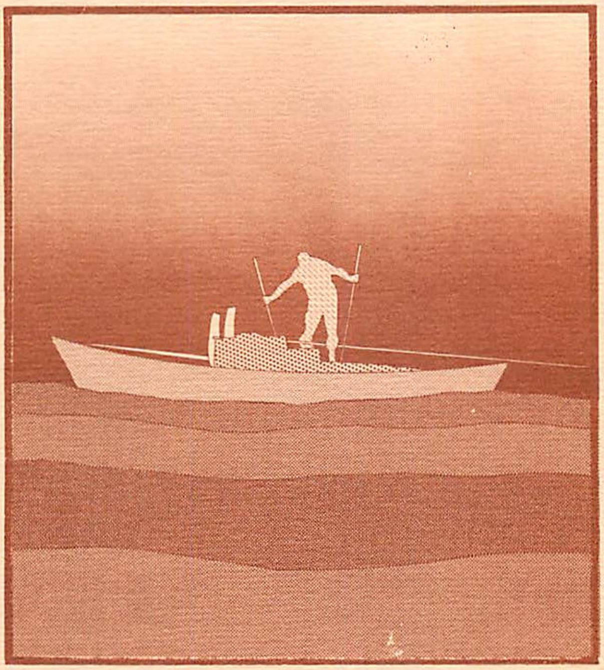
MARINE INVERTEBRATE RESOURCES



ANNUAL REPORT 1972-73

Field Station College of Marine Studies University of Delaware Lewes, Delaware

Annual Report 1972-1973

MARINE INVERTEBRATE RESOURCES

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The Department of Natural Resources

and Environmental Control

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October 1973

[DEL-SG-5-74] This work is the result of research sponsored in part by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 2-35223.

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SUMMARY

Our laboratory monitored spat-fall for the fifth consecutive year. The data indicated that natural recruitment in the Bay beds was highest (0-3651/collector) in 1972 for the past five years. Set in the rivers was low (0-121/collector). The spat-fall occurred unusually late (September). High temperatures in early summer before oysters were conditioned to spawn may have delayed spat-fall.

A study of long-line oyster techniques showed that oyster spat can be caught on the natural rocks and moved to other locations for growth. Growth rates indicate commercial size can be obtained in two years.

The hard clam in Indian River and Rehoboth Bay has become one of Delaware's most valuable shellfish resources. Planting experiments involving protective aggregate indicate that juvenile clams can be planted on a commercial basis. Protective aggregate techniques should allow at least a 50% return of planted stock when properly applied.

Sediment preference experiments show that clams can discern between silt and sand sediments. However, finer selection between sand sized particles is not evident. There is strong evidence that sediment chemistry is the controlling factor. Juvenile clams are attracted or stimulated to set in sediments

treated with clam liquor. The gregarious behavior is similar to that displayed by other benthic invertebrates.

The blue crab data for Indian River Bay show comparable population levels to past years. However, there has been an absence of juveniles that may become evident in decreased populations in future years. Size frequency data indicate a negative population trend.

Trap and tag studies in Delaware Bay have produced conservative population estimates. Tagging has shown that the majority of the crabs in the Port Mahon area do not migrate great distances.

A lobster creel census by the Marine Advisory Service indicates the importance of this fishery and the need for further investigation by the State and University.

OYSTER RESEARCH

Spat Monitoring

This section describes yearly spat monitoring and the long-line technique of oyster culture as an alternate to oyster raft culture in Delaware Bay. The data presented on spat collection represent the fifth consecutive year of sampling on Delaware's natural oyster rocks. The development of a data bank on spat monitoring over a long period of time is necessary to establish an understanding of setting patterns.

The University has served in an advisory capacity to the Department of Natural Resources and Environmental Control (DNREC) and has aided in oyster monitoring.

The prediction of oyster setting is important to the commercial oysterman because it enables him to plant cultch at the best location at the optimum time (Nelson, 1952). This research has been a vital part of the rehabilitation of Delaware's oyster beds through planting solid waste surf clam shells as cultch material from 1969 through 1973 (Howell, 1973).

The continued success of the Delaware oyster industry is dependent on adequate recruitment. A regular systematic shell planting program will prevent deterioration of the natural rocks through siltation, fouling, and removal of shell during harvesting.

The annual spat monitoring program is a valuable tool in assessing the success of the shell planting program. The data serve as a basis for predicting future production based on the abundance of each year's set and size class.

Methods

During the summer of 1972, spat collectors were placed in rivers and bay beds comparable to previous years' locations (Keck, et al., 1972). The collectors consist of 12 cm^2 asbestos plates placed in wooden frames. The frames were buoyed and anchored in place. All rivers except the Simons and Mahon contained three stations. Stations were located at the beginning, middle, and upper reaches of the oyster beds in each river. In the bay two stations each were located on the Ridge and Silver Bed. Collectors were sampled weekly and examined under a dissecting scope. All spat were recorded.

Results

A summary of these data are presented in Table 1 showing the weekly number of spat per station throughout the summer. Table 2 compares the 1972 data with data from 1968 through 1971. Figures 1, 2, and 3 show the relationship between spat-fall and temperature for 1972. Salinity, oxygen, and temperature data for the summer of 1972 are presented in Appendix A, Table 1.

Discussion

Data from the last five years have shown several trends which appear to be a yearly occurrence. Oyster spat have been found as early as the first week in July. These early spat are

TABLE 1

Weekly Summary of 1972 - Spat Collection/Station

	July 10	17	24	31	Aug. 7	14	21	28	Sept. 4	11	18	26	River Total
Leipsic	0	0	0	0	2	1	0	11	91	33	0	0	138
Ridge Bed	0	0	0	20	26	25	19	8	1586	62	0	5	1751
Silver Bed	0	0	0	14	30	5	5	44	3651	182	2	2	3935
Simons	0	0	0	0	2	2	1	0	50	84	0	0	139
Mahon	0	0	0	2	2	0	0	1	120	148	3	1	273
St. Jones	0	0	0	0	4	22	1	0	2	0	0	0	29
Murderkill	0	0	2	0	10	0	3	0	0	0	0	0	15
Mispillion	0	0	1	0	0	3	8	0	0	0	0	0	12
Broadkill	0	0	0	1	4	121	14	0	2	0	0	4	146
Weekly Total	0	0	3	37	78	179	51	63	5502	509	5	12	

TABLE 2

Total Number of Spat Collected/Station/Year

	1968	1969	1970	1971	1972	1972 Rank/Years Rec.
Ridge	-	-	472	18	1751	1/3
Silver	-	-	315	4	3935	1/3
Leipsic	529	63	113	0	138	2/5
Simons	-	-	82	0	139	1/3
Mahon	-	-	78	2	273	1/3
St. Jones	-	836	93	1	29	3/4
Murderkill	-	1374	35	0	15	3/4
Mispillion	-	39	33	0	12	3/4
Broadkill	0	2	10	1	146	1/5

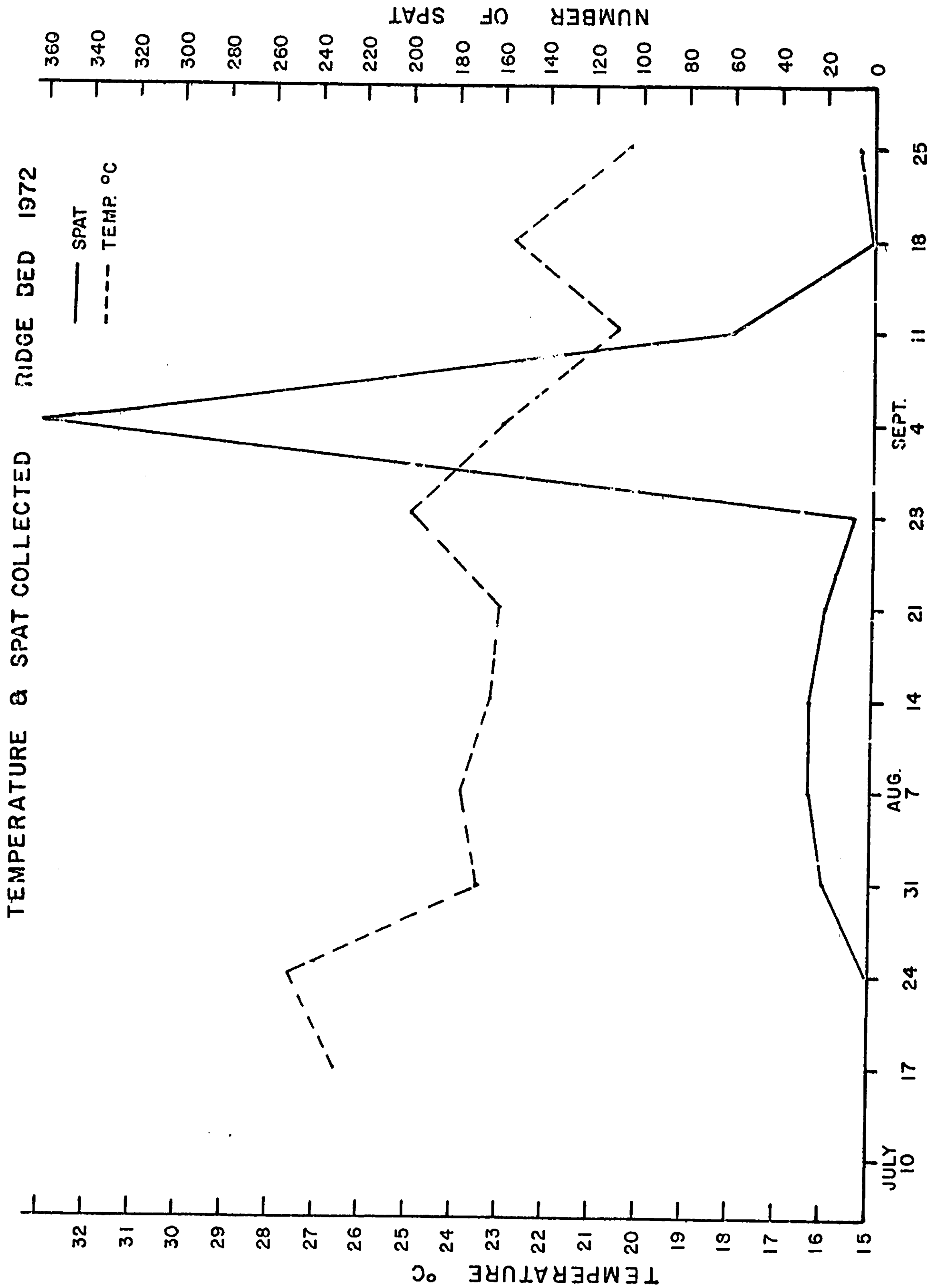

TEMPERATURE & SPAT COLLECTED RIDGE BED 1972
SPAT
TEMP. °C
NUMBER OF SPAT
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TEMPERATURE °C
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
JULY 10
17
24
31
AUG. 7
14
21
23
SEPT. 4
11
18
25

FIGURE I

TEMPERATURE & SPAT COLLECTED SILVER BED 1972

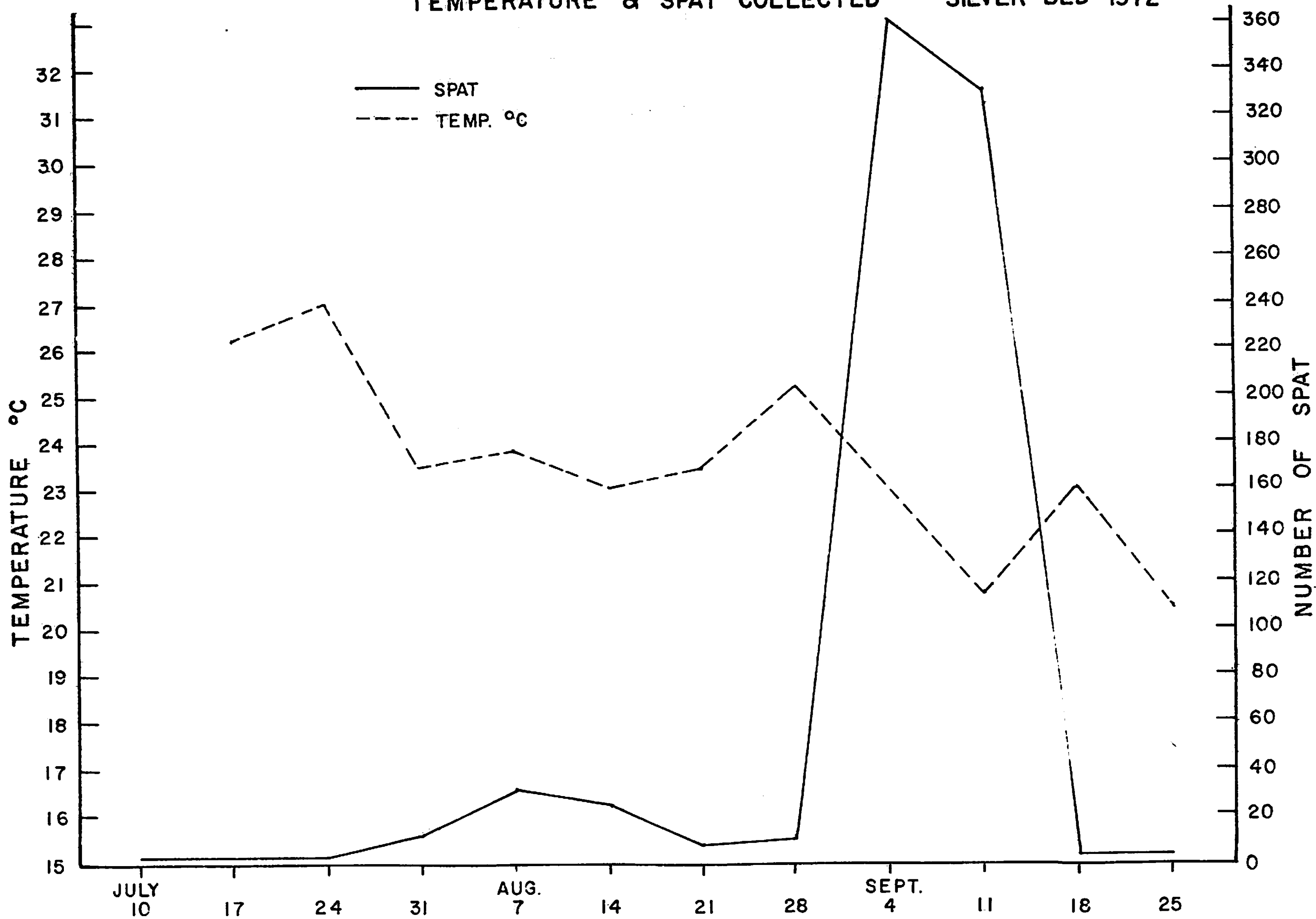


FIGURE 2

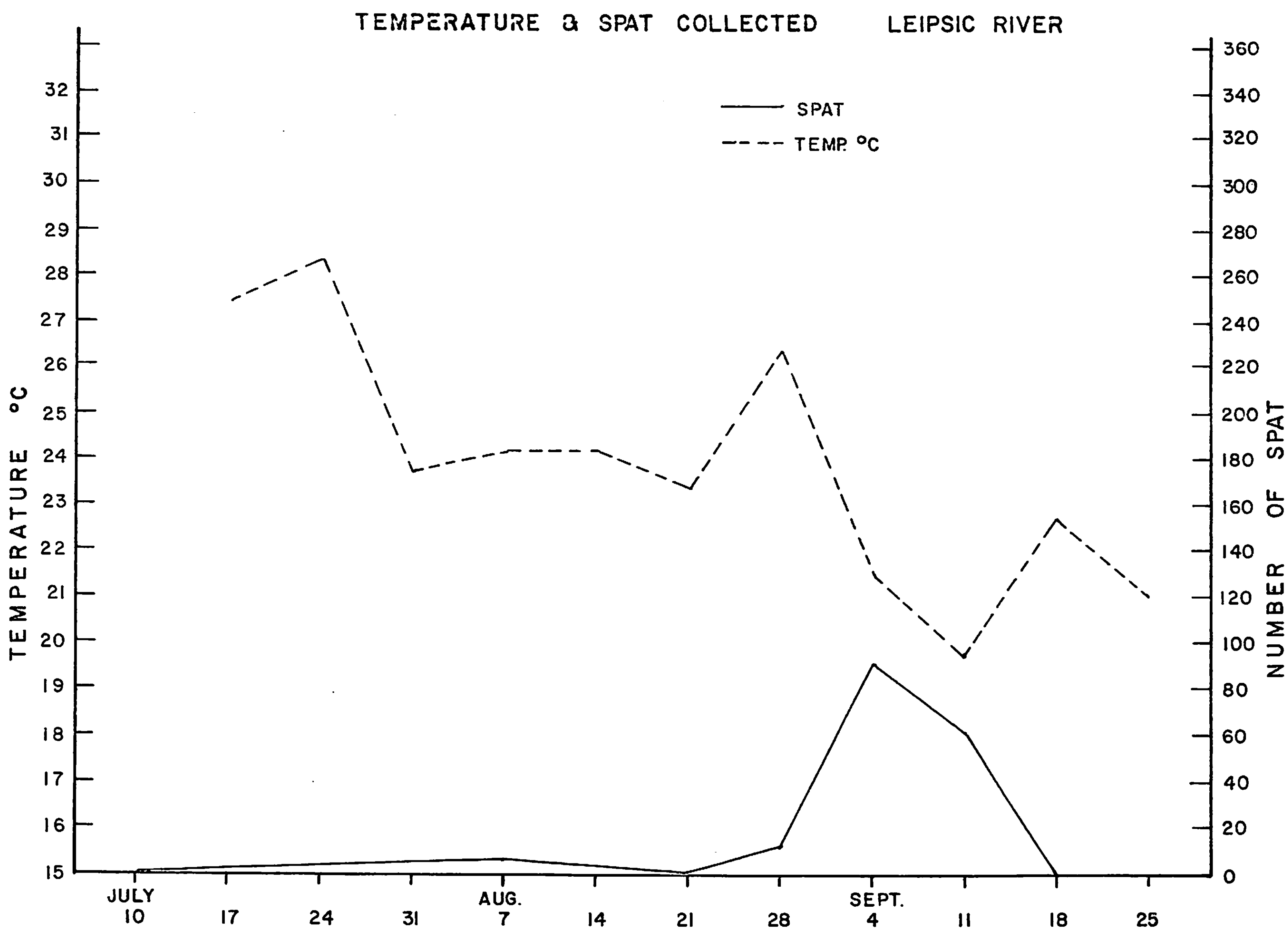

TEMPERATURE & SPAT COLLECTED LEIPSIC RIVER
SPAT
TEMP. °C
TEMPERATURE °C
NUMBER OF SPAT
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
JULY 10
17
24
31
AUG. 7
14
21
28
SEPT. 4
11
18
25

FIGURE 3

usually found in rivers where the water temperatures rise faster than the bay water temperatures. Setting is generally highest near the mouths of the oyster-producing rivers. Beaven (1954) states that conditions are ideal for setting where larvae-rich water empties into higher saline water. Also the larvae are entering the bay which has a slower exchange rate resulting in larval retention. Peak setting in rivers and the bay coincide indicating that successful setting in the rivers appears highly dependent on the exchange of larval-rich water on flood tides from the bay.

In general, peak setting occurs between the last week in July and the third week in August. Setting has been observed to occur in one rapid burst or at several sporadic intervals which extends the setting period into September. Spawning occurs sometime after a temperature of 26° C is reached. Peak setting is observed to occur after rapid temperature increases of more than 3° C which serve as spawning stimuli.

Figure 4 compares the temperatures on the Ridge during 1970, 1971, and 1972. The period of intense setting occurred late in 1972. However, the temperatures (Fig. 4) were depressed during the normal period of intense setting during the last week in July to the third week in August. Setting activity in September showed a normal lag following a temperature rise the 4th week in August. It is noted that high temperatures in early July were not sufficient to trigger spawning activity, suggesting that oysters were not sufficiently conditioned to spawn at this time. As reported (Keck, et al., 1972) constant temperatures, although

TEMPERATURE and SPAT DENSITY
RIDGE BED 1970, 1971 and 1972

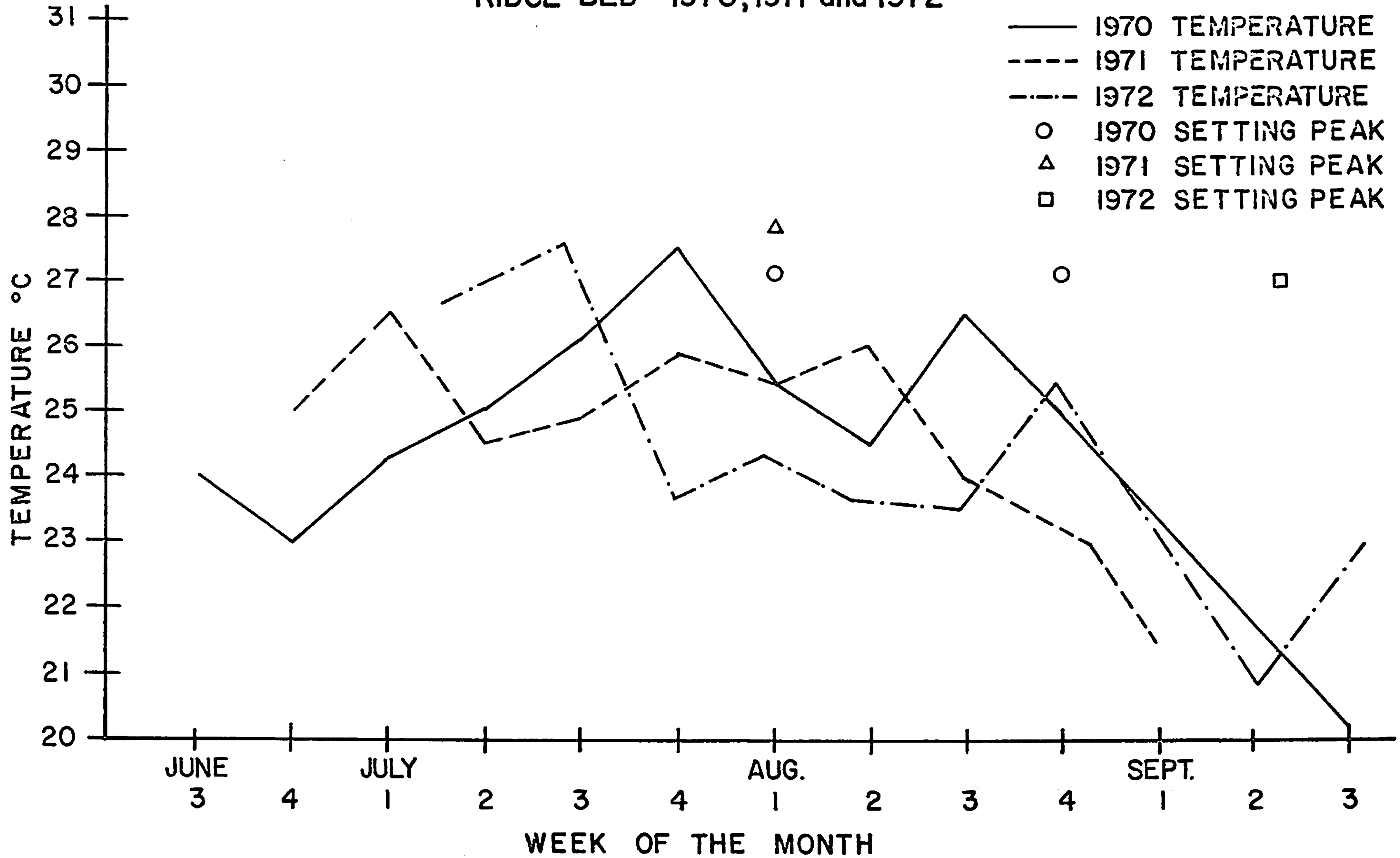


FIGURE 4

relatively high, make poor spawning stimuli. The temperature rise from 23° C to approximately 26° C in late August was sufficient to trigger spawning.

Although there is no evidence to explain the trend, commercial sets have occurred every other year--1968, 1970, 1972. It is important to realize the complexity of setting as explained by Hidu and Haskins (1970) and Loosanoff (1966). Combinations of tides, movement of water masses, wind, presence of food and temperature are all critical for successful setting.

OYSTER LONG-LINE

Our laboratory has conducted oyster raft culture experiments over the last four years (Maurer and Aprill, 1973). Setting had been poor on shell strings suspended from rafts, requiring alternate methods for catching spat. Two methods have proved highly successful. Bundles of shell were placed on the bottom of the Ridge Bed and two submerged long-lines with attached shell strings were anchored in the same area.

Methods

Construction of the long-line is detailed in Maurer and Aprill (1973) and shown in Figure 5.

Results

In 1972 strings of oyster shells were laid on the bottom of the Ridge Bed during the first two weeks of August through early September. After setting, the strings were then moved to rafts held in the Simons River where spat were allowed to grow for the remainder of the summer. In October, measurements showed that set averaged 107 oysters per string or approximately 10.7 oysters per shell which is a commercially feasible set. Ten percent of these were measured producing an average size of 1.5 cm.

One of the two long-lines lost during a storm during July

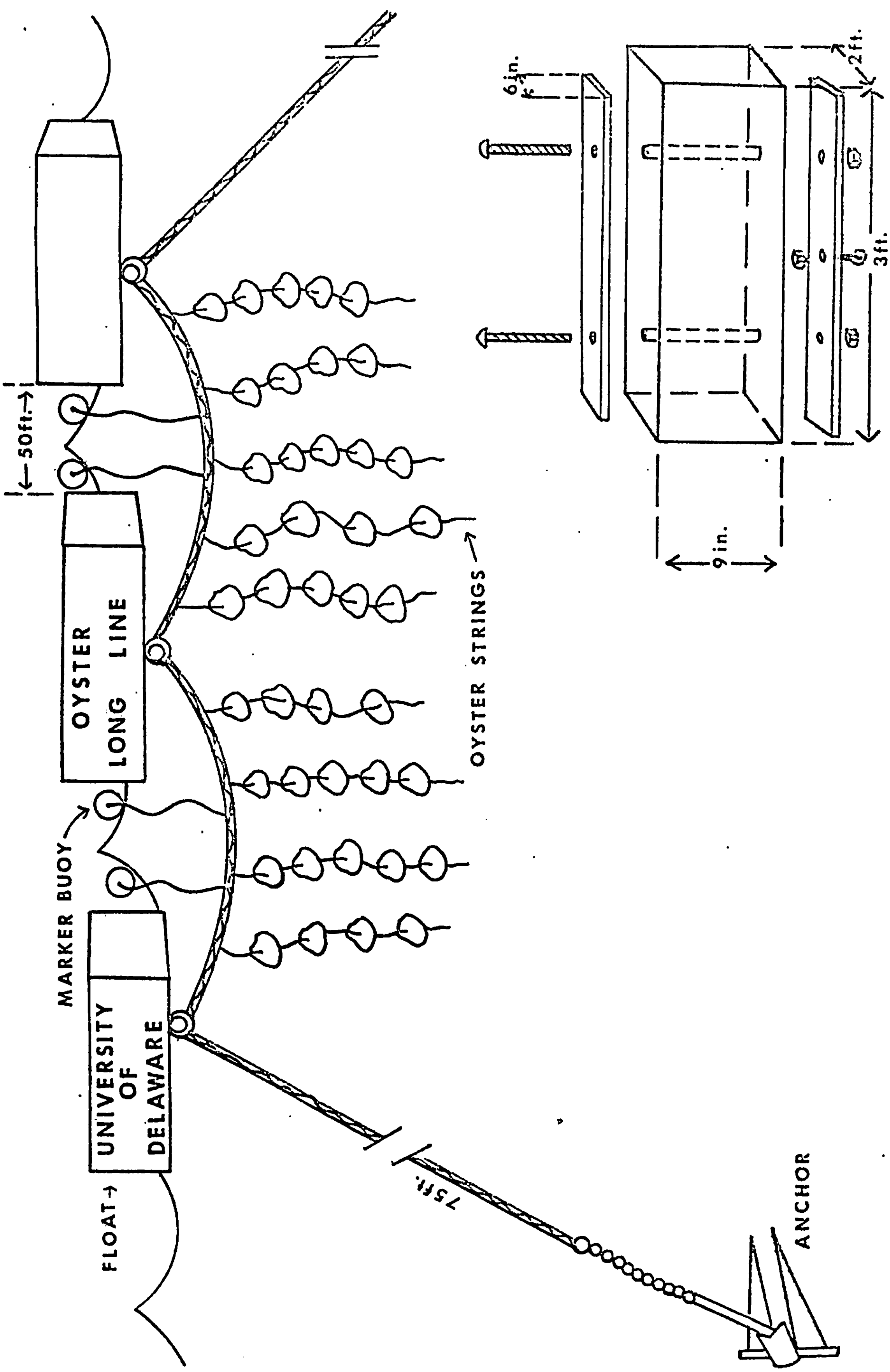


FIGURE 5
OYSTER LONG LINE

1973 was recovered on June 27, 1973. The measurements and counts provide some interesting comparisons with the data provided above. Table 3 presents the data collected.

Discussion

The data indicate that the long-line method is highly successful. After one year an average of 9.4 spat/shell remained with an average size of 2.1 cm. These data represent approximately 14% mortality and a 40% increase in size. Eight oysters/1000 measured were larger than 6.0 cm which represents phenomenal growth. It is highly probable that these large yearlings set early in August and had a four week head start on those that set in the second week of September. In all cases, these were single spat that did not suffer from spatial food competition of the dense September set. The data show that the possibility of producing a commercial size oyster in two years is a definite possibility under certain conditions.

The long-lines constructed for this project were simple and inexpensive. Long-lines have been successful in Japan (Bardach, et al., 1972) and have been described by Shaw (1972). Long-lines laid on the bottom are an efficient method of collecting natural spat-fall. This might be a feasible method for obtaining spat for restocking small scale tonging areas similar to the one presently established by DNREC off Bowers Beach. Long-lines could be established by private individuals for purposes of stocking leased grounds and in turn provide new revenue sources for the State.

TABLE 3

The Ridge

Oyster Long-Line Data

June 27, 1973

Strings and Number of Shells per String (Oysters)

# 1	32/ 9	#26	88/10
# 2	6/ 9	#27	154/10
# 3	47/ 9	#28	109/10
# 4	62/ 8	#29	28/ 9
# 5	14/10	#30	91/ 9
# 6	80/10	#31	80/ 9
# 7	72/ 9	#32	190/10
# 8	31/ 9	#33	42/ 9
# 9	82/10	#34	263/ 9
#10	42/ 8	#35	61/10
#11	43/ 8	#36	26/ 9
#12	86/ 8	#37	248/11
#13	137/10	#38	41/ 7
#14	98/10	#39	100/10
#15	23/ 5	#40	107/ 9
#16	47/ 9	#41	135/ 9
#17	49/ 9	#42	71/ 9
#18	150/ 8	#43	9/ 8
#19	60/ 9	#44	256/ 8
#20	243/10	#45	77/ 9
#21	48/ 9	#46	10/ 9
#22	17/10	#47	107/ 8
#23	142/10	#48	71/10
#24	80/ 7	#49	40/ 8
#25	48/ 8		

84.5/String of 9 Shells

Average 9.4 Spat/Shell

Average Size 2.103 cm

8 Oysters/1000 6.0 cm

HARD CLAM

Indian River and Rehoboth Bays provide the main source of hard clams in Delaware. There has been a progression toward increased landings in Indian River and Rehoboth Bays compared with Delaware Bay. For example, in 1955, of 444,000 lbs. landed in Delaware, 111,000 lbs. came from Indian River and Rehoboth Bays. In 1967, 281,900 lbs. were landed and only 40,900 lbs. came from Delaware Bay. Data reported by Keck, et al. (1972) show that hard clam densities from the two smaller bays are moderate and have decreased since the 1967 study (Humphries and Daiber). Because of increased fishing pressure and closures of bottom by the State Board of Health, the hard clam populations in both Indian and Rehoboth Bays should be closely studied and protected. The emphasis of this year's research was the development of techniques for raising and planting juvenile clams in the field. Rehoboth and Indian River Bay would make ideal locations for intensive clam culture.

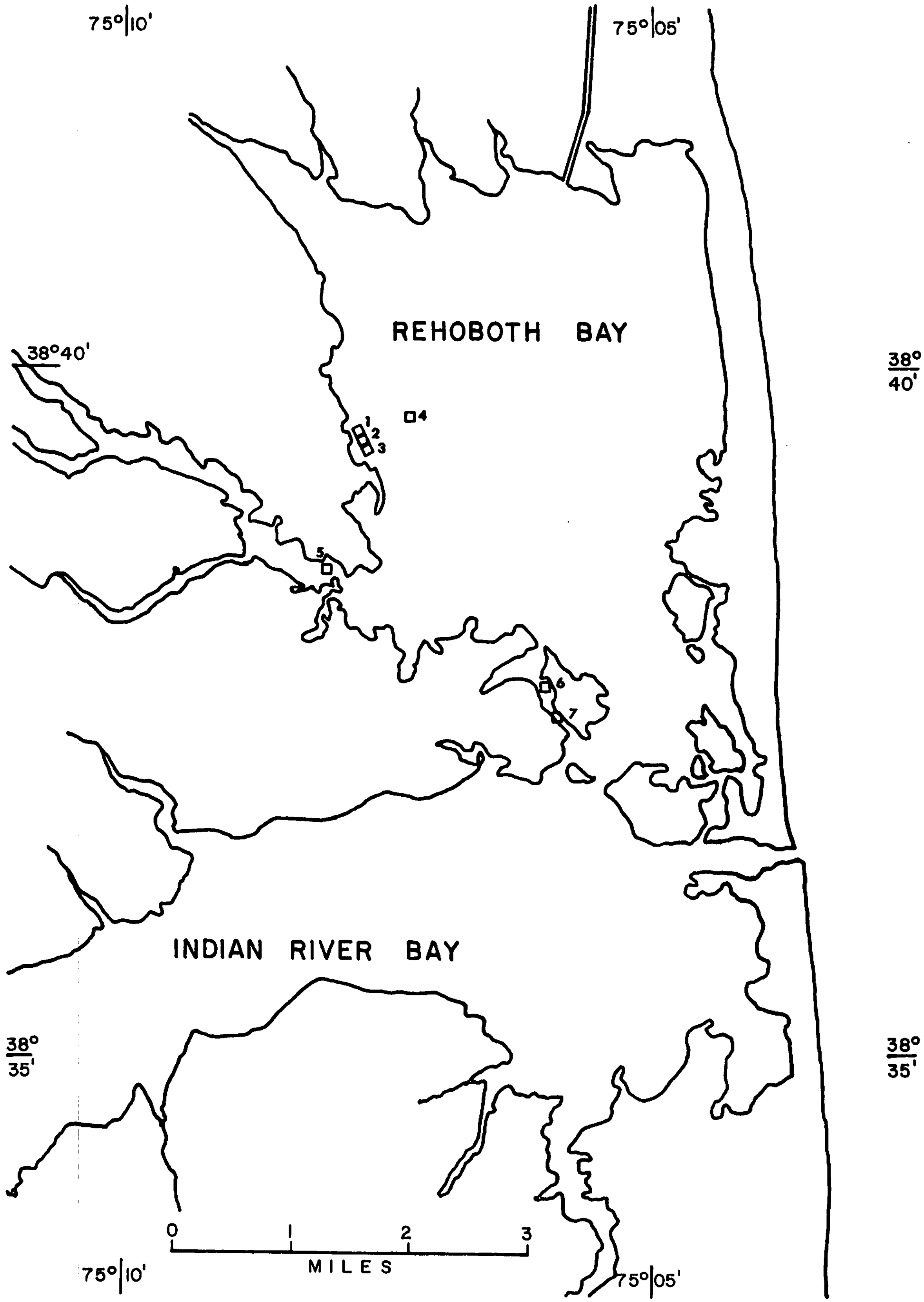
Methods

Hard clams are spawned and reared at the University's Mariculture facility as described by Loosanoff and Davis (1963) and Pruder, et al., 1973. Juvenile clams were reared in flow through recirculating tanks or in tanks where water was changed daily for approximately 4 weeks after setting. At this time, they were transferred to open system flow through tanks and grown until a size of approximately 1 mm was reached.

Castagna (1970) developed a method to protect juvenile hard clams by spreading aggregate over the bottom before planting seed clams. Aggregates should be selected that are cheap and plentiful. Our laboratory used crushed clam shell, a waste by-product of the HCA clam processing plant in Lewes. The aggregate costs approximately $20 for a 2-ton truckload which was sufficient to cover our plots. The aggregate is scattered evently over the selected bottom until a thickness of 1 to 3 inches is achieved.

Plot sites were selected to test survival on different bottom types in more protected (wind and current) areas of Rehoboth Bay. Figure 6 shows locations of four 64 square foot plots and three 25 square yard plots. Table 4 lists the plots with total numbers, densities, and average size of the clams planted.

Specialized sampling gear was developed to sample the plots. The shell aggregate and small size of the clams prohibit the use of rakes. Brett (1964) describes the use of a hydraulic benthic sampler more commonly referred to as a "gold sucker." We modified Brett's sampling gear as shown in Figure 7. Original sampling was approximately one year from planting date. Due to the small size of the clams, plot 1 was subsampled and only plots 2 and 3 have been completely sampled.



HARD CLAM PLANTING SITES

FIGURE 6

GOLD SUCKER BENTHIC SAMPLER

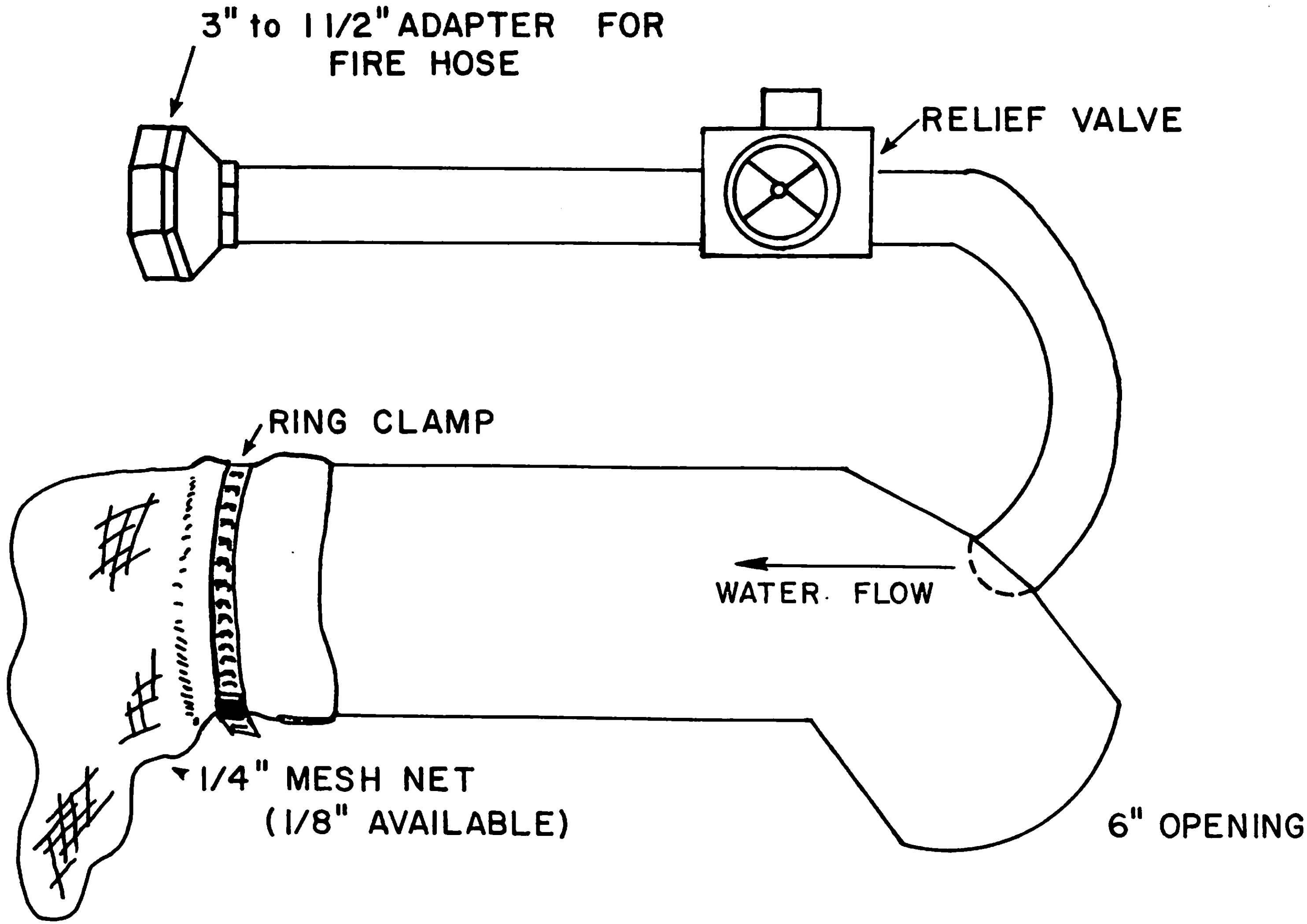


FIGURE 7

TABLE 4

HARD CLAM Planting Data

Plot No.	Date Planted	Area	Total No. of Clams	Density	Size
1	10/31/72	25 sq. yds.	744,000	3,300 sq. ft.	500 - 700 μ
2	8/21/72	25 sq. yds.	3,000	12 sq. ft.	3,089 cm.
3	8/21/72	25 sq. yds.	3,000	12 sq. ft.	2.911 cm.
4	6/28/73	64 sq. ft.	10,000	156 sq. ft.	700 μ to 1 mm
5	6/28/73	64 sq. ft.	10,000	156 sq. ft.	700 μ to 1 mm
6	6/28/73	64 sq. ft.	10,000	156 sq. ft.	700 μ to 1 mm
7	6/28/73	64 sq. ft.	10,000	156 sq. ft.	700 μ to 1 mm

NOTE: Plot No. 3 was unprotected to provide comparision to survival of clams in Plot No. 2. Plots 6 and 7 located in Massey's ditch are protected by fiberglass baffles to prevent currents from displacing small clams.

Results

The results of the clam planting experiments are detailed in Table 5. Plot 1 which was subsampled yielded a density of 40 clams/sq. ft. with an average size of 0.96 cm, a 78% growth increase from the 700 µ planting size.

Discussion

Although the data will be more complete in the next year, the data indicate that successful clam planting can be accomplished using a protective aggregate. The difference in survival between the protected and unprotected plots (Table 5) indicate predation to be a major problem in hard clam management. Predation is evident by crabs, drills, and even water foul. Preliminary predation experiments have shown that adult blue crabs are capable of cracking open clams as large as 4 to 6 cm. Most attempts at protection of planted clams are too expensive to be of commercial value. However, the use of aggregate is simple and increased yields should pay for the increased cost of the aggregate. The aggregate technique could be used to increase natural production and encourage the planting of hatchery reared stock.

The differential growth rates, lower in the protected plot where survival is higher (Table 5) demonstrate that success is highly dependent on planting densities. At small sizes the clams can be planted at relatively high densities (200 to 300/sq. feet); as the size increases, the clams should be removed and planted at densities of less than 12/sq. feet.

TABLE 5

Hard Clam Planting Results

Unprotected	Planted	22 Aug. 1972	Average Size	2.9
Protected	Planted	22 Aug. 1972	Average Size	3.1
Unprotected	Sampled	20 July 1973	Average Size	3.8
Protected	Sampled	1 Aug. 1973	Average Size	3.6
Unprotected	6.8%	Survival	29.9% Growth	
Protected	47.3%	Survival	18.5% Growth	

It appears that the aggregate method would enable sufficient survival and growth to permit commercial production from hatchery to table in three years. It is strongly recommended that the State consider a cooperative large scale application of this method in both Indian River and Rehoboth Bays.

HARD CLAM SETTING PREFERENCE

Wilson (1943), (1952), and (1954) in his studies on the larvae of the polychaete (Ophelia) has shown that their survival and the survival of other benthic invertebrates is dependent upon settlement of larvae on a favorable substrate. These authors together with Gurin and Carr (1971) suggest that sensitive chemoreception by the organism results in the proper choice of substrate. Keck, et al. (1971) and Veitch and Hidu (1972) have shown that the gregarious setting factor displayed by oysters is due to release of a pheromone by adults or recently set larvae. The ecological significance of this behavior varies. Sanders (1958) determined that there was a correlation between feeding mechanism and sediment type. Filter feeders were dominant in sand, while deposit feeders were common in mud. Bloom, et al. (1972) produced data which supported the trophic group amensalism hypothesis.

Maurer (1967) states that sediment qualities can be a limiting factor in pelecypod distribution. The density of pelecypods initially increases with an increase in organic content (Bader, 1954). However, at higher levels the products of decomposition produce increased bacteria and reduced oxygen levels resulting in decreased populations.

Zobell (1963) and Oppenheimer (1961) discuss the importance of bacteria in aggregation, nutrient and mineral cycles in sediments. Meadows and Anderson (1963), Crisp and Meadows (1962), Wilson (1958), Cole and Knight-Jones (1949) postulate on the importance of microorganisms and organic layers on the settlement of marine larvae.

There are numerous papers relating directly to the hard clam and its sediment preferences. Pratt (1953) reports that the hard clam is most abundant where the sediments are fine, but that abundance in these sediments is strongly related to the presence of large particles such as shell. Wells (1957) in a study of hard clam distribution in Chincoteague Bay found clams more prevalent in shell bottom, sand, sand mud, and mud, respectively. This distribution relates to either selection of substrate or a pattern of relative survival. Saila, et al. (19 7) studied several environmental parameters in areas of high and low population densities. The difference in population abundance could not be explained in terms of sediment properties alone. They concluded that current, vegetation, predation, and organic constituents all affect distribution.

The experiments in this portion of research are designed to simplify complex environmental interactions by performing controlled laboratory setting experiments. The experiments focus on three major goals. 1) Selection of substrate based on particle size, 2) Selection of substrate due to chemical constituency, and 3) Selection of substrate in the presence of a pheromone.

Methods

Larvae for the setting experiments were obtained from the University's Sea Grant Mariculture project. Laboratory reared larvae are released in a 75 gallon setting tank containing a grid with 36 randomly placed sediment blocks and controls. Approximately 200,000 clams are used in each experiment to insure significant sets. Experimentation has shown that the size and age of larvae are extremely critical variables. Large larvae ready to set immediately produce random sets. Larvae must be released at a smaller than setting size to assure that the clams are still highly mobile and capable of exhibiting a searching behavior. Experimental larvae are selected in three steps: 1) Larvae 8 to 10 days old are used, 2) These larvae are screened to selected specimens 140 to 170 μ in size, 3) The sized larvae are acclimatized 1 to 2 hours in a large beaker. At the end of this period, swimming larvae are poured off and used in the experiment. Larvae that have settled out are rejected. Larvae are released randomly or in measured aliquots over each test block.

The majority of the experiments are terminated after 48 hours. However, if numerous larvae are still swimming, the experiments are extended another 24 hours. Upon termination the tank is drained exposing the grid. A plastic 1 inch square metering device is placed on the bottom. All sediments in this area are pipetted into a small finger bowl. Replicate samples are taken to prevent bias due to localized distribution. The samples are sieved and washed to separate juvenile clams from the sediment to facilitate counting. The experimental design was developed to permit statistical evaluation of the results by analysis of variance and the Mann-Whitney U test. The experiments were conducted in the following series with adequate replicates for each step.

1. Larvae were exposed to different sediment particle sizes (1 mm, 700 μ, 500 μ, 250 μ, and 50 μ) that are natural to Delaware.

2. Larvae were exposed to the above series of sediments which were burnt at 500° C for 1 hour to remove organics and destroy attached microorganisms.

3. A specific substrate (500 μ sand) was treated with clam liquor and its "attractiveness" tested against a control.

Results

The results of the series of experiments are presented in Tables 6-8. The total sum of clams represented for each experimental block are presented. The results were tested by analysis of variance, Kruskal-Wallis H test and the Mann-Whitney U test to determine the significance of the data.

Discussion

Keck, et al., 1972 reported that juvenile hard clams displayed a sediment size preference that is possibly masked by chemical factors in natural sediments. Modification of the earlier experiments have failed to clarify the matter. Although trends appear favoring 250 to 500 μ size sand over 50 μ sand, the

TABLE 6

HARD CLAM Setting Results

Natural Sediments Numbers Represent
Sum of Clams Set in 6 Experimental Blocks

	1 mm	707 µ	500 µ	250 µ	50 µ	Control
Exp. 1	1844	2724	4230	2696	3154	2478
	F Value	1.91				
	H Value	8.05				
	U Value	27 *				
Exp. 2	2541	2776	3125	5469	3060	1483
	F Value	.642				
	H Value	6.86				
	U Value	28 *				
Exp. 3	476	402	629	1621	405	332
	F Value	1.17				
	H Value	4.77				
	U Value	26				
Exp. 4	914	1409	1015	866	470	341
	F Value	1.07				
	H Value	4.66				
	U Value	27.5 *				
Exp. 5	1406	1236	1663	1313	1293	1085
	F Value	2.73				
	H Value	1.43				
	U Value	21.0				

* Significant at 95% confidence level.

TABLE 7

Clam Setting Experiment Results--
Incinerated Number Represents Sum of Clams
Set in 6 Blocks Sediments

	1 mm	707 μ	500 μ	250 μ	50 μ	Control		
Exp. 1	242	225	364	412	248	307		
Analysis of Variance F Value							.546	
Kruskal-Wallis H Test							4.27	
Mann-Whitney U Test between Maximum and Minimum Value							24	
Exp. 2	378	368	724	752	322	249		
Analysis of Variance F Value							4.98	*
Kruskal-Wallis H Test							15.4	*
Mann-Whitney U Test between Maximum and Minimum Value							31.5	*
Exp. 3	523	936	355	301	345	473		
Analysis of Variance F Value							3.89	
Kruskal-Wallis H Test							11.79	
Mann-Whitney U Test between Maximum and Minimum Value							32	*
Exp. 4	255	425	193	345	259	183		
Analysis of Variance F Value							.517	
Kruskal-Wallis H Test							.828	
Mann-Whitney U Test between Maximum and Minimum Value							19	

* These values significant at FO_5 level.

TABLE 8

HARD CLAM Setting Results Treated vs. Untreated 500 u Sand

Ranked Assemblage of Data

Exp. 1		Exp. 2		Exp. 3		Exp. 4	
Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
0	82	17	38	11	18	5	17
29	86	17	48	13	46	7	29
37	111	26	49	14	48	8	40
47	119	36	60	16	51	12	44
56	123	43	74	19	55	12	47
67	130	45	75	21	79	14	48
75	149	49	80	23	81	18	54
80	155	50	84	26	84	28	59
94	174	52	94	27	92	40	67
103	266	54	98	28	100	45	79
131	301	55	102	32	102	48	84
161	317	60	104	48	114	61	85
204	361	69	118	50	122	98	104
243	495	70	250	53	142	119	116
256	573	89	289	63	164	139	204
332	578	94	381	118	207	148	349
351	627	97	585	226	204	287	365
1523	645	1643	2000	247	227	337	514

Mann-Whitney U Test

Exp. 1	Exp. 2	Exp. 3	Exp. 4
U = 237*	U = 253.5*	U = 255.5*	U = 218*

* For Significant Difference at 95% Level, U Must Be 215 ∴
All Treated vs. Untreated u Values are Significantly Different.

majority of the results are insignificant at the 95% level of confidence. However, the Mann-Whitney U test shows the maximum set in sand to be significantly different from the 50 μ silt sediment. It is possible that by expanding the size range, the experimental design offered too many choices. The data indicate that clams are not capable or do not select between different sizes of sand, but that the difference between the size of silt and sand remains a real selection. The fact that there are more significant differences between mud and sand in the natural sediments reinforces the possibility of chemical masking.

The results of the third series of experiments testing the affect of clam liquor as an attractant are all significant. The data indicate that pheromones released by juveniles and adults stimulate other larvae of the same species to settle in the sediment.

The results of the above experiments suggest two avenues for further research. 1) Testing sand vs. silt on a one to one basis and 2) Testing the gradient affect of a setting attractant.

BLUE CRAB SURVEY

Our laboratory has been collecting size-frequency data on the blue crab over the last four years in Indian River Bay. The general objectives are twofold: 1) To appraise fluctuations in abundance by studying relationships between adult and juvenile populations and 2) To provide the long-term data bank necessary to make predictions and formulate models.

Chittenden (1971) states that a long-term data base is a necessity for development of predictive models. Van Engle (1972) states that he makes a subjective and qualitative estimate based on raw numbers of a given size class as it moves through the Chesapeake Bay fishery.

The major emphasis of Delaware's collecting program has been the accumulation of size-frequency data. Research on the blue crab has been expanded to include a four week trap and tag study in the Port Mahon area. The success of this program was limited due to poor communication with local crabbers and their lack of understanding of how to report catches.

Methods

Sampling stations were established (Figure 8). Sampling was accomplished by haul seine as described in the 1969-1970 report (Winget, et al., 1970). The winter net is a dredging device. The bag consisted of standard 1/4" mesh about 7 m long.

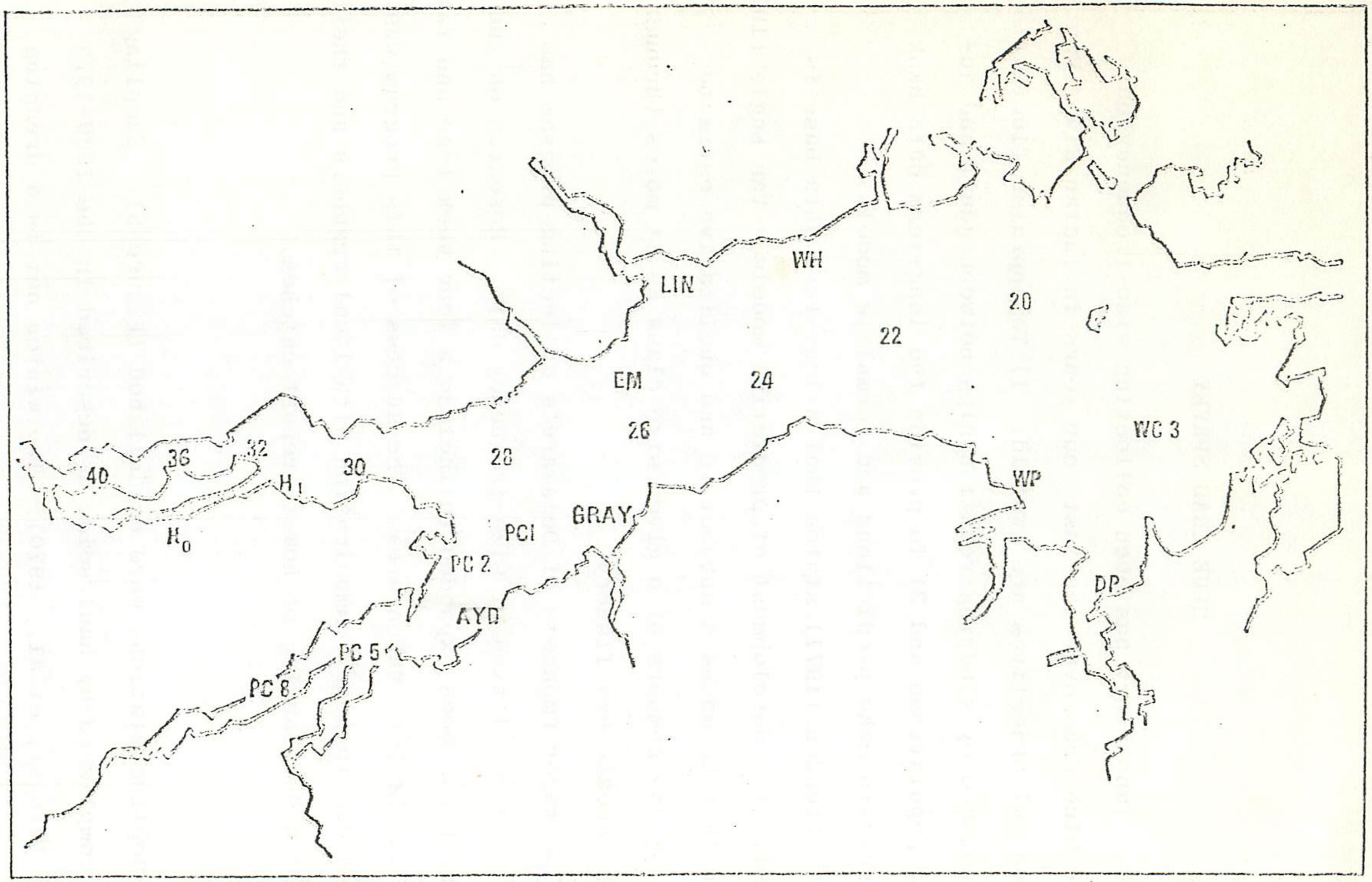


Figure 8 . Blue crab sampling stations in Indian River Bay and tributaries.

A 2.0 m beam trawl also 1/4" mesh was used in spring sampling. All nets were hauled a distance of 50 m over the bottom. Deep water stations were sampled with one of the trawl devices, while shallow water stations are seined.

Crabs caught at each station were measured from lateral spine to lateral spine, sexed, and molt stage recorded. Size-frequency for samples over 100 crabs were determined from a random subsample.

Crabs sampled in Delaware Bay were captured by use of standard commercial crab pots. Thirty traps were placed at regular intervals between the mouth of the Mahon River and the Simons River. The pots were fished every other day. The crabs were measured from lateral spine to lateral spine, sexed, and molt stage recorded. The crabs were then tagged by use of a yellow "spaghetti tag" affixed from lateral spine to lateral spine with stainless steel wire. The tags contained the following information: A) Tag number, B) When, Where, and How, and C) The University of Delaware's Lewes address. The tagging was accomplished during a 2 week period in August and October.

Results

The total catches of crabs for all seining and trawl stations are represented by size-frequency, sex, and total catch in Tables 1 and 2 in Appendix B. Table 9 contains crab density for trawl and seine stations for 1972. Figures 9 and 10 show compiled size-frequencies for trawl and seine respectively from April-November 1970 to June 1973. Size-frequency data for the

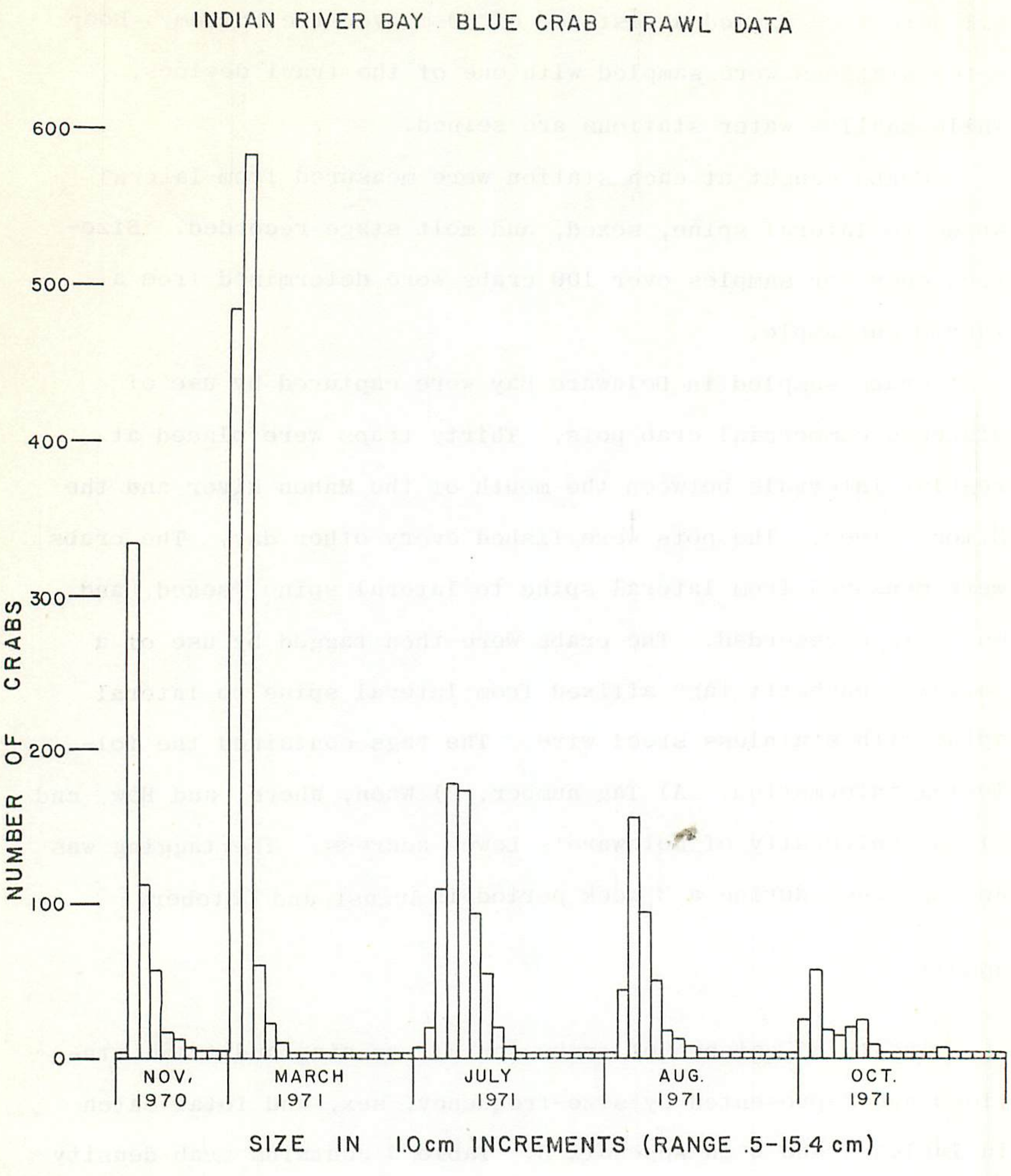

INDIAN RIVER BAY BLUE CRAB TRAWL DATA
600
500
400
300
200
100
0
NUMBER OF CRABS
NOV. 1970
MARCH 1971
JULY 1971
AUG. 1971
OCT. 1971
SIZE IN 1.0cm INCREMENTS (RANGE .5-15.4 cm)

FIGURE 9

INDIAN RIVER BAY BLUE CRAB TRAWL DATA (cont.)

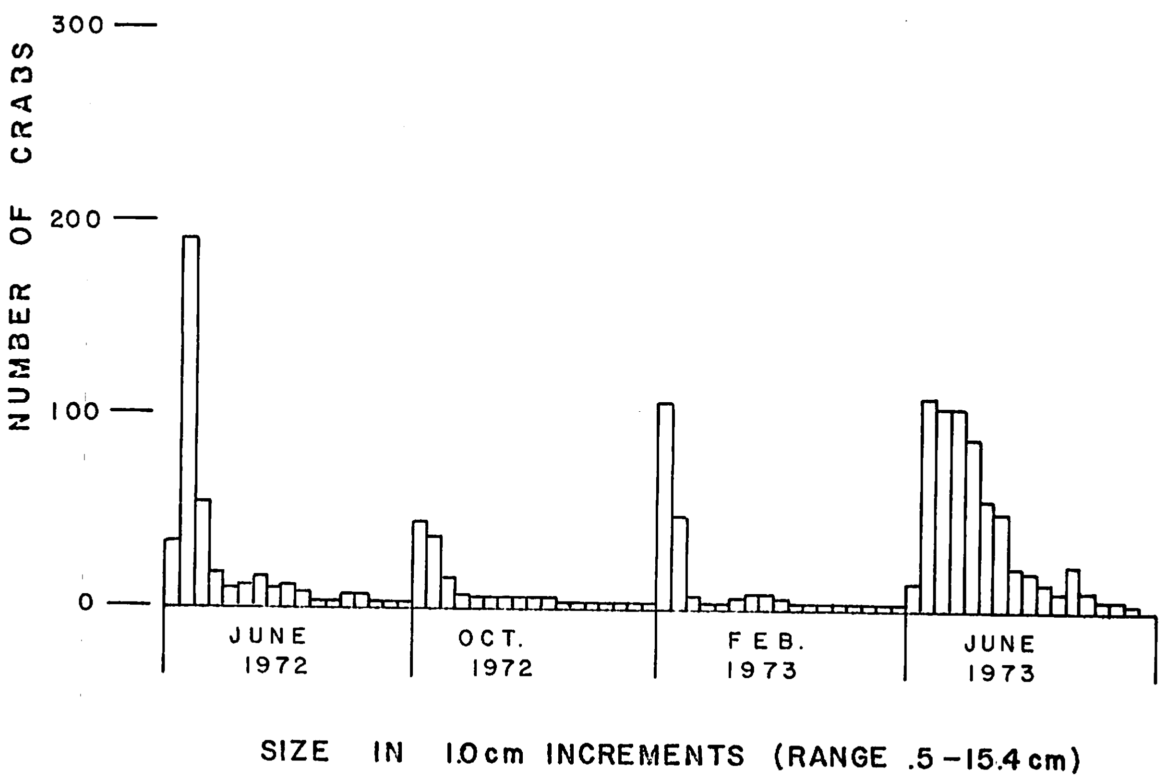


FIGURE 9 (cont.)

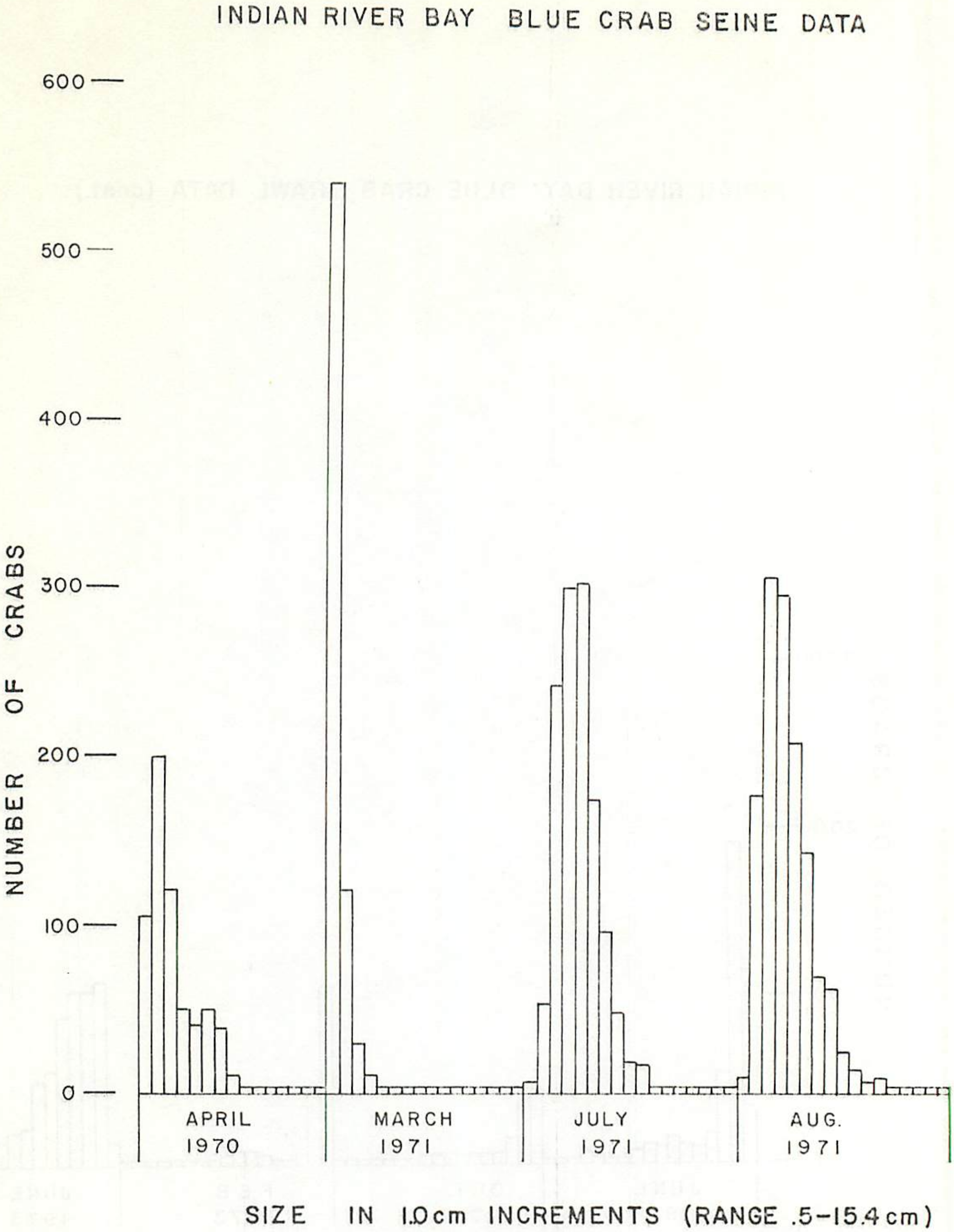

INDIAN RIVER BAY BLUE CRAB SEINE DATA
600
500
400
300
200
100
0
NUMBER OF CRABS
APRIL 1970
MARCH 1971
JULY 1971
AUG. 1971
SIZE IN 1.0 cm INCREMENTS (RANGE .5-15.4 cm)

FIGURE 10

INDIAN RIVER BAY BLUE CRAB SEINE DATA (cont)

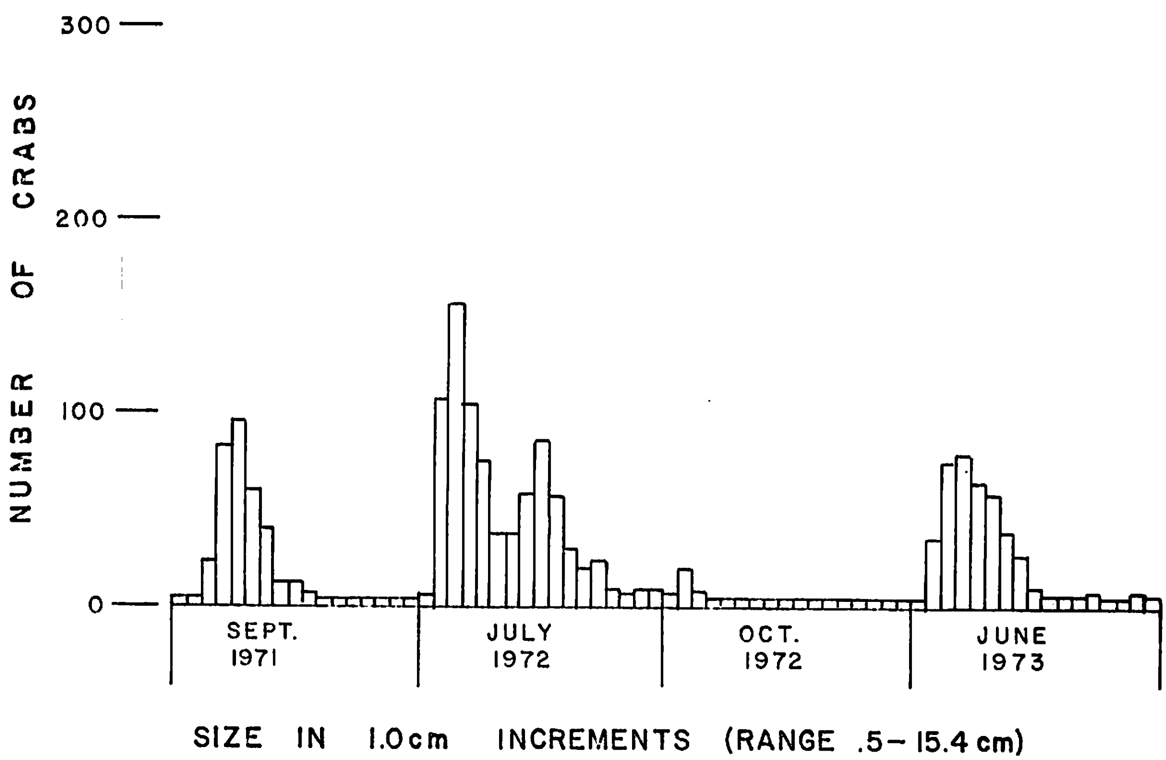


FIGURE 10 (cont.)

August and October Delaware Bay crab pot survey appear in Tables 1 and 2 in Appendix C. Tables 10 and 11 present blue crab return data for the August and October pot survey. Figure 11 is a graphic depiction of the compiled size-frequency data for the August and October survey.

Discussion

These data confirm Winget, et al., (1970, 1971); Keck, et al., (1972) that the population is dominated by young individuals in the late fall, winter, and spring. There is a model progression as explained by More (1969) for crabs caught in Galveston Bay.

The seine in terms of size-frequency (Figures 9 and 10) appears to be a more efficient sampling device. However, it is difficult to determine the exact area covered; and in terms of density, the seine appears less efficient (Table 9).

Population density figures expressed in crabs per m^2 (Table 9) are similar to those of Keck, et al. (1972). The mean values are slightly lower for both seine and trawl than the preceding year. However, the cumulative size-frequency graph (Figures 9 and 10) shows a decline in the crab population over the past four years. Particularly evident is the lack of juveniles in February 1973 as compared to March 1971. The large numbers of juveniles in March 1971 represent commercial sized crabs in the summer of 1973. Although catches are good this year, the future appears poor unless there is recruitment from offshore stock and juveniles show up in larger numbers in the winter of 1973.

TABLE 9

Indian River Bay Blue Crab Densities

SLED

Station	June 1972	October 1972	February 1973	June 1973
20	.25	.06	.04	.02
22	.09	.05	.09	.37
24	.14	.01	.05	.83
26	.04	.02	.05	.56
28	.14	.00	.07	.41
30	.70	.07	.26	.89
32	1.38	.54	.87	.83
36	.72	.01	.16	.24
40	.34	.43	.31	1.89
Hydrol	--	.15	--	.84
	$\bar{x}$ =.42	$\bar{x}$ =.14	$\bar{x}$ =.21	$\bar{x}$ =.68

SEINE

Station	July 1972	October 1972	February 1973	June 1973
Steeles Cove	.04	.01	No Crabs	.04
White House	.03	.003	Caught	.02
Pot Nets	.03	.005	--	.04
Lingo Pt.	.12	.005	--	.06
Oak Orchard	--	.009	--	.05
Aydelotte	.09	.005	--	.13
Grays Pt.	.14	.001	--	.03
Ellis Pt.	.23	.012	--	.06
Holts Ldg.	.06	.005	--	.04
Walters Pt.	.04	.02	--	.03
	$\bar{x}$ =.09	$\bar{x}$ =.008		$\bar{x}$ =.05

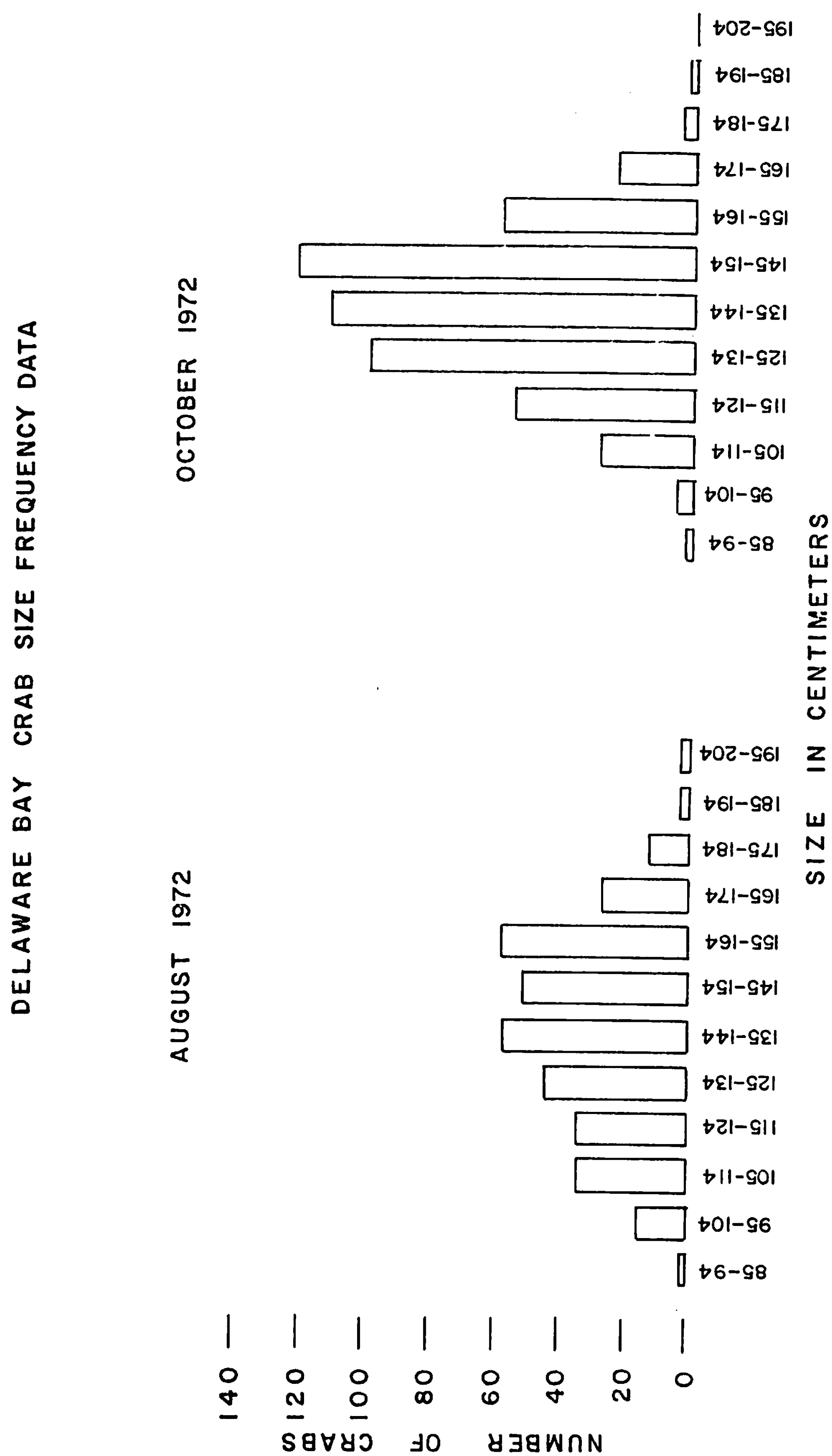

DELAWARE BAY CRAB SIZE FREQUENCY DATA
AUGUST 1972
OCTOBER 1972
85-94
95-104
105-114
115-124
125-134
135-144
145-154
155-164
165-174
175-184
185-194
195-204
SIZE IN CENTIMETERS
0
20
40
60
80
100
120
140
NUMBER OF CRABS

FIGURE 11

The data collected in the tag study have shown that the crabs tagged in this area do not move great distances. Only two crabs (Table 10) were captured at great distances from the tagging site (Woodland Beach and St. Jones River). A number of crabs were recaptured in the same pot from which they were released.

Several crabs tagged in October 1972 were recovered the following summer, June 1973, when the fishery began its new season. This indicates that there is probably very little tag loss due to molting, when crabs are tagged late in the year.

Tag studies can be used to estimate population densities based on the comparison of numbers tagged with those recaptured. The tag and recapture method can be conducted as a single census, in which large numbers of marked animals are released within a short period, or a multiple census, where marking and recapture are done concurrently over longer periods of time. Ricker (1958) defines the necessary data as follows: Mt = the number of marked crabs released up to the t th day less any removed from population by trapping; Ct = the total number of crabs caught on the t th day; Rt = the number of recaptures on Ct; N = an estimate of population size. The simplest formula (Schnable, 1938) for estimating population size is $N = (C_t M_t)/R_t$. Although there were numerous tag returns by commercial crabbers, these numbers cannot be used in computation of N because the total commercial catch is unknown. Therefore, only recaptures by our survey are used in computation of N (N = 70,290 for August and 43,635 for October). These estimates are considered conservative and apply only to the area between Port Mahon and Simons River.

TABLE 10

Delaware Bay Blue Crab Return Data

Date	Tag No.	Area of Return	Method of Return
17 Aug. 72	133	Mouth Leipsic River	Commercial Crabber
18 Aug. 72	5	Pot #4	U. of D. Survey
	Unknown (1)	S.E. of Leipsic	Commercial Crabber
19 Aug. 72	260	Mouth Simons River	Commercial Crabber
	387	Mouth Simons River	H. Moore
	855	Mouth Simons River	H. Moore
	856	Mouth Simons River	H. Moore
	833	Port Mahon Pt.	H. Moore
	166	Port Mahon Pt.	H. Moore
20 Aug. 72	Unknown (2)	Simons River	Commercial Crabber H. Moore
20 Aug. 72	Unknown (4)	Port Mahon	Commercial Crabber W. Hand
10 Sept. 72	Unknown (1)	St. Jones	Recreational Crabber H. Semans
20 Sept. 72	850	Port Mahon	Commercial Crabber
	280	Port Mahon	Commercial Crabber
	982	Port Mahon	Commercial Crabber
13 Oct. 72	463	Pot #29	U. of D. Survey
16 Oct. 72	1036	Pot #18	U. of D. Survey
18 Oct. 72	633	Pot #20	U. of D. Survey
18 Oct. 72	1159	Pot #19	U. of D. Survey

TABLE 10 (continued)

Delaware Bay Blue Crab Return Data

Date	Tag No.	Area of Return	Method of Return
5 through 15 May 73	1231	Little Creek Area	Commercial Crabber D. Moore
	202	Little Creek Area	Commercial Crabber D. Moore
	1289	Little Creek Area	Commercial Crabber D. Moore
	48	Little Creek Area	Commercial Crabber D. Moore
	304	Little Creek Area	Commercial Crabber D. Moore
	1064	Little Creek Area	Commercial Crabber D. Moore
	1233	Little Creek Area	Commercial Crabber D. Moore
7 June 73	1249	Woodland Beach	Commercial Crabber L. Voss
13 June 73	1056	Mouth Simons Creek	Commercial Crabber F. Kowisk
29 June 73	1092	Little Creek	Commercial Crabber H. Moore
	1075	Little Creek	Commercial Crabber H. Moore
	367	Little Creek	Commercial Crabber H. Moore

Total Crabs Tagged in August 72 = 217
October 72 = 347

TABLE 11

Location and Date of Tagging for Returned Crabs

Tag No.	Date Tagged	Location
133	15 Aug. 72	Pot #24
5	15 Aug. 72	Pot # 5
260	15 Aug. 72	Pot #29
387	18 Aug. 72	Pot #29
855	15 Aug. 72	Pot #13
856	15 Aug. 72	Pot #13
833	15 Aug. 72	Pot #27
163	15 Aug. 72	Pot # 9
850	18 Aug. 72	Pot # 9
280	18 Aug. 72	Pot #18
982	18 Aug. 72	Pot # 4
463	12 Oct. 72	Pot #30
1036	12 Oct. 72	Pot #18
633	12 Oct. 72	Pot #19
1159	16 Oct. 72	Pot #20
1231	23 Oct. 72	Pot #30
202	12 Oct. 72	Pot # 5
1289	23 Oct. 72	Pot #29
48		
304	15 Aug. 72	Pot # 3
1064	16 Oct. 72	Pot #30
1233	23 Oct. 72	Pot #30
1249	23 Oct. 72	Pot #30
1056	18 Oct. 72	Pot # 3
1092	18 Oct. 72	Pot #28
1075	18 Oct. 72	Pot # 7
367	13 Oct. 72	Pot #18

The data suggest the population is larger in August which is similar to data from Indian River Bay. However, the total number of crabs caught in October produced a lower population estimate due to increased recaptures, 4 as compared to 1 in August. It seems that it may be easier to trap crabs at this time of year and thus affect population estimates. Comparing size-frequencies (Figure 11), there is a wider distribution in August than October as noted in Indian River Bay. Stations located near the mouth of the Simons River produced the best catches, especially in late October when the warm effluent may have held crabs inshore for longer periods. The association of crabs with river mouths is an indication of the importance of marshes and marsh runoff in crab productivity.

THE AMERICAN LOBSTER

The following material is information collated by Marine Extension Agent Howard Seymour, with the cooperation of local lobstermen and extrapolated to provide an estimate of the lobster fishery during 1973. The data show that this is more than a recreational fishery and suggest the need for more intensified studies.

Table 12 presents a daily record of catches recorded from several sources. The key present at the bottom of the table explains the numbering scheme. Information indicates there were 9 groups or individuals lobstering with a low of 15 pots to a high of 50 pots per group. The data presented indicate an average of 57.7 lobsters were caught per pot for the season. Extrapolation indicates that 13,269 lobsters were caught during the season. Assuming these lobsters averaged 1.25 lb. apiece, Delaware's lobster landing was approximately 16,586 lb. The majority of these lobsters sold for $1.75/lb. producing a total market value of approximately $29,025. The figures presented in Table 12 are viewed a conservative record of the lobster catch.

Discussion

The evidence presented is that the lobster fishery is larger than most people realize. This conservative estimate is larger than any available federal statistics for the State of Delaware. The total estimated catches are similar to data present for 1970 and 1971 in Keck, et al., (1972). The data in Table 12 show several expected trends. The first 3 weeks in May "eggers" were caught regularly. The absence of "eggers" in June and July suggests that spawning takes place in late May and early June. The appearance of "eggers" (green eggs) in late August represents the appearance of new eggs which will be hatched the following spring. It is likely that large numbers of reproducing females are kept during June and July due to the absence of attached eggs. An earlier or later season would prevent the capture of females because attached eggs would be more prevalent. The abundance of small lobsters in May is reflected by increased catches in June as these lobsters entered the fishery due to natural growth. It is unlikely that this increase in catches was due to large scale migration by offshore populations, although the presence of "blue" offshore lobsters indicates that some migration does occur. The purpose of this report again as in past years (Keck, et al., 1972) is to indicate the importance of the lobster as a commercial fishery and to expand interest in the lobstering both inshore and offshore, which is currently being overlooked by Delaware watermen.

TABLE 12

Lobster Creel Census Data--1973

Weekly Total	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
149			May 1 26 4 E 8 Sm	2 40 35 Sm	3 43 2 E 6 So 20 Sm	4 X	5 40 1 E 20 Sm
78	6 X	7 22 10 Sm	8 X	9 3	10 18 1 E 2 So Sm	11 11	12 24
56	13 X	14 23	15 X	16 4 1E 8 Sm	17 13 2 So Sm	18 12	19 4
34	20 X	21 21 30 Sm	22 X	23 13 1 E	24 0	25 X	26 X
104	27 X	28 21	29 X	30 20	31 26	June 1 18	2 19
107	3 X	4 32	5 20	6 12	7 12	8 12	9 19
105	10 X	11 20	12 14	13 12	14 35	15 15	16 9
71	17 X	18 X	19 4	20 6	21 21	22 14	23 26
129	24 X	25 17	26 20	27 19	28 26	29 22	30 25
176	July 1 X	2 24	3 20	4 24	5 17	6 43	7 48

TABLE 12 (continued)

Lobster Creel Census Data--1973

155	X (8)	20 (9)	23 (10)	61 (11) 15 Sm	X (12)	27 (13) 1 E 1 So	24 (14)
116	X (15)	30 (16)	18 (17)	16 (18)	16 (19)	20 (20)	16 (21)
79	X (22)	31 (23)	21 (24)	X (25)	X (26)	20 (27)	7 (28)
43	X (29)	17 (30)	2 (31)	Aug. 1 X	X (2)	10 (3)	14 (4)
113	X (5)	50 (6) 6 E 1 So	X (7)	31 (8)	10 (9)	10 (10)	12 (11)
69	X (12)	22 (13)	X (14)	21 (15)	X (16)	X (17)	26 (18)
58	5 (19)	9 (20)	X (21)	X (22)	9 (23) 1 E	17 (24) 3 E	23 (25) 2 E
91	X (26)	18 (27) 6 E 6 So	16 (28) 4 E	16 (29) 2 E	29 (30) 4 E 6 So 4Sm	12 (31) 6 E 5 So	
Totals	5	377	184	298	275	263	336

X = No Lobstering Done on that Day

Keepers	Date
Eggers	
Soft	Small

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APPENDIX

APPENDIX A

SALINITY, OXYGEN, TEMPERATURE DATA 1972

APPENDIX A--TABLE 1

Salinity, Oxygen, Temperature Data, Summer 1972

		July 10	July 17	July 24	July 31	Aug. 7	Aug. 14	Aug. 21	Aug. 28	Sept. 4	Sept. 11	Sept. 18	Sept. 26
Ridge Bed #1	DO	10.07	12.68	10.48	8.27	8.54	10.86	12.16	11.75	8.09	-	3.33	14.[illegible]
	Sal.	12.582	11.19	12.702	16.445	20.249	15.420	15.710	17.310	18.002	18.904	18.930	19.772
	Temp.	-	27.0°	27.5°	23.5°	23.8°	23.0°	23.0°	25.0°	22.5°	22.5°	23.0°	20.5°
#2	DO	9.506	7.94	12.41	9.70	6.93	10.17	9.66	17.41	7.70	-	-	15.71
	Sal.	12.885	9.61	12.380	16.833	20.151	16.674	16.121	16.906	18.700	18.225	18.89	20.082
	Temp.	-	26.0°	27.5°	23.5°	24.0°	23.5°	23.0°	25.0°	23.0°	20.3°	22.8°	20.5°
Leipsic River #1	DO	6.188	8.33	6.39	6.84	7.83	9.69	8.80	7.77	-	-	-	12.35
	Sal.	9.308	8.246	9.45	14.411	17.691	15.362	14.752	15.769	-	-	-	17.800
	Temp.	-	28.0°	28.5°	23.5°	24.0°	24.0°	23.5°	26.5°	-	-	-	21.0°
#2	DO	6.300	7.31	10.40	8.18	6.75	8.08	8.68	11.31	4.86	16.88	13.38	11.67
	Sal.	9.023	7.243	10.13	14.201	17.166	14.970	14.031	15.995	16.063	15.276	15.597	17.333
	Temp.	-	27.5°	28.2°	23.8°	24.0°	24.0°	23.8°	26.5°	22.0°	19.6°	22.8°	21.0°
#3	DO	6.881	7.74	5.11	10.46	11.93	10.32	3.99	11.46	6.65	8.39	11.49	11.31
	Sal.	8.609	7.68	7.41	13.872	16.894	14.610	13.625	15.775	15.648	15.023	14.624	16.895
	Temp.	-	27.5°	28.5°	23.8°	24.0°	24.0°	23.5°	26.0°	21.0°	19.7°	22.8°	21.0°
Simons River #1	DO	6.09	9.04	7.46	8.42	5.14	9.61	10.99	16.47	6.52	-	12.38	-
	Sal.	9.424	9.030	9.582	15.556	17.328	16.753	14.943	18.262	16.081	16.429	19.961	-
	Temp.	-	28.3°	29.0°	23.8°	24.0°	24.0°	24.0°	26.5°	22.0°	20.5°	23.0°	-
Mahon River #1	DO	6.69	9.19	8.16	7.51	9.81	9.42	9.42	13.05	-	-	-	16.03
	Sal.	11.249	11.139	11.793	17.183	18.398	16.995	16.995	19.271	17.221	18.697	18.586	20.193
	Temp.	-	29°	29.5°	23.8°	24.5°	24.2°	24.2°	26.5°	22.0°	21.0°	23.0°	21.0°

APPENDIX A--TABLE 1 (continued)

Salinity, Oxygen, Temperature Data, Summer 1972

		July 10	July 17	July 24	July 31	Aug. 7	Aug. 14	Aug. 21	Aug. 28	Sept. 4	Sept. 11	Sept. 18	Sept. 25
St. Jones River #1	DO	8.72	6.02	6.44	7.10	7.60	7.13	5.39	-	7.36	-	-	11.20
	Sal.	16.522	12.271	19.54	21.357	21.805	20.779	23.148	-	21.289	-	-	21.975
	Temp.	-	29.5°	25.1°	24.2°	23.5°	22.5°	23.5°	-	20.5°	-	-	21.0°
#2	DO	7.95	2.78	2.40	7.32	6.98	5.81	5.73	6.74	8.11	-	-	13.55
	Sal.	16.755	8.06	19.18	20.711	20.946	19.430	21.783	20.239	20.675	-	-	17.454
	Temp.	-	23.5°	25.2°	24.2°	23.5°	22.5°	23.8°	25.0°	20.0°	-	-	21.0°
#3	DO	5.93	3.74	3.20	7.02	7.48	5.34	5.01	9.83	7.77	-	-	6.39
	Sal.	13.287	2.925	17.95	19.982	18.910	18.721	19.938	19.312	17.926	-	-	16.429
	Temp.	-	28.5°	25.5°	24.5°	23.5°	23.0°	23.5°	26.0°	20.0°	-	-	21.0°
Silver Bed #1	DO	8.44	9.61	8.53	10.88	7.11	10.36	6.44	15.30	8.66	8.68	13.70	10.75
	Sal.	11.240	9.160	12.46	16.217	18.556	16.755	13.121	17.061	17.837	17.168	18.208	19.081
	Temp.	-	26.0°	27.0°	23.5°	23.8°	23.0°	23.5°	25.0°	23.0°	20.2°	22.7°	20.5°
#2	DO	8.03	7.51	9.91	7.33	8.10	10.44	13.08	13.30	11.86	12.80	12.30	15.69
	Sal.	10.256	9.22	11.82	16.242	18.094	16.535	13.084	16.738	17.749	17.369	18.285	19.150
	Temp.	-	26.5°	-	23.5°	24.0°	23.0°	23.5°	25.5°	23.0°	20.1°	22.3°	20.5°
Murderkill River #1	DO	-	3.85	7.20	7.26	7.81	-	4.97	-	-	-	-	-
	Sal.	-	5.94	20.246	21.572	22.504	-	22.722	-	-	-	-	-
	Temp.	-	28.0°	25.5°	24.5°	23.5°	-	23.5°	-	-	-	-	-
#2	DO	-	2.61	5.19	7.32	8.86	-	8.78	11.72	-	-	-	12.33
	Sal.	-	3.013	20.39	21.045	18.910	-	21.219	13.229	-	-	-	22.300
	Temp.	-	27.5°	24.8°	24.5°	23.8°	-	23.6°	26.0°	-	-	-	21.5°

APPENDIX A--TABLE 1 (continued)

Salinity, Oxygen, Temperature Data, Summer 1972

	July 10	July 17	July 24	July 31	Aug. 7	Aug. 14	Aug. 21	Aug. 23	Sept. 4	Sept. 11	Sept. 18	Sept. 25
Murderkill River												
#3 DO	-	2.66	5.66	8.10	7.94	-	4.35	15.66	-	-	-	17.03
Sal.	-	1.916	19.53	20.452	16.403	-	17.663	9.309	-	-	-	18.206
Temp.	-	27.5°	24.8°	25.0°	23.5°	-	24.0°	26.0°	20.0°	-	-	21.5°
Mispillion River												
#1 DO	7.16	3.97	4.20	3.59	6.31	4.74	4.68	11.73	7.71	-	-	7.31
Sal.	21.435	10.264	19.95	13.954	25.882	11.227	26.235	18.225	21.878	-	-	23.960
Temp.	22.3°	27.6°	26.5°	23.6°	24.5°	23.80°	24.0°	24.5°	20.0°	-	-	22.0°
#2 DO	6.34	2.54	3.19	3.62	13.89	3.86	2.22	3.26	5.29	-	-	10.20
Sal.	20.959	5.186	15.63	8.705	25.861	6.151	26.235	12.311	15.956	-	-	23.723
Temp.	23.5°	27.6°	27.5°	23.5°	24.0°	23.5°	23.8°	25.0°	20.0°	-	-	21.0°
#3 DO	4.50	1.92	1.21	3.52	4.77	4.60	2.38	-	-	-	-	9.07
Sal.	14.815	2.165	10.53	3.166	23.398	1.675	22.576	-	-	-	-	23.830
Temp.	24.0°	27.5°	28.0°	23.5°	24.0°	23.5°	24.0°	-	-	-	-	21.5°
Broadkill River												
#1 DO	5.16	3.83	3.48	4.85	6.15	8.41	5.54	6.39	4.26	-	-	5.36
Sal.	19.577	11.584	25.16	26.771	12.540	7.215	23.114	16.638	11.337	-	-	28.547
Temp.	23.0°	26.5°	25.0°	24.5°	24.0°	23.5°	24.0°	25.5°	20.5°	-	-	22.5°
#2 DO	8.19	3.34	2.79	4.64	7.69	5.89	4.31	10.44	2.81	-	-	12.44
Sal.	23.99	1.090	19.41	25.805	24.935	8.791	12.647	9.612	2.422	-	-	28.969
Temp.	23.0°	26.5°	24.0°	23.0°	24.0°	23.5°	24.0°	25.0°	20.0°	-	-	20.0°
#3 DO	5.79	2.95	2.34	2.18	6.13	8.14	4.96	5.45	2.91	-	-	14.31
Sal.	18.89	0.779	15.17	11.852	18.955	4.698	8.987	2.348	1.063	-	-	28.440
Temp.	23.0°	28.0°	25.0°	25.0°	24.0°	23.5°	24.0°	26°	20.0°	-	-	22.0°

APPENDIX B

INDIAN RIVER BAY BLUE CRAB DATA:

SIZE FREQUENCY and SEX/STATION

APPENDIX B--TABLE 1

Indian River Bay Blue Crab Data: Size Frequency and Sex/Station

July 1972 Scine	Steeles Cove		White House		Pot Nets		Lingo Point		Ayde-lotte Point		Gray's Point		Ellis Point		Holt's Landing		Walter's Point		Derrick-son Point				TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Carapace Width in cm.																							
.5- 1.4														1					1	1			3
1.5- 2.4	2	1	2	2			4	9	9	2	2		9	9		2		1	26	29			109
2.5- 3.4	1	3		1	1	1	3	13	4	18	4	5	13	8	2	8	1	1	30	36			153
3.5- 4.4	4	1	3	2		2	2	4	5	7	3	4	8	10		5	1		13	27			101
4.5- 5.4	1	4		1	2	1	4	3	3	4	1	1	4	10	2	8	2	2	9	13			75
5.5- 6.4	1		1		3		3	4	1	2	1	6	1	2	1	4	1	2	1	5			39
6.5- 7.4	1	1		1			3	3		1	2	6	5	4	1	1	1	3	3	2			38
7.5- 8.4					3	1	1	2	5	1	8	3	11	4	1	4	2	3	3	4			56
8.5- 9.4	1	5	2	1	2	3	3	6	2	2	13	10	10	14			2	1	2	4			83
9.5-10.4		1	2	1	2		2	8			9	10	6	10	4	1			2				58
10.5-11.4					1		5	3	1		3	7	3	4	2			1					30
11.5-12.4			1		1		1				4	1	6	1			1						16
12.5-13.4				1	2		1				1	4	2	8				1	1	2			23
13.5-14.4							1					1	1	8			1	2		2			16
14.5-15.4				1				1						3					1				6
15.5-16.4																							0
16.5-17.4														2									2
TOTAL	11	16	11	11	17	8	33	56	30	37	51	53	79	98	13	33	12	17	92	125			808

APPENDIX B--TABLE 1 (continued)

Indian River Bay Blue Crab Data: Size Frequency and Sex/Station

Oct. 1972 Seine	Steeles Cove		White House		Pot Nets		Lingo Point		Oak Orchard Emily Creek		Aydelotte Point		Gray's Point		Ellis Point		Holt's Landing		Walter's Point				TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀			
Carapace Width in cm																							
.5- 1.4	1	2				1														2			6
1.5- 2.4		1		1				1	2	1	1	2			1			2	4	2			18
2.5- 3.4										1	1		1				1			3			7
3.5- 4.4						1	1		1						2	2			1	1			9
4.5- 5.4	1	2														1	1		1				6
5.5- 6.4	1		1							1					1	1							5
6.5- 7.4							1		1														2
7.5- 8.4																1							1
8.5- 9.4								1															1
9.5-10.4																							
10.5-11.4																							
11.5-12.4					1																		1
12.5-13.4																							
13.5-14.4						1																	1
14.5-15.4																							
15.5-16.4																							
16.5-17.4																							
TOTAL	3	5	1	1	1	3	2	2	4	3	2	2	1	0	4	5	2	2	6	8			57

APPENDIX B--TABLE 1 (continued)

Indian River Bay Blue Crab Data: Size Frequency and Sex/Station

June 1973 Seine	Holt's Landing		Walter's Point		White Creek		Aydelotte Point		Gray's Point		Ellis Point		Steel's Point		White House		Pot Nets		Lingo Point		Oak Orchard		TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Carapace Width in cm.																							
.5- 1.4							1						1										2
1.5- 2.4	1	2	1	2	2	4	8	7	2			1		1	1		1				1	1	35
2.5- 3.4	1	4	4	6	4	10	8	6		7	2	6							2	1	5	5	72
3.5- 4.4	2	2		2	4	7	12	17	2	5	7	8				1			1	1	1	6	78
4.5- 5.4	2	5	2	1	1	4	2	12		4	5	2				1	1	3	5	7	3	1	61
5.5- 6.4	2	3		1	2	6	4	8	2	2	2	4				4		2	8	2	1	6	59
6.5- 7.4		5	2	1	2	1	2	4		2	2	4				1	4	4	2	3			39
7.5- 8.4						4	1	5				1			2	1	1	4	2	7		1	29
8.5- 9.4					1		1	1							2		1	2	1	1			10
9.5-10.4																1	2	1		1		1	6
10.5-11.4														1			1	1		1	1		5
11.5-12.4		1															1						2
12.5-13.4							2	1										1	1				5
13.5-14.4																							0
14.5-15.4																							0
15.5-16.4																		1		1			2
16.5-17.4																		1					1
TOTAL	8	22	9	13	16	36	41	61	6	20	18	26	1	2	5	9	12	20	22	25	13	21	406

APPENDIX B--TABLE 1 (continued)

Indian River Bay Blue Crab Data: Size Frequency and Sex/Station

Sept.-Oct. 1972 Trawl	#20		#22		#24		#26		#28		#30		#32		#36		#40		Hydrol				TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀			
Carapace Width in cm.																							
.5- 1.4											1	2	14	11			3	3	7				41
1.5- 2.4				1							1		12	10			9	4					37
2.5- 3.4		2			1							1	1	2	1		3	4					15
3.5- 4.4												1	2				2						5
4.5- 5.4												1	1				1						3
5.5- 6.4																	1						1
6.5- 7.4														1			1	1					3
7.5- 8.4		2	1														1						4
8.5- 9.4		1		1															1	1			4
9.5-10.4																			3	2			5
10.5-11.4																							
11.5-12.4			1				1																2
12.5-13.4																			1				1
13.5-14.4			1																				1
14.5-15.4								1															1
15.5-16.4		1																					1
16.5-17.4																							0
TOTAL	0	6	3	2	1	0	1	1	0	0	2	5	30	24	1	0	21	12	12	3			124

APPENDIX B--TABLE 1 (continued)

Indian River Bay Blue Crab Data: Size Frequency and Sex/Station

Feb. 1973 Trawl	#20		#22		#24		#26		#28		#30		#32		#36		#40						TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀					
Carapace Width in cm																							
.5- 1.4			1	4				3	5	1	6	3	38	30	6	6	1	2					106
1.5- 2.4			3	1	3		1	1		1	11	6	7	8	2	2		2					48
2.5- 3.4						2																	2
3.5- 4.4																							0
4.5- 5.4																		1					1
5.5- 6.4														1			1	1					3
6.5- 7.4																	2	3					5
7.5- 8.4		1															3	3					7
8.5- 9.4																	4	3					7
9.5-10.4													1				3						4
10.5-11.4																	2						2
11.5-12.4	1													1									2
12.5-13.4		1																					1
13.5-14.4														1									1
14.5-15.4															1								1
15.5-16.4		1																					1
16.5-17.4																							0
TOTAL	1	3	4	5	3	2	1	4	5	2	17	9	46	41	9	8	16	15					191

APPENDIX B--TABLE 1 (continued)

Indian River Bay Blue Crab Data: Size Frequency and Sex/Station

June 1973 Trawl	#20		#22		#24		#26		#28		Hydro		#32		#36		#40		Pepper Creek		White Creek		TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Carapace Width in cm																							
.5- 1.4							1					1	4	3		1	3	1					14
1.5- 2.4				5	2	2	1	5	2		8	5	12	20	7	4	20	13	1	1		1	109
2.5- 3.4		1	3	9	7	8	5	9	1	3	5	6	5	8	1	2	14	12		1		1	101
3.5- 4.4			5	2	5	8	2	8	4	5	11	13	4	8	1	1	9	9	3	5			103
4.5- 5.4			4	2	6	13	5	3	3	6	3	14		1		1	12	8	2	4	1		88
5.5- 6.4		1	2	2	4	9	5	3		4	1	6	3	4			4	16	2				66
6.5- 7.4					1	3	2	1	1	4	1	4	1	1			15	12	2	2			50
7.5- 8.4					3	3		1		1							3	9		2			22
8.5- 9.4				1				1				2	1	1			5	8	1				20
9.5-10.4					1			1	1		1			1	1		3	3				1	13
10.5-11.4										1			1				5	1	1				9
11.5-12.4									1		1				1		1			1			5
12.5-13.4			1		2	1	1						1	1	1		1	2	1			1	13
13.5-14.4			1			2			1	1	1			1	1							1	9
14.5-15.4						1		1	1			1	1						1				6
15.5-16.4					1			1		1			1			1							5
16.5-17.4						1									1								2
TOTAL	0	2	16	21	32	51	22	34	15	26	32	52	34	49	14	10	95	94	14	16	1	5	635

APPENDIX C

DELAWARE BAY BLUE CRAB DATA

APPENDIX C--TABLE 1

Delaware Bay Blue Crab Data

Delaware Bay Crab Trap August 1972	Pot No. 1 ♂	1 ♀	3 ♂	3 ♀	4 ♂	4 ♀	5 ♂	5 ♀	6 ♂	6 ♀	7 ♂	7 ♀	9 ♂	9 ♀	10 ♂	10 ♀	11 ♂	11 ♀	12 ♂	12 ♀	13 ♂	13 ♀	14 ♂	14 ♀	15 ♂	15 ♀	16 ♂	16 ♀	TOTAL
Carapace width in cm.																													
8.5- 9.4				1	1	1																							[illegible]
9.5-10.4	2	1			1					1	1	1	3					1		1				1	1	1			15
10.5-11.4		3		1									1	1		1	1	5	1	1	2	2		3		6	1	3	32
11.5-12.4					1			1	5	1	1	2		1				2	1	1	2	1	2	5	1	2	3	2	[illegible]
12.5-13.4	1		5		3		2	1	2	1	1		3		3				3	1	1		4	4	2		5	2	[illegible]
13.5-14.4	4		3		3		3		3		6		1		3		2		3		3	2	10		4		3		[illegible]
14.5-15.4	7		1		1		5	2	2	1	2		3		3		3	2	3		1	1	4		6		2	1	[illegible]
15.5-16.4	3	1	7	1	4	3	4	1	4		2	2	2		2		4		5		3		2	2	3		3		[illegible]
16.5-17.4	2		1	2	1		2		3	1	1	1	3		2		1		1		1		1		2		1		[illegible]
17.5-18.4	2				1		1			1									2				2		1		1		11
18.5-19.4									1						1														2
19.5-20.4																1									1				2
TOTAL	21	5	17	5	16	4	17	5	20	6	14	6	16	2	14	2	21	10	19	4	13	6	25	15	21	9	19	6	[illegible]

APPENDIX C--TABLE 1 (continued)

Delaware Bay Blue Crab Data

Delaware Bay Crab Trap August 1972	17		18		19		20		21		22		23		24		25		26		27		28		29		30		TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Carapace width in cm.																													
8.5- 9.4							2														1								3
9.5-10.4		1		1		2	1		1	2		1				2			1		2		1	1					15
10.5-11.4		2						1		1	2		2	4	1	1	2		1	4	2	3		3	2	4		2	37
11.5-12.4	4	3	1		1	2	1	2	3	2	7	1	4	5	1	2	3	3	2	2	4	5	2	2	1	2	1	3	[illegible]
12.5-13.4	3		1		3		4	1	1	1	2	1	2		8						1		5		2		2	1	[illegible]
13.5-14.4	2		6		3		4		3	1	5		12		2		3	1	2		4	1	7	1	2	2	2		[illegible]
14.5-15.4	2	1	5		1	1	9	1	2		2		4	2	2	1	4	1	4	2	5		2	4	2	[illegible]	[illegible]	1	[illegible]
15.5-16.4	5	2	1	1	5		8	1	2	1	7	2	3		3	1	3		5	1	5	1	4		4	2	[illegible]		[illegible]
16.5-17.4	3		1		1		3		1	1	3	1	4			1	2	1	1				5	1	1	1			[illegible]
17.5-18.4	2		2		1	1			5		4		1		3		1		1		3	1	1						[illegible]
18.5-19.4	2				2												1												[illegible]
19.5-20.4									1												1						2		[illegible]
TOTAL	23	9	17	2	17	6	32	6	19	9	32	6	32	11	20	8	19	6	17	9	23	11	27	12	14	12	[illegible]	7	[illegible]

APPENDIX C--TABLE 1 (continued)

Delaware Bay Blue Crab Data

Delaware Bay Crab Trap October 1972	1		3		4		5		6		7		8		9		10		11		12	
Carapace Width in cm.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
8.5- 9.4																						
9.5-10.4	1														1				1	1		
10.5-11.4									3						2		1	2	2		1	1
11.5-12.4						1			2		1				1		2	1	2	2	3	
12.5-13.4			2						2		1				1				2	2	4	
13.5-14.4	2		1				2			2	1				5				3	1	4	1
14.5-15.4	1	1	3	1	3			1	4	1					3	1		2	3		2	1
15.5-16.4	1	1		1	1		1			1	2				3	1		1		1	2	2
16.5-17.4					1												2	2				
17.5-18.4									2	1												1
18.5-19.4																						
19.5-20.4																						
TOTAL	5	2	6	2	5	1	3	1	13	5	5				18	2	5	8	13	7	18	6

Delaware Bay Crab Trap October 1972	13		14		15		16		TOTAL
Carapace Width in cm.	♂	♀	♂	♀	♂	♀	♂	♀	
8.5- 9.4								1	1
9.5-10.4						1	1		6
10.5-11.4			1	1		1			15
11.5-12.4	1		3		2		3		24
12.5-13.4	3	1	3		2	2	2		27
13.5-14.4	3		1	2	1	1	6	1	37
14.5-15.4	1	2	5	1	3	2	2	2	47
15.5-16.4	2	1	3		2	1	1	1	29
16.5-17.4		1		1	1	1	1		10
17.5-18.4	1								5
18.5-19.4									
19.5-20.4									
TOTAL	11	5	16	5	11	9	16	5	203

APPENDIX C--TABLE 1 (continued)

Delaware Bay Blue Crab Data

Delaware Bay Crab Trap October 1972	17		18		19		20		21		22		23		24		25		26		27		28		29		30		TOTAL
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Carapace width in cm.																													
8.5- 9.4														1															
9.5-10.4												1		1		1							1		1				3
10.5-11.4	1	1	1		1		2	3	4	2	2		1	1			1		2				2		1		2	1	[illegible]
11.5-12.4	2	1	2	2	6		3				4	2	7	1			3		2	1			2	1	6		3		[illegible]
12.5-13.4	5		4	1	7		3	3	4	2	5	3	2		2		3	1	8	2			9	3	13	1	14	3	[illegible]
13.5-14.4	3	1	7	2	9	2	6	2	4		4	3	3	3	1	1	3		7	2			7	2	11	4	13	8	[illegible]
14.5-15.4	5	1	4		3	1	3	1	6	2	9	4	7			2	3	2	4	1			16	8	13	8	10	7	120
15.5-16.4	3	1	4			4	2	3	3		4		6					1	2				2	1	10	3	6	3	[illegible]
16.5-17.4	1	1	1	1	2		1				1	1							1				5	3	4			1	[illegible]
17.5-18.4		1							1														2						4
18.5-19.4				1	1										1														2
19.5-20.4																													
TOTAL	22	7	23	7	29	7	20	12	22	6	29	14	26	7	4	4	13	4	26	6			46	18	59	16	53	23	[illegible]