POPULATION STATISTICS AND COMMERCIAL CATCH RATE OF AMERICAN LOBSTER (*HOMARUS AMERICANUS*) IN THE CHARLESTOWN—MATUNUCK, RHODE ISLAND REGION OF BLOCK ISLAND SOUND

YANKEE ATOMIC ELECTRIC COMPANY

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SUMMARY

This report describes the results of a program to determine the population structure and harvest rate of the lobster fishery in the immediate vicinity of the abandoned Charlestown Naval Auxiliary Landing Field (NALF). The study was conducted in the Charlestown-Matunuck, Rhode Island region of Block Island Sound during the period 28 May through 31 August 1978. The objectives of this study were to determine legal/sublegal catch rates, sex ratio, size at sexual maturity of females, frequency of berried females, length-frequency distributions by sex, and total instantaneous mortality rates of post-recruitment lobsters by sex in the study area. After field work commenced, it appeared that the tagging of lobsters was feasible. The use of tags allowed some information to be collected on movement and population size of pre-recruit lobsters in the study area.

Approximately twice a week, the daily catch of a commercial lobsterman was recorded. For each lobster caught, the carapace length, sex, tag number, reproductive state of females, evidence of molting, claw complement and other general comments were recorded. All berried females and sublegal lobsters were tagged and released from 18 June to 31 August 1978.

During this study, 1,055 pot hauls were made; these resulted in a total catch of 2,974 lobsters. Of these lobsters, 25.6% were of legal size (>79 mm). Overall catch per pot averaged 2.8 lobsters. Mean legal catch per pot per set-over day ranged from 0.13 to 0.23 lobsters. Generally, there was no significant difference in the mean catch rates of lobsters from different areas. The catch rate of sublegal unberried female lobsters, however, was significantly higher at 3 sampling regions (1E, 3E and 0R).

Of the total catch, 1,228 were males and 1,744 were females for an overall sex ratio (M:F) of 1:1.42; a sex ratio significantly different from 1:1. No apparent trend in sex ratio with date or size class was observed. Expressed as frequencies, 41% of the catch were males and 59% were females.

Of the total catch of 1,744 female lobsters, only 90 (5.2%) were egg bearing or berried. The highest frequencies of berried females occurred during early June and in August. Of these egg bearing female lobsters, 31.5% were less than the minimum legal size.

Total mortality rates for post-recruitment male and female lobsters were estimated by two methods. Age frequency distributions were derived from length-frequency distributions by applying the Von Bertalanffy growth equation, probability mode analysis, and constant annual molt increments. Total mortality rates for males and females were estimated to be 67% and 58%, respectively.

To determine alongshore movement, 1,202 sublegal or berried female lobsters were tagged with coded bands and released. A total of 140 were recaptured of which it was possible to determine the date and point of release of 44 individuals. Of the 44 traceable returns, only 5 were recaptured outside of their release area. Distances traveled were approximately 1.4-2.7 nautical miles. There were no apparent trends in direction traveled, nor did the distances traveled appear related to sex or time at large. Use of the marking (banding) technique was found to be unsatisfactory for studies to discern movements of lobsters.

The population of pre-recruit (69-78 mm) lobsters in the area fished by the lobster traps was estimated by three different analytical methods. Final population estimates for the period 29 June—31 August 1978 ranged from 3837-4033 lobsters. Estimated densities of pre-recruit lobsters ranged from 77-100 lobsters per acre of similar (rocky) habitat.

The period of molt onset in 1978 was determined by graphical analysis to be approximately late June.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

There is a commercial fishery for American lobster (*Homarus americanus*) in the vicinity of the site of New England Power Company's proposed nuclear power facility (NEP 1&2) in Charlestown, Rhode Island. In view of this local fishery and its proximity to the proposed site, considerable effort has been directed toward compilation of data that would help identify and assess the significance of potential plant-induced effects on the lobster population.

Little information was available on the population structure and harvest rate of the lobster fishery in the immediate vicinity of the site. Accordingly, the present study was conducted to obtain estimates of these parameters. The study was conducted in the Charlestown-Matunuck, Rhode Island region of Block Island Sound during the period 28 May 1978 through 31 August 1978. The specific objectives of the study were to determine:

- legal/sublegal catch rates,
- sex ratio,
- size at sexual maturity of females,
- percent of gravid females,
- length-frequency distributions by sex, and
- total instantaneous mortality rates of post-recruitment lobsters by sex

of the lobster fishery in the vicinity of the site. Additionally, attempts to determine movement, estimate population size of pre-recruit lobsters, and approximate date of molt onset were made.

2.0 METHODS AND MATERIALS

2.1 Study Area

This study was conducted in the Charlestown-Matunuck, Rhode Island region of Block Island Sound. The region was divided into 11 sampling areas (Figure 2.1-1) based on visible shoreline landmarks. Areas 3W and 6E were non-bounded; however, fishing effort was generally in the immediate vicinity of the adjacent station boundary. The NEP 1&2 proposed intake and discharge locations are within area 1W. The proposed site is an abandoned Naval Auxiliary Landing Field (NALF).

2.2 Trap Description

The lobster traps used in this study were of two designs. The majority of the traps were rectangular, wooden framed, and lined with 1 inch (2.5 cm) plastic coated wire mesh (Figure 2.21). The traps were 34 inches (86 cm) long, 20 inches (51 cm) wide, and 11 inches (28 cm) high. The entrance funnels were constructed of 1 inch (2.5 cm) plastic coated wire mesh, while the single parlor funnel was fabricated of 2.5 inch (6.4 cm) mesh twine. Two to six bricks were secured in each trap for ballast.

A fewer number of rectangular traps, constructed entirely of 1 inch (2.5 cm) hardware cloth, were also fished. These traps were 36 inches (91 cm) long, 19 inches (48 cm) wide, and 11 inches (28 cm) high. The entrance and parlor funnels were constructed of 1.5 inch (3.8 cm) and 2 inch (5 cm) stretch mesh twine, respectively.

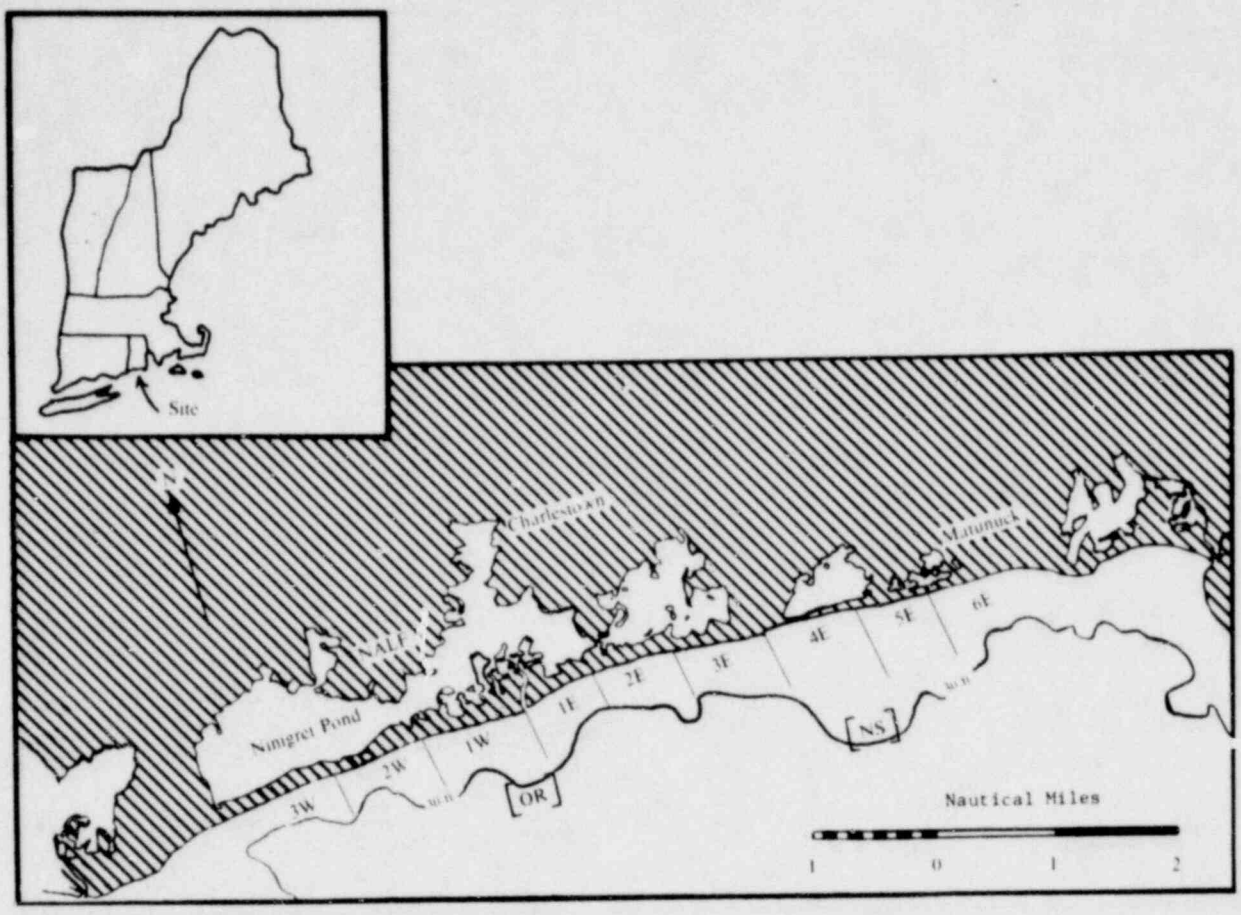

FIGURE 2.1-1. *1978 lobster pot survey sampling regions (NALF = Naval Auxiliary Landing Field).*

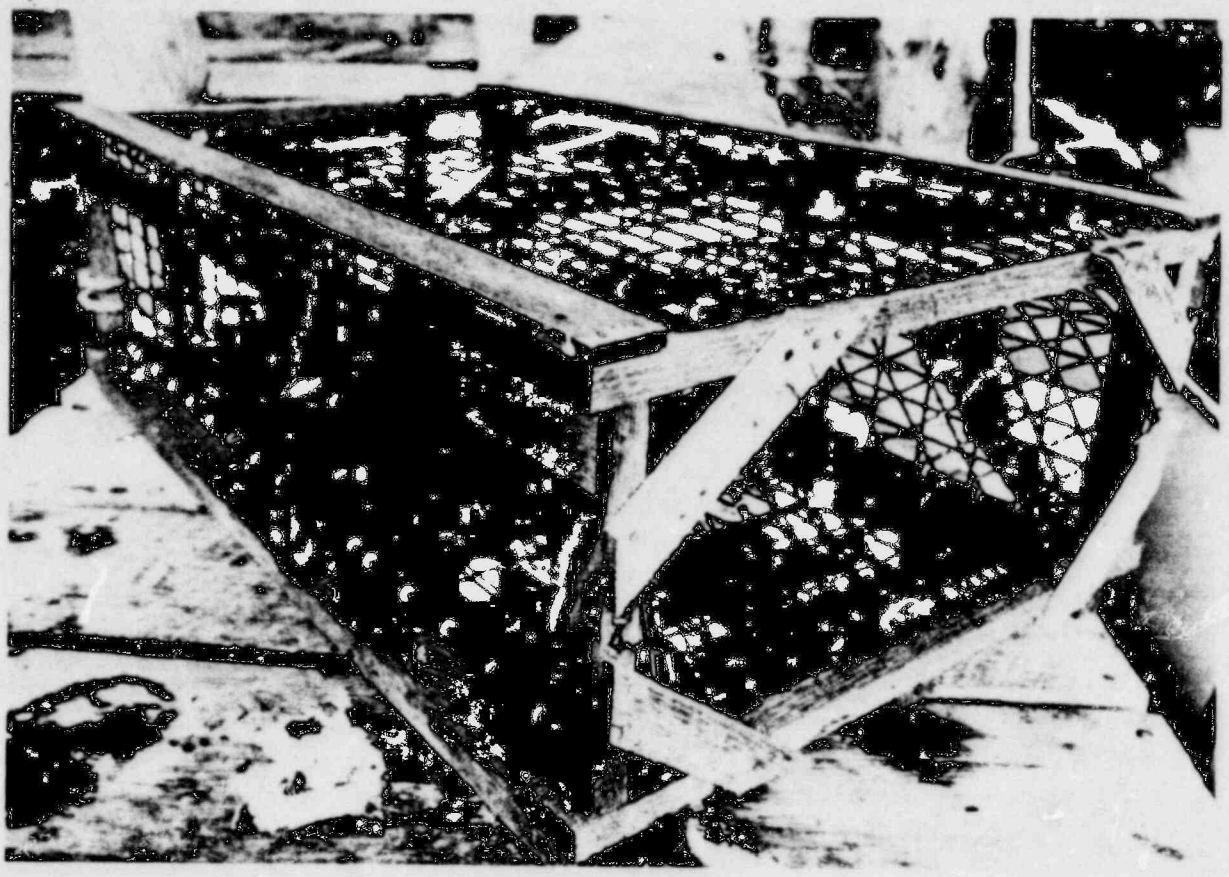

FIGURE 2.2-1. *Lobster traps used during 1978 lobster pot survey.*

2.3 Sampling Methods

2.3.1 General Trapping Survey Methods

All traps were fished as singles in rocky areas at depths generally ranging from 20 to 35 feet (6.1 to 10.7 meters). Traps were usually baited with six to eight winter flounder racks, although bluefish and hake racks were occasionally used.

Approximately twice a week, the daily catch of the participating lobsterman was recorded. The station, sample number (the sequential number of samples collected to date), replicate number (all pots within a sampling area were considered replicates), and the duration of the set were recorded prior to hauling each trap. Set-over days for traps hauled varied from approximately 2 to 7 days.

For each lobster caught, the carapace length to the nearest millimeter (measured parallel to the midline from the eyesocket to the distal edge of the carapace) (Figure 2.3-1), sex, tag number, reproductive state of females (i.e., berried or non-berried and the color of the eggs), evidence of molting, claw complement, and other general comments (e.g., presence of other species in the trap, lobster anatomical abnormalities such as broken claws, missing appendages, etc.) were recorded on cassette tape. Data collected on cassette tape in the field were transcribed onto data coding forms in the laboratory.

2.3.2 Tagging Study Methods

To determine whether repetitive catches of the same lobsters were occurring, all berried female and sublegal lobsters caught beginning 18 June 1978 were tagged prior to release by placing a 0.5 in (1.3 cm) rubber band (Figure 2.3-2) on the right cheliped (Figures 2.3-3 and 2.3-4) similar to the technique of Pecci et al. (1978). Additionally tagging data would be used to estimate movement, and population size of sublegal lobsters. Rubber bands were positioned proximally to the dactyl portion of the cheliped so as not to interfere with normal claw function. From 18 June to 29 June 1978, uncoded bands were used. In order to evaluate alongshore movement of individuals, lobsters were tagged with coded bands from 29 June 1978 through termination of the study. Bands were coded with up to four alpha-numeric characters using waterproof ink. Tag codes assigned to individual lobsters as well as carapace length, sex, area released, and any other pertinent observations were recorded on cassette tape in the field and subsequently transcribed onto data forms in the laboratory. Tagged lobsters were released in the same area that they were captured. All lobsters recaptured with tags were handled as described above. All sublegal or berried female lobsters recaptured with tags were released after processing. Points of release and recapture were designated only in the alongshore direction by station regions. It was not practical during this study to designate position in the onshore-offshore direction.

Since it was not initially planned to conduct a tagging study, no announcements to the general public on the nature of the program or rewards for recaptures made by others were offered. Thus, no information on recaptures made by other lobstermen who may have fished the study area is available.

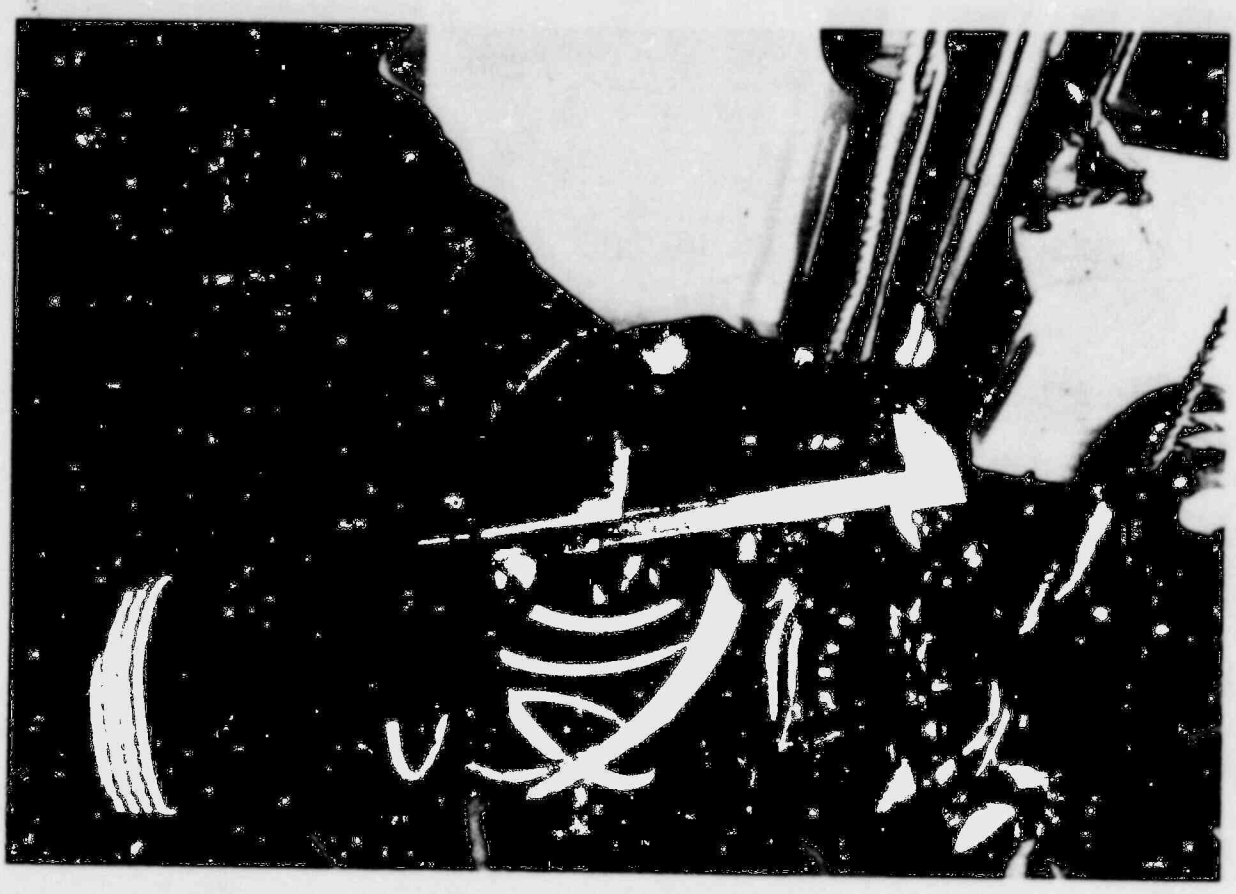

FIGURE 2.3-1. *Carapace length of lobster being measured.*

FIGURE 2.3-2. *Rubber bands used for marking all berried female and sublegal lobsters.*

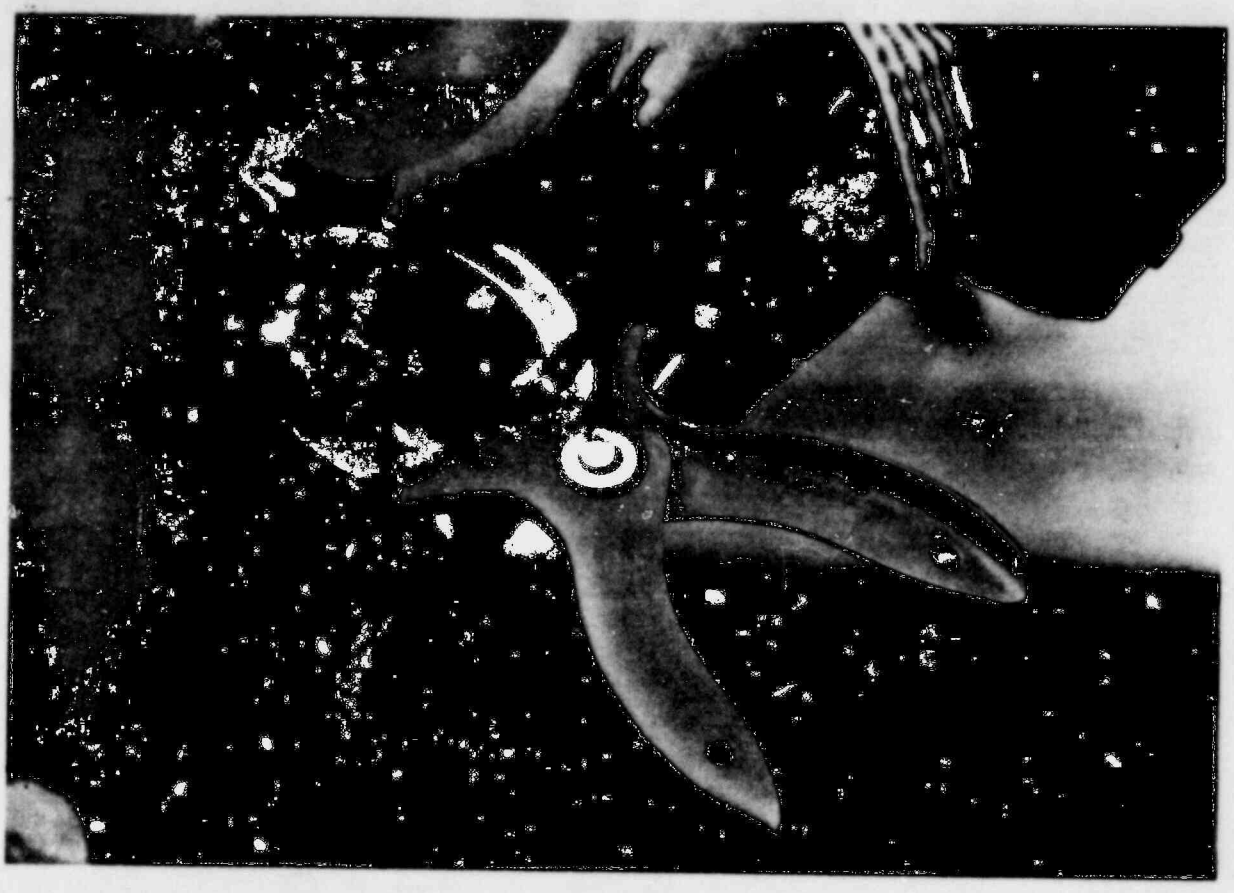

FIGURE 2.3-3. *Banding tool used for placing rubber bands on lobster cheliped.*

FIGURE 2.3-4. *Position of band on cheliped.*

2.4 Population Estimates

The practice of marking or tagging fish or other aquatic organisms to estimate population size began in the late 1800's. Among the methods generally employed are the:

- Peterson method,
- Schnabel method, and
- Schumacher—Eschmeyer method.

The Peterson method is generally a single census procedure. The individuals are marked only once; subsequently a single sample is taken and examined for marked individuals. Mathematically, the Peterson method for estimating the population is expressed as:

$$\hat{N} = \frac{AB}{C} \qquad \text{Eq. 1}$$

where $\hat{N}$ = estimate of the population

A = number of individuals caught during the sampling period

B = number of fish marked and returned prior to sampling period

C = number of marked individuals recaptured during the sampling period.

The Schnabel and Schumacher—Eschmeyer methods are multiple census methods. Individuals are marked and added to the population over a considerable period, during which time samples are taken and examined for recaptures or marked individuals. These methods assume zero mortality and recruitment (Jones 1976). The Schnabel method for estimating population is expressed as:

$$\hat{N} = \frac{\Sigma AB}{\Sigma C} \qquad \text{Eq. 2}$$

The Schumacher—Eschmeyer method is expressed as:

$$\hat{N} = \frac{\Sigma B^2 A}{(\Sigma BC)} \qquad \text{Eq. 3}$$

Further information on the general principles of population estimation by marking methods is given in Ricker (1975).

All three of the above methods were used to estimate population size of pre-recruit lobsters (69-78 mm) in the vicinity of the lobster traps. A computer program developed by McCann and Cruse (1969) was used to perform the calculations. This program also calculated the variance and error of the Schumacher—Eschmeyer method according to the formulae:

$$\text{Variance} = \left(\frac{1}{K-1}\right)\left(\Sigma \frac{C^2}{A} - \frac{\Sigma BC}{\hat{N}}\right) \qquad \text{Eq. 4}$$

$$\text{Error} = \frac{\sqrt{(\hat{N})^3(\text{Variance})}}{\Sigma BC} \qquad \text{Eq. 5}$$

where K = number of sampling periods

$\hat{N}$ = Schumacher-Eschmeyer population estimate

The Petersen method can also be applied to multiple census techniques simply by using the results for each day (or other short interval) for a Petersen estimate. (With this approach the minimum number of recaptures should preferable be 3 or 4) (Ricker 1975). The mean of these Petersen estimates is then taken as the estimate of population size.

3.0 RESULTS AND DISCUSSION

A summary of the data collected during this study is given in Table 3.0-1.

3.1 Catch Per Unit Effort

A summary of the lobster catch by date from the Charlestown-Matunuck region of Block Island Sound is presented in Table 3.0-1. During the 28 May—31 August 1978 study period, 1,055 pot hauls were made; this resulted in a total catch of 2,974 lobsters. Of this catch, 753 were legal and 2,214 were sublegal (7 lobsters could not be categorized as legal or sublegal because no length measurements were available) resulting in an overall legal to sublegal ratio of 1:2.9 (legal lobsters were considered to be $\geq$ 79 mm carapace length). Expressed as percentages, 25.6% of the lobsters were legal and 74.4% were sublegal. Overall catch per pot haul averaged 2.8 lobsters (of which 0.7 were legal) and ranged from 2.0 (15 August 1978) to 3.4 (11 July 1978) (Table 3.0-1). Russell et al. (1978) reported similar percentages of legal catch (21.1-44.4%) and legal catch per pot haul (0.62—0.76) for their lobster study in Narragansett Bay—Rhode Island Sound. Average legal catch per pot haul off Pilgrim Station in Plymouth, Massachusetts for the period 1970-1976 ranged from 0.51-0.83 (Lawton et al. 1978). Off Hampton Beach, New Hampshire, the average legal lobster catch per pot during 1972-1977 ranged from 0.50-0.66 (Normandeau Associates, Inc. 1978).

Catch data per pot per setover day by sample date and location for all lobsters, legal males, sublegal males, legal unberried females, legal berried females, sublegal berried females, sublegal unberried females, and legal male and unberried females is given in Tables 3.1-1 through 3.1-8, respectively. Mean legal catch rates per pot per setover day (males and unberried females combined) ranged from 0.13 (Station 6E) to 0.23 (Station 2W) (Table 3.1-8); rates similar to the lower rates for Narragansett Bay and Rhode Island Sound as reported by Russell et al. (1978).

To determine if statistical differences existed between mean catch rates (catch/pot/setover day) of the different areas for the lobster categories stated above, one-way analyses of variance (ANOVA) were conducted (Tables 3.1-9 through 3.1-14); (ANOVA for sublegal berried females was not conducted due to the paucity of data in this category). With the exception of sublegal unberried females, mean catch rates by area for all other lobster categories were not significantly different at the $\alpha = 0.05$ level. Differences between the mean catch rates by area for sublegal unberried females were distinguished by Duncans Multiple Range Test (Table 3.1-14). This analysis demonstrated that catch rates of sublegal unberried female lobsters for Stations 5E, NS, 4E, 2W, 2E and 1W were similar and significantly lower than catch rates for Stations 1E, OR, and 3E. We have no obvious explanation for this segregation of catch rates by area.

TABLE 3.0-1. *Summary of 1978 lobster pot survey results.*

Date (1978)	Number of Pots	Total Catch	Number of Males[a]	Number of Females	Number of Berried Females	Number of Legals[b]	Number of Sublegal	Legal: Sublegal Ratio	Sex Ratio (M:F)	Frequency (%) Males	Females	Berried Females	Catch/ Pot
5/28	42	112	44	68	3	23	89	1:3.9	1:1.55	39	61	4.4	2.7
5/30	41	93	36	57	10	26	67	1:2.6	1:1.58	39	61	17.5	2.3
6/2	47	132	60	72	8	42	90	1:2.1	1:1.20	45	55	11.1	2.8
6/5	52	164	71	94	12	47	117	1:2.5	1:1.34	43	57	12.8	3.2
6/11	55	154	58	95	10	36	118	1:3.3	1:1.64	38	62	10.5	2.8
6/18	64	190	68	122	11	36	154	1:4.3	1:1.79	36	64	9.0	3.0
6/22	15	48	16	32	0	2	46	1:23.0	1:2.0	33	67	0	3.2
6/24	19	58	19	39	3	12	46	1:3.8	1:2.05	33	67	7.7	3.0
6/27	36	104	38	66	1	14	90	1:6.4	1:1.74	37	63	1.5	2.9
6/29	24	77	23	54	1	15	62	1:4.1	1:2.35	30	70	1.9	3.2
7/2	40	111	35	75	1	30	81	1:2.7	1:2.14	32	68	1.3	2.8
7/6	49	137	59	78	0	32	104	1:3.2	1:1.32	43	57	0	2.8
7/11	59	198	91	107	0	65	133	1:2.1	1:1.18	46	54	0	3.4
7/15	56	180	76	104	0	56	124	1:2.2	1:1.37	42	58	0	3.2
7/18	56	183	76	107	0	58	124	1:2.1	1:1.41	42	58	0	3.2
7/21	22	53	26	26	0	25	28	1:1.1	1:1	49	51	0	2.4
7/28	61	202	92	110	3	65	137	1:2.1	1:1.20	46	54	2.7	3.3
7/31	65	188	82	106	1	37	149	1:4.0	1:1.29	44	56	0.9	2.9
8/5	59	136	61	75	6	40	96	1:2.4	1:1.23	45	55	8.0	2.3
8/10	56	123	45	78	4	24	98	1:4.1	1:1.73	37	63	5.1	2.2
8/15	46	94	43	51	5	23	70	1:3.0	1:1.19	46	54	9.8	2.0
8/19	51	143	70	73	4	31	112	1:3.6	1:1.04	49	51	5.5	2.8
8/31	40	94	39	55	7	14	79	1:5.6	1:1.41	42	58	12.7	2.3
Totals	1055	2974	1228	1744	90	753	2214	1:2.9	1:1.42	41	59	5.2	2.8

[a] Two lobsters caught were not sexed

[b] Seven lobsters were not measured and therefore could not be categorized as legal or sublegal

TABLE 3.1-1. *Catch per unit of effort (no./pot/setover day) of all lobsters by sample date and location.*

Date	Stations										
	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			1.36	.75	.79		1.20				
5/30/78			.92	.86	1.34	1.15	1.12	.92			
6/02/78			1.00	1.00	1.07	.85	.78	.94			
6/05/78		1.69	1.25	.76	1.13	1.07	1.00	.90			
6/11/78		.41	.49	.51	.69	.65	.34	.42			
6/18/78		.97	1.33	1.00	.67	.92				.98	
6/22/78			.71	.90							.81
6/24/78				.50			.50			.65	
6/27/78		.60	.91	.92							
6/29/78				.80	.87	.70				.56	
7/02/78		.58	.53	1.01							.40
7/06/78		.81	.54	.75	.14	.66	.48			.31	.63
7/11/78		.62	.71	.88	.60	.87	.40			.62	.73
7/15/78		.96	.75	1.00		.85	.64			.52	
7/18/78		1.06	.93	1.58	.69	1.21	1.38			.75	.78
7/21/78				1.00	1.00	.86	.67			.33	
7/28/78		1.02	.60	.76	.63	1.46	.60	.69		.61	
7/31/78		1.13	.89	1.05	1.13	1.22	.60	.33		.72	
8/05/78		.29	.40	.59	.30	.53	.48	.40		.47	
8/10/78		.25	.45	.44	.43	.64	.54	.40		.33	
8/15/78	.20	.50	.30	.41	.40	.53	.40				
8/19/78	.81	.56	.35	.87	.25	1.44	.44	.25	.63		
8/31/78		.75	0.00	.42	.88	.70	.63	.83			
Mean	.51	.76	.72	.82	.72	.91	.68	.61	.63	.57	.67
Std. Dev.	.43	.37	.36	.27	.34	.29	.30	.27		.20	.17

TABLE 3.1-2. *Catch per unit of effort (no./pot/setover day) by sample date and location of male lobsters (≥ 79 mm).*

Date	Stations										
	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			.07	.10	.07		.07				
5/30/78			.12	.05	0.00	0.00	.13	.12			
6/02/78			.22	.11	.27	.08	.22	.06			
6/05/78		.31	.06	.13	.24	0.00	0.00	.06			
6/11/78		.02	.02	.11	0.00	0.00	0.00	0.00			
6/18/78		.04	0.00	.06	0.00	0.00				.02	
6/22/78			0.00	0.00							0.00
6/24/78				0.00			.10			.04	
6/27/78		.03	.06	0.00							
6/29/78				0.00	0.00	0.00				.03	
7/02/78		.04	0.00	.03							.07
7/06/78		.16	.04	.07	.14	.03	.10			.01	0.00
7/11/78		.11	.07	.12	0.00	.07	.08			.12	0.00
7/15/78		.15	.11	.17		.05	.18			.05	
7/18/78		.13	0.00	.17	0.00	.08	.48			.13	0.00
7/21/78				.33	.33	.14	.17			.11	
7/28/78		.10	.05	.12	.13	.21	.15	.06		.14	
7/31/78		.10	0.00	.08	.04	.11	0.00	.08		.11	
8/05/78		.02	.04	.07	0.00	.10	0.00	0.00		.03	
8/10/78		.03	0.00	.04	.03	.04	.03	0.00		0.00	
8/15/78	.13	.10	.10	.05	0.00	.07	.10				
8/19/78	.06	0.00	.15	.05	0.00	.06	.03	.13	0.00		
8/31/78		.08	0.00	0.00	0.00	.07	.04	.08			
Mean	.10	.09	.06	.08	.07	.06	.10	.06	0.00	.07	.01
Std. Dev.	.05	.08	.06	.08	.11	.06	.12	.05		.05	.03

TABLE 3.1-3. *Catch per unit of effort (no./pot/setover day) by sample date and location of male lobsters (< 79 mm).*

	Stations										
Date	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			.43	.29	.21		.36				
5/30/78			.46	.28	.31	.51	.13	.29			
6/02/78			.11	.33	.20	.31	.33	.39			
6/05/78		.56	.48	.18	.30	.22	.36	.48			
6/11/78		.18	.11	.11	.26	.24	0.00	.15			
6/18/78		.32	.33	.30	.22	.50				.31	
6/22/78			.33	.15							.31
6/24/78				0.00			.10			.18	
6/27/78		.19	.31	.25							
6/29/78				.10	.33	.15				.16	
7/02/78		.18	.09	.32							0.00
7/06/78		.25	.21	.29	0.00	.23	.19			.11	.06
7/11/78		.21	.38	.16	.26	.23	.12			.16	.20
7/15/78		.28	.21	.25		.20	.11			.18	
7/18/78		.29	.37	.75	.24	.27	.24			.21	.11
7/21/78				.27	.33	.14	.17			0.00	
7/28/78		.44	.25	.21	.13	.38	.10	.13		.21	
7/31/78		.43	.50	.35	.46	.22	.13	0.00		.44	
8/05/78		.11	.16	.21	.10	.10	.20	.07		.23	
8/10/78		.10	.15	.10	.07	.28	.17	.08		.27	
8/15/78	.07	.10	0.00	.13	.20	.27	.07				
8/19/78	.44	.25	.05	.39	0.00	.56	.19	0.00	.13		
8/31/78		.17	0.00	.19	.25	.25	.21	.25			
Mean	.25	.25	.25	.24	.21	.28	.18	.18	.13	.21	.14
Std. Dev.	.26	.13	.16	.15	.12	.13	.10	.16		.11	.12

TABLE 3.1-4. *Catch per unit of effort (no./pot/setover day) by sample date and location of unberried female lobsters (≥ 79 mm).*

Date	Stations										
	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			0.00	.07	.14		.20				
5/30/78			.12	.14	.26	.14	.07	.23			
6/02/78			.33	.19	.27	.10	0.00	.03			
6/05/78		.36	.18	.04	.12	.13	.14	.18			
6/11/78		.06	.08	.06	.04	.17	0.00	.10			
6/18/78		.16	.13	.06	.22	.08				.13	
6/22/78			0.00	.10							0.00
6/24/78				0.00			0.00			.06	
6/27/78		.08	.03	.04							
6/29/78				.10	.13	.10				.11	
7/02/78		.14	.07	.10							.20
7/06/78		.22	.13	.07	0.00	.09	.10			.06	.13
7/11/78		.12	.18	.20	.09	.20	.16			.10	.13
7/15/78		.18	.14	.21		.15	.18			.07	
7/18/78		.27	.10	.25	.24	.30	.24			.17	.33
7/21/78				.27	.33	.05	.17			.11	
7/28/78		.12	.10	.19	.06	.21	.10	.31		.07	
7/31/78		.17	.06	.20	.17	.17	.07	.25		.11	
8/05/78		.09	0.00	.12	.05	.17	.08	.13		0.00	
8/10/78		.03	0.00	.10	.07	.16	.03	.12		0.00	
8/15/78	0.00	.10	0.00	.03	0.00	0.00	.03				
8/19/78	.19	.06	.10	.14	0.00	.25	.08	0.00	.13		
8/31/78		.08	0.00	.06	0.00	.07	.08	0.00			
Mean	.09	.14	.09	.12	.12	.14	.10	.14	.13	.08	.16
Std. Dev.	.13	.09	.08	.07	.11	.07	.07	.11		.05	.12

TABLE 3.1-5. *Catch per unit of effort (no./pot/setover day) by sample date and location of berried female lobsters (≥ 79 mm).*

	Stations										
Date	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			0.00	0.00	0.00		.07				
5/30/78			.12	.09	0.00	.09	.13	.06			
6/02/78			0.00	.04	0.00	.03	0.00	.09			
6/05/78		0.00	.03	.09	.06	0.00	.21	0.00			
6/11/78		.03	.01	.06	.09	0.00	0.00	.05			
6/18/78		.01	.07	.06	.11	0.00				.04	
6/22/78			0.00	0.00							0.00
6/24/78				0.00			0.00			.04	
6/27/78		0.00	0.00	0.00							
6/29/78				0.00	0.00	0.00				.01	
7/02/78		.01	.02	0.00							0.00
7/06/78		0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
7/11/78		0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
7/15/78		0.00	0.00	0.00		0.00	0.00			0.00	
7/18/78		0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
7/21/78				0.00	0.00	.05	0.00			0.00	
7/28/78		0.00	0.00	.01	.06	0.00	0.00	.06		0.00	
7/31/78		0.00	0.00	.02	0.00	0.00	0.00	0.00		0.00	
8/05/78		0.00	0.00	.01	0.00	0.00	.12	0.00		.03	
8/10/78		0.00	0.00	.01	0.00	0.00	0.00	.04		0.00	
8/15/78	0.00	.03	.05	.02	0.00	0.00	0.00				
8/19/78	0.00	.06	.05	0.00	0.00	0.00	0.00	0.00	0.00		
8/31/78		.08	0.00	.02	0.00	.02	.04	.08			
Mean	0.00	.01	.02	.02	.02	.01	.03	.04	0.00	.01	0.00
Std. Dev.	0.00	.02	.03	.03	.04	.02	.06	.04		.02	0.00

2284 096

TABLE 3.1-6. *Catch per unit of effort (no./pot/setover day) by sample date and location of berried female lobsters (< 79 mm).*

Date	Stations										
	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			0.00	.03	0.00		0.00				
5/30/78			0.00	0.00	0.00	.05	.07	0.00			
6/02/78			0.00	0.00	.07	.03	0.00	.03			
6/05/78		0.00	.03	.04	.06	.04	.07	0.00			
6/11/78		0.00	0.00	.06	0.00	.03	0 00	0.00			
6/18/78		.01	.07	.03	0.00	0.00				.02	
6/22/78			0.00	0.00							0.00
6/24/78				0.00			0.00			0.00	
6/27/78		0.00	.03	0.00							
6/29/78				0.00	0.00	0.00				0.00	
7/02/78		0.00	0.00	0.00							0.00
7/06/78		0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
7/11/78		0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
7/15/78		0.00	0.00	0.00		0.00	0.00			0.00	
7/18/78		0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
7/21/78				0.00	0.00	0.00	0.00			0.00	
7/28/78		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	
7/31/78		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8/05/78		0.00	0.00	.01	0.00	0.00	0.00	0.00		0.00	
8/10/78		0.00	0.00	.02	0.00	0.00	0.00	0.00		0.00	
8/15/78	0.00	0.00	0.00	.01	0.00	0.00	0.00				
8/19/78	0.00	0.00	0.00	.03	0.00	0.00	0.00	0.00	0.00		
8/31/78		0.00	0.00	0.00	.13	.02	0.00	0.00			
Mean	0.00	.00	.01	.01	.01	.01	.01	.00	0.00	.00	0.00
Std. Dev.	.00	.00	.02	.02	.04	.02	.02	.01	.00	.01	.00

2284 097

TABLE 3.1-7. *Catch per unit of effort (no./pot/setover day) by sample date and location of unberried female lobsters (< 79 mm).*

	Stations										
Date	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			.86	.26	.36		.52				
5/30/78			.12	.31	.77	.37	.59	.23			
6/02/78			.33	.33	.27	.31	.22	.33			
6/05/78		.46	.48	.27	.36	.67	.21	.18			
6/11/78		.13	.26	.11	.30	.21	.34	.12			
6/18/78		.42	.73	.48	.11	.33				.46	
6/22/78			.38	.65							.50
6/24/78				.50			.20			.34	
6/27/78		.30	.47	.63							
6/29/78				.60	.40	.45				.25	
7/02/78		.20	.35	.57							.13
7/06/78		.19	.17	.32	0.00	.31	.10			.13	.44
7/11/78		.19	.09	.40	.26	.37	.04			.24	.40
7/15/78		.36	.29	.38		.45	.18			.23	
7/18/78		.38	.47	.42	.21	.56	.43			.25	.13
7/21/78				.13	0.00	.48	.17			.11	
7/28/78		.37	.20	.24	.25	.67	.25	.13		.18	
7/31/78		.43	.33	.40	.46	.72	.40	0.00		.06	
8/05/78		.07	.20	.17	.15	.17	.08	.20		.17	
8/10/78		.10	.30	.17	.27	.16	.31	.16		.07	
8/15/78	0.00	.18	.15	.17	.20	.20	.20				
8/19/78	.13	.19	0.00	.25	.25	.56	.14	.13	.38		
8/31/78		.33	0.00	.15	.50	.27	.25	.42			
Mean	.06	.27	.31	.34	.28	.40	.26	.19	.38	.21	.36
Std. Dev.	.09	.13	.22	.17	.18	.18	.15	.12		.11	.14

TABLE 3.1-8. *Catch per unit of effort (no./pot/setover day) by sample date and location of male and unberried female lobsters ($\geq$ 79 mm).*

Date	Stations										
	3W	2W	1W	1E	2E	3E	4E	5E	6E	NS	OR
5/28/78			.07	.17	.21		.27				
5/30/78			.24	.19	.26	.14	.20	.35			
6/02/78			.55	.30	.54	.18	.22	.09			
6/05/78		.67	.24	.17	.36	.13	.14	.24			
6/11/78		.08	.10	.17	.04	.17	0.00	.10			
6/18/78		.20	.13	.12	.22	.08				.15	
6/22/78			0.00	.10							0.00
6/24/78				0.00			.10			.10	
6/27/78		.11	.09	.04							
6/29/78				.10	.13	.10				.14	
7/02/78		.18	.07	.13							.27
7/06/78		.38	.17	.14	.14	.12	.20			.07	.13
7/11/78		.23	.25	.32	.09	.27	.24			.22	.13
7/15/78		.33	.25	.38		.20	.36			.12	
7/18/78		.40	.10	.42	.24	.38	.72			.30	.33
7/21/78				.60	.66	.19	.34			.22	
7/28/78		.22	.15	.31	.19	.42	.25	.37		.21	
7/31/78		.27	.06	.28	.21	.28	.07	.33		.22	
8/05/78		.11	.04	.19	.05	.27	.08	.13		.03	
8/10/78		.06	0.00	.14	.10	.20	.06	.12		0.00	
8/15/78	.13	.20	.10	.08	0.00	.07	.13				
8/19/78	.25	.06	.25	.19	0.00	.31	.11	.13	.13		
8/31/78		.16	0.00	.06	0.00	.14	.12	.08			
Mean	.19	.23	.14	.20	0.19	0.20	0.20	0.19	.13	.15	.17
Std. Dev.	.08	.16	.13	.14	0.18	0.10	0.16	0.12		.09	.13

TABLE 3.1-9. *Analysis of variance between stations on the average catch per unit of effort of all lobsters, 1978 lobster pot survey.*

Source	D.F.	SS	MS	F	P
Total	139	13.415			
Between	8	1.260	0.157	1.697	0.105
Within	131	12.155	0.093		

TABLE 3.1-10. *Analysis of variance among stations on the average catch per unit of effort of male lobsters ($\geq$ 79 mm), 1978 lobster pot survey.*

Source	D.F.	SS	MS	F	P
Total	139	0.867			
Between	131	0.052	0.006	1.038	0.411
Within	8	0.816	0.006		

TABLE 3.1-11. *Analysis of variance among stations on the average catch per unit of effort of male lobsters (< 79 mm), 1978 lobster pot survey.*

Source	D.F.	SS	MS	F	P
Total	139	2.524			
Between	8	0.192	0.024	1.350	0.225
Within	131	2.332	0.018		

TABLE 3.1-12. *Analysis of variance among stations on the average catch per unit of effort of unberried female lobsters ($\geq$ 79 mm), 1978 lobster pot survey.*

Source	D.F.	SS	MS	F	P
Total	139	0.999			
Between	8	0.071	0.009	1.246	0.278
Within	131	0.928	0.007		

TABLE 3.1-13. *Analysis of variance among stations on the average catch per unit of berried female lobsters ($\geq$ 79 mm), 1978 lobster pot survey.*

Source	D.F.	SS	MS	F	P
Total	138	0.168			
Between	8	0.011	0.001	1.144	0.338
Within	130	0.156	0.001		

TABLE 3.1-14. *Analysis of variance among stations and Duncans Multiple Range Test on the average catch per unit of effort (CPUE) of unberried female lobsters (< 79 mm), 1978 lobster pot survey.*

Source	D.F.	SS	MS	F	P
Total	139	4.120			
Between	8	0.524	0.066	2.387	0.020
Within	131	3.596	0.027		

Station	5E	NS	4E	2W	2E	1W	1E	OR	3E
Mean CPUE	.19	.21	.26	.27	.28	.31	.34	.36	.40

3.2 Sex Ratio

During the study period, 1,228 males and 1,744 females were caught for an overall sex ratio (M:F) of 1:1.42 (Table 3.0-1); a sex ratio significantly different from 1:1 ($X^2 = 89.42 > X^2_{1.95} = 3.84$). Expressed as frequencies, 41% of the total catch were males and 59% were females. Changes in the sex ratio and frequencies of males and females by date are depicted in Table 3.0-1.

With respect to date sex ratios varied from 1:1 (21 July 1978) to 1:2.35 (29 June 1978). The frequency of males ranged from 30% (29 June 1978) to 49% (21 July and 19 August 1978) (Table 3.0-1).

Changes in the sex ratio by 5-mm size classes are shown in Table 3.2-1. Ratios varied from 1:1 for the 105-110 mm size class to 1:3.50 for the 100-105 mm size class. No apparent trend in sex ratio with size class was observed. In contrast, data presented by Russell and Borden (1975) for inshore Rhode Island waters indicated an apparent decline in the frequency of female lobsters with increasing size.

The observed sex composition of the lobster population in our study was similar to that reported by Smith (1977) for Long Island Sound, and Skud and Perkins (1969) for offshore waters of the North Atlantic. Other investigators, however, have reported lobster sex ratios that approach 1:1. Krouse (1973) found that in 1969 and 1970 female lobsters collected in the coastal waters near Boothbay Harbor, Maine comprised 48.1% and 50.3% of his total catch. In 1968, he found that the proportion of females was 56.4%; an increase he attributed to a small sample size. Cooper et al. (1975) found that in September 1967 and February 1968, males and females each comprised approximately 50% of the population of two inshore (i.e., less than 24 meters depth) lobster fishing regions in Maine. In deeper waters (30-60 meters), however, they reported preliminary findings of a predominance of females. Russell and Borden (1975) reported that the overall sex ratio of lobsters caught from the inshore waters of Rhode Island in April 1975 was 1:1.253 (M:F). In their Piscataqua River, New Hampshire ecological studies, Normandeau Associates (1978) found males to predominate. Sex ratios (M:F) for their area during 1971-1977 varied from 1.22:1 to 1.92:1.

Significant deviations from a 1:1 sex ratio could be attributed to sampling bias, differential gear vulnerability between sexes, differential molting and growth rates, regulations protecting females during part of their life cycle, or actual differences in sexual composition of the population (e.g., may be survival advantage for increased numbers of females for intensely fished populations that remove substantial numbers of individuals before they have an opportunity to reproduce). Skud (1969) has discussed the effect of fishing on size composition and sex ratio of offshore lobster stocks.

TABLE 3.2-1. *Number of male and female lobsters and sex ratios by 5 mm size classes, 1978 lobster pot survey.*

Size Class (mm)	Number of Males	Number of Females	Sex Ratio (M:F)
50-55	8	9	1:1.13
55-60	27	54	1:2.0
60-65	90	134	1:1.49
65-70	271	295	1:1.08
70-75	321	376	1:1.17
75-80	255	384	1:1.51
80-85	129	245	1:1.90
85-90	67	170	1:2.54
90-95	37	48	1:1.30
95-100	9	10	1:1.11
100-105	2	7	1:3.50
105-110	2	2	1.1
110-115	0	2	—
115-120	0	1	—

3.3 Maturity

Sexual maturity of female lobsters was determined by the external presence of eggs similar to Russell and Borden (1975), Russell et al. (1978) and others. Of a total catch of 1744 female lobsters, only 90 or 5.2% were egg bearing. Similar low percentages of egg bearing females were reported by Normandeau Associates, Inc. (1978) for lobsters from the Piscataqua River and off Hampton Beach, by Russell and Borden (1975) for Rhode Island Sound, by Pecci et al. (1978) for the Weepecket Islands (5 miles west of Woods Hole, Mass.) and by Lawton et al. (1978) from Cape Cod Bay in the vicinity of Plymouth, Massachusetts. From data of Smith (1977) on the Long Island Sound lobster fishery, we determined that 17% of the total catch of females during his lobster pot survey were egg bearing. For the size range 79 mm (minimum legal size) to 90 mm (a size rarely exceeded in the inshore fishery), 10.4% of the females caught in the vicinity of the proposed NEP 1&2 were egg bearing.

As seen in Table 3.0-1, the frequency of berried females varied from 0-17.5%. Highest frequencies occurred during early June and in August. Between these time periods, few, if any, egg bearing females were captured. In their study of the inshore Rhode Island lobster fishery, Russell et al. (1978) reported peak percentages of egg-bearing females in June and October.

The average size of egg bearing females was 83.1 mm (s.d = 7.5 mm) with a size range of 65-111 mm. The length-frequency distribution of egg bearing females caught during this study is shown in Figure 3.3-1 and Table 3.3-1. Results from the study of the inshore lobster fishery in Rhode Island by Russell and Borden (1975) and Russell et al. (1978) agree with those from our study. These investigators found that the smallest berried female in Rhode Island Sound was 70 mm and that the average size was 85.3 mm. The mean size of egg bearing females in Long Island Sound has been reported as 79.8-86.2 mm (Smith 1977) and 83.7-86.1 mm (Lund 1970). Thus, based on the above information, it appears that the onset of sexual maturing for female lobsters in the vicinity of the proposed NEP 1&2 site occurs around 70 mm.

The above reports on minimum and average size of female lobsters at maturity from Southern New England waters differ from that reported in Maine by Thomas (1973) and Krouse (1972), and for the offshore waters of the North Atlantic by Skud and Perkins (1969). These authors found that lobsters from their study areas seldom matured until they were between 90-100 mm. Aiken and Waddy (1976) as cited in Lawton et al. (1978) have indicated that there is extensive variability in the size at which female lobsters mature depending on geographical area. Areas where some lobsters are berried at a relatively small size, <70 mm, are characterized by relatively high summer temperatures of approximately 20 C (State-Federal Lobster Scientific Committee Workshop, 1975). Conversely in oceanic waters, e.g., in areas of the northern Gulf of Maine and the slopes and canyons of the continental shelf, with relatively low summer temperatures (11 C), lobsters mature at a relatively larger size (>85 mm). Intermediate areas may show varying characteristics of both extremes (State-Federal Lobster Scientific Committee Workshop, 1975).

Cumulative length-frequency distribution of egg bearing female lobsters from this study revealed that 31.5% were ≤ 79 mm (Table 3.3-1). From Rhode Island Sound, 21.6% of egg bearing females were <79 mm (Russell and Borden 1975). Smith (1977) reported percentages ranging from 25.5-63.5% sublegal berried females throughout Long Island Sound.

TABLE 3.3-1. *Length-frequency and cumulative frequency distributions of lobsters caught from the Charlestown-Matunuck region of Block Island Sound, 28 May—31 August 1978.*

Carapace Length (mm)	Frequency (%)					Cumulative Frequency (%)				
	Males and Females	Males	All Females	Non-berried Females	Berried Females	Males and Females	Males	All Females	Non-berried Females	Berried Females
21	<.1	<.1	0	0		<.1	<.1	0	0	0
22	<.1	<.1	0	0		<.1	<.1	0	0	0
23	<.1	<.1	0	0		<.1	<.1	0	0	0
24	<.1	<.1	0	0		<.1	<.1	0	0	0
25	<.1	<.1	0	0		<.1	<.1	0	0	0
26	<.1	<.1	0	0		<.1	<.1	0	0	0
27	<.1	<.1	0	0		<.1	<.1	0	0	0
28	<.1	<.1	0	0		<.1	<.1	0	0	0
29	<.1	<.1	0	0		<.1	<.1	0	0	0
30	<.1	<.1	0	0		<.1	<.1	0	0	0
31	<.1	<.1	0	0		<.1	<.1	0	0	0
32	<.1	<.1	0	0		<.1	<.1	0	0	0
33	<.1	<.1	0	0		<.1	<.1	0	0	0
34	<.1	<.1	0	0		<.1	<.1	0	0	0
35	<.1	<.1	0	0		<.1	<.1	0	0	0
36	<.1	<.1	0	0		<.1	<.1	0	0	0
37	<.1	<.1	0	0		<.1	<.1	0	0	0
38	<.1	<.1	0	0		<.1	<.1	0	0	0
39	<.1	0	0.1	0.1		0.1	.1	0.1	0.1	0
40	<.1	<.1	0	0		0.1	0.2	0.1	0.1	0
41	<.1	<.1	0	0		0.2	0.2	0.1	0.1	0
42	<.1	0	<.1	<.1		0.2	0.2	0.2	0.2	0
43	<.1	<.1	0	0		0.2	0.3	0.2	0.2	0
44	<.1	0	<.1	<.1		0.3	0.3	0.2	0.2	0
45	0	0	0	0		0.3	0.3	0.2	0.2	0
46	<.1	<.1	0	0		0.3	0.4	0.2	0.2	0
47	<.1	<.1	0	0		0.3	0.5	0.2	0.2	0
48	0	0	0	0		0.3	0.5	0.2	0.2	0
49	<.1	<.1	0	0		0.4	0.6	0.2	0.2	0
50	<.1	<.1	0	0		0.4	0.6	0.2	0.2	0
51	<.1	0	<.1	<.1		0.4	0.6	0.3	0.3	0
52	0.1	<.1	0.1	0.1		0.5	0.7	0.4	0.4	0
53	0.1	<.1	0.1	0.1		0.6	0.7	0.5	0.6	0
54	0.3	0.4	0.2	0.2		0.9	1.1	0.8	0.8	0
55	0.3	0.2	0.5	0.5	0	1.2	1.3	1.2	1.3	0
56	0.3	0.2	0.4	0.4	0	1.6	1.6	1.6	1.6	0
57	0.4	0.5	0.4	0.4	0	2.0	2.0	2.0	2.1	0
58	0.9	0.7	1.1	1.2	0	2.9	2.8	3.1	3.2	0

TABLE 3.3-1. *(Continued)*

Carapace Length (mm)	Frequency (%)					Cumulative Frequency (%)				
	Males and Females	Males	All Females	Non-berried Females	Berried Females	Males and Females	Males	All Females	Non-berried Females	Berried Females
59	0.7	0.6	0.8	0.8	0	3.7	3.4	3.9	4.1	0
60	0.8	1.0	0.8	0.8	0	4.5	4.3	4.0	4.9	0
61	1.2	0.9	1.4	1.5	0	5.7	5.2	6.0	6.3	0
62	1.0	0.9	1.2	1.3	0	6.7	6.1	7.2	7.6	0
63	1.9	2.2	1.8	1.9	0	8.7	8.3	9.0	9.5	0
64	2.6	2.5	2.6	2.7	0	11.3	10.7	11.6	12.2	0
65	2.9	3.0	2.9	3.1	1.1	14.3	13.7	14.5	15.2	1.1
66	3.0	4.0	2.4	2.5	0	17.3	17.7	16.9	17.7	1.1
67	3.7	4.2	3.4	3.6	0	21.0	21.9	20.2	21.3	1.1
68	4.8	5.9	4.0	4.2	0	25.8	27.8	24.2	25.2	1.1
69	4.6	5.1	4.3	4.4	1.1	30.4	32.8	28.5	29.9	2.2
70	5.6	6.0	5.3	5.5	1.1	36.0	38.8	33.8	35.5	3.4
71	3.9	4.8	3.4	3.5	1.1	40.0	43.6	37.2	38.9	4.5
72	4.6	4.9	4.4	4.7	1.1	44.6	48.6	41.5	43.5	5.6
73	3.8	5.2	2.8	2.8	0	48.4	53.8	44.3	46.4	5.6
74	5.5	5.2	5.8	5.8	4.5	53.9	59.1	50.0	52.2	10.1
75	5.0	5.2	4.8	4.7	7.9	58.9	64.2	55.0	56.8	17.9
76	4.0	4.2	3.9	3.9	2.2	62.9	68.5	58.7	60.8	20.2
77	5.1	4.8	5.4	5.5	3.4	68.0	73.3	64.1	66.4	23.6
78	4.2	3.9	4.5	4.5	4.5	72.2	77.2	68.6	71.0	28.1
79*	3.1	2.7	3.5	3.5	3.4	75.4	79.9	72.1	74.3	31.5
80	2.5	1.8	3.1	3.0	4.5	77.9	81.7	75.2	77.4	35.9
81	2.8	2.9	2.8	2.7	4.5	80.8	84.5	78.0	80.0	40.4
82	2.4	1.8	2.8	2.8	3.4	83.2	86.4	80.8	82.8	43.8
83	2.3	1.7	2.7	2.6	5.6	85.5	88.1	83.6	85.4	49.4
84	2.5	2.4	2.6	2.4	5.6	88.0	90.4	86.2	87.9	55.1
85	2.3	1.1	3.2	2.8	10.1	90.4	91.6	89.4	90.6	65.2
86	1.9	1.4	2.4	1.9	11.2	92.3	93.0	91.7	92.5	76.4
87	1.4	1.1	1.8	1.8	2.2	93.8	94.0	93.5	94.3	78.6
88	1.2	1.1	1.3	1.2	2.2	94.9	95.2	94.8	95.5	80.9
89	1.0	0.7	1.2	1.2	2.2	95.9	95.9	95.9	96.6	82.2
90	1.0	1.1	0.8	0.7	2.2	96.9	97.1	96.8	97.4	85.4
91	0.7	0.6	0.8	0.6	4.5	97.6	97.6	97.5	97.9	89.9
92	0.5	0.7	0.4	0.4	1.1	98.1	98.3	97.9	98.3	91.0
93	0.4	0.2	0.5	0.3	3.4	98.4	98.5	98.4	98.6	94.4
94	0.4	0.4	0.4	0.2	3.4	98.9	98.9	98.7	98.8	97.7
95	0.2	0.2	0.2	0.2	0	99.0	99.2	99.0	99.0	
96	0.1	<.1	0.1	0.1	0	99.2	99.3	99.1	99.2	97.7
97	<.1	0.2	0	0	0	99.2	99.4	99.1	99.2	97.7

TABLE 3.3-1. *(Continued)*

Carapace Length (mm)	Frequency (%)					Cumulative Frequency (%)				
	Males and Females	Males	All Females	Non-berried Females	Berried Females	Males and Females	Males	All Females	Non-berried Females	Berried Females
98	0.2	0.2	0.1	0.1	0	99.4	99.7	99.2	99.3	97.7
99	<.1	0	0.1	0.1	0	99.5	99.7	99.3	99.4	
100	0.1	<.1	0.1	0.1	0	99.5	99.8	99.4	99.5	97.7
101	<.1	0	0.1	0.1	0	99.6	99.8	99.5	99.6	97.7
102	0	0	0	0	0	99.6	99.8	99.5	99.6	97.7
103	0.1	<.1	0.2	0.2	0	99.7	99.8	99.7	99.6	97.7
104	0	0	0	0	0	99.7	99.8	99.7	99.6	97.7
105	0	0	0	0	0	99.7	99.8	99.7	99.6	97.7
106	<.1	0.2	<.1	<.1	0	99.8	100.0	99.8	99.8	97.7
107	0	0	0	0	0	99.8		99.8	99.8	97.7
108	<.1		<.1	0	1.1	99.8		99.8	99.8	98.9
109	0		0	0	0	99.8		99.8	99.8	98.9
110	0		0	0	0	99.8		99.8	99.8	98.9
111	0		0.1	<.1	1.1	99.8		99.9	99.9	100.0
112			0	0	0	99.8		99.9	99.9	
113			0	0		99.8		99.9	99.9	
114			0	0		99.8		99.9	99.9	
115			0	0		99.8		99.9	99.9	
116			<.1	<.1		100.0		100.0	100.0	

* Minimum legal size

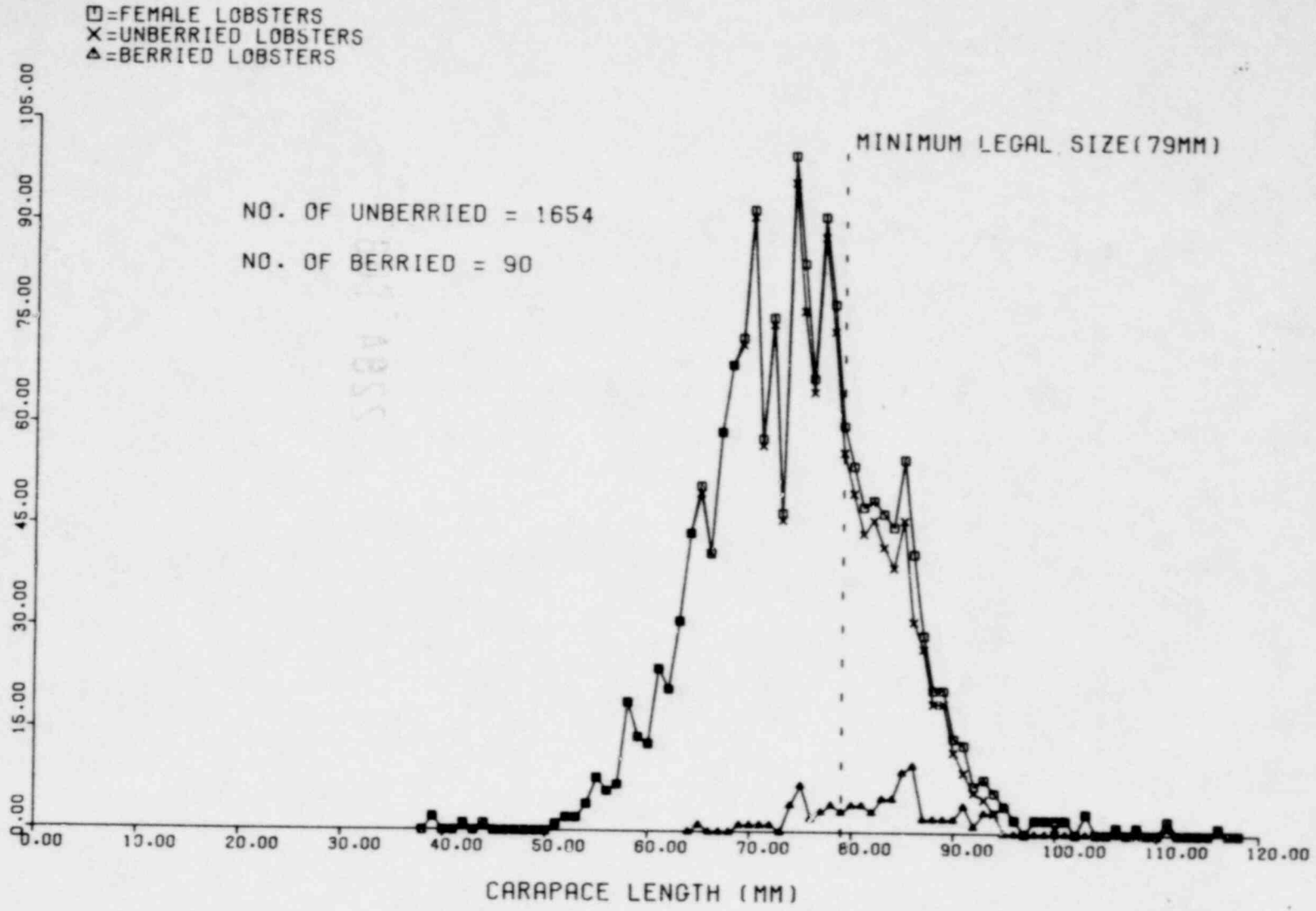

FIGURE 3.3-1. *Length-frequency distribution of all female lobsters, and berried and unberried females caught during the 1978 lobster pot survey.*

3.4 Length-Frequency

A total of 2,974 lobsters were collected during the study period. Of this total, 1,228 were males, 1,744 were females, and 90 were egg bearing females (the sex of 2 lobsters caught was not designated). The mean length, standard deviation, and minimum and maximum length of these lobster categories are presented in Table 3.4-1.

Length-frequency distributions of all lobsters, and males and females is shown in Figure 3.4-1, and for all females, and berried and non-berried females in Figure 3.3-1. Length-frequency and cumulative frequency distributions for these lobster categories are also given in Table 3.3-1. The stepwise increase in number of lobsters with size to approximately 70-75 mm suggests that this is the size range at which lobsters become fully vulnerable to the gear. Krouse (1973) has indicated that the reduced vulnerability of lobsters smaller than 70 mm in his study might best be attributed to the effects of gear selectively and, possibly, the more seclusive behavior of small lobsters. Sharp reductions in the number of lobsters 79 mm (minimum legal size) or greater reflects the influence of commercial exploitation. Legal size lobsters (males and females combined) comprised only 24.6% of the total catch (Table 3.31); a frequency similar to that reported for the Piscataqua River lobster survey by Normandeau Associates (1978).

TABLE 3.4-1. *Sample statistics on lobster size, 1978 lobster pot survey.*

	Lobster			
Statistic	All	Male	Female	Berried Female
Mean length (mm)	74.1	73.4	74.6	83.1
Standard deviation (mm)	8.7	8.4	8.8	7.5
Maximum length (mm)	116	106	116	111
Minimum length (mm)	21	21	39	65
Number	2,974	1,228[a]	1,744	90

[a] sex of 2 lobsters not designated

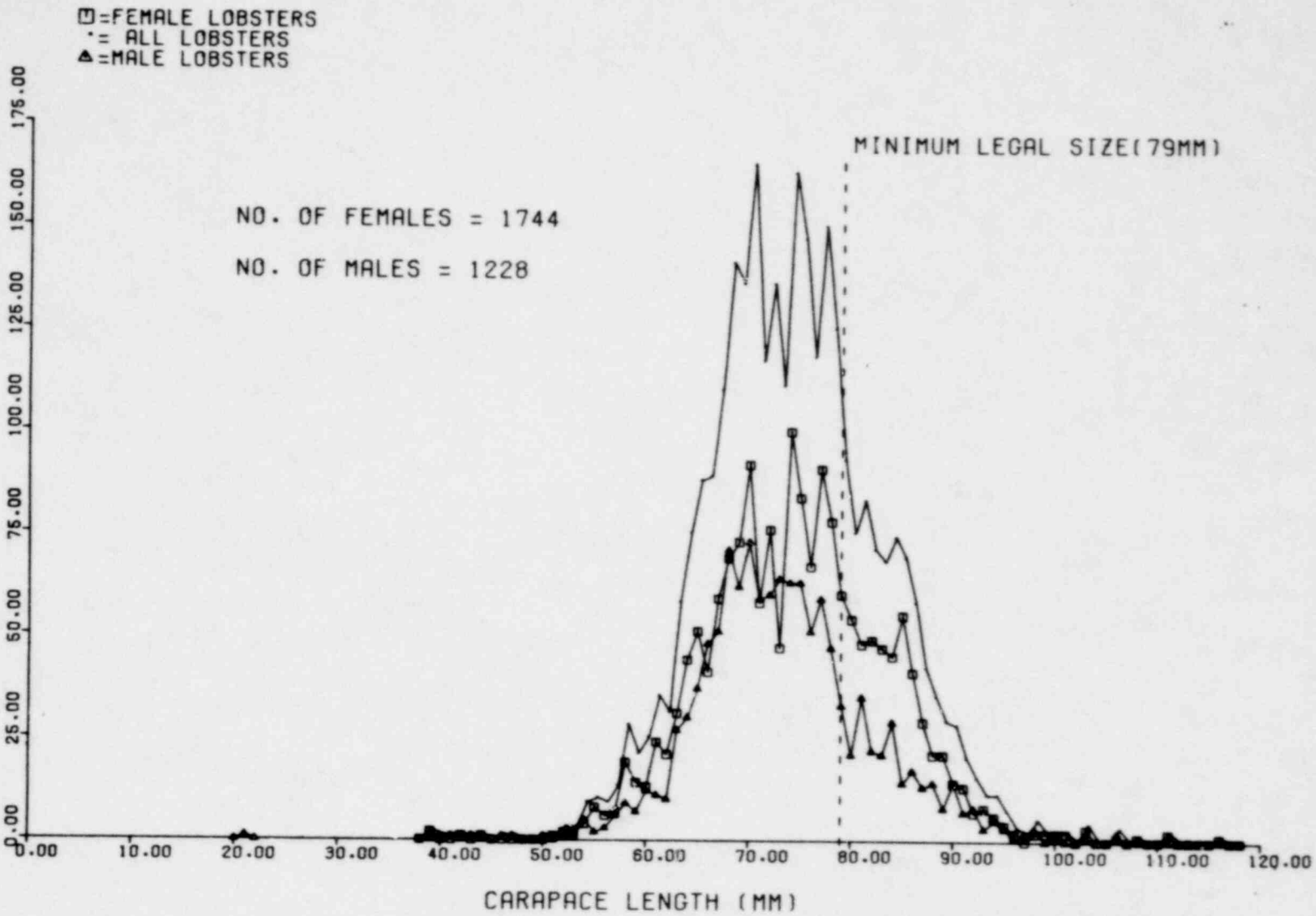

FIGURE 3.4-1. *Length-frequency distribution of all lobsters, and males and females caught during the 1978 lobster pot survey.*

3.5 Total Mortality Rates

Total instantaneous mortality rates (Z) for postrecruitment male and female lobsters were estimated from length-frequency data given above in Section 3.4 by two methods. The first method was based on the exponential regression of abundance in numbers on age in years. The slopes from these regressions provides an estimate of total mortality. The second method was described by Robson and Chapman (1961) and uses the relation:

$$S = \frac{T}{\Sigma N + T - 1} \qquad \text{Eq. 6}$$

where S = survival

$T = N_1 + 2N_2 + 3N_3 + \ldots$

$\Sigma N = N_0 + N_1 + N_2 + \ldots$

and N_0, N_1, $N_2 \ldots$ are indices of abundance of fully vulnerable age classes represented in the catch. Estimates of the instantaneous mortality are then derived from the negative logarithm of survival, S.

Assumed age-class distributions used to estimate mortality rates were developed from the length-frequency data by applying the following methods:

- Von Bertalanffy growth equation (Ricker 1975) rearranged for t, age in years for fully recruited age classes.

$$t = \frac{t_0 - \ln\left(1 - \frac{l_t}{L_\infty}\right)}{K} \qquad \text{Eq. 7}$$

where t = age in years

t_0 = age at first egg extrusion

l_t = length at age t

L_∞ = mean asymptotic length

K = Brody growth coefficient

The coefficients for the above equation for Rhode Island Sound male and female lobsters were developed by Russell et al. (1978) and are presented in Table 3.5-1.

- Probability mode analysis to determine the size range associated with fully recruited age classes as developed for the inshore Rhode Island lobster fishery by Russell et al. (1978), and
- Annual 13.25% molt increments to establish size ranges associated with fully recruited age classes. (Molt increment from Russell et al. (1978) for the inshore Rhode Island lobster fishery.)

The total instantaneous mortality rates estimated for male and female lobsters are presented in Table 3.5-2. No major discrepancies between estimates were found; hence mean Z values for male and female lobsters were calculated to be 1.95 and 1.79, respectively. Converted to percentages, total mortality for males and females would be 67% and 58%, respectively. These rates are similar to those reported by Russell et al. (1978) for the inshore Rhode Island lobster fishery.

Based on several methods, Russell et al. (1978) estimated overall mean Z-values for male and female lobsters from Narragansett Bay and Rhode Island Sound to be 1.99 and 1.70, respectively. For other areas (Cox Ledge and Mid-shelf), estimated mean mortality rates for males ranged from 0.78-1.60, and for females from 0.56-0.93.

Mortality rates for the Maine lobster fishery have been reported by Thomas (1973) and Krouse (1977). Thomas (1973) estimated the annual mortality rate to range from 29.8% to 94.6% depending on the method and yearly data set used. Krouse (1977) reported mortality rates for three areas of Maine to range from 72.5%-96.6%.

TABLE 3.5-1. *Von Bertalanffy growth equation coefficients for Rhode Island Sound derived by Russell et al. (1978).*

Category	L_∞	K	t_0
Males	189.552	0.094	–0.290
Females	184.589	0.097	–0.198

TABLE 3.5-2. *Estimated total instantaneous mortality rates (Z) for post-recruitment lobsters in the inshore Charlestown-Matunuck region of Block Island Sound.*

		Total instantaneous mortality for age distributions from		
Technique	Category	Von Bertalanffy	Probability mode	Annual molt increments
1. Exponential regression	males	2.09	2.02	2.17
	females (all)	1.52	1.73	2.04
	unberried females	1.54	1.81	2.13
	berried females	1.05	1.43	1.61
2. Robson & Chapman (1961)	males	1.74	1.83	1.83
	females (all)	1.80	1.66	2.01
	unberried females	1.82	1.71	2.18
	berried females	1.39	1.36	1.56

3.6 Movement

During the period 29 June—31 August 1978, 1,202 sublegal or berried female lobsters were tagged with coded bands and released in the study area. Through 31 August, a total of 140 were recaptured. Of these recaptures, it was possible to determine the date and point of release of 44 individuals. The inability to determine the date and point of release of the remaining lobsters was attributed to the method of tagging as explained later in this section. A summary of the individually identifiable recaptures is given in Table 3.6-1.

The majority of tagged lobsters were recaptured within their respective release zone (Table 3.6-1). Of the 44 traceable tag returns, only 9 were recaptured outside of their release area. Of these 9 lobsters, however, four (tag no. 37, 24, .124, .96) were recaptured in areas immediately adjacent to their release zone. Based on measurements from the center of each station area, the above four lobsters may have moved alongshore for distances up to approximately 0.7-0.8 nautical miles (nm). These recaptures, however, may not represent movement of any magnitude if the lobsters were captured and released in close proximity to station area boundaries. Furthermore, movements of this magnitude are within the range of intra-station alongshore distances. The remaining five lobsters (tag no. 11, 141, .088, 749, 920) which were caught outside their release area moved further than the adjacent station (approximately 1.4-2.7 nm alongshore).

There were no apparent trends in direction traveled (i.e., easterly or westerly) for these lobsters, nor did the distance traveled appear related to sex or human factors. Time at large for all recaptures averaged approximately 14 days with a range of 3-44 days (Table 3.6-1).

TABLE 3.6-1. *Summary of lobster recaptures during 1978 lobster pot survey.*

Tag Number	Date Released	Date Recaptured	Recapture Length (mm)	Change From Release Length (mm)	Station Released	Station Recaptured	Sex	Alongshore Distance Moved (naut. mi.)	Time at Large (days)
37	2 July 78	11 July 78	68	+2	1E	1W	M	0.7	9
94	11 July 78	15 July 78	73	0	1E	1E	M	0	4
171	11 July 78	15 July 78	76	0	2W	2W	F	0	4
28	11 July 78	15 July 78	75	+2	2W	2W	F	0	4
24	29 June 78	18 July 78	77	+2	2E	1E	M	0.7	19
.01	15 July 78	18 July 78	65	0	3E	3E	M	0	3
318	15 July 78	18 July 78	66	0	NS	NS	F	0	3
221	15 July 78	18 July 78	72	0	2W	2W	F	0	3
32	15 July 78	18 July 78	72	−1	2W	2W	M	0	3
.124	11 July 78	18 July 78	68	0	2W	1W	F	0.8	7
11	29 June 78	21 July 78	71	−1	1E	3E	F	1.4	22
141	29 June 78	2 July 78	76	0	2E	2W	M	2.3	3
141	2 July 78	28 July 78	76	0	2W	2W	M	0	26
52	2 July 78	31 July 78	71	0	1E	1E	F	0	29
.088	11 July 78	31 July 78	75	−1	3E	1E	F	1.4	20
689	28 July 78	31 July 78	77	U	2E	2E	F	0	3
775	28 July 78	31 July 78	71	0	1W	1W	M	0	3
.066	2 July 78	31 July 78	68	0	2W	2W	F	0	29
902	28 July 78	5 Aug 78	70	0	1E	1E	F	0	8
.027	11 July 78	5 Aug 78	76	0	1E	1E	M	0	25
1011	31 July 78	5 Aug 78	75	0	2E	2E	M	0	5
749	28 July 78	31 July 78	68	+1	3E	NS	M	1.4	3
749	31 July 78	10 Aug 78	69	0	NS	NS	M	0	10
77	6 July 78	10 Aug 78	75	0	4E	4E	F	0	35
611	28 July 78	10 Aug 78	70	0	3E	3E	M	0	13
920	28 July 78	10 Aug 78	72	+1	5E	1E	F	2.7	13
94A	5 Aug 78	15 Aug 78	77	0	1E	1E	F	0	10
.96	11 July 78	15 Aug 78	68	0	1W	1E	F	0.7	35
922	28 July 78	15 Aug 78	78	0	1E	1E	M	0	18
.63	6 July 78	19 Aug 78	68	0	1E	1E	M	0	44
984	31 July 78	19 Aug 78	70	+4	1E	1E	F	0	19
14E	10 Aug 78	19 Aug 78	74	−1	1E	1E	F	0	9
6A	5 Aug 78	19 Aug 78	72	+2	3E	3E	M	0	14
23A	5 Aug 78	31 Aug 78	66	+1	1E	1E	M	0	26
44E	19 Aug 78	31 Aug 78	70	0	1E	1E	M	0	12
42C	19 Aug 78	31 Aug 78	68	0	1E	1E	M	0	12
47C	10 Aug 78	31 Aug 78	78	0	3E	3E	F	0	21
24F	19 Aug 78	31 Aug 78	67	0	3E	3E	F	0	12
70F	19 Aug 78	31 Aug 78	77	0	3E	3E	M	0	12
25C	15 Aug 78	31 Aug 78	77	−1	3E	3E	F	0	16
.80	31 July 78	5 Aug 78	72	0	4E	4E	M	0	5
26	28 July 78	5 Aug 78	74	0	1E	1E	F	0	8
26	5 Aug 78	10 Aug 78	74	0	1E	1E	F	0	5
39	15 July 78	28 July 78	64	0	NS	NS	M	0	13

U = Unknown

Observations from this study on movement agree with those of other authors. In their lobster tagging studies in the Piscataqua River, New Hampshire, Normandeau Associates, Inc. (1978) found that the majority of recaptures were taken from within the study area and generally from the same trap location as originally released. From their data, they concluded that Piscataqua River lobsters are either remarkably stationary in their habit or else those that travel always return to the same "home" area or do not return at all. Studying the migration of American lobster near Monhegan Island, Maine, Cooper (1970) found that approximately 99% of the 1,755 recaptures during the period January 1966 to June 1968 were caught within the 2-mile fishing limit of Monhegan.

Krouse (1977) also studied lobster movement along the Maine Coast and found that from 73.6%-98.0% (depending on area) were recaptured within a 5-mile radius of the release site and only 1% of the recaptures moved greater than 10 miles. He also found little association between time lobsters were at large with the extent of movement. Similar observations were reported by Russell and Borden (1975) in their study on the inshore lobster fishery in Rhode Island. They found that only 2 out of 88 recaptured lobsters moved a distance greater than 3 nm. Average distances travelled ranged from 0-2.6 nm. Direction of movement was random but with a tendency for lobsters to move into or remain in rocky areas.

Lawton et al. (1978) studied the lobster fishery in the vicinity of the Pilgrim Nuclear Power Station, Plymouth, Massachusetts and found that 1,533 (71.2% of those tagged) tagged lobsters were recaptured within their respective release zone. Only 16.2% of tagged lobsters were recaptured at distances greater than 3 miles from release sites, a finding similar to that of Fair (1977), who also studied the Plymouth lobster fishery. Similar to others, Lawton et al. 1978 did not find any apparent relationship between time at large and distance travelled.

Based on their own tagging studies and those of a considerable number of other authors, Cooper et al. (1975) as cited in Normandeau Associates, Inc. (1978) stated that lobster populations shoreward of the 30 m isobath are essentially nonmigratory.

The inability to determine the date and point of release of the remaining 96 lobsters recaptured during our study can be attributed to the method of coding. Tag codes, which consisted of up to 4 alpha-numeric characters, were legible prior to placement on the cheliped. However, after placement on the cheliped, the expansion of the band often resulted in illegible codes, or codes easily subject to misinterpretation (e.g., the character, 0, could appear as 1 or as a decimal point depending on the degree and direction of band stretching). Thus, while the data record would indicate the initial date and release point of a lobster tagged with a specific code, the subsequent record of a recapture of that coded tag did not necessarily imply that the originally tagged lobster was recaptured (e.g., there were many cases of lobsters initially tagged and subsequently recaptured being of different sex). Furthermore, the problem of the characters of the codes fading with time was also encountered.

Since it was not originally the objective to mark lobsters for the purpose of determining movement or making population size estimates (see Section 2.3.2), a method of coding and tagging was selected which would not interrupt normal field data acquisition, but which would provide some information on alongshore movement of lobsters and enhance the overall usefulness of the study. While some information on movement was obtained, the use of rubber bands coded by marking with waterproof ink was found to be an unsatisfactory method for tracking the movement of individual lobsters. Any future attempts at determining lobster movement should use more conventional tagging methods.

3.7 **Population Estimates**

During the tagging period 18 June—31 August 1978, a total of 1,416 lobsters (either sublegal in size or berried) were tagged and released. Of this total, 140 or 9.9% were recovered. A summary of the number of all lobsters caught, marked, and recaptured by date is given in Table 3.7-1. A similar summary for lobsters in the pre-recruitment size range of 69-78 mm is presented in Table 3.7-2 (lobsters in this size range were judged fully vulnerable to the gear).

Population estimates of lobsters in the pre-recruitment size range of 69-78 mm by date in the Charlestown-Matunuck region of Block Island Sound for the period 29 June—31 August 1978 by the Petersen, Schnabel, and Schumacher and Eschmeyer techniques are presented in Table 3.7-3. Although tagging of lobsters began 18 June 1978, population estimates were not calculated until 29 June in order to have at least 2 recaptures. Final population estimates by the Peterson, Schnabel, and Schumacher and Eschmeyer methods were 3832, 3837, and 4033 lobsters, respectively.

TABLE 3.7.1. *Summary of mark-recapture information for 1978 lobster tagging study.*

Date	Total Captured	Marked	Recaptures
1978			
May 28	112	0	0
May 30	93	0	0
June 2	132	0	0
June 5	164	0	0
June 11	154	0	0
June 18	190	19	0
June 22	48	47	0
June 24	58	51	1
June 27	104	91	0
June 29	77	61	2
July 2	111	75	7
July 6	137	90	7
July 11	198	122	4
July 15	180	107	13
July 18	183	113	9
July 21	53	25	2
July 28	202	135	13
July 31	188	136	18
August 5	136	91	9
August 10	123	91	13
August 15	94	61	14
August 19	143	87	15
August 31	94	14	13
Total	2,974	1,416	140

TABLE 3.7-2. *Summary of mark-recapture information for pre-recruit lobsters in the size range of 69-78 mm, 1978 lobster tagging study.*

Date	Total captured	Marked	Recaptures
1978			
May 28	50	0	0
May 30	40	0	0
June 2	67	0	0
June 5	78	0	0
June 11	72	0	0
June 18	96	10	0
June 22	26	25	0
June 24	29	29	1
June 27	47	47	0
June 29	41	39	2
July 2	51	40	6
July 6	69	60	6
July 11	85	78	3
July 15	79	68	9
July 18	79	70	6
July 21	14	10	2
July 28	92	90	10
July 31	84	77	14
August 5	67	63	8
August 10	62	59	10
August 15	48	42	10
August 19	54	46	12
August 31	49	10	9
Total	1,379	863	108

TABLE 3.7-3. *Estimates of population size and density (rocky habitat) of pre-recruit lobsters (69-78mm) in the Charlestown-Matunuck region of Block Island Sound, 29 June-31 August 1978.*

Date (1978)	Number of pots	Total effective area fished A ($100m^2$)	Population estimate (2 standard error)						Estimated density (No./$100m^2$) based on population estimate of		
			Peterson		Schnabel		Schumacher & Eschmeyer		Peterson	Schnabel	Schumacher & Eschmeyer
6/29	24	984	2,275	(11,061)	2,275	(4,021)	2,275	(0)	2.3	2.3	2.3
7/2	40	1,640	1,275	(1,446)	1,525	(1,123)	1,473	(487)	0.8	0.9	0.9
7/6	49	2,009	2,185	(2,479)	1,807	(981)	1,831	(572)	1.1	0.9	0.9
7/11	59	2,419	7,083	(16,501)	2,738	(1,340)	3,139	(2,201)	2.9	1.1	1.3
7/15	56	2,296	2,879	(2,481)	2,787	(1,092)	3,010	(1,319)	1.2	1.2	1.3
7/18	56	2,296	5,214	(5,916)	3,242	(1,141)	3,638	(1,545)	2.3	1.4	1.6
7/21	22	902	3,262	(15,857)	3,243	(1,106)	3,600	(1,338)	3.6	3.6	4.0
7/28	61	2,501	4,379	(3,468)	3,501	(1,046)	3,864	(1,160)	1.8	1.4	1.5
7/31	65	2,665	3,396	(2,075)	3,476	(902)	3,695	(832)	1.3	1.3	1.4
8/5	59	2,419	5,385	(4,972)	3,707	(901)	4,016	(888)	2.2	1.5	1.7
8/10	56	2,296	4,377	(3,467)	3,795	(859)	4,090	(780)	1.9	1.6	1.8
8/15	46	1,886	3,672	(2,908)	3,781	(803)	4,014	(663)	1.9	2.0	2.1
8/19	51	2,091	3,631	(2,476)	3,762	(748)	3,942	(565)	1.7	1.8	1.9
8/31	40	1,640	4,644	(4,002)	3,837*	(730)	4,033*	(539)	2.8	2.3*	2.5*
Mean	48.9	2,003	3,832*		**		**		1.9*	**	**
S.d.	13.2	542.5	1,501								

* Final population or density estimate

** Schnabel, and Schumacher and Eschmeyer techniques are averaging methods; therefore overall mean not appropriate.

A. Based on Miller's (1975) estimate of the effective area fished for traps used in the commercial spider crab fishery in Newfoundland.

The population estimates given in Table 3.7-3, along with information on the effective area fished per trap, can be used to estimate density of pre-recruit lobsters in the 69-78 mm size range. Miller (1975) estimated that the effective area fished for traps used in the commercial spider crab (*Chionoecetes opilio*) fishery in Newfoundland was approximately 4100 m^2/trap. If his estimate is assumed adequate for lobster traps used in our study, then densities of lobsters can be estimated. Estimated densities of pre-recruit lobsters (no./100 m^2) by date are given in Table 3.7-3. The final estimated density varied from 1.9-2.5 pre-recruits/100 m^2 of similar (rocky) habitat. Expressed as numbers per acre, the densities ranged from approximately 77-100 pre-recruit lobsters/acre of similar bottom.

3.8 **Molt Onset**

An approximation of the date of molt onset can be determined by plotting the legal catch per pot versus sampling date. A nadir in the plot would indicate the near depletion of legal lobsters just prior to the molt, and should be followed by a sharp increase in the catch rate as a result of a new cohort of lobsters reaching legal size with the molt. The catch rate of legal male and unberried female lobster for Station 1E by date is shown in Figure 3.8-1 (Station 1E was selected due to the continuous sampling effort). From Figure 3.8-1, as well as examination of catch rates for other stations (Tables 3.1-2 and 3.1-4), it would appear that molt onset occurred in approximately late June. Few soft shell or recently molted lobsters were caught during our study (Table 3.8-1), thus giving little additional evidence on the approximate date of molting. Lund et al. (1970) observed two distinct periods of massive molting in Fishers Island Sound; June-July and October-November. Russell et al. (1978) also suggested that two molting periods (June and in late September—early October) occur in Narragansett Bay—Rhode Island Sound. Our study terminated prior to when the later molting period could have occurred.

TABLE 3.8-1. *Date and location (station) of capture of recently molted lobsters, 1978 lobster pot survey.*

Date	Station	Number Caught
1978		
6/18	1W	1
6/18	1E	1
6/27	1W	1
7/15	NS	1
7/18	3E	1
8/10	2E	1
8/31	3E	1
Total		7

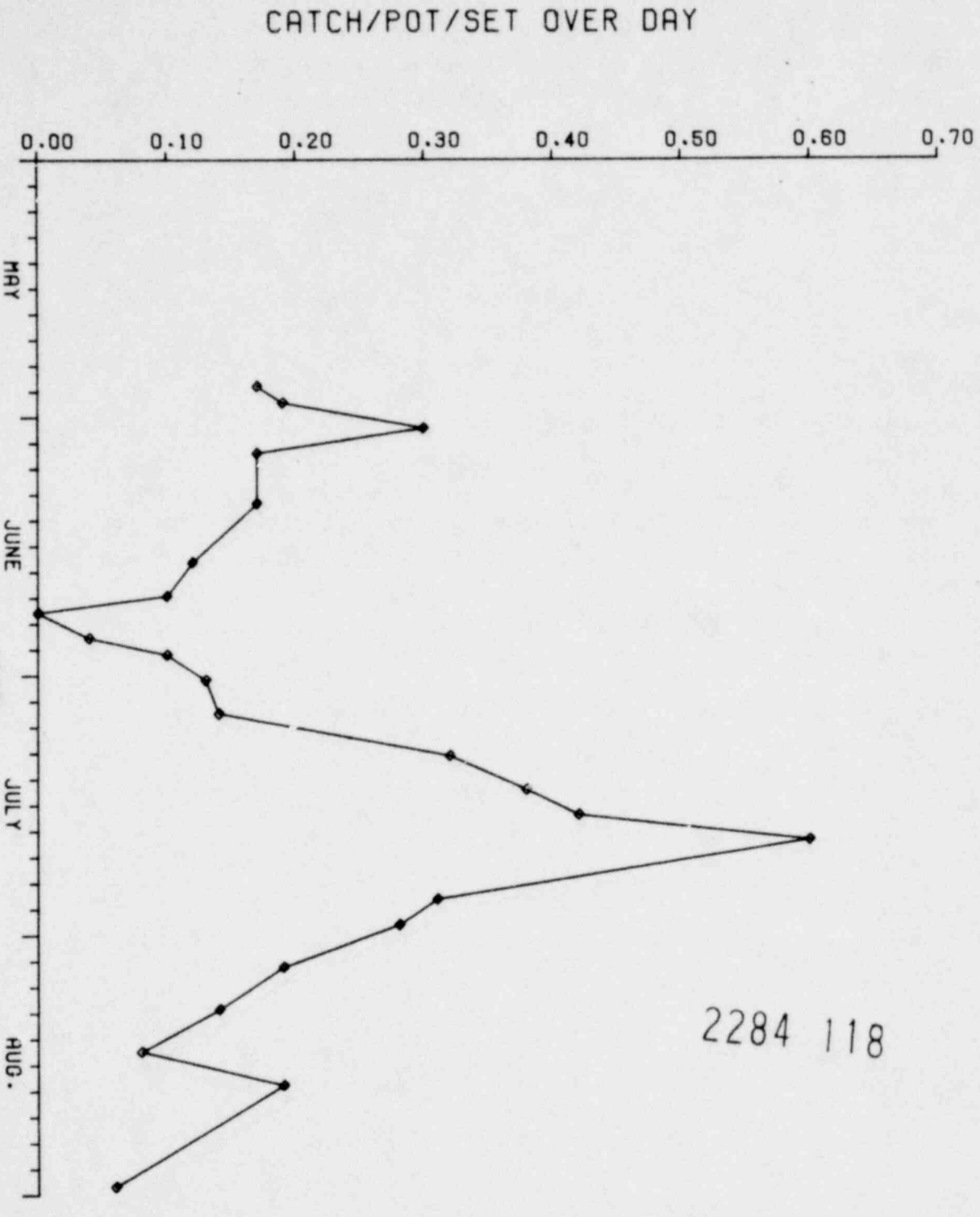

FIGURE 3.8-1. *Catch per pot per set over day of legal unberried females and legal males by date at station 1E.*

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