	1.9	3.8		11.5	13.4
23	3.8	1.9		3.8	11.5
24	3.8	1.9	1.9	9.6	7.6
25	3.8	7.6		11.5	3.8
26	3.8	7.6	1.9	3.8	9.6
27	3.8	3.8		3.8	5.7
28	3.8	3.8		1.9	3.8
29	5.7	1.9			
30	7.6	3.8	1.9		
31	1.9	1.9			
32	7.6	3.8	1.9	3.8	
33	3.8	1.9		1.9	
34	5.7	1.9			1.9
35	7.6	1.9		1.9	1.9
36	3.8	3.8		3.8	
37	3.8	9.6	7.6		
38	1.9	3.8	3.8	1.9	1.9
39	1.9	3.8	1.9		1.9
40	1.9	1.9	1.9	1.9	3.8

(Continued)

APPENDIX TABLE 7.2 (Continued)

SIZE CLASS (mm)	6 JAN	4 APR	13 JUN	11 AUG	12 OCT
41				1.9	1.9
42		1.9	1.9	5.7	5.7
43		1.9			3.8
44				5.7	1.9
45			1.9	1.9	1.9
46					
47		1.9	1.9		
48			1.9	1.9	
49					
50				1.9	1.9
51				3.8	1.9
52					1.9
53				1.9	
54					
55					
56				1.9	
57					
58					1.9
59					
60				1.9	

APPENDIX TABLE 7.2 (Continued)

MERRIMACK RIVER ESTUARY
BALL'S FLAT #1 1978

SIZE CLASS (mm)	4 JAN	5 APR	19 JUN	9 AUG	13 OCT
1		0.8			
2	283.4	59.6			
3	51.2	45.8	8.4		
4	16.0	17.6	19.9		
5	8.4	5.3	28.3		
6	2.3	1.5	24.4		
7	2.3		35.1		
8		0.8	29.8		
9	0.8		20.6		
10			15.3		
11			9.9	1.5	
12		0.8	8.4	1.5	
13			1.5	3.1	
14			1.5	4.6	
15	0.8			6.1	
16				6.1	1.5
17				4.6	1.5
18				14.5	0.8
19				6.1	4.6
20				6.1	6.1
21				3.8	6.1
22				6.9	9.2
23				3.1	10.7
24				0.8	8.4
25				0.8	6.9
26					3.8
27					6.1
28				1.5	3.8
29					0.8
30				0.8	
31					0.8
32					
33					
34					
35					
36					
37					0.8

APPENDIX TABLE 7.2 (Continued)

MERRIMACK RIVER ESTUARY
SALISBURY FLAT #3

SIZE CLASS (mm)	5 JAN	6 APR	19 JUN	9 AUG	13 OCT
1					
2	3.8	3.8		6.9	0.8
3	6.9	9.9		14.5	4.6
4	3.8	3.8	0.8	5.3	3.8
5	0.8	3.8		3.1	3.8
6		4.6	0.8		1.5
7		0.8			0.8
8			3.1		0.8
9					0.8
10	0.8	0.8	0.8		0.8
11					
12					1.5
13			0.8		0.8
14					
15					
16				0.8	
17				0.8	
18				0.8	
19					
20					
21				0.8	
22				0.8	0.8
23					
24					
25				0.8	
26					0.8
27					
28					
29					0.8
30					
31					
32					
33					
34					
35					
36					
37					

APPENDIX TABLE 7.2 (Continued)

HAMPTON HARBOR
FLAT #2

SIZE CLASS (mm)	4 JAN	5 APR	9 JUN	14 AUG	9 OCT
1	0.6	2.3		1.5	3.8
2	37.6	52.0	5.3	9.9	24.4
3	17.2	48.9	3.1	0.8	35.9
4	7.0	24.4	5.3	2.3	21.4
5	5.7	13.0	10.7	3.1	11.5
6	8.3	9.9	9.2	2.3	6.1
7	1.9	6.1	8.4	4.6	3.1
8	5.7	5.3	6.9	6.9	0.8
9	5.7	3.8	6.9	5.3	
10	10.2	3.0	9.2	7.6	0.8
11	14.6	8.4	11.5	9.2	2.3
12	22.3	8.4	3.1	13.8	1.5
13	19.7	13.8	4.6	13.0	4.6
14	27.4	13.8	1.5	15.3	1.5
15	15.3	18.3	2.3	19.9	6.9
16	16.6	15.3		15.3	6.1
17	8.3	7.6		13.8	9.9
18	7.0	7.6	0.8	14.5	10.7
19	5.1	4.6	2.3	17.6	13.8
20	2.5	3.1		11.5	18.3
21		3.1		11.5	9.2
22	0.6	2.3		8.4	9.2
23				9.9	16.0
24				12.2	12.2
25		0.8		10.7	8.4
26		0.8		5.3	8.4
27				7.6	6.1
28				6.1	5.3
29				3.1	5.3
30				5.3	4.6
31				2.3	1.5
32				1.5	3.8
33				0.8	3.1
34				0.8	
35				0.8	0.8
36					0.8
37				0.8	
38					
39				0.8	
40					
41					
42					0.8

APPENDIX TABLE 7.2 (Continued)

HAMPTON HARBOR
FLAT #4

SIZE CLASS (mm)	5 APR	9 JUN	14 AUG	9 OCT
1	3.1			2.3
2	57.3	2.3	11.5	25.2
3	60.4	13.8	48.9	77.2
4	48.1	21.4	55.8	105.4
5	32.9	14.5	27.5	119.9
6	39.7	8.4	14.5	104.7
7	40.5	9.1	11.5	94.7
8	45.8	14.5	4.6	67.2
9	47.4	9.9	9.2	32.8
10	63.4	22.2	9.2	16.0
11	67.2	18.3	9.9	8.4
12	82.5	19.9	14.5	13.0
13	74.9	19.1	9.2	16.0
14	94.7	22.2	8.4	16.8
15	104.7	16.0	9.9	35.9
16	74.1	17.6	10.7	36.7
17	45.1	20.6	17.6	39.7
18	28.3	13.0	13.0	32.1
19	19.1	14.5	19.9	26.0
20	11.5	13.0	13.8	36.7
21	6.1	10.7	16.8	26.7
22	3.1	5.3	11.5	19.1
23	1.5	1.5	6.1	17.6
24		3.1	3.8	7.6
25	1.5		3.8	14.5
26	0.8		7.6	10.7
27	0.8		5.3	9.9
28		0.8	5.3	3.8
29			4.6	4.6
30			3.1	5.3
31			3.1	3.8
32				3.8
33			1.5	2.3
34			0.8	0.8
35				1.5
36			0.8	
37				0.8
38				
39				
40				
41				
42				
43				
44			0.8	
45				

APPENDIX TABLE 7.2 (Continued)

LITTLE HARBOR CHANNEL
FLATS

SIZE CLASS (mm)	13 JAN	10 APR	16 JUN	8 AUG	6 OCT
1					
2	0.6		0.6		7.0
3	1.9	2.5	1.3		9.6
4	3.2	2.5	5.7		3.8
5	2.5	2.5	1.3		1.3
6	0.6	2.5	2.5		0.6
7		0.6			
8		1.9	1.9		
9		0.6	0.6		
10		0.6	1.3		
11			0.6		
12		0.6		0.6	
13					
14					
15					
16				0.6	
17					
18					0.6
19					
20					
21				0.6	

APPENDIX TABLE 7.2 (Continued)

YORK RIVER FLAT AT
ROUTE 103 BRIDGE 1978

SIZE CLASS (mm)	17 JAN	3 APR	14 JUN	10 AUG	11 OCT
1					1.5
2	11.5	1.5			14.5
3	13.0	1.5	6.1	1.5	11.5
4	13.8	6.1	5.3	2.3	
5	14.5	8.4	8.4	1.5	
6	14.5	6.8	5.3	2.3	
7	9.2	4.6	6.1	1.5	
8	4.6	3.1	3.1	2.3	
9	2.3	4.6	3.8	3.1	1.5
10	0.8	4.6	3.1	2.3	
11	3.1	3.1	3.8	3.1	
12	0.8	3.8	1.5	0.8	
13		0.8	0.8	2.3	
14			3.1		
15		0.8	0.8		0.8
16			0.8	0.8	
17				1.5	0.8
18		C.8		0.8	
19		0.8			0.8
20					
21					0.8
22		1.5		0.8	
23					0.8
24					
25					
26					
27		0.8			
28					
29					
30					
31				0.8	
32				0.8	
33				1.5	
34					
35					0.8
36					
37					
38					
39					
40					

APPENDIX TABLE 7.2 (Continued)

SIZE CLASS (mm)	17 JAN	3 APR	14 JUN	10 AUG	11 OCT
41					0.8
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					0.8

APPENDIX TABLE 7.2 (Continued)

OGUNQUIT BEACH 1978

SIZE CLASS (mm)	17 JAN	3 APR	14 JUN	10 AUG	11 OCT
1	0.6			1.3	1.3
2	7.0	0.6		12.1	9.6
3	3.8	1.9		3.8	17.8
4	3.8	2.5	2.5	1.3	9.6
5	0.6	1.3	10.8		0.6
6	0.6	0.6	1.9		0.6
7	1.3	1.9	5.1		
8	0.6	0.6	1.9		
9	0.6	0.6	7.6	0.6	
10			1.3	0.6	
11	0.6		1.3		
12		1.3	1.3		
13			1.3	3.2	
14			1.3	1.9	
15			1.3	1.3	
16		0.6		2.5	
17	0.6		0.6	3.2	0.6
18	0.6	1.3	0.6	0.6	1.3
19		1.3		1.9	0.6
20	2.5	1.3		3.2	0.6
21	3.2	2.5		1.3	
22		3.8		1.9	
23	3.2	4.5		0.6	0.6
24	1.9	3.8	1.3		1.3
25	2.5	3.8	0.6	1.3	0.6
26	1.9	2.5	1.3	2.5	0.6
27	1.9	1.9	1.9		0.6
28		3.8	2.5		0.6
29	1.9	2.5	4.5	0.6	
30	1.9	1.9	0.6	1.3	0.6
31		1.9	1.3	0.6	1.3
32		1.9	0.6	2.5	0.6
33		0.6	0.6	1.9	
34		0.6		0.6	
35					1.9
36		0.6	1.3	2.5	
37				1.3	0.6
38				3.2	1.3
39				0.6	
40		0.6	0.6	2.5	1.9

(Continued)

APPENDIX TABLE 7.2 (Continued)

SIZE CLASS (mm)	17 JAN	3 APR	14 JUN	10 AUG	11 OCT
41				1.9	1.3
42					1.3
43				0.6	1.3
44				1.3	1.3
45				1.3	1.3
46				0.6	
47					
48					
49					1.3
50					0.6
51					
52					
53					
54					
55					
56					0.6

APPENDIX 7.3.

TABLE A. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 1 FOR THE NOVEMBER SURVEYS, 1971-1978. SEABROOK *MYA ARENARIA* STUDY, 1978.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978
5	19.00	74.00	30.00	2.50	55.00	1031.00	283.00	38.00
10	11.00	9.00	6.00		1.14	52.00	413.00	100.00
15	11.00	15.00	3.00			0.75	117.00	148.00
20	7.00	11.00	5.00		0.02		5.82	76.00
25	0.47	2.50	0.16	0.11			0.48	9.20
30	1.30	2.30	0.51	0.17	0.02	0.02		0.56
35	1.50	1.20	0.60	0.48	0.04			0.03
40	1.80	1.40	0.67	0.89	0.23		0.01	0.03
45	1.80	0.61	0.49	1.10	0.14	0.10	0.01	
50	1.00	0.83	0.42	1.20	0.36	0.03	0.02	0.03
55	0.64	1.60	0.30	0.82	0.25	0.04	0.03	0.03
60	0.36	0.33	0.29	0.42	0.28	0.23	0.02	0.03
65	0.08	0.19	0.18	0.31	0.1[illegible]	0.13	0.01	0.04
70	0.03	0.19	0.11	0.10	0.11	0.06	0.04	
75	0.03	0.08	0.05	0.10	0.03	0.03	0.02	0.02
80				0.02	0.07		0.02	
85						0.01	0.01	0.01
90						0.01		

APPENDIX 7.3 (Continued)

TABLE B. SHELL SIZE DISTRIBUTION OF SOFT SHELL CLAMS ON FLAT 2 FOR QUARTERLY SURVEYS, 1975-1978.

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
5	5.90	9.80	3.40	9.10	---	---	---	351.00	---	---	---	83.00	---	11.00
10					---	---	---		---	---	---	2.90	---	
15					---	---	---		---	---	---		---	
20					---	---	---		---	---	---		---	1.94
25													0.04	2.61
30														1.58
35	0.13	0.06									0.02			0.29
40	0.32	0.18	0.02			0.11				0.02				0.15
45	0.37	0.28	0.13			0.02					0.02			0.04
50	0.67	0.32	0.06		0.02	0.02		0.02		0.04			0.08	0.06
55	0.72	0.52	0.09	0.02	0.02								0.02	0.02
60	0.24	0.44	0.02	0.07		0.04		0.02		0.02				0.03
65	0.18	0.18	0.06	0.02	0.02	0.11				0.06				0.03
70	0.20	0.11	0.02	0.09		0.02					0.02		0.03	
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	
90	0.02	0.02	0.02	0.04	0.09							0.06	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 7.3 (Continued)

TABLE C. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 3 FOR NOVEMBER SURVEYS, 1971-1978. SEABROOK *MYA ARENARIA* STUDY, 1978.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978
5	35.00	28.00	6.00	0.64	1.14	556.00	67.00	38.00
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
30	0.92	0.25	1.00	0.14				0.85
35	0.67	0.17	0.38	0.12		0.02	0.10	0.27
40	1.50	0.33	0.62	0.11				0.02
45	1.40	0.42	0.50	0.30		0.02		0.04
50	1.30	0.17	0.29	0.11	0.03		0.02	0.02
55	1.1	0.17	0.79	0.08	0.03	0.02		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
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			

APPENDIX 7.3 (Continued)

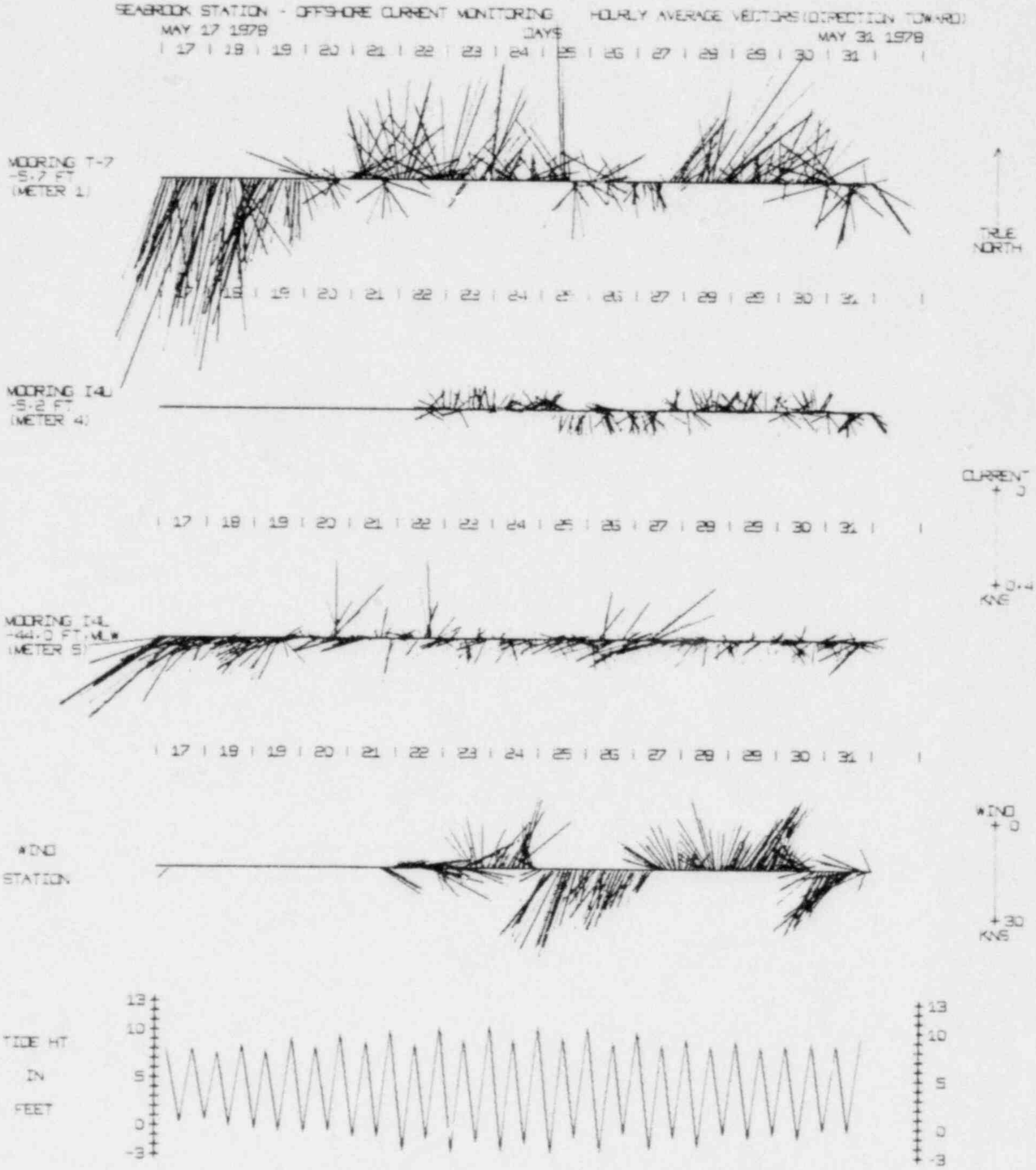
TABLE D. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 4 FOR NOVEMBER SURVEYS, 1971-1978. SEABROOK *MYA ARENARIA* STUDY, 1978.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978
5	38.00	116.00	12.00	2.50	66.00	830.00	117.00	113.00
10	11.00	31.00	1.00		1.80	13.20	183.00	91.00
15	7.00	20.00	3.00				115.00	48.00
20	4.00	18.00	2.00	0.64			20.40	45.10
25	2.80	1.10	0.52	0.05		0.01	0.62	12.38
30	3.50	3.00	1.40	0.26	0.01	0.02		8.29
35	4.60	2.80	0.62	0.58	0.01	0.01		3.19
40	4.00	1.70	0.46	0.96	0.16			0.85
45	2.60	2.00	0.35	0.92	0.16		0.09	0.02
50	1.30	1.00	0.38	0.80	0.18			0.03
55	1.10	0.79	0.14	0.50	0.21	0.13		0.01
60	0.25	0.21	0.08	0.29	0.12			
65	0.17	0.04	0.14	0.21	0.14		0.01	0.01
70	0.12	0.08	0.06	0.03	0.04			
75			0.02		0.01	0.01		
80		0.04		0.01		0.01		
85				0.01	0.01	0.01		

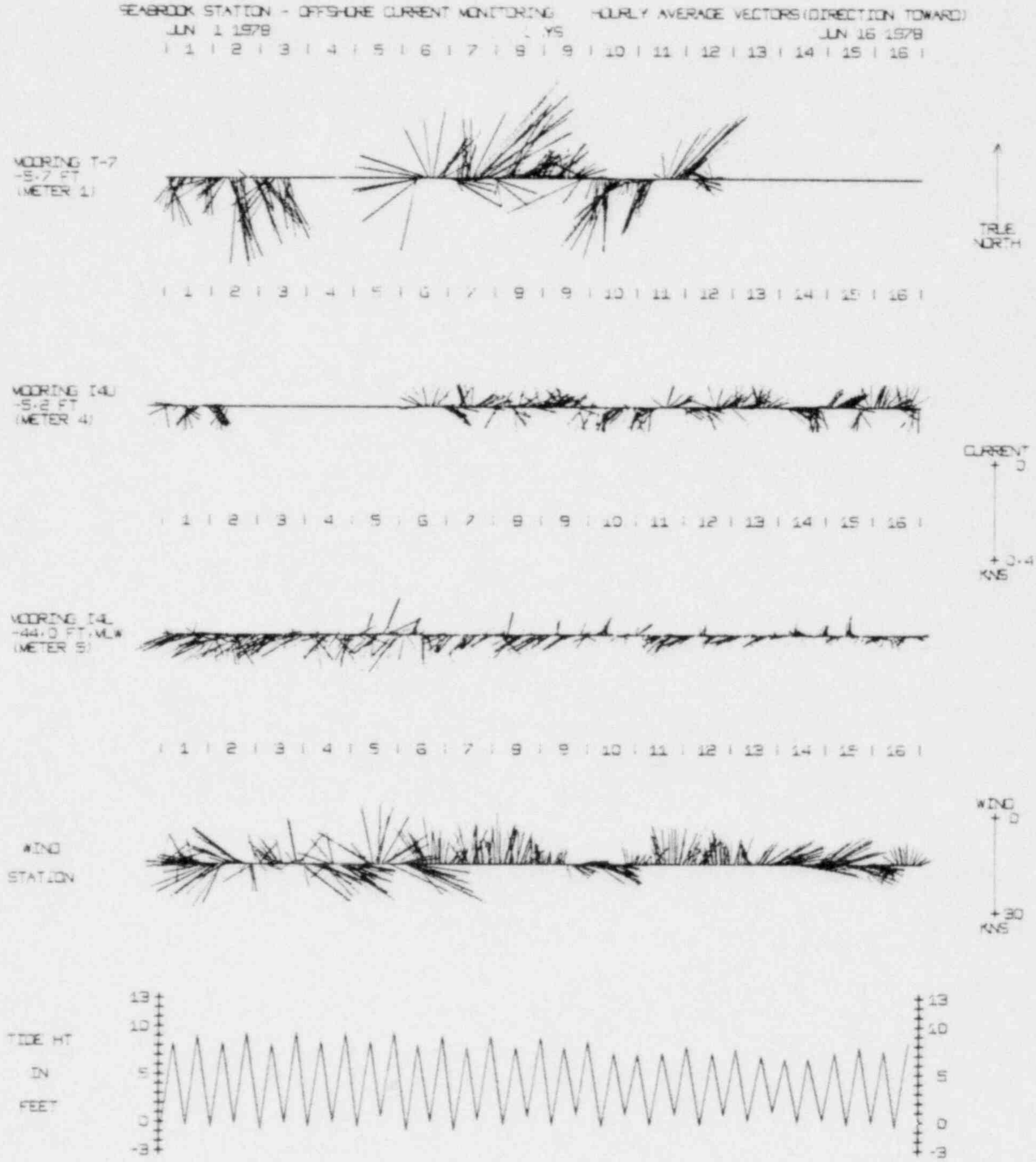
APPENDIX 7.3 (Continued)

TABLE E. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 5 FOR NOVEMBER SURVEYS, 1971-1978. SEABROOK *MYA ARENARIA* STUDY, 1978.

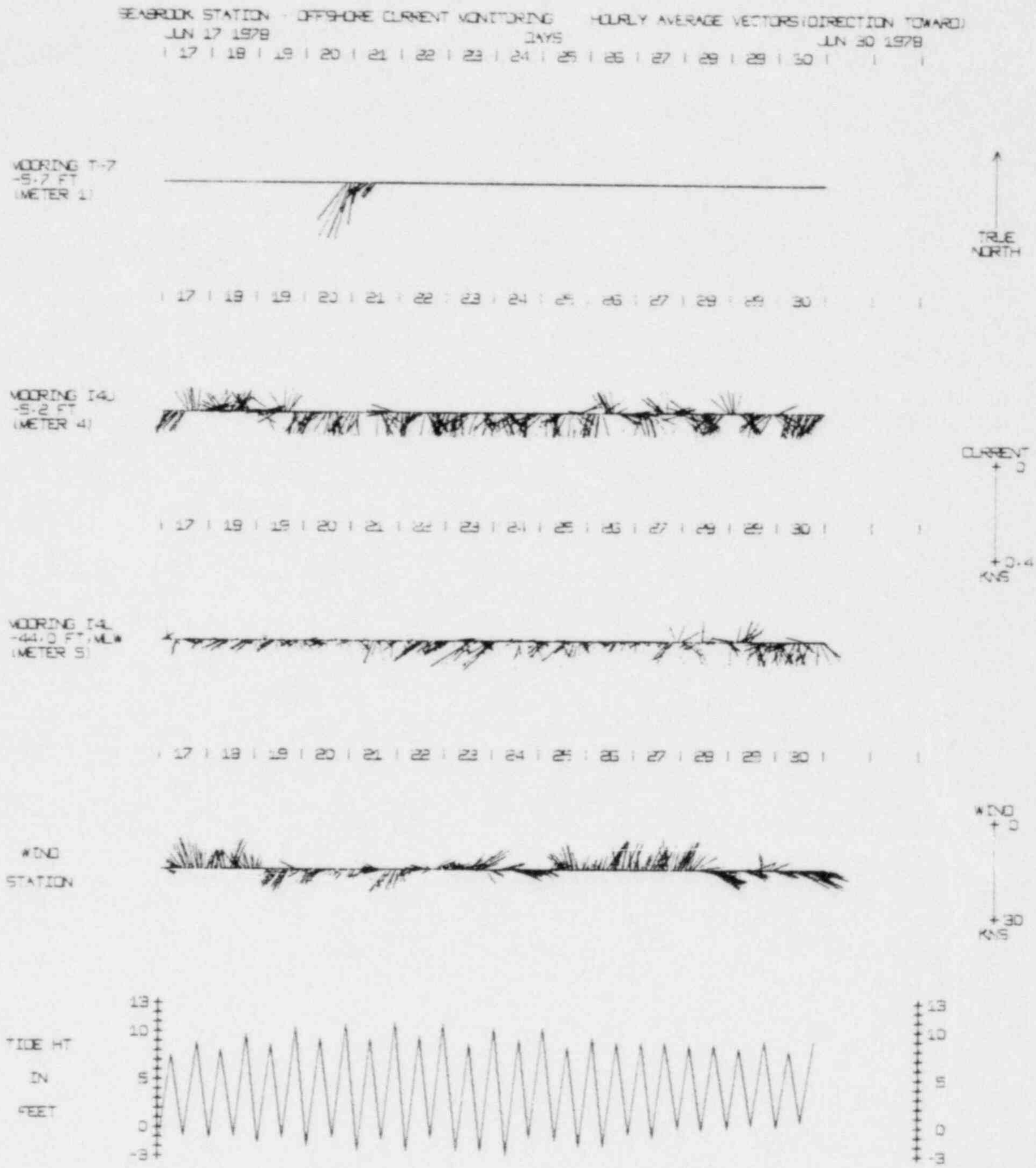
SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978
5	67.00	136.00	22.00	2.40	7.50	546.00	92.00	44.00
10	38.00	94.00	1.00			2.80	8.30	4.80
15	12.00	16.00					7.50	
20	3.00	6.00					5.30	4.80
25	0.06	0.55	0.10				0.75	2.28
30	0.11	0.89	0.31					2.17
35	0.33	0.61	0.14	0.01			0.01	1.41
40	0.44	1.00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



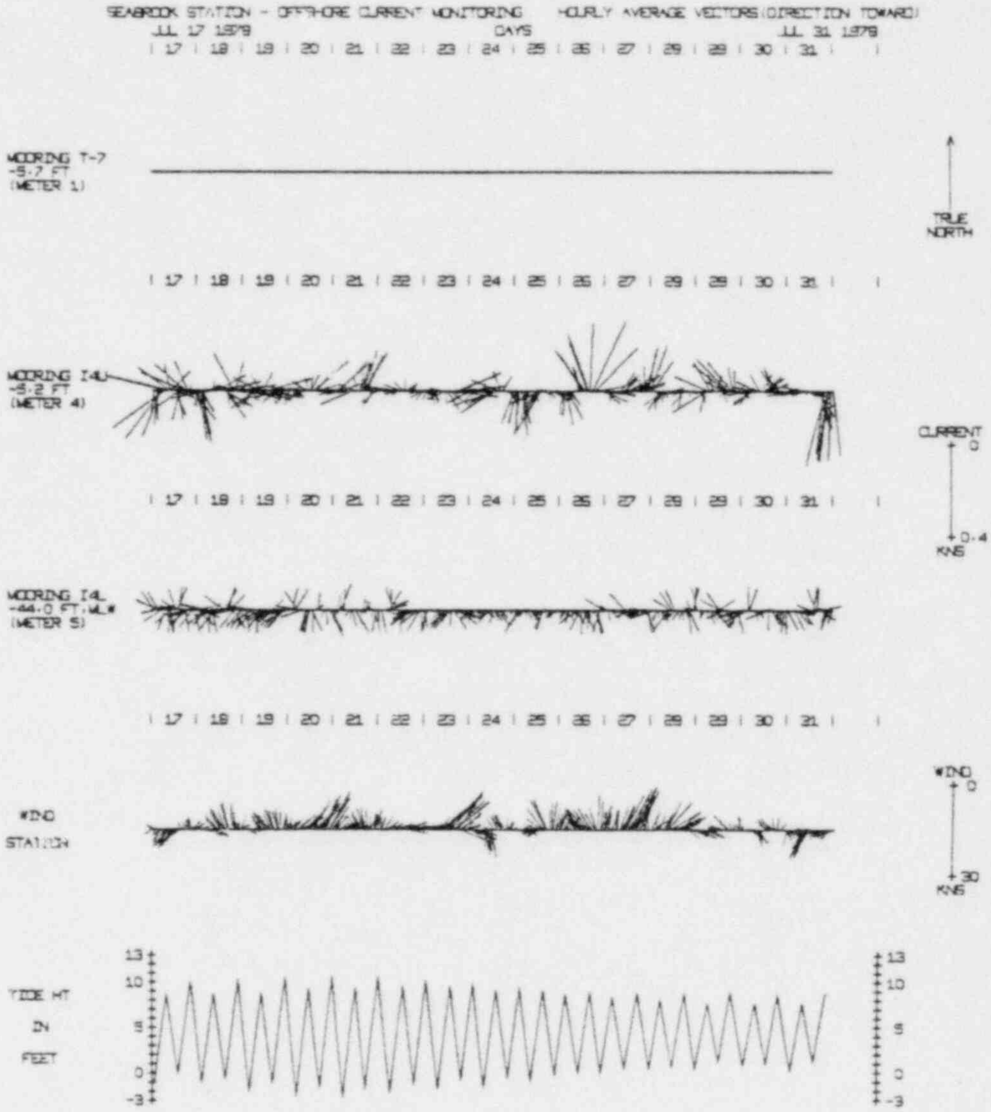
Appendix Figure 7.4. Hourly average sequential vector plots of water current meter data and wind data (both representing direction toward) as well as high and low tide heights for May 17 to Sept 30, 1978.



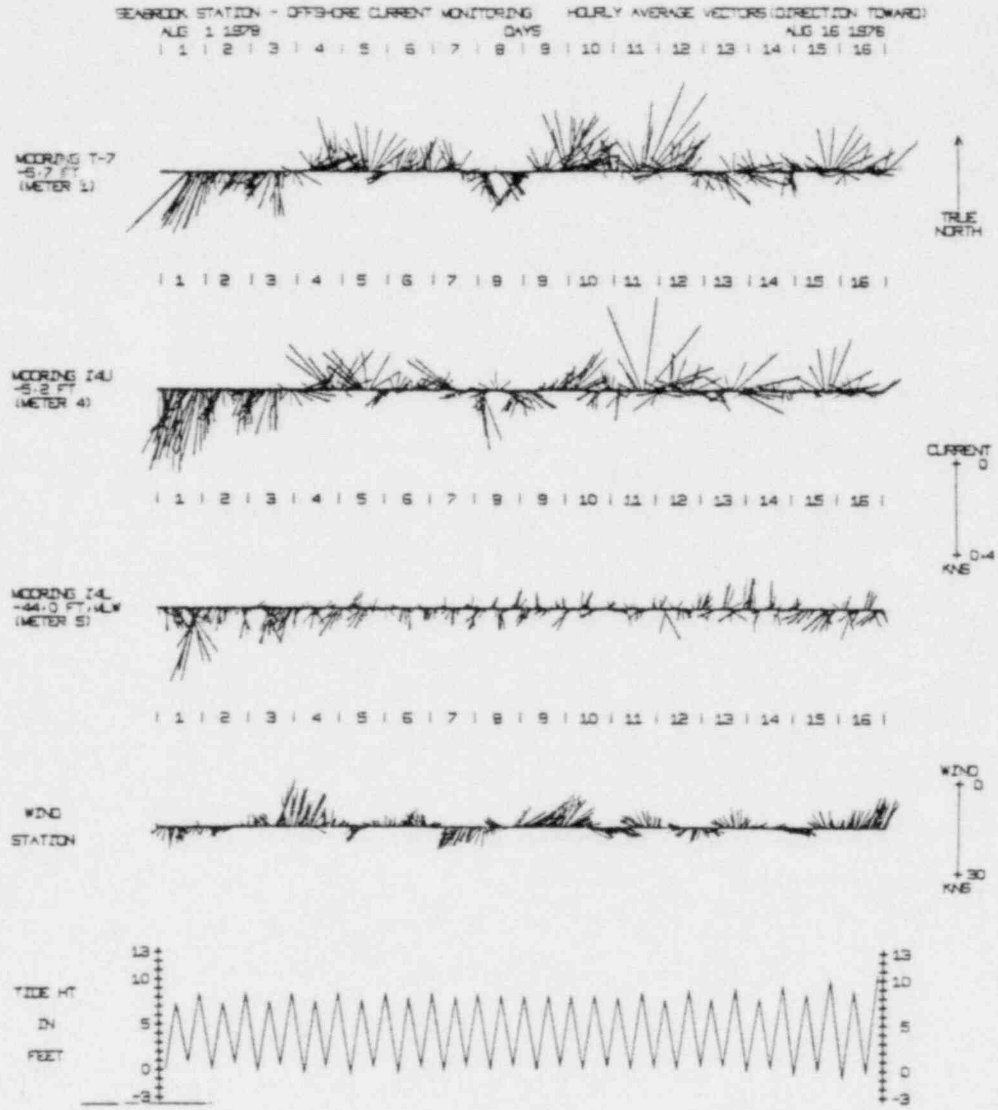
Appendix Figure 7.4. (Continued)



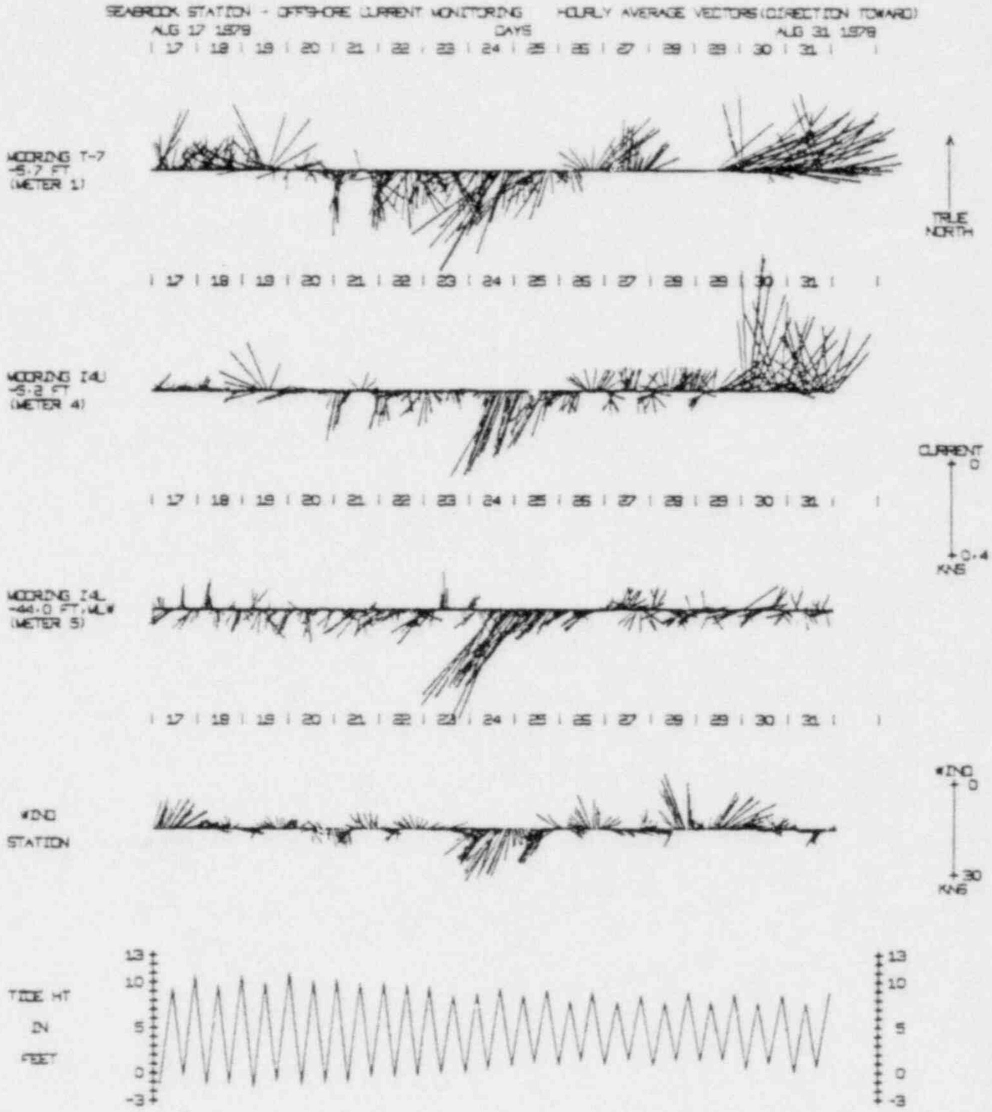
Appendix Figure 7.4. (Continued)



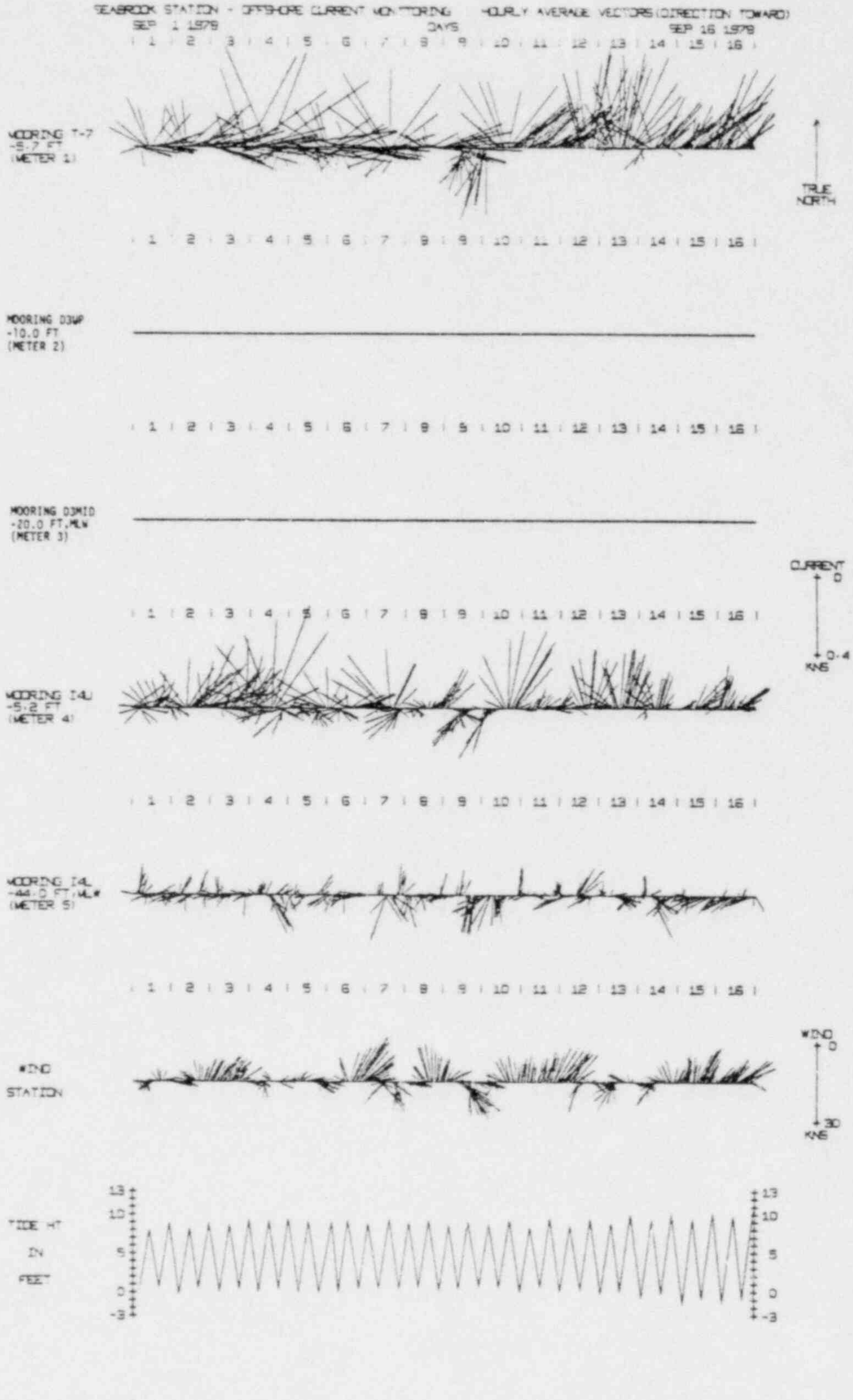
Appendix Figure 7.4. (Continued)



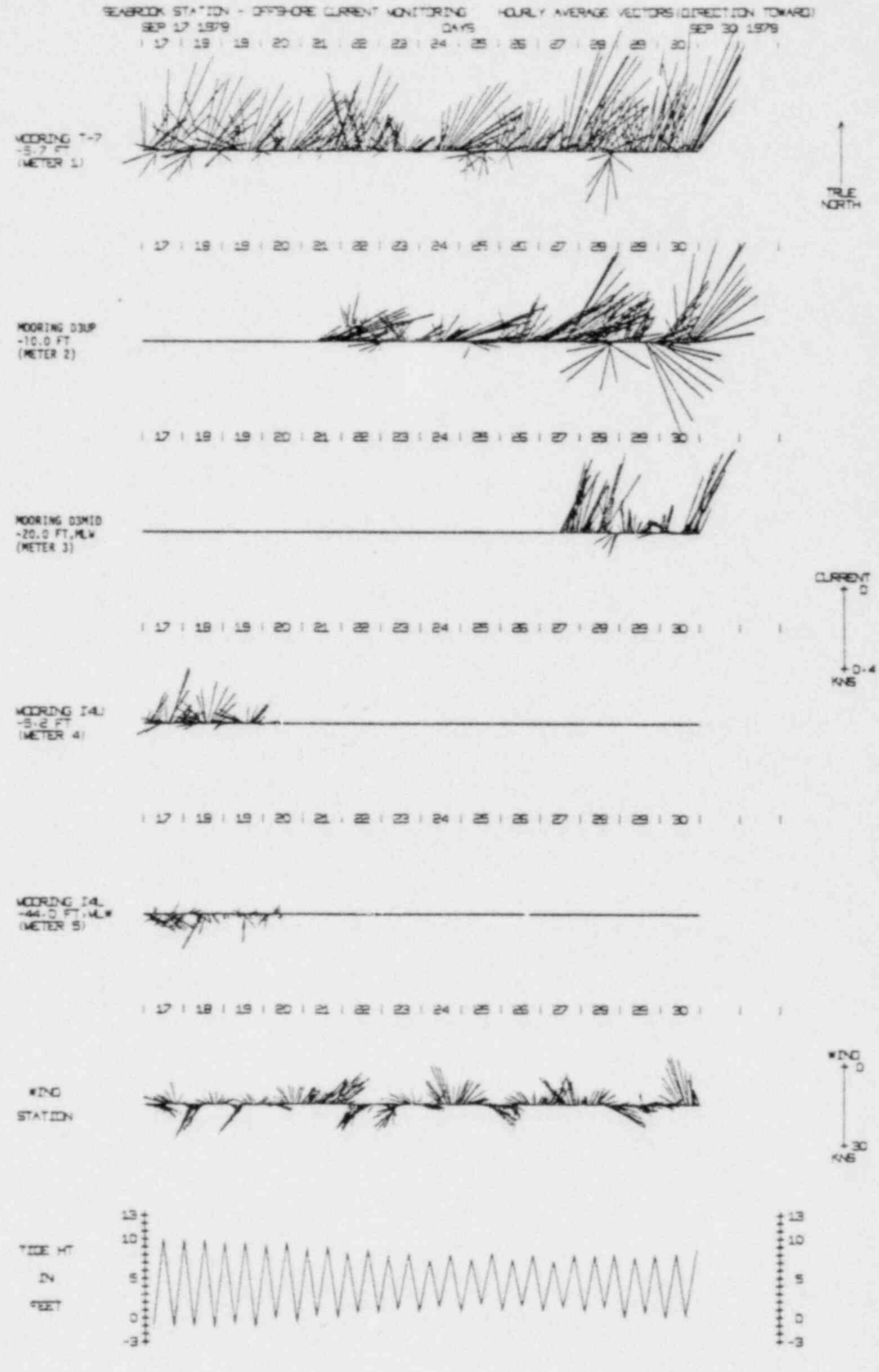
Appendix Figure 7.4. (Continued)



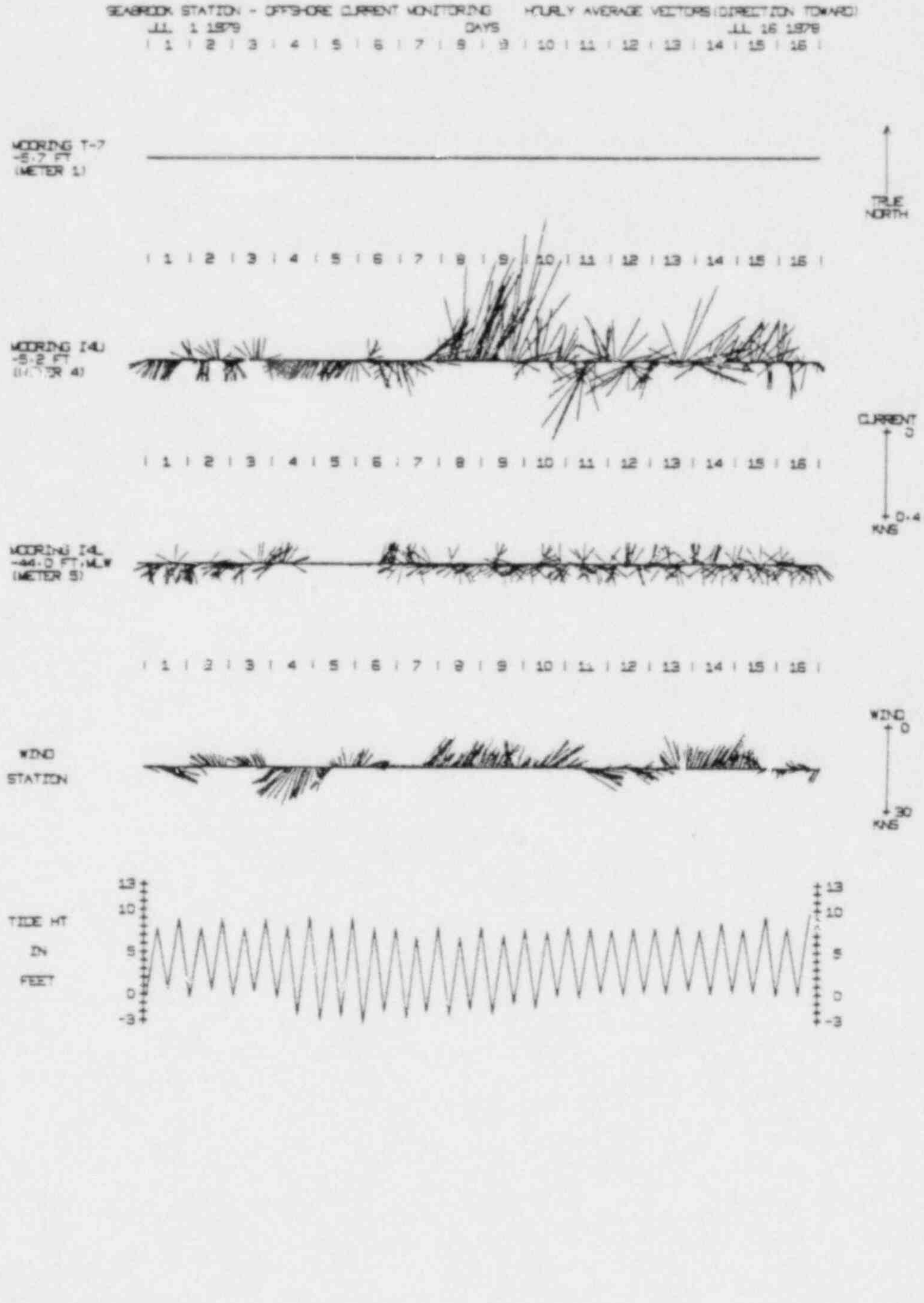
Appendix Figure 7.4. (Continued)



Appendix Figure 7.4. (Continued)



Appendix Figure 7.4. (Continued)



Appendix Figure 7.4. (Continued)

APPENDIX 7.5. *CARCINUS MAENAS* CATCH RECORD, SUMMER 1977, TWO "PRISM" TRAPS[a].

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
8-11 Jul		4M 2F(g)		7M 84F;6F(g)		12M 78F;2F(g)		5M 6F		1M
11-13 Jul	1M	1F;2F(g)		4M 49F;1F(g)		9M 34F;4F(g)		12M 3F		1M
13-15 Jul		1F(g)	5F;1F(g)	1M 9F;4F(g)	4M 26F;2F(g)	1M 18F;3F(g)	1M 10F	1M 1F	2M	
15-18 Jul	1F	1M	1M 2F	2M 11F;2F(g)	2M 30F;1F(g)	1M 9F	5F	4M 3F	2M	
18-20 Jul			2M 3F;1F(g)	7M 17F;6F(g)	6M 48F;1F(g)	2M 32F	8M 14F;1F(g)	4M 1F	6M 1F	
20-23 Jul		2F	1M 12F	26F;1F(g)	6M 41F;3F(g)	4M 35F;4F(g)	5M 14F	5M 2F	4M	1M
23-27 Jul			8F	3M 29F;3F(g)	7M 68F;2F(g)	4M 43F;2F(g)	6M 15F	6M 5F	3M	
27-29 Jul		1F	1M 9F	4M 20F;1F(g)	2M 28F;1F(g)	2M 23F;1F(g)	4M 4F	7M 1F	1M	1M
29 Jul-3 Aug		1F	1M 3F;1F(g)	1M 22F;5F(g)	3M 34F;6F(g)	3M 32F;3F(g)	2M 15F;1F(g)	7M 2F	5M 1F	2M
3-7 Aug		1F	2F	1M 12F	18F;1F(g)	2M 22F;2F(g)	2M 10F	4M 2F	6M	2M

(Continued)

APPENDIX 7.5. (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
7-12 Aug			5F	16F;3F(g)	1M 34F;1F(g)	6M 23F	2M 11F;3F(g)	8M 6F	4M	3M 1F
12-17 Aug			1M 2F;2F(g)	1M 5F;4F(g)	3M 26F;3F(g)	4M 19F;3F(g)	6M 8F;1F(g)	5M 1F	5M 1F	2M
17-25 Aug[b]				1F	3M 15F;1F(g)	2M 15F;2F(g)	3M 3F	4M 2F;1F(g)	2M	
13-16 Sep		1F	1F	2M 10F	1M 22F;1F(g)	4M 15F	7M 12F	3M 3F	1M	
16-20 Sep[b]			1F	8F	2M 12F	1M 19F;1F(g)	4M 13F	2M 2F	3M	
20-23 Sep[b]			2F	1M 6F	2M 22F	8M 44F	13M 23F	2M 6F	1M	

M = Male F = Female F(g) = Egg bearing female

[b] 1 trap only [a] on loan from Maine Dept. Marine Resources

APPENDIX 7.5. *CARCINUS MAENAS* CATCH RECORD FALL 1977 THROUGH FALL 1978, 8 RECTANGULAR TRAPS.

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
27-28 Oct			1M 5F	6F	2M 16F	7M 14F	17M 19F	9M 2F	4M 1F	
9-10 Nov		3F	3M 5F	1M 10F	5M 18F	11M 26F	13M 19F	4M 3F	3M	
21-22 Nov		1F	3M 2F	3M 7F	7M 16F	18M 27F	11M 23F	9M 1F	4M 1F	2M
7-8 Dec	1M	1F	2M 5F	11M 22F	21M 18F;1F(g)	78M 28F	66M 18F	37M 3F	11M	2M
19-20 Dec			2F	1M 3F		1M 3F	1F	1M		
4-5 Jan					1F	2F	1F			
17-18 Jan	No catch									
1-2 Feb	No catch									
16-17 Feb	No catch									
6-7 Mar	No catch									
20-21 Mar	No catch									
3-4 Apr	No catch									

APPENDIX 7.5. (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
17-18 Apr				2F	3F	2M 1F	1F		2M	
1-2 May		1F	1F;1F(g)	2M 7F	4M 5F	10M	7M 5F	5M 1F	1M	
18-19 May		1F	2F	12F;1F(g)	1M 43F;2F(g)	2M 51F;5F(g)	2M 17F	3M 3F		
8-9 Jun		1M	1M 1F	1F	2M 2F(g)	2M 5F	10M 3F	4M	1M	1M
22-23 Jun		1M	1M 3F;1F(g)	3F;2F(g)	1M 13F	1M 19F	6F;1F(g)	2M 3F	1F;1F(g)	
10-11 Jul		3M 1F	4F	1M 6F;1F(g)	4M 14F;1F(g)	10M 25F	8M 23F	11M 2F	8M	3M
25-26 Jul			1F	3M 3F;1F(g)	2M 4F;1F(g)	3F	1M	1M 1F	1M	1M
8-9 Aug			1M 5F	3M 12F	5M 18F;2F(g)	13F 25F	11M 17F	9M 3F	3M	2M
22-23 Aug			1F;1F(g)	6F	3M 7F	5M 8F	9M 5F	7M	4M	1M
8-9 Sep			2M 1F	1M 1F(g)	4M 10F	2M 4F	5M 3F	2M	1M	
20-21 Sep		1F	1F	3F	1M 6F	3M 8F	5M 8F	5M 3F		

(Continued)

APPENDIX 7.5. (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
5-6 Oct		2M 1F	3F	1M 5F	1M 4F	4M 9F	2M 9F	2M 3F	1M	1M
19-20 Oct		3M 4F	4M 4F	7M 9F	8M 17F	15M 21F	10M 12F	15M 2F	5M	3M
3-4 Nov		1M 7F	3M 6F	3M 9F	1M 7F	7M 10F	5M 2F	2M 1F	2M 1F	
16-17 Nov		1M 3F		2M 7F	6M 9F	7M 5F	4M 5F	6M 4F	3M	
11-12 Dec		1F	1F	2M 4F	1M	2M 3F	2M 2F	1M 1F		
20-21 Dec	1F	1M	1M	3F	2M 1F(g)	1M		2M		

M = male F = Female F(g) = Egg bearing female