SEABROOK ENVIRONMENTAL STUDIES 1980

SOFT-SHELL CLAM, *MYA ARENARIA* STUDY

TECHNICAL REPORT XII-1

Proposed for

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
Manchester, New Hampshire

by

NORMANDEAU ASSOCIATES, INC.
Bedford, New Hampshire

R-366

March 1981

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1.0 INTRODUCTION

Soft-shell clams, Mya arenaria, in Hampton-Seabrook Estuary have been the subject of extensive investigation for the past ten years or more (NAI 1971 1972a, 1972b, 1972c, 1973, 1974, 1975a, 1975b, 1976a, 1976b, 1977, 1978, 1979, 1981). Temporal changes in population densities and standing crop have been monitored, as have trends in spatial and temporal distribution of the pelagic larvae during the summer months. Catch records of the green crab, Carcinus maenas, a major predator of soft-shell clams in New Hampshire have been maintained since the summer of 1977; in 1978, a study of the reproductive cycle in Hampton-Seabrook clams was reinstated almost eight years after the first reproduction investigation (NAI, 1971).

All of these data have been accumulated to provide a baseline for assessing impact of Seabrook Station's once-through cooling water system which, when operating, will draw from and return seawater to nearshore waters off Hampton Beach, New Hampshire. Direct impact on soft-shell clam resources may occur through entrainment of the pelagic larvae. However, since populations of both soft-shell clams and green crabs have been shown to respond to climatic temperature change (Welsh, 1969, Dow 1977), the full range of the soft-shell clams' life history is being studied, including: gonad development, larval abundance, spat settlement, recruitment of harvestable stocks, and relative abundance of green crabs (a principal non-human predator; Dow and Wallace, 1961; Welch, 1969, 1975).

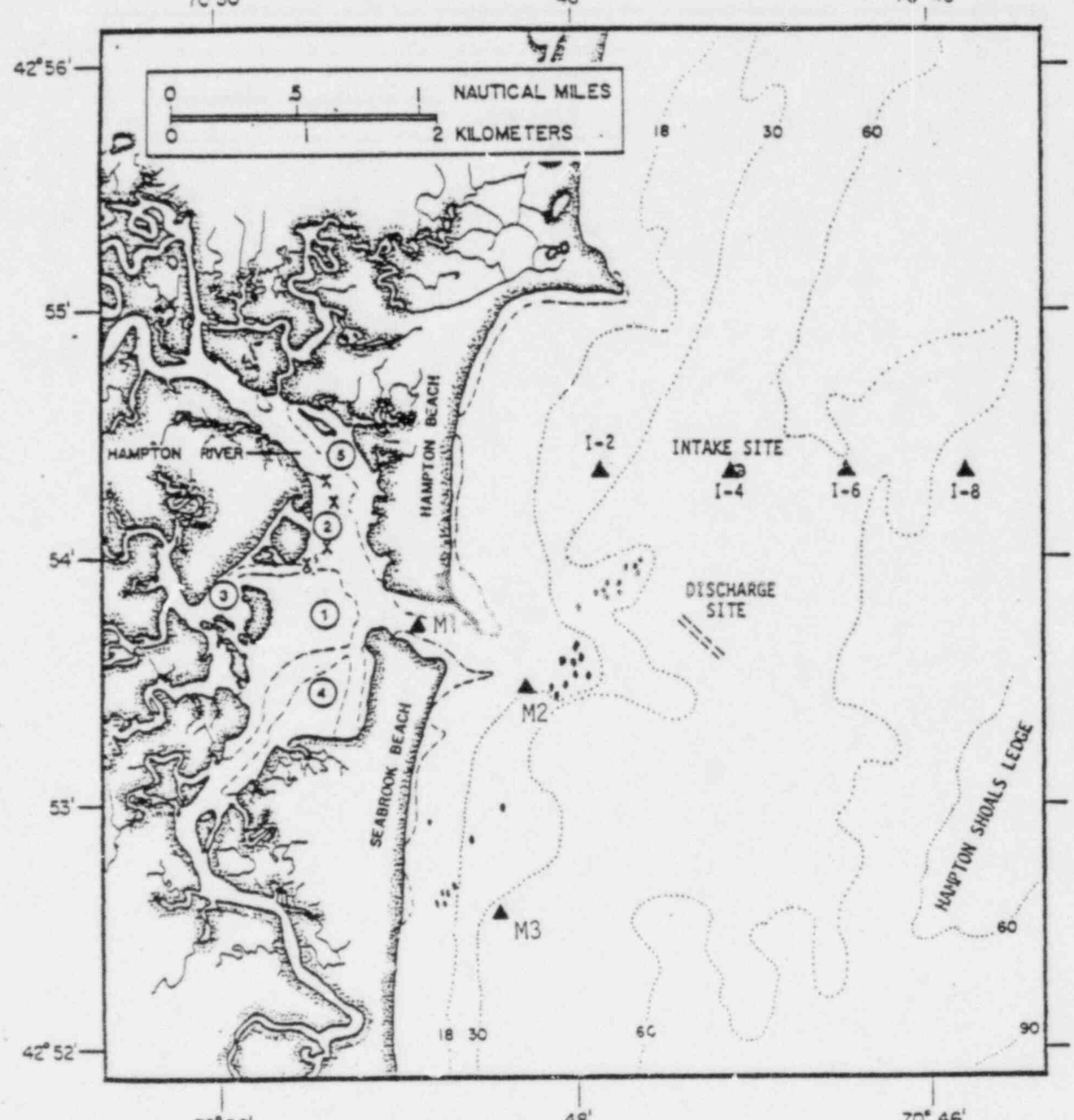
2.0 METHODS AND MATERIALS

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 17 June to 16 October; weekly tows were taken from 16 April through 9 June and from 20 October through 3 November 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.

To separate the live bivalve larvae from the bulk of the plankton, in the laboratory 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 than enumerated.

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



▲ 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, 1980.

(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.

Principal references used as aids in identifying larvae to species were: Sullivan (1948), Culliney (1974), de Schweinitz 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, at the entrance to Hampton Harbor, and at a station to the south of the Harbor entrance; in Hampton Harbor inlet, and outside the entrance, oblique tows were made on both high and low slack tides (Figure 1). Sample analysis procedures were as described above. A series of distribution free median tests (Conover 1971) were computed to investigate spatial distribution patterns.

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 two adjacent estuaries, in northern Massachusetts and southern Maine (Figure 2 and Table 1). In the April, July and early October surveys, the stations were fixed; once established (on

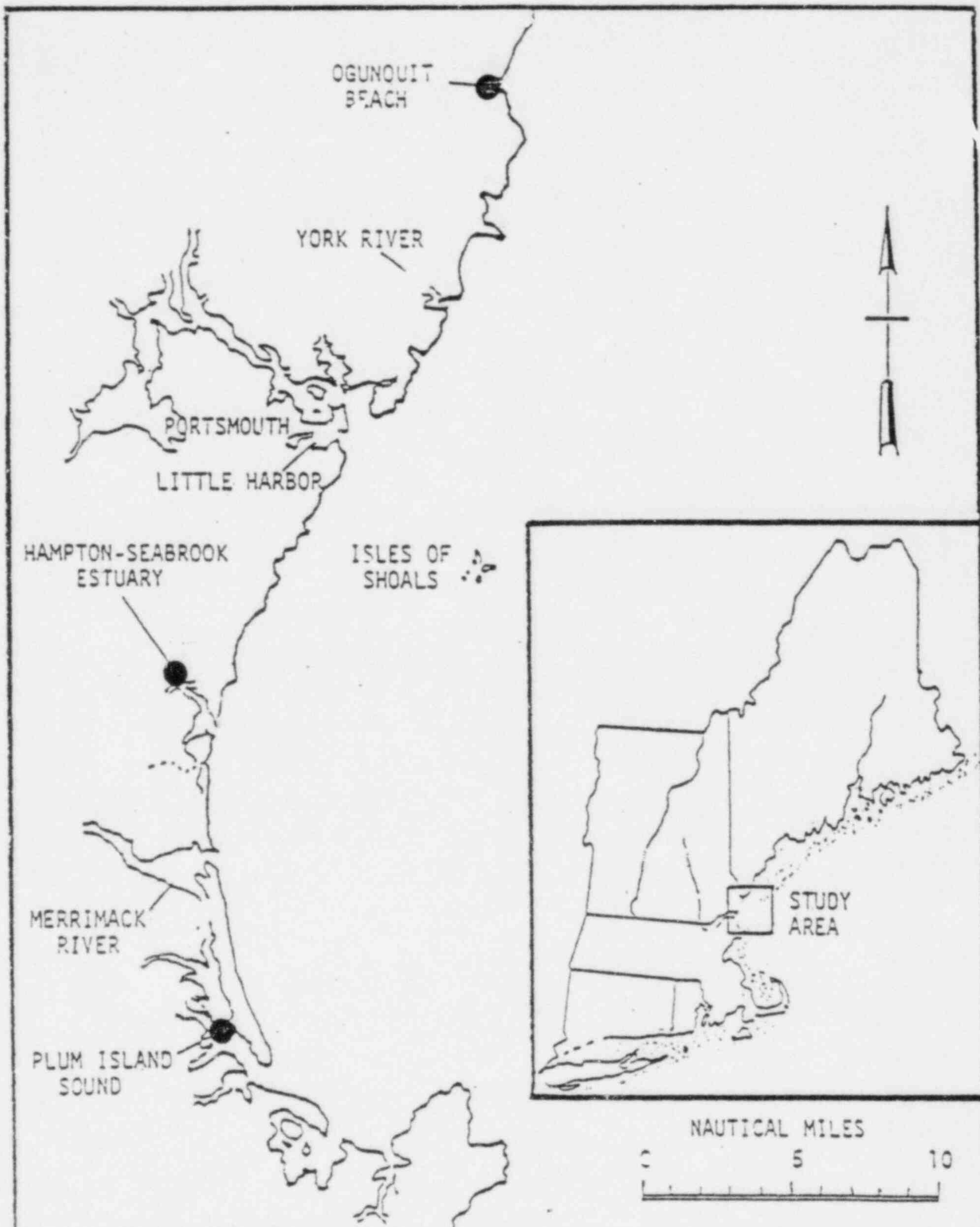


Figure 2. Spat study sites. Seabrook *Mya arenaria* Study, 1980.

TABLE 1. CLAM SPAT SAMPLING EFFORT. SEABROOK *MYA ARENARIA* STUDY, 1980.

a. FIXED STATIONS

LOCATION	NO. OF STATIONS	DATES
Plum Island Sound, MA	5	6 Apr, 2 Jul, 1 Oct
Middle Ground	3	
Lufkin's Flat	2	
Nut Shoal		
Hampton Harbor, NH		
Flat 2	5	3 Apr, 1 Jul, 2 Oct
Flat 4	5	
Southern Maine		
Ogunquit Beach	10	7 Apr, 3 Jul, 3 Oct

b. RANDOM STATIONS

LOCATION	NO. OF STATIONS		DATES
	SPAT	ADULT	
Hampton Harbor, NH			
Flat 1	19	30	25, 28 Oct
Flat 2	25	40	24 Oct
Flat 3	25	40	23 Oct
Flat 4	25	32	27 Oct
Flat 5	20	42	20 Oct

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 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 late October; however, the stations (Table 1) were chosen at random from 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 annual sampling program in late October provided better estimates of spat densities for the five major Hampton-Seabrook flats, including areas less favorable for spat settlement.

2.3 ADULT SURVEYS

As in past years, the five largest harbor flats were each surveyed in the autumn (late October) for adult clams (Figure 1).

Aerial photographs, taken in August 1980 at mean low water, were used to construct sampling charts as in the three previous 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%.

Statistical evaluation of previous survey data indicated that the sampling protocol instituted in 1976 to reduce unproductive sampling (the "no-holes" protocol) produced potentially biased estimates of *M. arenaria* abundance. Accordingly, a total random sampling protocol was

instituted in 1980. Results of a "worst case" comparison between the two methods (utilizing 1980 data) indicate that the "no-holes" protocol consistently overestimated soft-shell clam abundance in the 1980 data (Appendix 7.1).

To determine the number of (totally random) sampling stations needed on each flat to adequately characterize soft-shell clam populations, statistical power analysis (Sokal and Rohlf, 1969) was performed on the previous years (1979) data (NAI, 1981). Adequacy was defined as the ability to detect a real 50% change in mean clam density per flat with 90% confidence (50% $\Delta\bar{x}$, α=0.10). Flats 2, 3, 5 were shown to require a number of sampling stations well beyond the scope of these studies in order to meet this criterion for adequacy; alternatively, a judgement was made to sample at least 40 stations on each of these flats. For Flats 1 and 4, a range of 25 to 30 stations was determined to provide statistically adequate data.

To select the 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 was attained. In the field, stations were located by compass bearing and distance from a predetermined central reference point. Seven of the randomly generated stations for Flat 4 and two for Flat 5 fell in areas occupied by dense mussel beds; because the substrate around mussel beds tends to be very silty (i.e. unsuitable for sand-dwelling molluscs) these were not approached, but were assumed to be devoid of soft-shell clams.

To delineate the sample area, a frame, two feet by one foot, 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, and then dug to a depth of about 16 inches. 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). 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).

2.4 GREEN CRAB (CARCINUS MAENAS) TRAPPING

Carcinas maenas were trapped twice a month, in January and from April through December, 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 Carcinas maenas from each trap was also recorded.

2.5 HISTOLOGICAL STUDY OF GONADAL CONDITION

On the dates shown in Table 2 approximately 25 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, ets.) was taken out and fixed in 10% buffered formalin. Blocks of gonadal tissue were dissected from each specimen and sent to Path Laboratories, Portsmouth, New Hampshire, 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 2. CLAM GONAD SAMPLING EFFORT. SEABROOK *MYA ARENARIA* STUDY, 1980.

COLLECTION DATES	NO. SPECIMENS EXAMINED
25 March	17
9 April	25
23 April	25
7 May	25
22 May	25
4 Jun	25
19 Jun	25
2 Jul	25
21 Jul	25
6 Aug	25
19 Aug	25
3 Sep	25

3.0 RESULTS

3.1 PLANKTONIC LARVAE

3.1.1 Temporal Distribution

Mya arenaria umboned veligers first appeared in plankton samples taken on 20 June; although a few straight-hinge larvae appeared as early as 3 June; a larvae swarm occurring on 17 June consisted of late straight-hinge individuals (Table 3). In sample collections after 20 June, umboned larval densities first declined and then peaked at approximately 173 larvae per m^3 on 3 July. Midsummer density levels generally fluctuated between 1 and 30 larvae per m^3.

Larval densities were generally in the range of 50 to 900 larvae per m^3 throughout September. Larvae swarms were particularly intense from 2 to 4 September, from 15 to 22 September and on 29 September. October densities were intermediate between midsummer and September levels (Table 3).

3.1.2 Spatial Distribution

Onshore-offshore distribution trends were different on each date of the intensive tows (Table 4). Offshore stations had more larvae on 2 September; while, inshore stations had more larvae on 18 September. Differences between inshore stations were more consistent with stations I4 and M3 being equivalent and having less larvae than M1 or M2 on both 2 and 18 September. The inshore spatial distribution pattern may have had a significant tidal component, as I4 was found to be equivalent to M2 and greater than M1 under conditions approaching slack low water on 15 September.

TABLE 3. DENSITIES (PER m^3) OF UMBONED *M. ARENARIA* VELIGERS COLLECTED AT THE COOLING WATER INTAKE SITE (I4) 1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

DATE	REPLICATE 1	REPLICATE 2	MEAN	REMARKS
16 Apr	0.0	0.0	0.0	
22 Apr	0.0	0.0	0.0	
1 May	0.0	0.0	0.0	
5 May	0.0	0.0	0.0	
12 May	0.0	0.0	0.0	
19 May	0.0	0.0	0.0	
28 May	0.0	0.0	0.0	
3 Jun	0.0	0.0	0.0	a few straight-hinge larvae present
9 Jun	0.0	0.0	0.0	
17 Jun	(54)	(83)	(62)	all late straight-hinge
20 Jun	36.	13.	22.	
24 Jun	9.0	14.	11.	
27 Jun	8.0	2.6	5.0	
30 Jun	35.	68.	52.	
3 Jul	158.	188.	173.	
7 Jul	14.	21.	18.	
10 Jul	1.8	1.8	1.5	
14 Jul	19.	23.	21.	
17 Jul	25.	32.	28	
21 Jul	0.0	1.2	0.7	
25 Jul	1.2	3.4	2.3	
28 Jul	2.9	1.4	2.2	
1 Aug	3.3	5.2	4.2	
4 Aug	3.3	4.0	3.6	
7 Aug	16.	14.	15.	
11 Aug	6.7	8.8	7.7	
14 Aug	5.7	4.4	5.0	
18 Aug	11.	10.	11.	
25 Aug	16.	19.	17.	
28 Aug	9.6	7.2	8.2	
2 Sep	720.	620.	670.	see also: Table 4
4 Sep	900.	800.	850.	
8 Sep	80.	110.	94.	
11 Sep	56.	46.	51.	
15 Sep	600.	458.	525.	see also: Table 4
22 Sep	290.	345.	320.	
25 Sep	15.	8.8	12.	
29 Sep	188.	183.	186.	
2 Oct	12.	10.	11.	
6 Oct	8.2	7.1	7.7	
9 Oct	35.	39.	37.	
13 Oct	5.7	5.4	5.5	
16 Oct	1.2	1.3	1.3	
20 Oct	2.1	2.1	2.1	
27 Oct	72.	80.	76.	
3 Nov	3.0	3.1	3.1	

TABLE 4. DENSITIES (PER m^3) OF UMBONED *M. ARENARIA* VELIGERS COLLECTED ON SELECTED DATES AND AT SELECTED STATIONS IN THE VICINITY OF HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1980.

EVENT	DESCRIPTION	STATION	TOW A SPLIT 1	TOW A SPLIT 2	TOW B SPLIT 1	TOW B SPLIT 2
2 Sep.	Mooring, ebbing, tide	I-4	722	665	345	892
2 Sep.	Afternoon, flooding tide	I-2	983	538	783	496
		I-4	330	155	113	140
		I-6	1230	1640	1090	1040
		I-8	1150	986	1220	1440
		M-1	2690	1760	2600	2330
		M-2	5140	5260	3080	3730
		M-3	943	893	1230	1260
3 Sep.	late morning, ebbing tide (nearing slack low water)					
		M-1	628	686	1100	980
		M-2	1570	1400	1140	802
4 Sep.	ebbing tide	I-4	1150	640	751	842
15 Sep.	Mooring, ebbing tide (nearing slack low water)	I-4	512	687	492	423
		M-1	166	161	124	137
		M-2	453	595	604	502
15 Sep.	Afternoon, flooding tide	I-4	280	344	289	252
		M-2	1220	1660	1310	2190

(Continued)

TABLE 4. (Continued)

18 Sep.	Morning, flooding tide					
		I-2	349	394	410	567
		I-4	413	278	326	259
		I-6	258	194	146	271
		I-8	85	117	135	79
		M-1	4910	2590	1710	3390
		M-2	415	513	557	454
		M-3	210	157	219	274
18 Sep.	Afternoon, ebbing tide (nearing slack low water)					
		M-1	493	285	352	266
		M-2	4130	5000	3230	2940

3.1.3 Species Composition

Mya arenaria umboned veligers comprised more than 5% of the total bivalve assemblage on only one occasion in 1980. That was during the earliest September swarming (Table 5). Mussels were the usual dominants with Mytilus edulis predominating in early summer and late fall, and Modiolus modiolus predominating during mid to late summer. From the beginning of the monitoring program in mid April, until late May, Hiatella sp. was practically the only bivalve species present. Other bivalve mollusc species exhibiting prominent seasonality of occurrence included: Anomia sp. - mid August, Ensis directus - late October, and Macoma balthica, also late October.

3.2 AREAWIDE SPAT AND JUVENILE CLAM SURVEYS

Compared to Ipswich, Massachusetts, and Ogunquit Beach, Maine, flats, Hampton Harbor flats retained a relatively dense population of juvenile clams (shell size: 13 to 42 mm) throughout 1980 (Table 6). Juvenile clams were especially scarce on the Ogunquit Beach flat, a condition to which green crab predation may have contributed (B. Sterl, Maine Dept. of Marine Resources, personal communication). In all three study areas, the 1980 spat set appeared to be moderate compared to previous years (Appendix 7.2).

3.3 HAMPTON HARBOR SOFT-SHELL SURVEYS

3.3.1 Population Density Trends by Shell Size Categories

Figure 3 compares clam densities by 1-mm size class for all five principal flats combined. The smallest clams measured (shell length: 1 to 4 mm) were by far the most abundant. Least represented among size classes below 50 mm was the 9 mm class. From 10 mm upwards, the length-density distribution had a generally bell-shaped appearance,

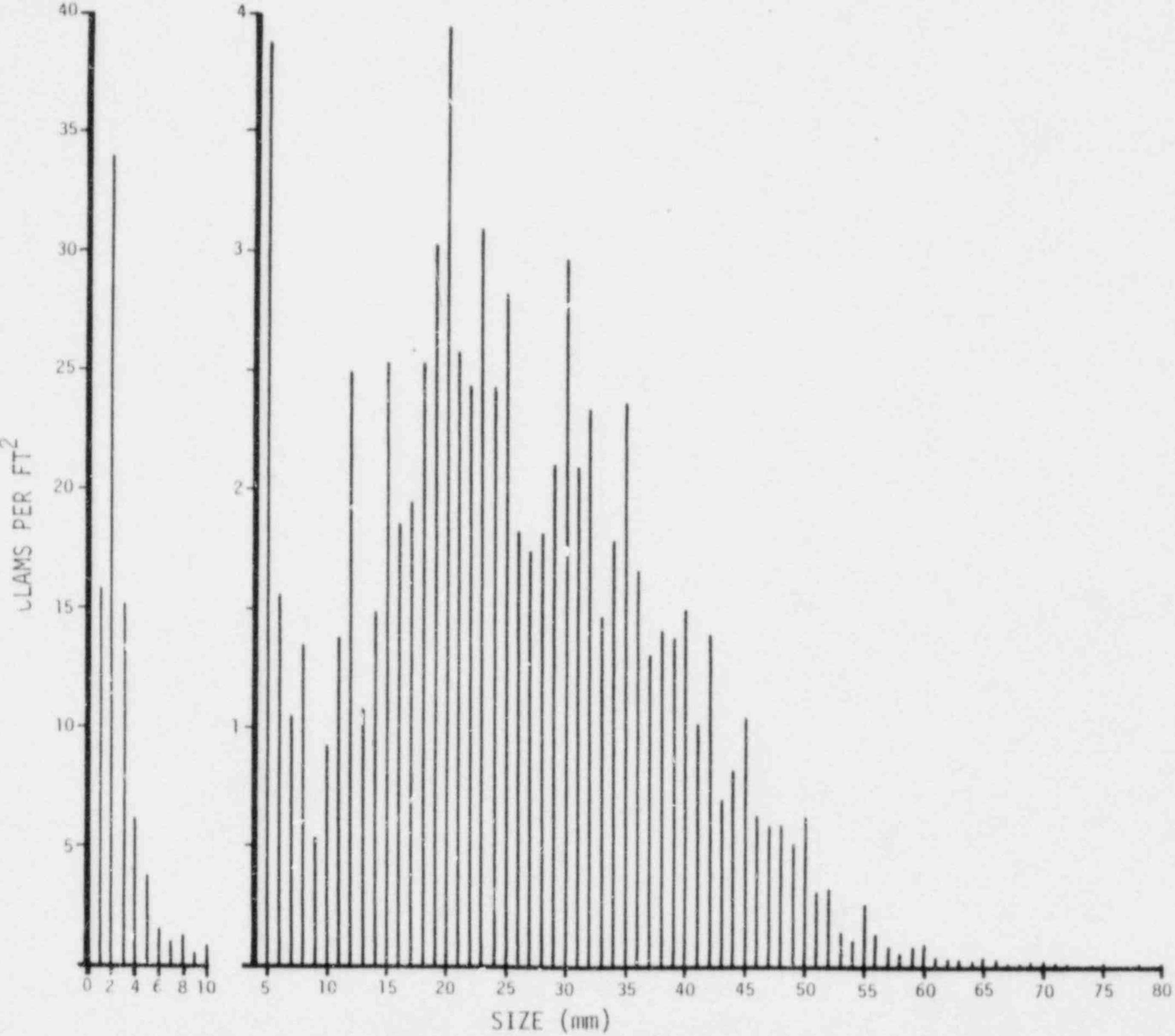


Figure 3. 1-mm size class length-frequency distribution of *Mya arenaria* collected October 1980. Seabrook *Mya arenaria* Study, 1980.

TABLE 5. PERCENT COMPOSITION AND TOTAL ABUNDANCE OF BIVALVE UMBONED VELIGERS IN OBLIQUE NET TOWS @ I_4 (INTAKE SITE). SEABROOK *MYA ARENARIA* STUDY, 1980.

	M. modiolus	*M. edulis*	*Hiatella* sp.	*Anomia* sp.	*E. directus*	*M. arenaria*	*M. truncata*	*P. magellanicus*	*M. balthica*	*S. solidissima*	All Others	Average Density All Bivalves (no per m^3)
16 Apr	0.0	0.0	99.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70
22 Apr	0.0	0.0	100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
1 May	0.0	0.0	99.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91
5 May	0.0	0.0	99.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	550
12 May	0.0	0.0	99.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	275
19 May	0.0	<.1	97.9	0.0	<.1	0.0	0.0	0.0	0.0	0.0	2.0	5230
28 May	0.3	8.6	88.8	0.0	0.2	0.0	0.1	0.6	0.0	0.0	0.5	8250
3 Jun	0.0	7.4	90.7	<.1	0.0	0.0	0.2	1.5	0.0	0.0	0.1	2980
9 Jun	0.0	8.5	85.6	1.4	0.6	0.0	0.1	1.9	0.0	0.0	1.8	12300
17 Jun	0.3	66.0	21.7	2.3	3.3	0.0[a]	<.1	0.8	0.0	0.0	4.9	10400
24 Jun	0.2	67.1	21.0	0.7	1.6	0.4	<.1	0.1	0.0	0.0	8.8	2720
30 Jun	0.4	81.6	8.7	3.6	4.3	0.4	<.1	0.0	<.1	<.1	0.9	12400
7 Jul	11.9	64.7	15.9	3.9	1.4	0.2	0.3	0.0	0.0	0.2	1.5	7940
14 Jul	84.0	13.1	1.2	1.0	0.5	<.1	<.1	0.0	0.0	<.1	0.1	69300

Notes:

[a] 50 to 80 late straight-hinged veligers per m^3

TABLE 5. (Continued)

	M. modiolus	*M. edulis*	*Hiatella* sp.	*Anomia* sp.	*E. directus*	*M. arenaria*	*M. truncata*	*P. magellanicus*	*M. balthica*	*S. solidissima*	All Others	Average Density All Bivalves (no per m^3)
21 Jul	65.0	20.8	8.3	2.4	0.6	<.1	0.2	0.0	<.1	0.2	2.4	34,300
28 Jul	66.0	20.4	6.1	6.0	0.3	<.1	<.1	0.0	0.1	0.1	0.9	71,000
4 Aug	27.4	48.1	8.6	13.8	0.3	<.1	<.1	0.2	<.1	<.1	1.5	18,600
11 Aug	32.7	11.7	5.1	43.8	0.1	0.1	<.1	<.1	0.1	0.5	5.8	9,940
18 Aug	16.3	49.4	1.3	27.3	0.1	0.5	<.1	<.1	0.2	3.6	1.2	1,960
25 Aug	39.5	32.7	2.6	14.2	0.2	2.1	0.0	0.3	0.4	5.2	2.8	804
2 Sep	34.4	0.7	7.9	30.0	1.4	15.0	0.0	0.0	0.0	0.3	1.3	4,460
8 Sep	91.2	4.0	0.8	2.6	0.2	0.1	0.0	0.0	<.1	0.7	0.3	145,000
15 Sep	82.2	7.9	1.5	2.1	0.4	1.8	0.0	<.1	0.2	3.2	0.6	29,900
22 Sep	53.9	19.2	0.5	17.9	0.1	1.9	<.1	0.0	0.6	4.8	1.1	16,600
29 Sep	59.8	30.8	0.4	4.1	0.4	1.0	<.1	0.0	1.9	0.8	0.8	18,400
6 Oct	64.8	11.6	1.3	9.2	3.8	1.5	<.1	0.2	2.5	1.9	3.2	519
13 Oct	57.1	21.2	2.4	12.3	<.1	0.5	0.0	0.4	0.7	0.4	4.9	1,210
20 Oct	13.3	11.1	3.7	26.0	9.3	0.3	0.0	4.5	22.3	1.8	7.6	790
27 Oct	2.5	45.8	0.4	2.6	35.6	4.6	0.0	0.1	4.9	1.8	1.7	1,660
3 Nov	4.4	59.6	0.8	13.5	8.4	1.5	0.0	0.1	0.3	1.5	9.8	211

TABLE 6. YOUNG-OF-THE-YEAR (1-12 mm) AND JUVENILE (13 to 42 mm) SOFT-SHELL CLAM DENSITIES (PER FT^2) IN POTENTIALLY PRODUCTIVE AREAS OF THREE NORTHERN NEW ENGLAND ESTUARIES. SEABROOK *MYA ARENARIA* STUDY, 1980.

ESTUARY	APRIL		JULY		OCTOBER	
	YOUNG-OF-THE-YEAR	JUVENILES	YOUNG-OF-THE-YEAR	JUVENILES	YOUNG-OF THE-YEAR	JUVENILES
Plum Island Sound (Ipswich, MA)	28	27	8	30	136	10
Hampton Harbor (Hampton & Seabrook, NH)	124	84	50	98	82	84
Ogunquit River (Ogunquit Beach, ME)	44	4	8	11	26	2

tapering markedly toward the larger-sized clams. The median shell size of all clams, over 8 mm, was 26 mm. By October 1980, an average of 7.4 clams per ft^2 had attained a shell size of 43 mm or more on all flats, while an average of 1.9 per ft^2 had attained a shell size of 51 mm or more (Appendix 7.3). Since the previous annual survey, in November 1979, clam densities in each of the 5 mm size categories, 30 mm through 70 mm, have increased substantially (Figure 4; Appendix 7.4).

On all flats, population densities of juvenile and adult clams (shell length >25 mm) were restored to levels comparable with or higher than densities shown for the years prior to 1976 (Table 7). In certain ways, however, each of the five principal flats demonstrated considerable individuality, in 1980. On Flat 4, the mean density of clams larger than 50 mm matched the highest previously recorded mean density. On Flat 1, mean densities of juvenile and young adult clams (shell length 26 to 50 mm) established a new record. Flat 2 experienced a spatfall second in intensity only to the great spatfall of 1976; while Flats 1, 3 and 5 showed increases in spatfall only over 1979 levels. Flat 4 exhibited a decline in mean spat density to the lowest level since 1975. Over all flats there were considerably more clams in the 26 to 50 mm size class in 1979 and 1980 compared to any previous year of study, due primarily to higher numbers at Flats 1 and 4.

3.3.2 Standing Crop

Estimates of standing crop (Table 8) show that clams over 50 mm in shell length comprised approximately 15% by volume of the total standing stocks in Hampton Harbor, in October 1980. Clams 43 to 50 mm in length (young adults) represented approximately an additional 26%. More than 58% of the total volume consisted of juvenile clams, 25 to 43 mm long, 92% of which was found on Flats 1 and 4 (Table 8). On Flat 2 the majority of the standing crop consisted of clams over 50 mm; Flat 2 ranked second, only slightly behind Flat 4, in potential yield per acre of clams over 50 mm (Table 8).

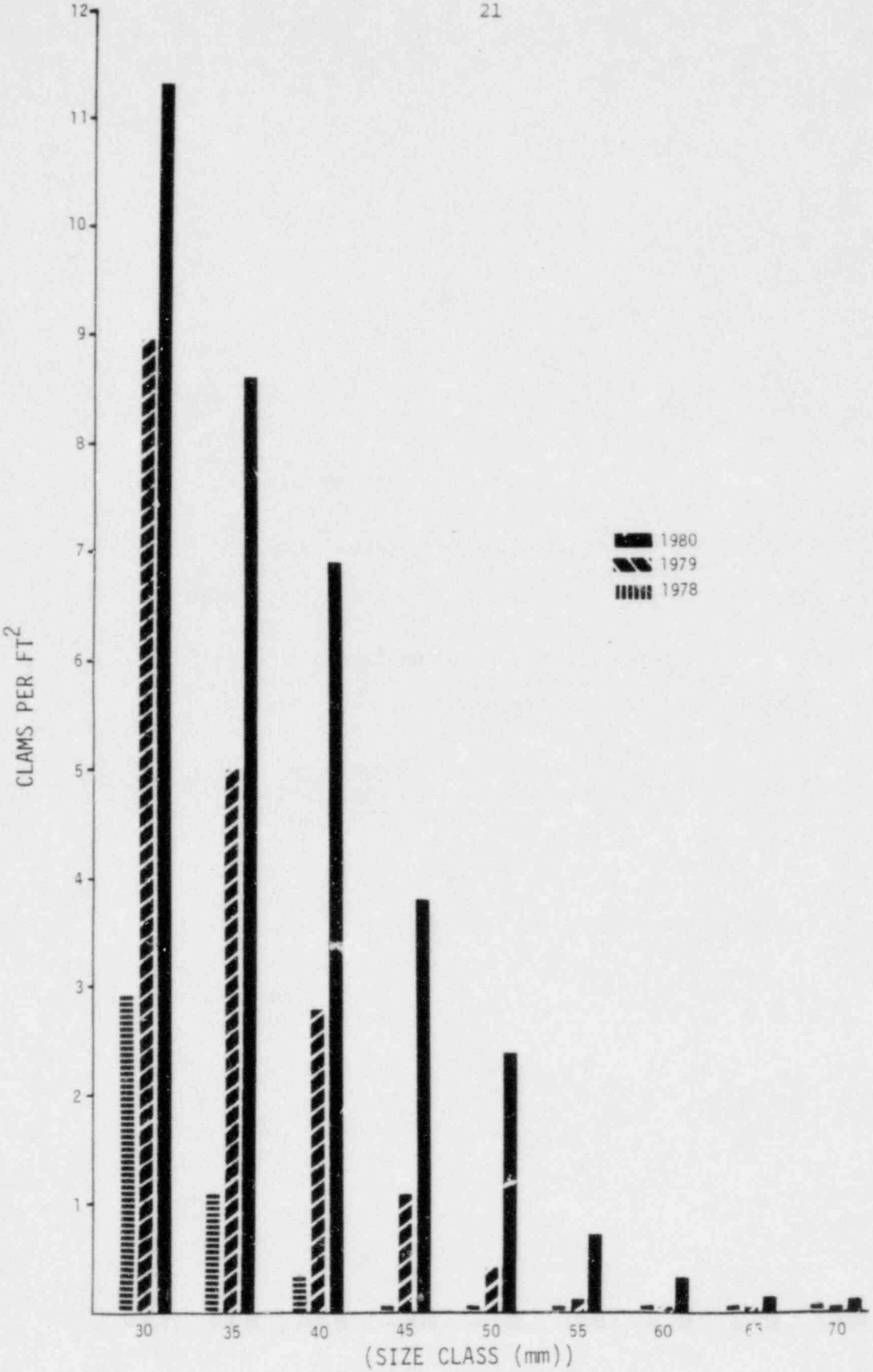


Figure 4. 5 mm class length-density distribution of *Mya arenaria* juveniles and adults, comparing November 1978 through 1980 surveys in Hampton Harbor. Seabrook *Mya arenaria* Study, 1980.

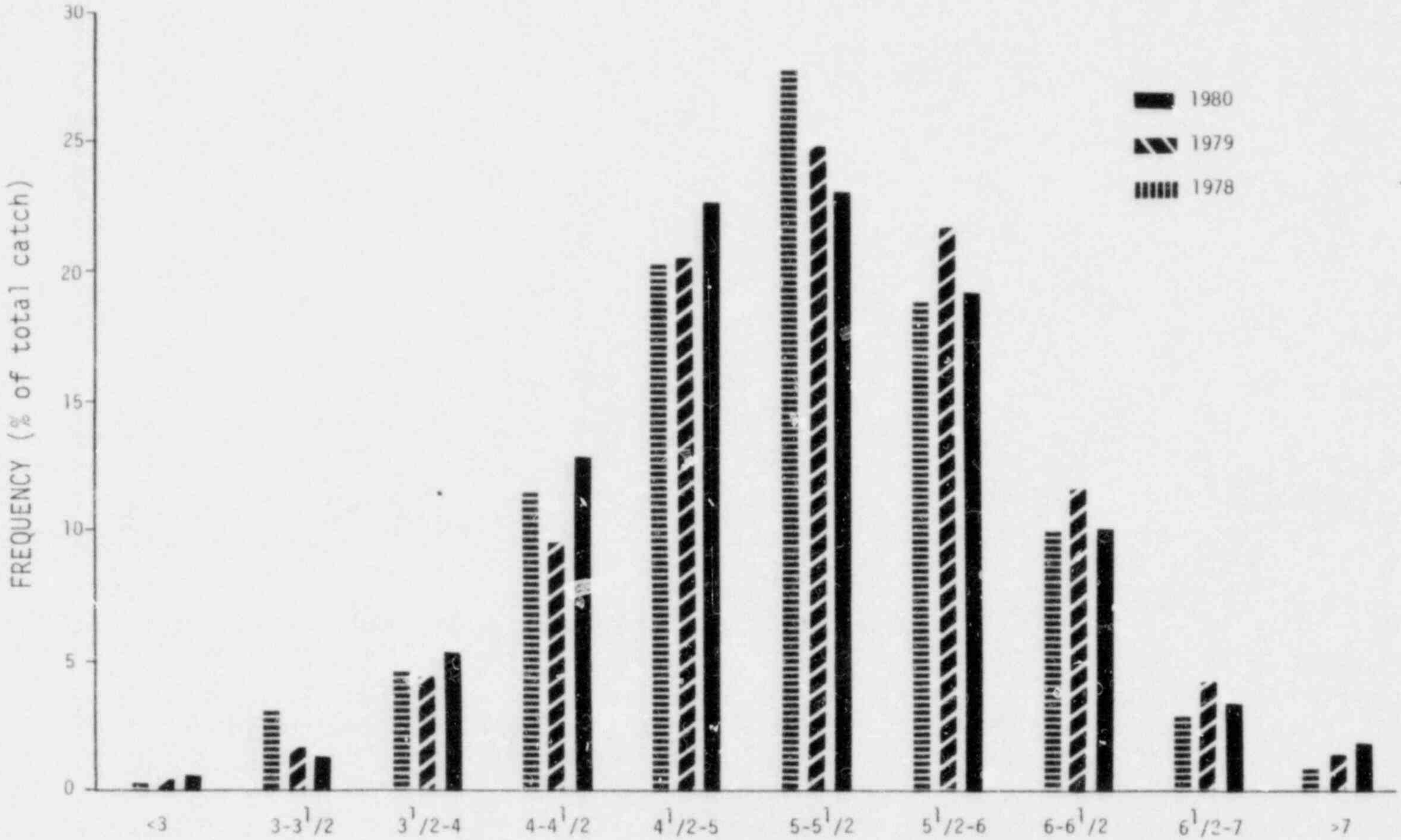


Figure 5. Size-frequency distribution of *Carcinus maenas* catch at Flat #2 in Hampton Harbor. Seabrook *Mya arenaria* Study, 1980.

TABLE 7. SUMMARY OF *MYA ARENARIA* POPULATION DENSITIES, ANNUAL NOVEMBER SURVEY. SEABROOK *MYA ARENARIA* STUDY, 1980.

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
	1980	30	19	103	72.	1.7
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	[illegible]	15	2.1	0.16
	1979	33	9	57	3.6	0.29
	1980	40	25	254	4.1	2.2
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
	1980	40	25	56	0.47	0.36
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	0.52
	1980	32	25	99	36	2.8

(Continued)

TABLE 7. (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	0.9	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
	1980	42	20	68	2.1	0.9
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	0.3
	1980	184	114	116	36	1.9

TABLE 8. ANNUAL SURVEY STANDING CROP ESTIMATES. SEABROOK *MYA ARENARIA* STUDY, 1980.

FLAT	SURFACE AREA[a]	CLAMS >50 mm		CLAMS 43-50 mm		CLAMS 25-42 mm	
		AVERAGE BUSHELS/ACRE	BUSHELS	AVERAGE BUSHELS/ACRE	BUSHELS	AVERAGE BUSHELS/ACRE	BUSHELS
1	53.95	47.5	2565	156.	8396	416.	22,450
2	24.74	72.3	1789	31.0	768	18.1	448
3	10.83	17.1	185	4.4	48	1.5	16
4	50.83	75.4	3832	113.	5762	212.	10,760
5	23.98	21.7	521	17.4	418	9.7	230
All	164.33	54.1	8892	93.7	15,390	206.	33,900

[a] from aerial survey, August 1980

Gains in standing crop of adult clams (shell length >42 mm) were achieved on all flats from November 1979 to late October 1980, with the highest absolute gain occurring on Flat 1 (Table 9). Although possessing a relatively modest standing crop, Flats 2 and 5 both showed comparatively large proportional gains. The smallest gain, in both proportional and absolute terms, was realized on Flat 3, where clams have in general been sparsely distributed in recent times. On all flats, except Flat 3, clam populations were sufficiently dense in some places as to potentially yield from 230 to more than 1000 bushels per acre. A yield of 250 bushels per acre is equivalent to approximately ten two-inch clams per ft^2 and is comparable to some of the best commercial clamming grounds in New England. Sample yields equivalent to 40 bushels per acre (slightly less than two two-inch clams per ft^2) approximate the threshold between a marginal fishery and one with a healthy potential for recreational digging. As of October 1980, almost half of the 164 1/3 acres surveyed in Hampton Harbor had exceeded the 40 bushels-per-acre threshold. Over all flats, approximately the same proportion of samples yielded adult clams (Table 9) as produced clams over 25 mm in shell length (Table 10).

3.4 GREEN CRAB, CARCINUS MAENAS, TRAP CATCHES

For comparison, data from surveys in 1977 through 1979 are presented in Table 11, along with 1980 catch data; size-frequency distribution data for 1977 through 1980 catches are presented in Figure 5.

As in 1979, the largest trap catches of C. maenas occurred in the fall of 1980. Catches in 1980 exceeded all previous records except during spring when catches were at about the same level as in 1978 and 1979 (Table 11). The 1979 record catch of 58 crabs per trap was surpassed on three occasions in 1980, 17 October, 7 November and 21 November (Appendix 7.5). A new record of 108 crabs per trap was established on 21 November 1980.

TABLE 9. ESTIMATES OF "HARVESTABLE"[1] STANDING CROP. SEABROOK *MYA ARENARIA* STUDY, 1980.

FLAT	TOTAL ESTIMATED HARVESTABLE CROP (BUSHELS)		% OF SAMPLES YIELDING HARVESTABLE CLAMS		% OF SAMPLING YIELDING EQUIVALENT OF >40 BUSHELS PER ACRE		% OF SAMPLES YIELDING EQUIVALENT OF >250 BUSHELS PER ACRE	
	1980	1979	1980	1979	1980	1979	1980	1979
1	10,960	1890	83	44	60	21	33	1
2	2,560	350	68	44	42	18	10	0
3	230	126	38	29	25	14	0	0
4	9,600	3160	59	52	56	40	28	3
5	940	143	50	22	21	6	5	0
All	24,300	5670	66	43	48	24	22	1

[1] Defined as clams with shells $\geq$43 mm long

TABLE 10. ESTIMATES OF CLAM FLAT PRODUCTIVE AREA[1] (%) IN HAMPTON-SEABROOK ESTUARY. SEABROOK *MYA ARENARIA* STUDY, 1980.

LOCATION	1980	1979	1978	1977	1976	1975	1974
Flat 1	83	72	60	17	35	53	80
Flat 2	72	62	36	15	17	44	63
Flat 3	50	29	42	32	48	39	67
Flat 4	59	76	62	20	19	57	88
Flat 5	55	22	43	22	27	4	20
All Flats	68	62	52	19	26	45	66

[1] of total number of samples taken, proportion in which at least one clam, ≥25 mm, was found

TABLE 11. SELECTED *C. MAENAS* CATCH STATISTICS 1977-1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

SAMPLE PERIOD	AVERAGE CATCH PER UNIT EFFORT[a]	SEX RATIO (M:F)	FECUNDITY (% GRAVID FEMALES)
Summer 1977			
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	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
Apr-Jun 1980	6.7	1:1.1	8.4
Jul-Sep 1980	15.8	1:1.0	2.3
Oct-Dec 1980	53.1	1:2.0	0.0

[a] Number of C. maenas per trap per day; summer 1977, two "prism" traps, fishing for 2 to 5 days at a time; after September 1977, eight "box" traps, fishing for 24 hours twice per month.

The largest green crab captured in 1980 was 8.1 cm at the widest part of the carapace. Approximately 98% of the crabs caught had carapaces between 3.0 and 7.0 cm at the widest point. Crabs with carapaces wider than 7.0 cm were almost exclusively males (Appendix 7.5).

Sex ratios were close to parity except in October and November when there were more than two female crabs for every male (Appendix 7.4). Egg bearing females were captured on 18 April, 8 May, and from 20 June to 7 August. Fecundity peaked, at 13.7% of females bearing eggs, on 20 June 1980.

3.5 SOFT-SHELL CLAM REPRODUCTIVE CYCLE

In 1980, histological examination of gonadal development (Table 12) showed one spawning female occurring in early April and a ripe female in early May, while males showed no evidence of ripeness until late in May. First indications of sperm releases occurred in early June. The greater proportion of both sexes appeared to participate in the main reproductive sequence, in which spawning activity began in earnest in early August, culminating in early September.

TABLE 12. RESULTS OF HISTOLOGICAL STUDY OF GONADAL CONDITION. NUMBERS OF SPECIMENS IN EACH GONADAL CONDITION CATEGORY. SEABROOK *MYA ARENARIA* STUDY, 1980.

GONAD CONDITION	SAMPLE DATES 25 MAR	9 APR	23 APR	7 MAY	22 MAY	4 JUN	19 JUN	2 JUL	21 JUL	6 AUG	19 AUG	3 SEP	17 SEP
Males													
Indifferent	4	2	1	1	3		1		1		1	3	
Developing	5	8	8	5	8	12	4	5	2	4	3	1	
Ripe					1	1	3	6	9	7	6	3	
Spawning						1				2	2	1	
Spent												3	
Females													
Indifferent	2	3	1		2	2			1	1		1	
Developing	6	11	15	18	7	3	5		1		1		
Ripe				1	3	1	9	10	7	6	10	4	
Spawning		1			1		2	1	3	3	3	5	
Spent						2	1	1		1		4	
Hermaphrodites													
Ovary developing/testes indifferent						1							
Ovary ripe/testes developing						1		1					
Testes ripe/ovary developing						1							
Ovary spawning/testes developing								1					
Ovary and testes both ripe									1				

4.0 DISCUSSION

4.1 PLANKTONIC LARVAE SPATIAL DISTRIBUTION

Results of the two 1980 intensive surveys were mixed, with clear support on only one of the dates for the conventional view that larval densities decrease with distance from shore. Exceptions to the general pattern of seaward decreasing larval density have occurred on the same spatial scale in the past, notably in 1976 and 1979 (NAI, 1977, 1981).

In 1980, larvae tows were conducted for the first time at a point (Station M2) immediately seaward of Hampton Harbor Inlet. On the afternoons of 2 September (flooding tide) and 18 September (ebbing tide), M. arenaria umboned veliger densities exceeded 3000 larvae per m^3 at Station M2, while densities of only a few hundred larvae per m^3 were found elsewhere including the intake site (I4). Given the limited data so far available, any speculation as to the environmental significance of these spatial distribution patterns would be premature.

4.2 TEMPORAL RELATIONSHIPS: LARVAL SWARMING AND REPRODUCTIVE CYCLE

Temporal occurrences of M. arenaria veligers in 1980 suggest the continuance of a gradual shift in peak abundance towards autumn. This trend appears to affect both the early and late summer modes of larval abundance. In 1978, for example, the early summer mode occurred around the second week of June; while, in 1979, a comparable mode occurred towards the end of June and into early July. In 1980, a relatively minor mode was briefly observed on or about 3 July. Similarly, the late summer (principal) mode has progressed from commencement in early August, in the years prior to 1976, to commencement no earlier than 2 September, in 1980. Major swarms (defined as abundances exceeding 50 larvae per m^3) have, over the years, occurred later.

In apparent departure from 1978, and to a lesser extent, 1979, breeding activity (coincidence of sperm and egg release) in Hampton Harbor soft-shell clams was in close synchrony with the timing of larval swarming in 1980. Also, ripening of testes and release of sperm appears to have shifted from essentially a single-mid summer episode in 1978, toward two periods of activity in 1980, slightly suggestive of bimodal reproductive periodicity (cf. Table 12).

In all three years of recent gonad study, 1978 through 1980, females have ripened beginning in early spring. The 1980 data, produced scant evidence of a spring egg release, the function of which is unknown;with none of the 28 male specimens collected in early spring 1980 showing the slightest sign of ripeness, few eggs released at that time are likely to have been fertilized.

4.3 LARVAL ABUNDANCE AND SPATFALL

In general, M. arenaria umboned veligers were approximately as abundant in 1980 as in 1978, and slightly less abundant than in 1979 (Table 13). In contrast, young-of-the-year spat densities were more than twice as high in 1980 as in 1979. Present and previous data, taken together, support the conclusion that the quantity of larvae available in the vicinity of the cooling water intake has little relation to spatfall intensity in the Hampton-Seabrook Estuary. Possible explanations for the lack of correspondence include: 1) geographic and hydrographic isolation of the intake site from Hampton Harbor and 2) the majority of larvae enumerated did not represent potential spat (i.e. were not ready to set).

4.4 BIVALVE MOLLUSCS SPECIES COMPOSITION

Surveys from 1977 through 1980 have established a reasonably consistent general pattern of bivalve mollusc species composition for New Hampshire coastal waters. Even during major larval swarms, M.

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, 1980.

YEAR	PERIOD OVER WHICH LARVAE WERE COLLECTED	MEAN (per m^3/day)	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	3,500	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	56
1979	21 May to 29 Oct (162 days)	136	22,000	30
1980	20 Jun to 3 Nov (137 days)	90	12,400	79

arenaria is rarely dominant. By the time the larvae investigated here have developed to the umboned stage, they have probably been in the water column at least a week; nevertheless, abundance patterns at the intake site reflect the presence of bivalves which are common to the local coastal nearshore environment such as Mytilus edulis, Modiolus modiolus and to a lesser extent, Hiatella sp. Mya truncata is occasionally found nestled among populations of M. Modiolus and Hiatella sp. which is probably why larvae of this species are present at detectable levels in our collections. Larvae of other species, known to inhabit patches of sandy substrate, (namely, Anomia sp., E. directus, S. solidissima and M. balthica), are well represented during what appears to be their breeding season. Of the bivalve larvae routinely identified in these studies, those of the sea scallop, P. magellanicus, likely originate from the most remote source (nearest known populations are off Rye Beach); correspondingly, the larvae are among the least abundant in our samples.

4.5 GREEN CRAB CATCHES IN HAMPTON HARBOR AND SOFT-SHELL STANDING CROP

Crab trap data suggest a trend toward increasing catchability from 1978 through 1980. Coincidentally, winter water temperature minima off Hampton Beach have also increased over the same period (Figure 6) Welsh (1969) and Dow (1977) have proposed a mathematical relationship between green crab catchability and winter water temperature minima at Boothbay Harbor, Maine. Their model also implies an inverse relationship between soft-shell clam harvests and winter water temperature minima, given a two to three-year time lag; the Dow (1977) model seems not to pertain to Hampton Harbor, however, as standing crop estimates declined to their lowest point in 1978 (Table 14) the same year that the lowest winter temperature minima were recorded (Figure 6). Probable reasons for the failure of Hampton Harbor soft-shell clam stocks to correlate inversely with winter water temperature trends are: 1) that the fate of Hampton Harbor clam stocks rests primarily on the strength of occasional superabundant year classes like those of 1976 and 1977,

TABLE 14. RECENT HISTORY OF THE STANDING CROP OF ADULT[a] *MYA ARENARIA* IN HAMPTON HARBOR. SEABROOK *MYA ARENARIA* STUDY, 1980.

DATE	ESTIMATED NUMBER OF BUSHELS PER ACRE	TOTAL ESTIMATED NUMBER OF BUSHELS
November 1967	152[b]	23,400[b]
July 1969	103	15,840
November 1971	94	13,020
November 1972	58	8,920
November 1973	41	6,310
November 1974	56	8,690
November 1975	29	4,945
November 1976	11	1,350
November 1977	6.4	1,060
November 1978	5.7	940
November 1979	8.5	1,400
November 1980	54	8,890

[a]shell length >50 mm

[b]from Ayer (1968)

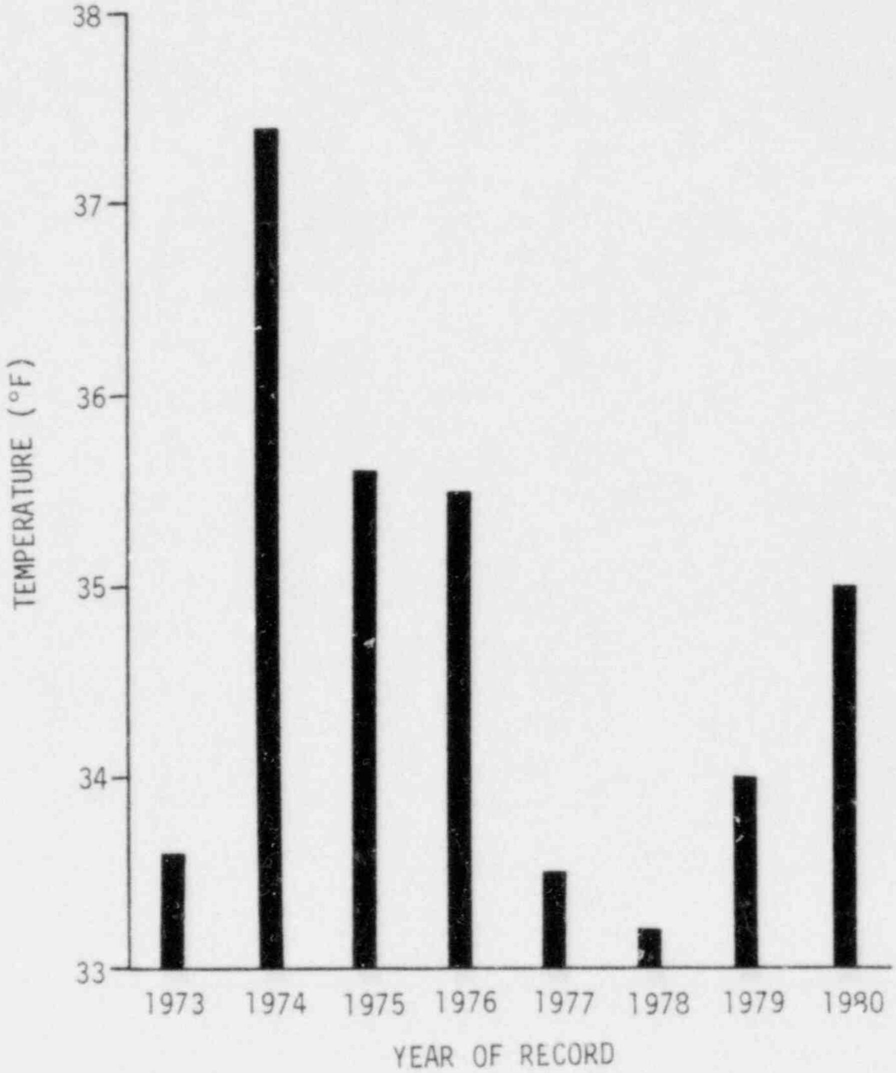


Figure 6. Means of daily minimum winter (February and March) water temperatures off Hampton Beach, New Hampshire. Seabrook *Mya arenaria* Study, 1980.

and 2) human predation, which responds more to the availability of clams than to climatic shifts and is believed to be the primar· factor influencing future clam stocks in Hampton Harbor.

5.0 SUMMARY

Mya arenaria umboned veligers were present in plankton samples from 20 June until sampling ended on 3 November, having exhibited a brief abundance peak (173 larvae per m^3) on 3 July and a sustained abundance of 50 to 900 larvae per m^3 throughout September 1980. Sampled intensively on two dates in September (when larval abundance was particularly high), more larvae were collected within one mile of shore than 1-1/2 to 2 miles from shore on one date, while on the other date the reverse was true. Differences between inshore stations were more consistent, with fewer larvae collected at the cooling water intake site and a point south of the entrance channel to Hampton Harbor than at the Harbor entrance channel and inlet. Mussels were the dominant bivalve larval taxa, with *M. arenaria* comprising more than 5% of the total bivalve assemblage on only one occasion (15% on 2 September).

In 1980, the cycle of reproductive development and activity in Hampton Harbor soft-shell clams appeared to agree well with seasonal larval abundance. Female clams began to ripen in early spring; while males showed little evidence of ripening until late May. Some sperm and egg releases apparently occurred in early June; however, the majority of clams sampled showed evidence of breeding activity beginning in early August and culminating in early September.

As measured in late October 1980, young-of-the-year spat densities were low compared to the dense sets of 1976 and 1977, but were more than twice as dense as in 1979, when spat set was light. On Hampton Harbor flats, clams one year or older (up to a shell length of approximately 72 mm) were numerous compared to populations in Ogunquit Beach, Maine and Ipswich, Massachusetts. Total standing crop on Hampton Harbor flats was estimated in October 1980 to be approximately 58 thousand bushels with approximately 41% consisting of clams over 42 mm long (i.e. adults and potentially harvestable).

Notwithstanding continued increases in soft-shell clam standing stocks, from a 14-year low in 1978, in 1980 trap catches of green crabs (an important natural predator) surpassed previous records going back to 1977. As in 1979, the largest trap catches occurred in autumn. Egg bearing females, usually representing less than 5% of the trap population, were captured mainly in spring, as in previous years.

6.0 LITERATURE CITED

Armed Forces Institute of Pathology. 1949. Manual of histologic and special staining techniques. McGraw Hill. 2nd edition. pp. 7-14, 25-30.

Ayer, W. C. 1968. Soft-shell clam population study in Hampton-Seabrook Harbor, New Hampshire. New Hampshire Fish and Game Dept. 39 pp.

Belding, D. L. 1930. The soft-shelled clam fishery of Massachusetts. Commonw. Mass. Dep. Conserv. Div. Fish Game, Mar. Fish. Ser. 1,65 p.

Brousseau, D. J. 1978. Spawning cycle, fecundity and recruitment in a population of soft-shell clam, Mya arenaria, from Cape Ann, Massachusetts. Fishery Bulletin. 76(1):155-166.

Coe, W. R. and H. J. Turner, Jr. 1938. Development of the gonads and gametes in the soft-shell clam (Mya arenaria). J. Morphol. 62:91-111.

Conover, W. J. 1971. Practical nonparametric statistics. John Wiley & Sons, Inc. 462 pp.

Culliney, J.L. 1974. Larval development of the giant scallop, Placopecten magellanicus (Gmelin). Biol Bull. 147: 321-332.

Dow, R. L. 1977. Effects of climatic cycles on the relative abundance and availability of commercial marine and estuarine species. J. Cons. Int. Explor. Mer. 37(3):274-280.

Dow, R.L. and D.E. Wallace. 1961. The soft-shell clam industry of Maine. U.S. Fish & Wildlife Service Circular, 110. 36 pp.

Normandeau Associates, Inc. 1971. Seabrook Ecological Study: Phase I 1969-1970, Hampton-Seabrook Estuary, New Hampshire. Prepared for Public Service Company of New Hampshire. 313 pp.

__________. 1972a. Seabrook Ecological Study 1971. Soft-shelled clam spat density. Technical Report III-1.

__________. 1972b. Seabrook Ecological Study 1971. Soft-shelled clam spat density. Technical Report III-3.

__________. 1972c. Seabrook Ecological Study 1971. Soft-shelled clam (Mya arenaria) larvae studies. Technical Report III-8.

__________. 1973. Seabrook Ecological Study 1972. Studies on the soft-shelled clam, Mya arenaria, in the Hampton-Seabrook estuary, New Hampshire. Technical Report IV-2.

__________. 1974. Seabrook Ecological Study 1973. Studies on the soft-shelled clam, Mya arenaria, in the Hampton-Seabrook estuary, New Hampshire. Technical Report V-2.

__________. 1974. Seabrook Ecological Study 1973. The impact of entrainment by the Seabrook Station. Technical Report V-4.

__________. 1975a. Seabrook Ecological Study 1974. Spatial and temporal distribution of the larvae of the soft-shelled clam, Mya arenaria, in the Hampton-Seabrook estuary and nearby offshore waters. Technical Report VI-1.

__________. 1975b. Seabrook Ecological Study 1974. Studies on the soft-shelled clam, Mya arenaria, in the Hampton-Seabrook estuary, New Hampshire. Technical Report VI-3.

__________. 1976a. Seabrook Ecological Studies 1975. Studies on the soft-shelled clam, Mya arenaria, in the Hampton-Seabrook Estuary, NewHampshire. Technical Report VII-1.

__________. 1976b. Spatial and temporal distribution of the larvae of the soft-shelled clam, Mya arenaria, in the New Hampshire coastal waters, 1975. Technical Report VI-10.

__________. 1977. Seabrook Ecological Studies 1975-1976. Studies on the soft-shelled clam, Mya arenaria in the vicinity of Hampton-Seabrook estuary, New Hampshire. Technical Report VII-3.

__________. 1978. Seabrook Ecological Studies 1976-1977. Studies on the soft-shelled clam, Mya arenaria, in the vicinity of Hampton-Seabrook estuary, New Hampshire, New Hampshire. Technical Report VIII-2.

__________. 1979. Seabrook Ecological Studies 1978. Soft-shell clam, Mya arenaria, Technical Report X-3.

__________. 1981. Seabrook Ecological Studies 1979. Soft-shell clam, Mya arenaria studies. Technical Report XI-1.

Porter, R. G. 1974. Reproductive cycle of the soft-shell clam, Mya arenaria, at Skagit Bay, Washington. Fish. Bull. 72:648-656.

Ropes, J. W. and A. P. Stickney. 1965. Reproductive cycle of Mya arenaria in New England Biol. Bull. 128:315-327.

Savage, N. B. and R. Goldberg. 1977. Investigation of practical means of distinguishing Mya arenaria and Hiatella sp. larvae in plankton samples. Proc. Nat. Shellfish Assoc. 66:42-53.

de Schweinitz, E. H. and R. A. Lutz. 1976. Larval development of the northern horse mussel, Modiolus modiolus (L.), including a comparison with the larvae of Mytilus edulis (L.) as an aid in planktonic identification. Biol. Bull. 150(3):348-360.

Sokal, R. F. and F. J. Rohlf. 1969. Biometry. W. H. Freeman Co., San Francisco. 776 pp.

Sullivan, Charlotte M. 1948. Bivalve larvae of Malpeque Bay, PEI. Fish. Res. Bd. Can. Bull. 77. 36 pp.

Welch, W. R. 1975. Report on the relative abundance of green crabs along the Maine coast, Fall 1975. Maine Dept. of Marine Resources.

Welch, W. R. 1969. Changes in abundance of the green crab, Carcinus maenas (L.) in relation to recent temperature changes. U.S. Fish Wildl. Serv. Fish. Bull. 67(337-345).

APPENDIX 7.1. ANALYSIS OF COMPARABILITY BETWEEN SAMPLING DESIGNS.

To compare the random sampling design, presently used, with the ("no-holes") sampling method, used from 1976 through 1979, a "worst case" situation for maximum and minimum sampling results differences was simulated using 1980 survey data (adult and juvenile clams, shell lengths greater than 25 mm). This comparison allowed a flat by flat estimate to be made of the greatest potential disparity between the two sampling designs in population mean estimates.

Substantial potential differences between the population estimates made by the current random sampling method and the previous "no-hole" sampling method, are indicated by the results of this analysis (Table 7.1-1). The random sample mean fell within the range of the worst case "no-hole" method mean estimates only for Flats 2 and 5. For Flats 1 and 4, the "no-hole" method generally overestimated the mean by 10-20% (Table 7.1-2). For Flat 3, the overestimate could be as high as 70%. Variability was so great on Flats 2 and 5 that no consistent comparability trend could be ascertained from this analysis.

TABLE 7.1-1. MEAN ($\bar{x}$), STANDARD DEVIATION (S), COEFFICIENT OF VARIATION (CV), AND 90% CONFIDENCE INTERVALS FOR MINIMUM AND MAXIMUM WORST CASE ESTIMATES AND RANDOM SAMPLING ESTIMATES OF SOFT-SHELL CLAM POPULATION DENSITIES (no. per 2 ft^2 plot) BY FLAT.

	$\bar{x}$	S	CV	CONFIDENCE LIMITS LOWER	CONFIDENCE LIMITS UPPER
FLAT 1					
minimum	163.2	111.2	68.1	159.7	166.7
maximum	184.8	103.6	56.1	181.4	188.2
random sample	149.2	113.9	76.4	145.9	152.9
FLAT 2					
minimum	9.0	30.0	333.5	7.3	10.7
maximum	15.5	30.	198.9	13.8	17.1
random sample	13.4	27.7	206.5	12.0	14.8
FLAT 3					
minimum	2.0	8.0	141.4	1.4	2.6
maximum	2.9	8.0	98.6	2.3	3.5
random sample	1.7	6.7	150.3	1.3	2.2
FLAT 4*					
minimum	93.1	105.3	113.1	89.8	96.3
random sample	84.3	103.8	123.0	83.3	87.4
FLAT 5					
minimum	4.5	12.1	267.4	3.4	5.6
maximum	7.	15.0	190.6	6.6	9.1
random sample	5.4	12.9	237.9	4.5	6.4

*Maximum worst case does not apply for 1980 data, only one "ho holes" station was found to contain <u>one</u> clam.

TABLE 7.1-2. RANGE OF PERCENT DIFFERENCES IN MEAN VALUES, COMPARING WORST CASE "NO-HOLES" METHOD SIMULATIONS WITH THE RANDOM SAMPLE MEAN ESTIMATE.

	RANGE OF PERCENTAGES OF UNDER (-) AND OVER (+) ESTIMATION	MINIMUM AND MAXIMUM DIFFERENCE (%) BETWEEN WORST CASE AND RANDOM ESTIMATES
FLAT 1	+9 to +24	109 to 124
FLAT 2	-33 to +15	67 to 115
FLAT 3	+16 to +66	116 to 166
FLAT 4	+10	110
FLAT 5	-17 to +45	83 to 145

APPENDIX 7.2 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, 1980.

SIZE CLASS (mm)	PLUM ISLAND SOUND MIDDLE GROUND																			
	19 APR 1976	21 JUN 1976	17 AUG 1976	28 OCT 1976	11 FEB 1977	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	6 APR 1980	2 JUL 1980	1 OCT 1980
5	5	2	11	208	101	149	127	7	625	91	127	31	19	114	44	24	18	11	4	136
10	7			8	10	44	132	5	46	22	20	69	27	29	7	93	14	2	11	9
15	1			1	1	6	98	49	29	7	6	32	112	94	13	33	48	1	3	2
20						1	29	87	45	35	23	7	61	28	12	6	14	2	5	
25							15	38	37	41	33	8	14	9	17	8	3	2	3	
30								9	21	24	26	13	15	12	17	14	6	5	5	1
35								2	4	5	7	6	14	12	17	12	8	5	6	2
40										2	3	2	9	10	12	11	14	12	5	1
45												1	8	9	4	13	16	9	5	3

APPENDIX 7.2 (Continued)

SIZE CLASS	PLUM ISLAND SOUND LUFKIN'S FLAT													
	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	2 JUL 1980	1 OCT 1980
5	165	169	10	171	60	87	5	16	8	29	2	41	3	82
10	43	79	1		15	15	31	3	6	3	8	46	11	36
15	32	13			1		9	13	10	3	2	8	13	5
20	5	4	5	6	3	2	3	10	25	11	3	9	14	
25	3	1	14	8		3	1	19	17	15	1	5	13	6
30		4	8	23	3	11		13	5	8	2	8	6	
35			3	15	4	9	1	3	5	13	5	9	3	
40				1	1	4	5	1	4	8	3	2	3	8
45				1		1	1	1	1	1	2	2	3	8

APPENDIX 7.2. (Continued)

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	6 APR 1980	2 JUL 1980	1 OCT 1980
	PLUM ISLAND SOUND EAGLE HILL RIVER AT NUT SHOAL														
5	142	23	68	912	199	182	50	97	80	292	17	534	67	4	136
10	28	58		12	36	27	143		13	10	59	10	8	2	4
15	11	110	28		4	2	38	55	74	10	57	4	4	6	
20	2	26	66	8	6	6	15	59	63	25	17	8			4
25			49	30	19	23	4	32	38	32	19	8	2		
30			10	27	27	15	4	6	4	6	11	10	8	2	
35				8	25	19	8	8	4	11	11	13	15		2
40				8	6	11	10	11	15	23	13	17	15	4	2
45				2		4	4	8	8	23	8	6	6	8	6

APPENDIX 7.2. (Continued)

SIZE Class (mm)	HAMPTON HARBOR FLAT #2																				
	12 MAR 1976	21 APR 1976	18 JUN 1976	16 AUG 1976	21 OCT 1976	11 JAN 1977	14 APR 1977	7 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	3 APR 1980	1 JUL 1980	2 OCT 1980
5	168	112	18	80	1284	612	691	593	219	118	78	157	42	24	106	97	93	103	79	36	105
10		1	2				1	10	104	119	58	29	38	43	5	9	40	10	7	30	1
15									39	89	87	69	8	77	29	10	17	3	4	37	
20									2	4	15	21	3	64	61	39	12	9	3	7	
25												2		46	51	29	17	20	2	3	
30														18	20	22	21	10	1	9	1
35														2	5	8	12	11	8	11	3
40														2	1	4	12	14	5	9	5
45																	2	12	2	2	6

APPENDIX 7.2. (Continued)

SIZE CLASS (mm)	HAMPTON HARBOR FLAT #4 (MIDDLE GROUND)									
	5 APR 1978	9 JUN 1978	14 AUG 1978	5 OCT 1978	5 APR 1979	11 JUL 1979	9 OCT 1979	3 APR 1980	1 JUL 1980	2 OCT 1980
5	282	70	170	529	268	30	144	118	21	52
10	306	85	47	137	80	141	46	44	12	6
15	394	96	56	145	77	62	36	34	13	22
20	68	56	75	140	86	64	30	29	21	26
25	5	5	26	60	59	43	37	36	20	34
30		1	16	21	17	25	29	28	33	37
35			3	5	14	13	12	19	14	26
40					7	7	7	2	18	14
45			1			5	4	4	8	5

APPENDIX 7.2. (Continued)

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	7 APR 1980	JUL 1980	OCT 1980
	OGUNQUIT BEACH FLAT																			
5	35	2	8	57	100	64	48	19	26	18	9	20	18	40	22	11	89	40	6	25
10	2	1			1		50	4		2	3	13	1		4	15		4	2	<1
15							5	33	2	1	1	4	12	1		11		1	3	
20								66	12	6	10	1	9	2	2	1	1		1	
25								8	6	11	5	5	4	4	1		2	1	1	
30									4	4	10	10	5	3	2	5	2	<1	3	
35											2	2	6	2	2	6	2	<1	<3	1
40											1	1	8	3	4	3	2	2	1	1
45													4	4	4	5	4	2	3	1

APPENDIX 7.3. LENGTH-DENSITY DATA FROM THE NOVEMBER 1980 SURVEY. SEABROOK *MYA ARENARIA* STUDY, 1980.

LENGTH (mm)	DENSITY (#/ft^2)	% - AGE	CUM % - AGE	LENGTH (mm)	DENSITY (#/ft^2)	% - AGE	CUM % - AGE	LENGTH (mm)	DENSITY (#/ft^2)	% - AGE	CUM % - AGE
1	15.91	10.325	100.00	26	1.82	1.181	24.495	51	0.31	0.201	1.219
2	34.06	22.104	89.675	27	1.73	1.123	23.314	52	0.32	0.208	1.018
3	15.35	9.962	67.571	28	1.81	1.174	22.191	53	0.128	0.083	0.810
4	6.27	4.070	57.609	29	2.10	1.363	21.017	54	0.114	0.074	0.727
5	3.77	2.446	53.539	30	2.97	1.927	19.654	55	0.26	0.169	0.653
6	1.56	1.012	51.093	31	2.10	1.363	17.727	56	0.140	0.091	0.484
7	1.05	0.681	50.081	32	2.34	1.518	16.364	57	0.075	0.049	0.393
8	1.34	0.870	49.400	33	1.46	0.947	14.846	58	0.052	0.034	0.344
9	0.53	0.344	48.530	34	1.79	1.162	13.899	59	0.080	0.052	0.310
10	0.92	0.597	48.186	33	2.36	1.531	12.737	60	0.089	0.058	0.258
11	1.38	0.896	47.589	36	1.65	1.071	11.206	61	0.044	0.028	0.200
12	2.49	1.616	46.693	37	1.31	0.850	10.135	62	0.045	0.029	0.172
13	1.08	0.701	45.077	38	1.41	0.915	9.285	63	0.033	0.021	0.143
14	1.48	0.960	44.376	39	1.37	0.889	8.370	64	0.026	0.017	0.122
15	2.52	1.635	43.416	40	1.80	1.168	7.481	65	0.048	0.031	0.105
16	1.85	1.200	41.781	41	1.02	0.662	6.313	66	0.029	0.019	0.074
17	1.95	1.265	40.581	42	1.26	0.818	5.651	67	0.004	0.002	0.055
18	2.54	1.648	39.316	43	0.71	0.461	4.833	68	0.005	0.003	0.053
19	3.03	1.966	37.668	44	0.83	0.539	4.372	69	0.014	0.009	0.050
20	3.90	2.531	35.702	45	1.05	0.681	3.833	70	0.018	0.012	0.041
21	2.58	1.674	33.171	46	0.64	0.415	3.152	71	0.008	0.005	0.029
22	2.44	1.583	31.497	47	0.59	0.383	2.737	72	0.012	0.008	0.024
23	3.10	2.012	29.914	48	0.60	0.389	2.354	75	0.009	0.006	0.016
24	2.43	1.577	27.902	49	0.52	0.337	1.965	80	0.016	0.010	0.010
25	2.82	1.830	26.325	50	0.63	0.409	1.628				
								Σ	154.099		

APPENDIX 7.3. LENGTH-DENSITY DATA FROM THE NOVEMBER 1979 SURVEY.
SEABROOK *MYA ARENARIA* STUDY, 1980.

LENGTH [mm]	DENSITY [#/ft²]	%-AGE	CUM %-AGE	LENGTH [mm]	DENSITY [#/ft²]	%-AGE	CUM %-AGE	LENGTH [mm]	DENSITY [#/ft²]	%-AGE	CUM %-AGE
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	0.049
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
								Σ	112.577		

APPNDIX 7.3. LENGTH-DENSITY DATA FROM THE NOVEMBER 1978 SURVEY. SEABROOK *MYA ARENARIA* STUDY, 1980.

LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	CUM %-AGE
1	0.45	0.211	100.000
2	4.38	2.056	99.789
3	7.39	3.469	97.732
4	11.47	5.385	94.233
5	9.20	4.319	88.878
6	9.51	4.465	84.559
7	10.41	4.887	80.094
8	10.56	4.958	75.207
9	10.11	4.746	70.249
10	11.92	5.596	65.503
11	11.32	5.314	59.907
12	10.26	4.817	54.593
13	10.11	4.746	49.176
14	12.22	5.737	45.072
15	11.32	5.314	39.292
16	12.00	5.634	33.978
17	12.55	5.892	28.344
18	11.27	5.291	22.452
19	8.06	3.784	17.161
20	7.09	3.329	13.378
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

LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	CUM %-AGE
26	1.19	0.559	3.185
27	1.07	0.502	2.627
28	0.66	0.310	2.124
29	0.74	0.347	1.815
30	0.74	0.347	1.467
31	0.38	0.178	1.120
32	0.41	0.192	0.941
33	0.30	0.141	0.749
34	0.23	0.108	0.608
35	0.30	0.141	0.500
36	0.15	0.070	0.359
37	0.15	0.070	0.289
38	0.10	0.047	0.218
39	0.08	0.038	0.171
40	0.06	0.028	0.134
41	0.04	0.019	0.106
42	0.03	0.014	0.087

LENGTH [mm]	DENSITY [#/ft^2]	%-AGE	CUM %-AGE
43	0.02	0.009	0.073
44	0.005	0.002	0.063
45	0.005	0.002	0.061
46	0.002	0.001	0.059
47	0.005	0.002	0.058
48	0.02	0.009	0.655
49	0.007	0.003	0.046
50	0.002	0.001	0.043
51	0.002	0.001	0.042
52	0.007	0.003	0.041
53	0.	0.0	0.038
54	0.	0.0	0.038
55	0.019	0.009	0.038
60	0.014	0.007	0.029
65	0.023	0.011	0.022
70	0.005	0.002	0.011
75	0.012	0.006	0.009
80	0.005	0.002	0.003
85	0.002	0.0009	0.0009
Σ	213.005		

APPENDIX 7.4

TABLE A. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 1 FOR THE ANNUAL FALL SURVEYS, 1971-1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
5	19.00	74.00	30.00	2.50	55.00	1031.00	283.00	38.00	16.98	25.50
10	11.00	9.00	6.00		1.14	52.00	413.00	100.00	8.15	12.50
15	11.00	15.00	3.00			0.75	117.00	148.00	14.26	17.90
20	7.00	11.00	5.00		0.02		5.82	76.00	20.00	34.40
25	0.47	2.50	0.16	0.11			0.48	9.20	19.50	24.50
30	1.30	2.30	0.51	0.17	0.02			0.56	13.57	25.60
35	1.50	1.20	0.60	0.48	0.04			0.03	6.10	17.40
40	1.80	1.40	0.67	0.89	0.23		0.01	0.03	3.33	13.00
45	1.80	0.61	0.49	1.10	0.14	0.10	0.01		0.94	6.60
50	1.00	0.83	0.42	1.20	0.36	0.03	0.02	0.03	0.31	3.50
55	0.64	1.60	0.30	0.82	0.25	0.04	0.03	0.03	0.06	0.68
60	0.36	0.33	0.29	0.42	0.28	0.23	0.02	0.03	0.03	0.15
65	0.08	0.19	0.18	0.31	0.14	0.13	0.01	0.04		0.08
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	0.03
85						0.01	0.01	0.01	0.05	
90						0.01			0.01	

APPENDIX 7.4 (Continued)

TABLE B. SHELL SIZE DISTRIBUTION OF SOFTSHELL CLAMS ON FLAT #2, ANNUAL FALL SURVEYS 1971-1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
5	37.00	116.00	114.00		9.10	351.00	83.00	11.00	32.44	153.00
10	35.00	26.00	8.00				2.90		10.56	0.60
15	11.00	2.40	2.60						10.56	0.15
20	9.00	0.91	10.00					1.94	2.26	0.15
25	0.89	0.11	0.67	0.50				2.61	1.04	0.33
30	0.44	0.44	0.80	0.22				1.58	1.03	0.47
35	0.67	0.50	0.66	0.30				0.29	0.88	0.79
40	1.20	0.83	0.61	0.40				0.15	0.90	0.96
45	1.60	0.27	0.39	0.65				0.04	0.35	1.02
50	1.10	0.22	0.36	0.75		0.02		0.06	0.21	1.28
55	0.89	0.33	0.33	0.32	0.02			0.02	0.10	0.80
60	0.94	0.27	0.08	0.34	0.07	0.02		0.03	0.05	0.37
65	0.44	0.22	0.14	0.15	0.02			0.03		0.31
70	0.33	0.11	0.11	0.19	0.09				0.04	0.28
75		0.11	0.08	0.06	0.04	0.02		0.02		0.05
80	0.06	0.06	0.06	0.06	0.07	0.02		0.02		
85	0.06	0.06		0.02	0.02					
90			0.11	0.02	0.04		0.06			
95			0.06		0.06					
100					0.04	0.02	0.02			
105										
110										

APPENDIX 7.4 (Continued)

TABLE C. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 3 FOR ANNUAL FALL SURVEYS, 1971-1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
5	35.00	28.00	6.00	0.63	1.14	556.00	67.00	38.00	10.18	55.60
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	0.02
30	0.92	0.25	1.00	0.14				0.85	0.14	0.05
35	0.67	0.17	0.38	0.12		0.02	0.10	0.27	0.14	0.06
40	1.50	0.33	0.62	0.11				0.02	0.29	0.08
45	1.40	0.42	0.50	0.30		0.02		0.04	0.14	0.19
50	1.30	0.17	0.29	0.11	0.03		0.02	0.02	0.07	0.10
55	1.10	0.17	0.79	0.08	0.03	0.02		0.04	0.04	0.06
60	0.83	0.08	0.54	0.18	0.08		0.02			0.08
65	0.58		0.46	0.38	0.08	0.04		0.02	0.07	0.05
70	0.33		0.08	0.42	0.14	0.02		0.02		0.06
75	0.25		0.08	0.22	0.03	0.06	0.02	0.02		0.01
80	0.08		0.08	0.14	0.03	0.06				0.05
85			0.04	0.03	0.08					
90	0.08			0.06	0.08				0.04	

APPENDIX 7.4 (Continued)

TABLE D. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 4 FOR ANNUAL FALL SURVEYS, 1971-1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
5	38.00	116.00	12.00	2.50	66.00	830.00	117.00	113.00	49.13	58.20
10	11.00	31.00	1.00		1.80	13.20	183.00	91.00	38.34	7.90
15	7.00	20.00	3.00				115.00	48.00	49.13	9.60
20	4.00	18.00	2.00	0.64			20.40	45.10	30.75	14.40
25	2.80	1.10	0.52	0.05		0.01	0.62	12.38	16.77	12.40
30	3.50	3.00	1.40	0.26	0.01	0.02		8.29	13.46	10.20
35	4.60	2.80	0.62	0.58	0.01	0.01		3.19	8.98	8.70
40	4.00	1.70	0.46	0.96	0.16			0.85	4.98	7.60
45	2.60	2.00	0.35	0.92	0.16		0.09	0.02	2.21	4.50
50	1.30	1.00	0.38	0.80	0.18			0.03	0.85	3.10
55	1.10	0.79	0.14	0.50	0.21	0.13		0.01	0.27	1.06
60	0.25	0.21	0.08	0.29	0.12				0.07	0.58
65	0.17	0.04	0.14	0.21	0.14		0.01	0.01	0.02	0.16
70	0.12	0.08	0.06	0.03	0.04				0.01	0.03
75			0.02		0.01	0.01				
80		0.04		0.01		0.01				
85				0.01	0.01	0.01				

APPENDIX 7.4 (Continued)

TABLE E. SHELL SIZE DISTRIBUTION OF SOFT-SHELL CLAMS ON FLAT 5 FOR ANNUAL FALL SURVEYS, 1971-1980. SEABROOK *MYA ARENARIA* STUDY, 1980.

SIZE CLASS (mm)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
5	67.00	136.00	22.00	2.40	7.50	546.00	92.00	44.00	11.03	67.90
10	38.00	94.00	1.00			2.80	8.30	4.80	2.55	0.19
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	0.17
35	0.33	0.61	0.14	0.01			0.01	1.41	0.73	0.33
40	0.44	1.00	0.28				0.07	0.41	0.33	0.56
45	0.44	0.77	0.12					0.10	0.22	0.67
50	0.94	0.94	0.10			0.02		0.04	0.12	0.50
55	0.39	0.61	0.12	0.01					0.03	0.47
60	0.28	0.50	0.12							0.16
65		0.11	0.05	0.08			0.01			0.07
70		0.11	0.05	0.04						0.01
75			0.05		0.01		0.01	0.01		
80		0.06						0.01		0.01

APPENDIX TABLE 7.5. 1980 GREEN CRAB CATCH STATISTICS. SEABROOK MYA ARENARIA STUDY, 1980.

DATE	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 1/2	>7 1/2	TOTAL NO. OF *CARCINUS MAENAS* MALES	FEMALES	TOTAL NO. OF *CANCER* SPP.
10 Jan			1M	1F	1F			1M	1F			2	3	7
24 Jan												0	0	
4 Apr			2F	5F 1M	2F 1M	2F 4M	3F 3M	11M	2M			22	14	49
18 Apr		1F	1F	4F 1M	9F(2g) 7M	1F 14M	8F 17M	6F 14M	2F 6M			59	32	70
8 May				1F(g) 1M	1F 1M	1F(g) 6M	1F 12M	9M	1F 1M	1M		31	5	25
23 May				1M	1F	2M	1F 4M	4M	1M	2M		14	2	68
5 Jun			2F	2F	8F	12F 4M	15F	2F	1M			5	41	66
20 Jun		1M	2F(1g) 5M	9F 2M	12F(1g) 2M	25F(4g) 2M	17F(1g) 3M	7F(2g) 4M	1F(g) 3M	1M		23	73	67
11 Jul			4F 1M	7F	22F(1g) 4M	30F 14M	23F 12M	15F 16M	3F 20M	1F 14M	8M	79	105	28
24 Jul		1F	7F(1g) 2M	15F 1M	28F(3g) 6M	19F(3g) 17M	13F 18M	6F 15M	1F 10M	8M	5M	82	99	57
7 Aug		2F 2M	7F 2M	12F(1g) 7M	9F 2M	12F 6M	8F 8M	4F 14M	1F 5M	4M	3M	53	55	85
20 Aug		2M	2M	3F 2M	14F 4M	16F 8M	9F 21M	4F 10M	2M	1M		52	46	73
4 Sep	1F 5M	2F 7M	9F 10M	4F 6M	8F 8M	4F 3M	3F 6M	1F 4M	1M	1M		51	32	58
18 Sep			2F 2M	6F 7M	13F 16M	8F 9M	15F 10M	8F 7M	1F 3M			54	53	215
3 Oct		2F 1M	8F 1M	21F 3M	67F 19M	80F 15M	44F 5M	16F 2M	1F			58	241	67
17 Oct		1F	5F 6M	51F 5M	145F 22M	135F 36M	117F 24M	38F 13M	7F 9M	2M		117	499	19
7 Nov	2F 4M	11F 3M	35F 7M	97F 30M	100F 35M	68F 58M	19F 52M	10F 21M	1F 7M	1M 1M		218	343	44
21 Nov	2F 2M	6F	31F 32M	85F 37M	126F 51M	104F 78M	67F 86M	32F 50M	8F 12M	1F 7M		355	462	83
12 Dec		2F 1M	12F 8M	22F 17M	56F 26M	20F 29M	10F 32M	6F 10M	7M	2M	1M	132	128	29
30 Dec												0	0	6
1980 Totals	5F 11M	28F 17M	127F(1g) 79M	345F(2g) 121M	622F(7g) 204M	537F(8g) 302M	373F(1g) 326M	157F(2g) 208M	28F(1g) 92M	2F 44M	17M	1407	2233	
Frequency (%)	.44	1.24	5.66	12.80	22.69	23.05	19.20	10.03	3.30	1.26	.47			