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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

An Analysis of the Commercial Lobster *(Homarus americanus)* Fishery Along the Coast of Maine, August 1966 Through December 1970

JAMES C. THOMAS

SEATTLE, WA
June 1973

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An Analysis of the Commercial Lobster (*Homarus americanus*) Fishery Along the Coast of Maine, August 1966 Through December 1970[1]

By

JAMES C. THOMAS[2]

ABSTRACT

We have used some life history information and detailed catch and effort data from probability sampling of the commercial catch of lobsters to estimate a biological minimum size of 89-mm (3½ inches) carapace length for maximum sustainable yield. In view of this recommendation, the maximum size regulation of 127-mm (5 inches) carapace length is unnecessary.

INTRODUCTION

A review of the publications concerning the lobster fishery along the coast of Maine reveals that limited funds have prevented any sustained collection of detailed catch (numbers, pounds, value; individual lengths, weights; percentages of females, shedders, culls) and effort (traps, trap-hauls, trap-haul-set-over-days, man-days and hours, boat-days and hours) data from this commercial fishery. The relatively new Federal-State aid program has enabled us not only to accomplish these prerequisites but also to sample as many sizes as possible of the natural population of lobsters within the limitations of several types of gear. In addition, this funding has enabled us to collect other biological information on lobsters that might have management implications, such as (1) size ranges of berried females and (2) relationship of premolt and postmolt sizes.

From this combination of information, we have made a first approximation of population parameters that are necessary to make management recommendations in accordance with some theories in population dynamics. Budgetary limitations still prevent a complete study of all the relationships usually analyzed in a comprehensive investigation, for example, parent-progeny or stock-recruitment relationships.

To make the best use of appropriated funds, we used probability rather than intuitive sampling of the commercial catch. In this way, it is possible for this and future surveys to be more efficient in terms of determining the sample sizes within a prescribed degree of accuracy in each of the described catch and effort categories.

Some Aspects of the History of the Commercial Lobster Fishery

Before undertaking the stated objectives, we examined the possible effects that regulations had on the historical catch and effort information. One way of evaluating these relationships is to juxtapose the regulations on the compiled catch in pounds and number of

[1] This study was conducted in cooperation with the Department of Commerce, National Marine Fisheries Service, under Commercial Fisheries Research and Development Act, Project 3-14-R.

[2] State of Maine Department of Sea and Shore Fisheries, Fisheries Research Station, West Boothbay Harbor, ME 04575.

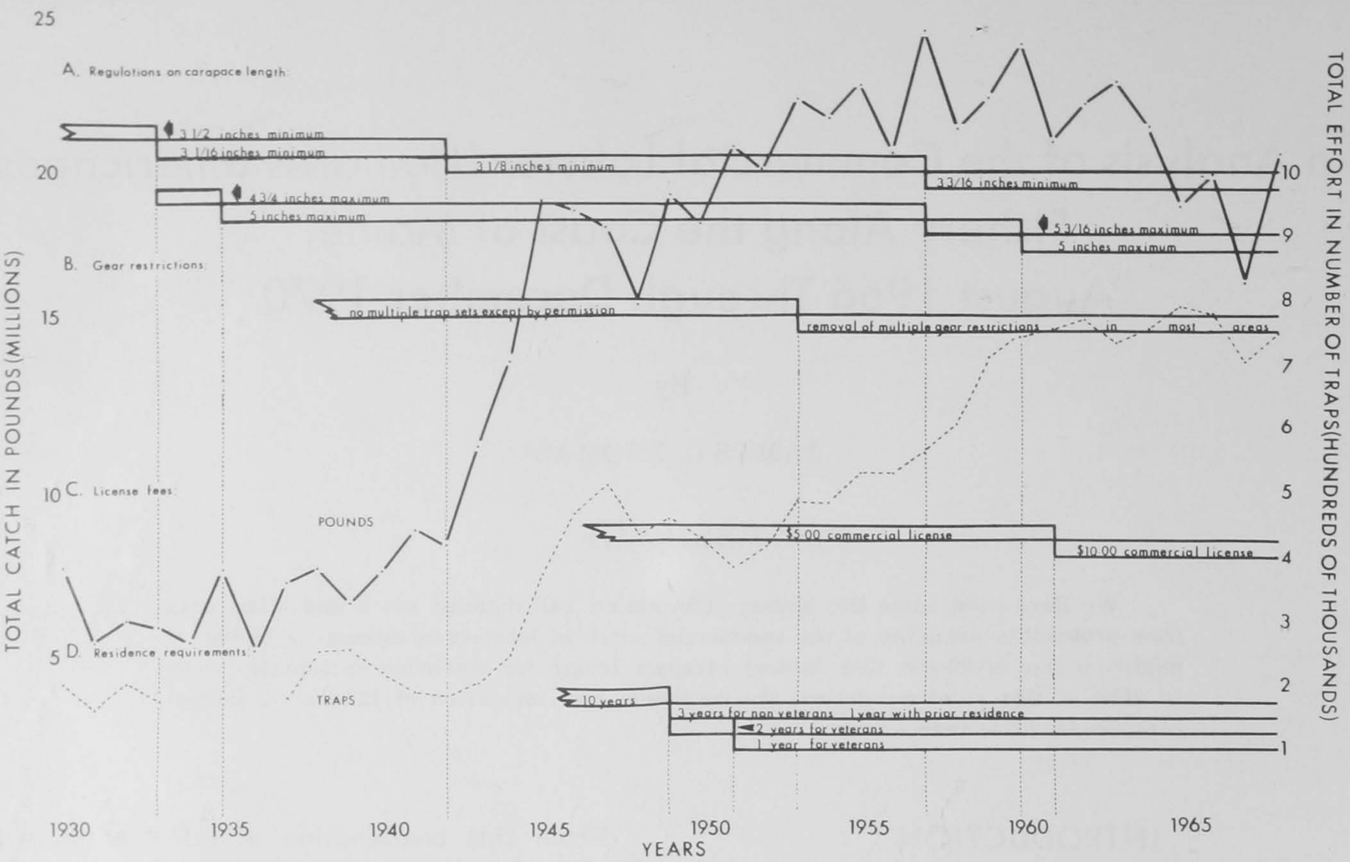


Figure 1. — A summary of some regulations and historical catch and effort data from the commercial lobster fishery in Maine, 1930 through 1968.

traps as reported in "Maine Landings" (Fig. 1). Apparently the catch in pounds has increased with increasing minimum size regulations in 1933, 1942, and 1957. Of course, the generally higher corresponding number of traps (assuming more trap-hauls) by year could account for the higher catches, whereas Dow (1969) advocated the influence of mean ocean temperature on the catch. Another factor, varying recruitment, could cause fluctuations in the catch from year to year.

With this amount of conjecture, it is obvious that we need more detailed information on the fishery before we can hope to demonstrate these types of cause and effect.

The Lobster Trap: Description and Ramifications

We have described and measured the traps presently in use (Fig. 2) not only because of the influence of gear selectivity on the size composition of the catch but also because of the possible effect of alterations in this gear on catch-per-unit-of-effort values. That is, if changes occur in the future and there is a continuous survey of the fishery, then we can make a determination concerning the influence of these factors when compared with the present set of conditions.

The intent of the above concept could be applied partially to an informational leaflet "The Maine Lobster Pot," mimeographed in 1948 by the Maine Department of Sea and Shore Fisheries. That paper described two basic designs of traps, (1) the "double-header" and (2) the "parlor." The measurements were not detailed on trap dimensions, mesh sizes, and lath spacings. Nevertheless, we used the information to determine if there has been a change in the basic design of traps.

For the present study on traps, we selected two areas from each of seven coastal counties, with the exception of Sagadahoc where we sampled only one area. In each area, we measured and noted the design of four traps

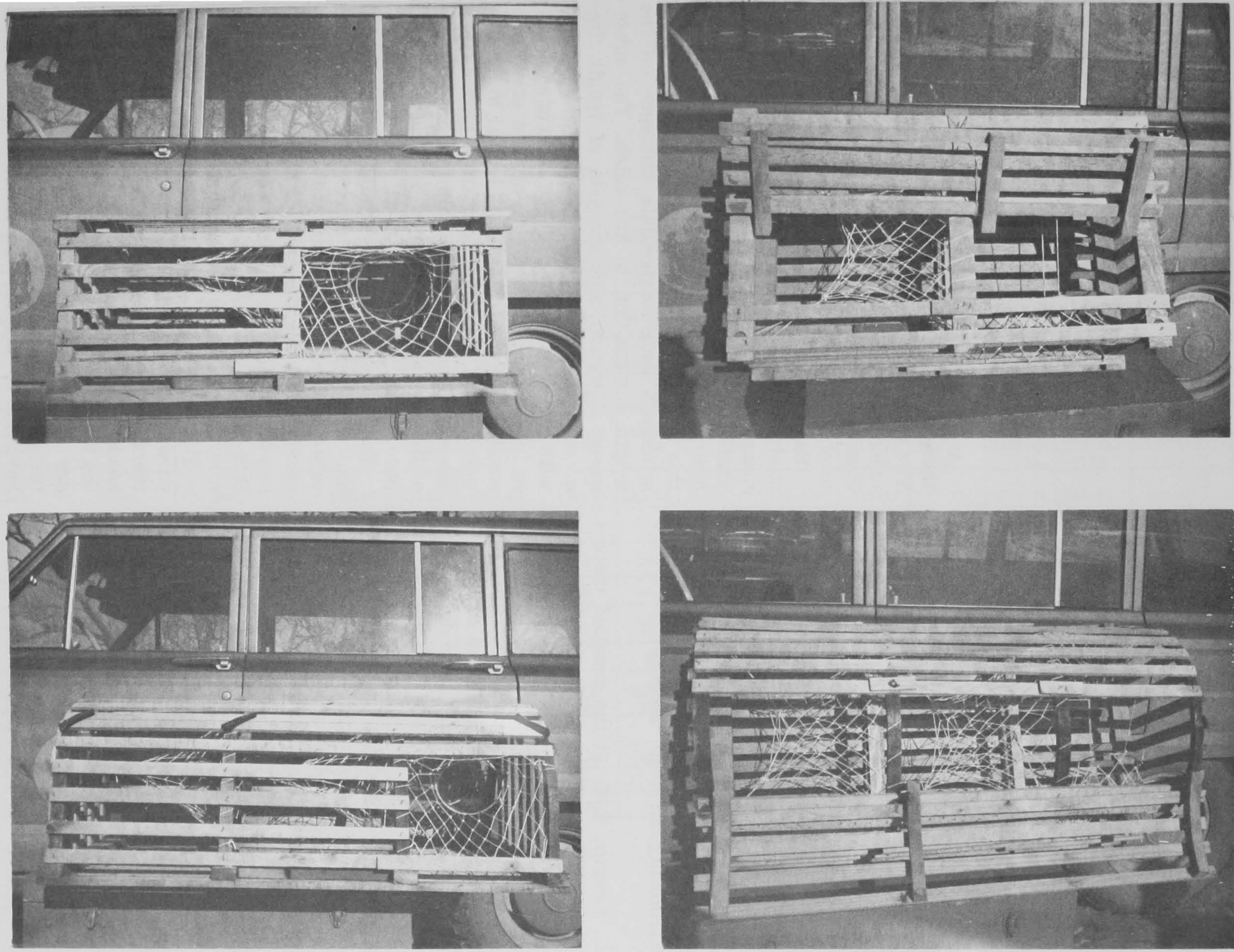


Figure 2. — Two designs of traps used in the commercial lobster fishery in Maine. The standard square trap in cross section (also semicylindrical) has entrance ports with wire hoops and a parlor with no hoop. The oversize semicylindrical trap has "skate mouth" entrance ports with two parlors.

(Photographs by Louis Kazimer, State of Maine Department of Sea and Shore Fisheries.)

per fisherman from five different fishermen for a total of 20 traps per area. Again there was an exception in area 1 of Knox County where we only measured the prescribed number of traps from four fishermen. As a consequence, we sampled a total of 256 traps in all selected counties and areas.

Certainly there are more versions in design and dimension of traps than we sampled. Intuitively, I assume that those designs and measurements approximate the sampled traps.

The measurements on each trap included: (1) the length, width, and height, (2) the lath spacing on the side of the trap from the bottom through the fifth lath spacing, (3) the wire hoop diameter for the entrance port, and where applicable, the "skate mouth" width. The "skate mouth" is a knitted head in the entrance port with no wire hoop.

Also we noted if the trap in cross section was square (usually trapezoidal) or half-round and whether each had a parlor, and if so, the number.

Trap measurements and types from all areas have the following ranges by category:

(1) a. Length; 95% of the sampled traps vary from 670 to 900 mm (2.20 to 2.95 ft); while the remaining 5%, usually with two parlors, vary from 1,210 to 1,250 mm (3.97 to 4.10 ft).

b. Width; varies from 440 to 660 mm (1.44 to 2.16 ft) with little demarcation between traps of different lengths.

c. Height; the round trap, constituting 45% of the sampled traps, varies from 360 to 410 mm (1.18 to 1.34 ft); while the square trap, comprising 55% of the sampled traps, varies from 270 to 355 mm (0.88 to 1.16 ft).

(2) Lath spacings; all types of traps vary from 12 to 55 mm (0.47 to 2.16 inches) with the narrowest measurement usually at the first spacing on the side nearest the bottom of the trap; the spacings thereafter are more uniform. The mean lath spacing is 30.8 ± 0.6 mm (1.21 inches), again with no demarcation as to type of trap.

(3) Hoop diameter or "skate mouth" width; 86% of sampled traps have wire hoops in the entrance ports; these hoops vary from 110 to 154 mm (4.33 to 6.06 inches) with a mean diameter of 128 ± 0.6 mm (5.06 inches). The remaining 14% of the sampled traps have "skate mouths" which vary in width from 118 to 194 mm (4.64 to 7.64 inches) with a mean width of 150.6 ± 3.3 mm (5.93 inches).

All of the sampled traps have parlors; usually these parlors have no wire hoops in the mouth. The parlors and heads are usually knitted from nylon twine. In both cases the mesh sizes range from 50 to 77 mm (1.97 to 3.03 inches), stretched mesh, knot to knot.

Based upon the measurements from this study, we concluded that trap designs and measurements vary between fishermen and areas and that each fisherman may alter the design from trap to trap (Table 1). At first this is an alarming situation in regard to gear selectivity and its possible influence on the length composition of the catch. The subsequent collection and analysis of length frequencies from the commercial catch, coupled with the 10 to 15:1 throwback ratio of sublegal- to legal-sized lobsters from area to area (personal observations), make it logical to assume that most of the present-day traps have a mean selection range below the minimum legal size of 81-mm (approximately 3-3/16 inches) carapace length.

The influence of the variable measurements and trap design on catch-per-unit-of-effort values cannot be resolved because of the mandatory sampling design for the survey of the commercial fishery. There is a possibility that this situation could cause some of the aberrancies in the catch and effort section.

The trap design from the current study compared to the description in 1948 reveals that there has been a change from the "double-header" to the "parlor" traps. We found that the two most widely used types in cross section are (1) the half-round, and (2) the square (usually trapezoidal) traps. Both types usually have one or two parlors. Evidently, fishermen believed that parlors in traps reduce escapement.

Table 1. — The measurements and description by county and area of some traps used in the commercial lobster fishery in Maine.

Categories for trap measurements (mm)		Locations by county														
		York		Cumberland		Sagadahoc	Lincoln		Knox		Hancock		Washington		Totals	
		area 1	area 2	area 1	area 2	area 1	area 1	area 2	area 1	area 2	areas 1 and 2		areas 1 and 2			
Lath spacing	range	15 to 55	14 to 45	18 to 41	20 to 40	24 to 47	19 to 41	18 to 46	12 to 39	21 to 36	12 to 41		14 to 46		12 to 55	
	mean	31.06	29.85	30.68	31.95	34.53	30.41	32.75	31.39	29.48	30.94		28.08		30.77	
	SE	.74	.76	.48	.33	.50	.38	.41	.49	.30	.38		.44		.56	
Hoop diameter or "skate mouth" width											hoop	skate mouth	hoop	skate mouth	hoop	skate mouth
	range	126 to 141	115 to 152	117 to 140	105 to 143	123 to 145	121 to 145	118 to 136	114 to 128	115 to 129	110 to 154	154 to 194	115 to 133	118 to 178	110 to 154	118 to 194
	mean	134.80	135.55	130.10	131.60	130.45	134.25	125.25	121.47	121.95	126.62	177.09	122.88	141.50	128.60	150.64
	SE	.81	1.84	1.51	2.13	1.36	1.57	1.10	1.28	.93	2.34	5.14	2.68	2.51	.61	3.29
Number of traps	round	-	-	-	20	18	12	20	14	-	32		-		116	256
	square	20	20	20	-	2	8	-	2	20	8		40		140	
Number with parlor	single	20	20	16	20	20	20	12	16	20	40		40		244	256
	double	-	-	4	-	-	-	8	-	-	-		-		12	
Trap dimensions, ranges in	length	779 to 845	770 to 890	720 to 1250	735 to 820	720 to 880	750 to 850	750 to 1210	750 to 790	800 to 870	770 to 900		670 to 910		670 to 1250	
	width	550 to 600	510 to 660	440 to 520	520 to 590	510 to 590	540 to 590	530 to 585	560 to 580	530 to 560	520 to 600		490 to 580		440 to 660	
	height	310 to 330	320 to 355	270 to 310	360 to 400	330 to 400	340 to 390	380 to 410	295 to 390	310 to 360	280 to 400		285 to 360		270 to 410	

The stimuli for this change to parlors could be associated with (1) the conversion to the hydraulic hauler by the majority of fishermen, and (2) the more powerful engines resulting in faster boats. These factors possibly led to an increase in the number of traps and trap-hauls per fisherman. If the number of traps set out exceeded the number that could be hauled in a day, then there would be an increase in the number of set-over-days, thus creating the reason for a change to a trap design that might reduce escapement over time. Of course there could be many more explanations for this change, but this speculative premise seems most plausible.

BIOLOGICAL NOTES

In accordance with the stated objectives, but as a supplement to the probability sampling plan for the commercial lobster fishery, we calculated: (1) the premolt and postmolt relationship, (2) the size ranges of berried females in relation to size at maturity, (3) the fecundity of females from historical data, and (4) the alternatives to the maximum size limit.

These relationships either have management implications or make it possible to compare these collected data with measurements in other publications.

Premolt and Postmolt Relationship

We calculated the premolt and postmolt relationship to help in determining the percent increase in carapace length with shedding. This has direct application in the analysis of the length frequencies in the commercial catch. In addition, the calculated regression coefficients can be compared with the corresponding estimates by Wilder (1953) in order to determine if there were differences.

We collected lobsters from along the coast and held them in laboratory tanks if they appeared ready to molt. Of these, 44 lobsters shed (33 males and 11 females). They ranged in premolt sizes from 20- to 176-mm carapace length.

The premolt and postmolt lengths are linear in character; therefore, we ran a linear regression and solved the equations by the method of least squares, where (x) is the premolt carapace length in millimeters. These equations by category are:

$y = 0.64986 + 1.07578x$ (males)
$y = -0.46448 + 1.09612x$ (females)
$y = 0.59543 + 1.07619x$ (sexes combined).

The 95% confidence limits about the slopes or b values are $\pm$ 0.10142, $\pm$ 0.19753, and $\pm$ 0.04352 respectively.

Using these solved equations, the increase in carapace length is about 8%. Wilder (1953) and Dow (no date) calculated a 14% increase in length; however, both authors demonstrated some variability in the growth of individual lobsters by size and sex.

Wilder (1953) cautioned that lobsters held in tanks in the laboratory before ecdysis might not increase in length at the same percentage as those lobsters in the natural environment.

Cognizant of these factors, we analyzed the length frequencies of the commercial catch by two methods: (1) 14% increments in carapace length and (2) probability analysis as described by Harding (1949) and Cassie (1954). With the latter method, the percent increase between certain consecutive modes does approximate the 8% that we calculated from the laboratory study.

Berried Female Measurements

To aid in determining the range of sizes that female lobsters become mature (extrude eggs), we have measured the carapace lengths of berried females each year since 1966.

The State purchases these females from pound owners. Perhaps some background on this operation would be beneficial:

> In order to fill the pounds (usually in May) with boat-run, legal-sized lobsters for the summer demand, pound owners in Maine purchase males and non-berried females from fishermen in this State and from dealers in Canada. From the time these lobsters are impounded until they are sold in July or August, some of the females become berried. Because it is illegal to sell berried females on the market, the pound owners have an arrangement to sell these berried females to the Department of Sea and Shore Fisheries; then the coastal wardens cut a "v" notch in the telson and release these females in the ocean.

I will not comment on the validity of such a management plan; however, if the intent were to provide an adequate spawning stock, then certain sections in this paper offer alternatives for consideration.

Returning to the initial objective, I reasoned that by measuring these berried females, separated from all of the reclaimed lobsters, and by asking the pound owners the origin of the stock (Maine or Canada) and when he impounded them, we would gain information on: (1) time of egg extrusion, (2) size at egg extrusion, (3) possible differences in the preceding categories between Maine and Canadian stocks.

I must reiterate that there is an 81-mm (3-3/16 inches) and 127-mm (5 inches) legal minimum and maximum carapace length in Maine. Therefore, the berried female measurements should fall anywhere within that range.

On the basis of this study, I believe that females extrude their eggs sometime between May and July. In this regard, there is no difference between Maine and Canadian stocks, at least when kept in pounds in Maine. To further attest to the period of egg extrusion, pound owners maintain that fall impoundments of lobsters have not resulted in any berried females when the lobsters are reclaimed in the winter.

For the native stock in pounds, the average length of berried females is 102-mm (approximately 4 inches) carapace length, with a size range from 83-mm (approximately 3-¼ inches) to 127-mm (5 inches) carapace length (Table 2). I concluded from this information that most females in coastal waters off Maine are not mature until they are between 90- and 100-mm carapace length.

It appears that females from certain parts of Canada extrude their eggs at a smaller size than the stocks from Maine. Whether this is environmentally and/or genetically linked, it is impossible to determine from these data.

Comparing this information on the possible size at maturity with the size composition of the commercial catch led us to an immediate decision to study this relationship in more detail. Krouse (1971)[3] examined gonads of males and females from 1968 through 1970, and his results compare favorably with the

[3] Krouse, J. S. 1971. Maturity, sex ratio, and size composition of the natural population of the American lobster (*Homarus americanus*) along the coast of Maine. Maine Dep. Sea Shore Fish., Completion Rep., Proj. 3-14-R, 17 p. (Manuscr.)

Table 2. — Carapace measurements of berried females taken from lobster pounds in Maine.

Year	Date	Sampling location	Type of stock	Sample size	Range in length (mm)	Mean length (mm)	Standard deviation	Standard error
1966	12 July	Boothbay Harbor, Maine	Native-local	56	88-124	109.09	8.17	1.09
	22 July	Medomak, Maine	Native-local	75	84-127	101.44	8.39	.97
	26 July	Vinalhaven, Maine	Native-local	51	86-122	107.18	7.20	1.01
	18 August	Tenents Harbor, Maine	Native-local	217	85-126	101.07	8.23	.56
1967	18 July	Pigeon Hill, Maine	Native-local	16	87-126	104.31	10.91	2.73
	20 July	East Boothbay, Maine	Native-Nova Scotia	49	88-125	102.92	9.92	1.42
	27 July	Hancock, Maine	Native-Canadian	41	79-121	97.00	13.12	2.05
	27 July	Sunshine, Maine	Native-local	41	92-121	108.27	7.46	1.17
	29 July	Camden, Maine	Native-Canadian	52	83-120	98.92	7.96	1.10
	2 August	Beals Island, Maine	Newfoundland	49	81-116	90.31	7.47	1.07
	2 August	South Addison, Maine	Nova Scotia-Newf'ld	49	81-116	89.86	6.90	.99
	2 August	Friendship, Maine	Native-local	51	86-125	103.71	6.89	.97
	9 August	Jonesport, Maine	Native-Canadian	50	80-124	92.22	9.11	1.29
	9 August	Beals Island, Maine	Newfoundland	51	80-105	88.45	6.58	.92
	9 August	Hancock, Maine	Native-local	23	95-123	108.74	7.68	1.60
	12 Sept.	Boothbay Harbor, Maine	Native-local	50	84-120	95.12	8.57	1.21
1968	10 July	Boothbay Harbor, Maine	Native-local	68	85-117	101.78	7.99	.97
	11 July	Friendship, Maine	Native-local	51	90-125	105.16	7.93	1.11
	11 July	Friendship, Maine	Native-local	35	88-118	102.63	7.77	1.31
	15 July	Trevett, Maine	Magdelein Island	133	79-112	87.10	6.09	.53
	22 July	Sunshine, Maine	Native-local	23	98-119	107.61	5.19	1.08
	22 July	Stonington, Maine	Native-P.E.I.	19	84-116	97.74	11.17	2.56
	24 July	Friendship, Maine	Native-local	63	90-127	106.91	8.33	1.05
	25 July	South Addison, Maine	Nova Scotia-Newf'ld	217	81-113	90.61	6.27	.43
	4 Sept.	Stonington, Maine	Native-P.E.I.	25	82-119	98.24	8.72	1.74
1969	11 July	Friendship, Maine	Native-local	29	87-122	102.72	9.30	1.73
	14 July	Boothbay Harbor, Maine	Native-Canadian	51	82-119	100.37	9.23	1.29
	28 July	Trevett, Maine	Magdelein Island	60	81-100	87.70	4.31	.56
	31 July	Jonesport, Maine	Magdelein Island	129	80-127	89.34	8.06	.71
1970	7 July	Friendship, Maine	Native-local	56	83-115	97.91	8.70	1.16
	8 July	Trevett, Maine	Native-local	105	83-119	98.26	8.40	.82
	17 July	Southport, Maine	Native-local	140	83-119	98.25	7.79	.66
	22 July	Beals Island, Maine	Canadian	259	80-115	90.68	7.51	.47
			Native-local	1150	83-127	102.08	8.90	.26
			Native-Canadian	287	80-125	98.28	10.32	.61
			Canadian	947	80-127	89.61	6.99	.23
			Total	2384				

determinations from the berried female measurements. I decided from this that the measurements on berried females do serve as an indicator of the size at maturity.

Implications for management. — On the basis of the preceding information and the length frequency section of this paper, we speculated that the population has been at a precarious limit to ensure an adequate parent-progeny relationship or derivatives thereof along the coast of Maine.

It could be argued that the program of berried female releases is an attempt to ensure an adequate relationship. Considering the possibilities of (1) a high mortality of the resultant larvae from females and (2) the relatively few females that reach a size to extrude eggs, let alone to the protected size of 127-mm (5 inches) carapace length in this commercial fishery, we could only conclude that the parent-progeny relationship should be given more consideration in order to ensure an adequate number of recruits to the commercial fishery.

There have been examples of parent-progeny relationships or derivatives thereof being density dependent (Ricker, 1958). Other limiting factors could be predation, environmental variables, and amount of food available to the larvae. Assimilating the information on the present condition of the commercial fishery for lobsters, I cannot accept the possibility that this population is limited by these conditions.

Fecundity

Taylor (1947), using the gravimetric method, estimated the number of extruded eggs for each of 10 berried females. The number of eggs appear to be dependent on the size of the female; for example, a female of approximately 83-mm (3-¼ inches) carapace length has an estimated 9,835 eggs while a female of approximately 121-mm (4-¾ inches) carapace length has an estimated 38,047 eggs.

The above data are so limited in the number of observations that I will not include the calculated regression equation. However, Perkins (1971) did calculate curvilinear regressions for 196 berried females from several offshore areas. His calculated number of eggs compare favorably with those of Taylor (1947).

Consideration of the Maximum Size Limit

In the light of the foregoing considerations, this might be an opportune time to discuss the maximum size limit in Maine. The original intent of this regulation was to protect larger females because they carry a greater number of eggs.

The length frequencies from the commercial catch demonstrate that most females are caught not only before they reach this maximum size, but even before they reach a size to extrude eggs. Therefore, an alternative to the present minimum and maximum regulations would be to raise the minimum size and remove the maximum size limit. In this way, we can expect a greater number of the first mature females to produce more eggs than the relatively few larger mature females that make it through the commercial fishery to the protected size at 127-mm (5 inches) carapace length, even though any sized berried or "v" notched female cannot be legally taken. Dow (1955) made a similar recommendation in regard to the maximum size limit.

Of course it is not good management to increase or eliminate a size limit on the basis of maturity and fecundity alone; such things as age and growth, natural mortality, and fishing mortality must be considered. The section on yield will discuss these requirements; therefore, the recommendations for the minimum size are delayed until the yield section.

PROBABILITY SAMPLING PLAN

To survey the commercial fishery by probability sampling, we developed a multistage sampling plan with stratification. Because of manpower and monetary limitations, it was necessary to set up the sampling plan in the following manner:

(1) List the days within a year or time period as the primary sampling unit.
(2) Due to the regulation of no Sunday fishing during June, July, and August and the limited fishing activity during this day in other months of the year, stratify this day from the others, when applicable, by proportional allocation.

(3) List the lobster buyers that had five or more boats fishing for them as the secondary sampling units. From this list we compiled a dealer-code which represents the county and the number assigned to each dealer in that county (Fig. 3).

(4) Interview all of the lobstermen who delivered their catches on sample-days during the period of maximum landings, 12:00 noon to 5:00 p.m. In addition, we selected a random cluster of 10 lobsters per boat.

It was only possible to sample 10 days a month due to commitments to entirely different jobs still within this project.

From the interviews and the cluster samples, we compiled the following information by boat:

(1) Total catch in pounds
(2) Total catch in numbers
(3) Total hours expended for catch
(4) Total number of traps hauled for the day
(5) Number of days set-over for the hauled traps
(6) Total number of traps-set-out
(7) From the cluster of 10 lobsters, we made individual determinations of:
    (a) carapace length (millimeters)
    (b) weight (grams)
    (c) sex
    (d) cull or normal
    (e) shedder or hard-shell.

This information was tabulated in a format of five boats per sample sheet (Fig. 4), then these sheets were summarized by day (Fig. 5), month, and year with an additional calculation of catch in numbers per trap-haul-set-over-day after August 1967. The ratios of catch per unit of effort and the variances were calculated using these formulas:

(1) $\hat{R} = y / x$;

(2) $$S\hat{R} = \frac{\sqrt{1-f}}{\sqrt{n}\,\bar{x}} \sqrt{\frac{\Sigma y_i^2 - 2R\Sigma y_i x_i + R^2 \Sigma x_i^2}{n-1}}.$$

In addition to the summary compilations, we calculated the average length and weight, percentages of females, shedders, and culls. The estimates and variances were calculated using these formulas:

(1) $$\bar{x}_j = \frac{\Sigma N_{ij}\bar{y}_{ij}}{\Sigma N_{ij}};$$

(2) $$\hat{v}_{(\bar{x}.)} = \frac{\Sigma(\bar{x}_j - \bar{x}.)^2}{n(n-1)}.$$

Probability sampling also enabled us to make unbiased estimates in the prescribed categories on a monthly and yearly basis for all of the dealer-days in the survey. In this case, the estimates and variances were calculated using these formulas:

(1) $x_{hij} = x_{hijk}$;

(2) $$x_{hi} = \frac{U}{\mu} \Sigma x_{hij};$$

(3) $$x_h = \frac{N}{n} \Sigma x_{hi};$$

(4) $$\hat{v}_h = N^2 \left[\frac{\Sigma x^2{}_{hi} - \frac{(\Sigma x_{hi})^2}{n}}{n(n-1)}\right].$$

$k = 1, \ldots, m$

$j = 1, \ldots, \mu$

$i = 1, \ldots, n$

$h = 1, 2$

Methods for Improving Survey Estimates

Another important determination can be made from the expanded estimates of the survey, that is ways to improve the precision of these estimates and, in fact, include the entire fishery in the sampling.

After completing the sampling and expanded estimates for 1967 and 1968, we determined by optimum allocation the number of days that we should sample a month with a 15% standard error of the estimate. We were not optimistic about reducing the maximum of 10 days that we have to sample per month because of the restriction of the total number of days

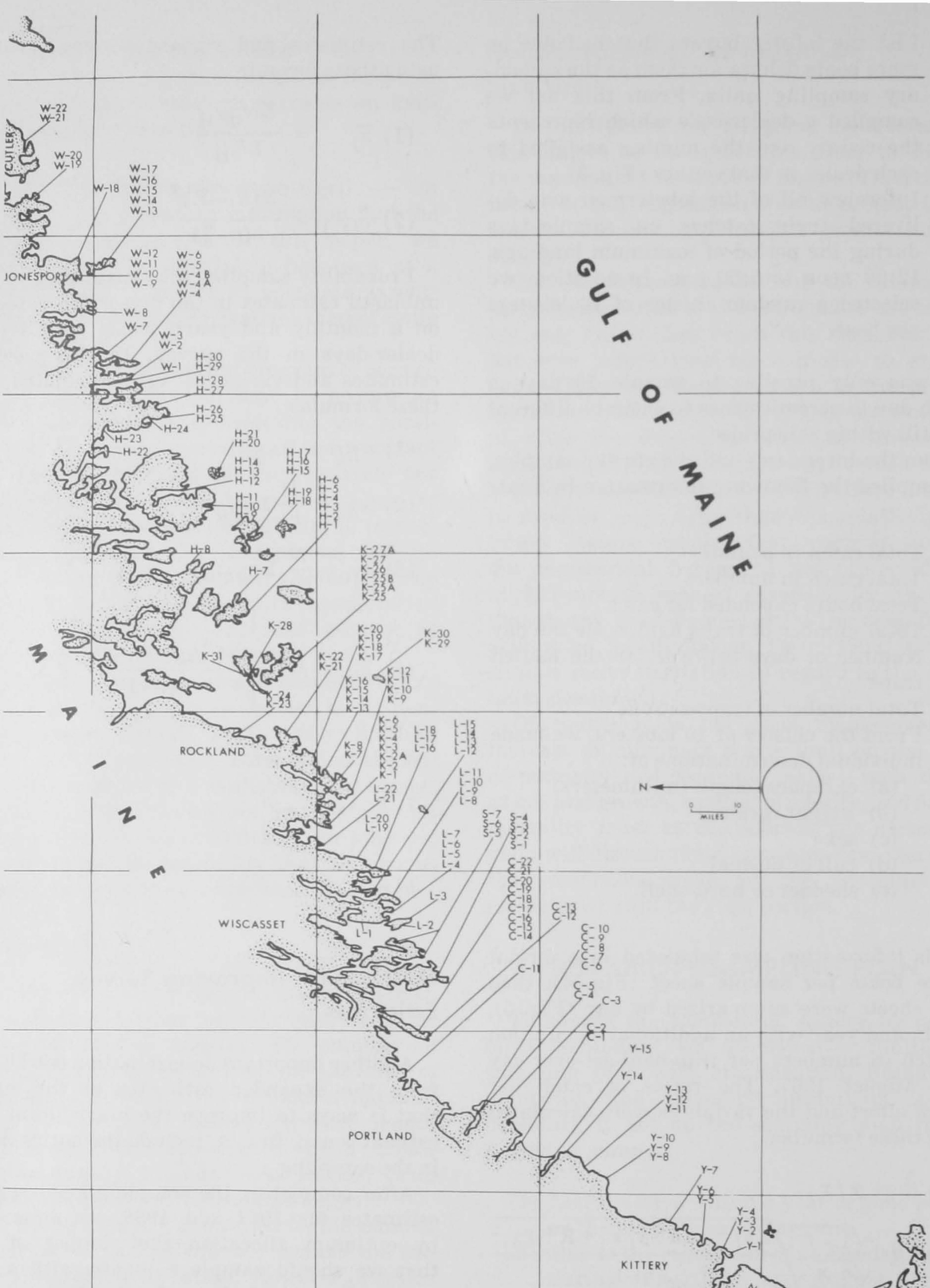


Figure 3. — Sampling locations along the coast of Maine where the letter represents the county and the number represents each dealer in that county. The county designations are: Y for York, C for Cumberland, S for Sagadahoc, L for Lincoln, K for Knox, H for Hancock, and W for Washington.

COMMERCIAL LOBSTER SAMPLING

Date 13 AUGUST 1968 | Sampler BURKE-ROBINSON-KAZIMER

Dealer (code no) Y-6 | Sampling fraction 1:1 (1:1, 1:2, 1:3, 1:4)

Price per pound $ .90

IF NOT BOAT RUN, USE PRICE CATEGORIES

BOATS

	1	2	3	4	5
1) Total catch in pounds	40	24	74	24	37
2)					
3) Time of interview military)	12:35	12:50	13:30	13:45	14:25
4) Time left dock to pull traps	07:00	09:30	08:30	10:00	08:00
5) No. of traps for day's catch	114	70	80	60	80
6) Total no. of traps set out	114	70	80	275	225
7) No. of people in boat crew	1	1	1	1	2
8) No. of days set over	1	1	1-2	4	3

9) Sample of lobsters		1 lgth mm	1 wt grms	1 sex M F	2 lgth mm	2 wt grms	2 sex M F	3 lgth mm	3 wt grms	3 sex M F	4 lgth mm	4 wt grms	4 sex M F	5 lgth mm	5 wt grms	5 sex M F
A) L. Pinch miss	1	92	550	F	91	600	F	94	580	F	91	460[B]	M	93	530	F
B) R. Pinch miss	2	87	520	M	85	440	F	94	600	F[s]	85	450	M	89	550	F
C) B. Pinch miss	3	95	680	M[s]	91	540	F	105	820	F	85	460	M	91	520	M
S) Soft shedder	4	85	450	M	93	450[B]	M	90	560	M	86	470	F	91	590	F
H) Hard	5	92	550	F[s]	92	580	F	88	490	F	89	480	F[s]	90	540	F
	6	88	570	M	87	440	M	91	480[A]	F[s]	85	450	F	98	650	M[s]
	7	93	590	M	81	510	F[s]	91	580	F	93	540	F	90	540	F
	8	92	570	M	85	440	F	90	570	F	86	450	M[s]	88	480	F
	9	84	440	M	88	510	F	93	590	M[s]	96	470[A]	M	91	560	F
	10	93	580	F	91	550	F[s]	90	540	F	87	460	F	95	560	F[s]

	1	2	3	4	5
Totals					
Number of lobsters per boat	36	22	72	21	32

Comments:

Time 12:00 | Tide: FLOOD

	Surface	Bottom
Temp:	62°F	60°F
D.O:	6.0	
pH:	8.0	
CO_2:	15.0	
Salinity:	—	

Figure 4. — Actual sample sheet of catch and effort information compiled by boat and day.

CATCH STATISTICS

Dealer Y-6 Day 13 Month AUGUST Year 1968

1.	Total catch in pounds	199	h s 199
2.	Total catch in numbers	183	
3.	Total value of catch	$179.10	$ h s 179.10
4.	Total number of females in sample	32	
5.	Total number of males in sample	18	
6.	Total number of trap-hauls	404	
7.	Total number of traps set out	764	
8.	Total number of man-days	6	
9.	Total number of man-hours	31.50	
10.	Total number of boat-days	5	
11.	Total number of boat-hours	25.08	
12.	Mean weight of lobsters in catch	1.09	
13.	Catch in pounds/trap-haul	.49	
14.	Catch in numbers/trap-haul	.45	
15.	Catch in pounds/man-day	33.17	
16.	Catch in numbers/man-day	30.50	
17.	Catch in pounds/man-hour	6.32	
18.	Catch in numbers/man-hour	5.81	
29.	Catch in pounds/boat-day	39.80	
20.	Catch in numbers/boat-day	36.60	
21.	Catch in pounds/boat-hour	7.93	
22.	Catch in numbers/boat-hour	7.30	
23.	Value/trap-haul	$ .44	
24.	Value/man-day	$29.85	
25.	Value/man-hour	$ 5.69	
26.	Value/boat-day	$35.82	
27.	Value/boat-hour	$ 7.14	

Figure 5. — Summary sheet of collected data for the sample-day.

in a month; nevertheless, we felt an attempt should be made in accordance with the methodology as outlined by Abramson and Tolladay (1959). As mentioned above, the limitation of usually 30 days in a month resulted in some months with a greater number of sample-days than there were total days in that month. In addition, the 1967 optimum allocation (disregarding the feasibility) when applied to the 1968 data was unsuitable for the desired estimates and confidence limits (Table 3).

Of course the alternative is to stratify the year into larger periods (groups of months), but as the catch effort, length frequency, and mortality sections demonstrate, we would lose needed data by month and the resultant analyses. Therefore, we accepted the results of 10 days of sampling per month with its large standard error for certain months of the year. Even in this situation the total yearly expanded estimates have acceptable standard errors of approximately 15%.

Expanded Estimates From Probability Sampling

Probability sampling of the commercial lobster fishery enabled us to make estimates of the total catch and effort (by several categories) for the collective total of 153 dealers and all

Table 3. — Optimum allocation required for 0.15Y, 90% confidence limits in 1967 compared with true optimum allocation of sample size for 1968.

Strata	1967 Allocation	1968 Allocation	n_h 1967 / n	n_h 1968 / n
I	20.9	3.9	.073	.021
II	13.2	2.9	.046	.016
III	6.9	3.7	.024	.021
IV	4.3	6.2	.015	.035
V	32.9	25.1	.115	.140
VI	39.6	12.4	.138	.069
VII	12.2	9.9	.042	.055
VIII	26.0	32.8	.091	.183
IX	32.6	41.2	.114	.230
X	29.4	40.8	.102	.228
XI	43.5	--	.151	--
XII	25.7	--	.089	--
n =	287.2	178.9		

of the days by year from 1966 (partial year), through 1970 (Table 4).

These estimates include many catch, effort, and catch-per-unit-of-effort categories that are not reported in "Maine Landings." The comparable estimates of catch in pounds, numbers, and number of traps that are reported in "Maine Landings" must exceed the estimates from the survey because of the necessary constraints of the sampling period and the fact that we cannot efficiently sample individual fishermen who retail their catches.

Aside from the absolute need of detailed catch, effort, and catch-per-unit-of-effort data in order to make management recommendations, the expanded estimates might have the following additional useful purposes:

(1) Gulland (1965) and others have advocated the use of catch-per-unit-of-effort subsamples in relation to the actual total catch (as reported in "Maine Landings") in order to estimate the total effort in more pertinent categories than just the number of traps.

(2) The survey totals by month or year could serve as indices by category of what actually occurs in the entire fishery.

(3) These indices after a series of years might make it possible to again compile a figure of total catch with effort by year with the juxtaposed regulations and then make some meaningful determinations about the fishery, particularly since this effort could be in several categories rather than the only previously available category of number of traps.

Cluster Samples

The cluster samples of 10 lobsters per boat are vitally important to this study not only for the lengths, but also for the weights, and percentages of females, culls, and shedders. All of these categories have varying degrees of importance on the assessment of the population. The following sections demonstrate how each category is used.

Length frequency analysis. — In this paper, lobster lengths are the basic building blocks for estimating most population parameters. With this degree of importance, we included the compilation of the number of lobsters by size, sex, month and year (Table 5). These data will also make it possible for the reader to make any other determinations that he wishes.

We used actual numbers or percent frequencies to analyze the data in two ways: (1) 14% groupings of length and (2) 1-mm increments of length with the probability method.

Analysis by 14% increments. — I chose 14% increments because they closely approximate the calculated percent increase in carapace length with ecdysis for legal-sized lobsters from the premolt and postmolt section and from the study by Wilder (1953).

On this basis, we separated the carapace lengths in millimeters into groupings of 81 through 92, 93 through 106, 107 through 122, and 123 through 127 (the legal maximum size in this State). It is not logical to assume that an age or molt group starts at 81 mm rather than extending below this size. I will discuss this in the section comparing 14% increments with the probability modes.

Silliman (1943), Beverton and Holt (1957), and Ricker (1958) have discussed the assumptions that must be met when using length frequencies in place of the age composition. We cannot determine the age of any lobster that

Table 4. — Some expanded totals with standard errors of catch and effort statistics calculated by year for all of the dealer-days in the survey of the commercial lobster fishery, 1966 through 1970.

Year	Month	Catch in pounds	Catch in numbers	Value in dollars	Number of traps	Number of trap-hauls	Number of trap-haul-set-over-days	Number of man-days	Number of boat-days	Pounds per trap-haul	Numbers per trap-haul	Numbers per trap-haul-set-over-day	Pounds per boat-day	Pounds per man-day
1966	January													
	February													
	March													
	April													
	May													
	June													
	July													
	August	1,919,697 ±370,136	1,594,790 ±319,377	1,610,910 ±287,841	224,253 ±65,498	4,442,583 ±1,131,406	- -	36,627 ±6,708	25,608 ±4,827	.4342 ±.0377	.3602 ±.0241	- -	74.1153 ±4.8212	52.0811 ±2.5049
	September	3,260,887 ±1,333,086	2,679,300 ±1,044,055	2,283,460 ±939,681	316,414 ±90,333	4,627,350 ±1,752,882	- -	33,638 ±11,314	26,325 ±9,149	.7047 ±.0332	.5790 ±.0252	- -	123.8703 ±10.2913	96.9420 ±7.4602
	October	2,928,328 ±1,176,890	2,450,214 ±985,397	2,041,578 ±826,139	252,573 ±96,592	4,214,522 ±1,571,653	- -	34,151 ±13,929	25,493 ±10,677	.6948 ±.0202	.5813 ±.0372	- -	114.8679 ±12.8708	85.7465 ±4.4652
	November	757,651 ±232,163	662,457 ±203,225	517,796 ±157,165	150,519 ±43,818	1,362,565 ±465,832	- -	15,452 ±5,315	11,448 ±3,701	.5816 ±.0997	.5103 ±.0862	- -	68.6667 ±14.8560	51.5000 ±10.9203
	December	427,410 ±216,914	389,151 ±201,241	281,958 ±146,967	77,161 ±16,674	489,645 ±216,914	- -	6,925 ±3,125	6,088 ±2,920	.8371 ±.1234	.7583 ±.1271	- -	69.0625 ±5.3934	61.3889 ±8.0362
	Total	9,293,973 ±1,830,894	7,775,912 ±1,984,992	6,735,702 ±1,282,625	- -	15,136,665 ±2,670,630	- -	126,793 ±20,124	94,962 ±15,427	.6192 ±.0238	.5188 ±.0187	- -	96.9801 ±4.1503	73.0970 ±2.9814

Table 4. — Some expanded totals with standard errors of catch and effort statistics calculated by year for all of the dealer-days in the survey of the commercial lobster fishery, 1966 through 1970. — Continued.

Year	Month	Catch in pounds	Catch in numbers	Value in dollars	Number of traps	Number of trap-hauls	Number of trap-haul-set-over-days	Number of man-days	Number of boat-days	Pounds per trap-haul	Numbers per trap-haul	Numbers per trap-haul-set-over-day	Pounds per boat-day	Pounds per man-day
1967	January	399,200 ±347,851	329,056 ±287,840	286,416 ±247,389	120,797 ±33,912	551,609 ±438,175	- -	8,080 ±6,488	5,876 ±4,336	.7237 ±.0794	.5965 ±.0625	- -	67.9375 ±12,3817	49.4091 ±4,9193
	February	264,096 ±243,663	249,984 ±232,163	226,329 ±206,399	86,744 ±16,986	324,576 ±262,778	- -	4,368 ±3,126	3,360 ±2,435	.8137 ±.1736	.7701 ±.1736	- -	78.6000 ±34.7113	60.4615 ±27.5418
	March	160,714 ±115,200	137,113 ±97,263	153,802 ±111,359	74,743 ±12,550	401,598 ±296,568	- -	3,746 ±3,000	2,997 ±2,244	.4000 ±.0233	.3414 ±.0314	- -	53.6250 ±5.2454	42.9028 ±8.3439
	April	109,500 ±70,958	91,500 ±58,822	104,025 ±67,082	56,800 ±15,133	265,125 ±175,788	- -	2,250 ±1,231	2,250 ±1,231	.4130 ±.0748	.3451 ±.0242	- -	48.6667 ±8.1189	48.6667 ±8.1189
	May	1,278,126 ±549,547	1,084,563 ±450,553	1,082,877 ±470,109	179,673 ±78,070	2,074,707 ±945,121	- -	18,333 ±6,881	14,202 ±5,292	.6189 ±.0767	.5266 ±.0612	- -	89.5000 ±16.9697	69.8536 ±8.1009
	June	1,382,823 ±681,912	1,141,244 ±832,470	1,086,175 ±545,894	156,855 ±85,866	2,735,401 ±1,333,086	- -	18,852 ±7,736	15,037 ±6,124	.5184 ±.0309	.4277 ±.0235	- -	93.7667 ±7.0604	78.1388 ±5.2848
	July	563,232 ±203,225	456,469 ±166,736	491,468 ±179,448	106,483 ±25,475	1,042,951 ±224,393	- -	8,541 ±2,473	7,117 ±1,949	.5400 ±.0483	.4377 ±.0381	- -	79.1333 ±11.0522	65.9444 ±10.0933
	August	781,198 ±433,590	673,494 ±378,150	723,808 ±339,115	133,589 ±72,595	1,759,246 ±826,139	- -	14,415 ±5,315	12,440 ±4,955	.4473 ±.0402	.3871 ±.0371	- -	61.6667 ±10.8901	52.0312 ±10.8182
	September	1,077,440 ±560,807	917,267 ±495,481	882,320 ±450,553	279,387 ±72,595	2,016,833 ±965,922	5,722,938 ±3,087,190	17,316 ±7,483	14,430 ±5,882	.5342 ±.0978	.4548 ±.0853	.1603 ±.0255	74.6667 ±16.7942	62.2222 ±11.2010
	October	935,516 ±489,902	816,948 ±428,952	690,952 ±353,554	115,193 ±29,207	1,113,156 ±545,894	2,383,488 ±1,311,747	10,116 ±4,658	10,116 ±4,658	.8156 ±.3312	.7103 ±.3944	.3646 ±.0465	90.4400 ±4.2065	90.4400 ±4.2065
	November	1,443,926 ±748,336	1,260,968 ±651,900	1,151,615 ±602,495	191,700 ±60,249	2,124,427 ±1,176,891	6,388,639 ±3,800,051	17,550 ±8,514	12,724 ±6,124	.6797 ±.0347	.5935 ±.0339	.1847 ±.0313	113.4828 ±17.3890	82.2750 ±17.2813
	December	941,415 ±428,952	847,715 ±388,334	754,765 ±344,967	184,504 ±55,498	1,229,405 ±566,131	6,707,930 ±3,613,547	12,095 ±5,265	10,145 ±4,422	.7554 ±.0683	.6798 ±.0524	.1219 ±.0306	88.8928 ±11.3371	75.4242 ±7.1075
	Total	9,337,186 ±1,571,654	8,006,321 ±1,490,685	7,634,552 ±1,255,025	- -	15,639,034 ±2,586,531	21,202,995 ±6,224,399	135,662 ±19,493	110,694 ±15,427	.6060 ±.0297	.5210 ±.0320	- -	83.6094 ±5.7423	68.6026 ±4.5958

Table 4. — Some expanded totals with standard errors of catch and effort statistics calculated by year for all of the dealer-days in the survey of the commercial lobster fishery, 1966 through 1970. — Continued.

Year	Month	Catch in pounds	Catch in numbers	Value in dollars	Number of traps	Number of trap-hauls	Number of trap-haul-set-over-days	Number of man-days	Number of boat-days	Pounds per trap-haul	Numbers per trap-haul	Numbers per trap-haul-set-over-day	Pounds per boat-day	Pounds per man-day
1968	January	101,363 ±101,363	90,667 ±90,667	111,367 ±111,367	43,260 ±43,260	208,465 ±208,465	980,665 ±980,665	1,570 ±1,570	1,219 ±1,219	.4764 ±.0344	.4260 ±.0309	.0931 ±.0023	73.2500 ±30.5046	58.6000 ±18.8647
	February	121,550 ±81,241	95,875 ±64,382	133,703 ±89,778	71,760 ±12,042	269,750 ±175,788	1,885,000 ±1,258,245	2,275 ±1,667	1,300 ±985	.4506 ±.0679	.3554 ±.0561	.0509 ±.0013	93.5000 ±27.6733	53.4286 ±12.1245
	March	112,892 ±94,868	93,964 ±78,071	140,270 ±120,419	78,520 ±13,331	259,584 ±183,089	728,728 ±555,814	2,366 ±1,572	1,690 ±1,131	.4348 ±.1401	.3619 ±.1100	.1289 ±.1498	66.8000 ±32.3435	47.7142 ±37.4213
	April	294,694 ±163,589	265,034 ±144,222	281,575 ±157,165	72,797 ±19,494	855,195 ±400,000	1,462,441 ±548,403	9,126 ±3,808	7,605 ±3,256	.3445 ±.0451	.3099 ±.0381	.1812 ±.0441	38.7500 ±10.7753	32.2916 ±8.6204
	May	1,009,822 ±643,820	856,315 ±531,510	789,780 ±509,903	225,913 ±49,548	1,657,948 ±1,067,718	3,893,531 ±2,268,764	11,781 ±7,259	10,853 ±6,982	.6166 ±.0278	.5230 ±.0274	.2255 ±.0323	94.1667 ±9.7939	86.9230 ±15.5977
	June	805,815 ±328,630	657,060 ±271,112	610,360 ±247,390	131,694 ±31,938	1,393,433 ±541,299	4,326,232 ±1,857,289	10,928 ±3,975	10,575 ±3,782	.5783 ±.0729	.4715 ±.0629	.1519 ±.0261	76.2000 ±13.1063	73.7419 ±12.8977
	July	982,665 ±254,756	856,993 ±229,902	851,302 ±209,766	140,843 ±31,257	2,495,813 ±578,277	5,757,790 ±1,114,165	21,533 ±7,036	17,226 ±5,495	.3937 ±.0254	.3433 ±.0245	.1488 ±.0194	57.0454 ±8.8263	45.6363 ±6.3751
	August	1,582,443 ±839,050	1,412,924 ±742,966	1,218,251 ±602,496	240,369 ±69,282	3,081,105 ±1,392,883	5,033,907 ±1,794,369	24,665 ±9,033	18,401 ±6,277	.5136 ±.0425	.4585 ±.0369	.2807 ±.0690	86.0000 ±17.9140	64.1587 ±11.2081
	September	2,140,635 ±1,090,868	1,833,525 ±953,943	1,485,582 ±787,404	204,329 ±62,770	3,034,125 ±1,603,150	5,225,220 ±2,413,333	20,010 ±8,450	19,140 ±8,000	.7055 ±.0534	.6043 ±.0452	.3509 ±.0791	111.8409 ±15.8328	106.9784 ±15.3847
	October	3,418,531 ±1,044,054	2,886,869 ±878,640	1,919,239 ±582,239	269,239 ±66,559	4,592,117 ±1,513,274	8,268,221 ±2,651,472	29,462 ±8,124	24,552 ±6,380	.7444 ±.0950	.6287 ±.0978	.3491 ±.0151	139.2364 ±18.6461	116.0303 ±15.2111
	November	747,720 ±393,069	638,376 ±328,630	435,678 ±235,801	174,770 ±35,072	875,154 ±433,590	1,991,508 ±1,121,336	7,638 ±3,286	5,628 ±2,587	.8543 ±.0619	.7294 ±.0435	.3205 ±.0379	132.8571 ±25.1625	79.8947 ±29.0044
	December	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Total	11,318,130 ±1,949,377	9,687,602 ±1,603,150	7,976,920 ±1,333,086	- -	18,772,689 ±2,965,685	39,553,243 ±5,477,651	141,354 ±19,262	118,189 ±16,032	.5968 ±.0255	.5109 ±.0249	.2375 ±.0143	93.8591 ±5.8780	78.2607 ±4.8641

Table 4. — Some expanded totals with standard errors of catch and effort statistics calculated by year for all of the dealer-days in the survey of the commercial lobster fishery, 1966 through 1970. — Continued.

Year	Month	Catch in pounds	Catch in numbers	Value in dollars	Number of traps	Number of trap-hauls	Number of trap-haul-set-over-days	Number of man-days	Number of boat-days	Pounds per trap-haul	Numbers per trap-haul	Numbers per trap-haul-set-over-day	Pounds per boat-day	Pounds per man-day
1969	January	189,410 ±105,310	159,650 ±85,006	181,675 ±98,722	47,667 ±7,616	231,570 ±127,769	1,253,950 ±711,982	2,480 ±1,447	2,170 ±1,311	.8179 ±.2987	.6894 ±.1945	.1273 ±.0157	87.2857 ±39.7689	76.3750 ±26.1522
	February	135,274 ±135,274	113,098 ±113,098	136,626 ±136,626	74,250 ±74,250	190,159 ±190,159	1,264,032 ±1,264,032	1,940 ±1,940	1,386 ±1,386	.7114	.5948	.0895	97.6000	69.7143
	March	56,777 ±56,777	49,104 ±49,104	56,777 ±56,777	19,800 ±19,800	61,380 ±61,380	61,380 ±61,380	307 ±307	307 ±307	.9250	.8000	.8000	185.0000	160.0000
	April	340,992 ±273,127	308,358 ±247,590	337,401 ±273,006	90,576 ±19,467	640,692 ±523,637	1,722,594 ±1,320,857	5,331 ±4,275	4,662 ±3,619	.5322 ±.0188	.4813 ±.0175	.1790 ±.0123	73.1429 ±2.9836	64.0000 ±.6734
	May	571,448 ±244,307	484,040 ±212,882	425,466 ±173,385	108,838 ±29,665	1,071,155 ±528,705	4,813,603 ±2,999,330	7,834 ±3,278	7,834 ±3,278	.5335 ±.0919	.4519 ±.0775	.1006 ±.0279	72.9474 ±9.1640	72.9474 ±9.1640
	June	570,492 ±184,921	475,686 ±146,922	609,744 ±196,118	128,478 ±33,015	1,754,118 ±546,631	6,024,114 ±2,368,994	15,732 ±4,852	13,248 ±4,222	.3252 ±.0442	.2712 ±.0374	.0790 ±.0140	43.0625 ±7.0879	36.2637 ±4.5427
	July	918,257 ±274,882	769,910 ±225,285	794,406 ±237,007	132,699 ±32,818	2,242,819 ±691,001	6,410,192 ±2,239,456	18,488 ±4,989	16,728 ±4,723	.4094 ±.0456	.3433 ±.0351	.1301 ±.0232	54.8947 ±5.8979	49.6667 ±4.4392
	August	2,280,850 ±615,364	1,959,646 ±522,085	1,835,938 ±506,663	235,544 ±53,910	4,103,268 ±977,491	7,560,735 ±1,470,484	35,061 ±6,229	29,406 ±5,501	.5559 ±.0406	.4776 ±.0379	.2608 ±.0246	77.5641 ±12.5657	65.0538 ±9.2068
	September	2,288,736 ±594,988	1,951,344 ±514,745	1,754,617 ±446,254	174,053 ±35,819	2,935,008 ±675,717	6,142,608 ±1,107,088	23,328 ±4,653	21,600 ±4,554	.7798 ±.0754	.6649 ±.0574	.3177 ±.0522	105.9600 ±18.2182	98.1111 ±15.6977
	October	1,945,532 ±771,413	1,675,404 ±668,114	1,400,137 ±544,445	169,006 ±52,215	2,606,864 ±1,265,329	5,450,637 ±1,834,255	24,041 ±10,927	19,670 ±8,552	.7163 ±.0662	.6168 ±.0565	.3074 ±.0717	98.9111 ±9.6668	80.9273 ±9.5480
	November	653,952 ±320,840	572,994 ±283,108	509,835 ±254,133	79,805 ±16,324	623,691 ±252,468	1,745,313 ±799,242	7,860 ±3,564	5,502 ±2,430	1.0485 ±.2157	.9187 ±.1838	.3283 ±.0862	118.8571 ±11.7535	83.2000 ±14.9424
	December	394,841 ±250,001	329,034 ±206,064	308,177 ±198,874	122,573 ±26,686	493,371 ±294,434	4,884,087 ±3,823,999	8,630 ±6,415	6,113 ±4,013	.8003 ±.0834	.6669 ±.0447	.0674 ±.0171	64.5882 ±5.0675	45.7500 ±7.4205
	Total	10,346,561 ±1,198,703	8,848,268 ±1,143,641	8,350,799 ±1,042,744	- -	16,954,095 ±2,123,579	47,333,245 ±6,741,195	151,032 ±17,809	128,626 ±14,991	.6075 ±.0220	.5197 ±.0174	.1845 ±.0120	80.3719 ±4.6664	68.2202 ±3.9281

Table 4. — Some expanded totals with standard errors of catch and effort statistics calculated by year for all of the dealer-days in the survey of the commercial lobster fishery, 1966 through 1970. — Continued.

Year	Month	Catch in pounds	Catch in numbers	Value in dollars	Number of traps	Number of trap-hauls	Number of trap-haul-set-over-days	Number of man-days	Number of boat-days	Pounds per trap-haul	Numbers per trap-haul	Numbers per trap-haul-set-over-day	Pounds per boat-day	Pounds per man-day
1970	January													
	February													
	March													
	April	613,125 ±497,260	519,930 ±417,309	633,612 ±496,319	152,464 ±41,999	1,079,100 ±711,415	3,932,829 ±2,522,915	9,810 ±6,088	6,213 ±4,149	.5682 ±.1157	.4818 ±.0937	.1322 ±.0290	98.6842 ±17.3947	62.5000 ±14.9397
	May	506,407 ±304,807	431,684 ±261,905	403,515 ±277,020	87,167 ±22,695	985,605 ±577,615	2,301,368 ±1,300,272	8,528 ±4,081	7,716 ±3,991	.5138 ±.0276	.4380 ±.0233	.1876 ±.0202	65.6316 ±12.1260	59.3810 ±12.8731
	June	654,810 ±301,902	542,880 ±254,900	692,019 ±313,482	221,724 ±79,355	1,652,430 ±979,368	5,803,786 ±2,845,130	11,310 ±5,192	8,190 ±3,257	.3963 ±.0794	.3285 ±.0641	.0935 ±.0111	79.9524 ±10.4325	57.8966 ±2.8681
	July	934,872 ±366,178	810,273 ±323,504	818,027 ±297,602	96,744 ±25,378	1,743,644 ±653,636	3,445,629 ±970,547	13,511 ±3,761	12,385 ±3,671	.5362 ±.0433	.4647 ±.0385	.2352 ±.0496	75.4845 ±10.7637	69.1944 ±11.7195
	August	2,793,492 ±954,120	2,388,032 ±823,031	2,679,810 ±915,694	493,701 ±132,634	5,497,167 ±2,145,447	12,747,049 ±4,614,999	39,959 ±15,471	32,627 ±12,066	.5082 ±.0684	.4344 ±.0548	.1873 ±.0121	85.6180 ±8.9921	69.9083 ±8.8860
	September	3,519,180 ±1,102,616	3,008,880 ±941,856	3,336,510 ±1,091,602	377,020 ±111,787	7,341,180 ±2,661,882	15,266,580 ±5,019,245	47,040 ±14,800	40,740 ±13,297	.4794 ±.0406	.4099 ±.0354	.1971 ±.0147	86.3814 ±9.5508	74.8125 ±6.6242
	October	2,100,566 ±1,086,966	1,776,945 ±924,040	1,877,205 ±988,398	224,817 ±68,202	3,058,689 ±1,677,825	6,798,597 ±3,083,374	20,810 ±10,158	16,988 ±7,882	.6868 ±.0702	.5810 ±.0528	.2597 ±.0262	123.6500 ±14.4850	100.9388 ±11.4415
	November	3,091,353 ±1,688,659	2,598,420 ±1,408,040	2,774,544 ±1,519,247	197,866 ±67,330	2,807,589 ±1,124,201	11,579,733 ±5,691,746	25,527 ±12,182	19,812 ±8,610	1.1010 ±.2232	.9255 ±.1781	.2244 ±.0154	156.0192 ±18.8786	121.0896 ±9.2149
	December	469,492 ±307,187	412,782 ±270,382	390,824 ±254,586	107,520 ±18,715	658,137 ±422,384	4,035,621 ±2,477,801	6,944 ±4,051	5,015 ±2,900	.7134 ±.2188	.6272 ±.1912	.1023 ±.0075	93.6154 ±16.2035	67.6111 ±9.5703
	Total	14,683,297 ±2,611,329	12,489,826 ±2,210,520	13,606,066 ±2,426,908	- -	24,823,541 ±4,262,873	65,911,192 ±10,565,368	183,439 ±28,657	149,686 ±22,897	.5929 ±.0339	.5043 ±.0274	.1883 ±.0063	98.0862 ±4.5119	79.7601 ±3.3347

we sampled because lobsters shed all of their hard parts. Therefore, we should have additional corroboration on the age and growth relationship either by a tagging program (which usually creates more uncertainties because of an additional set of assumptions) or a genetic-biochemical approach such as that in studies on the aging process in humans.

Table 5. — Carapace length frequencies from cluster samples of lobsters, compiled by sex, month, and year, 1966 (partial year) through 1970.

1966																		
Carapace length (mm)	August			September			October			November			December			Total		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	4	3	7	4	7	11	2	4	6	2	4	6	-	-	-	12	18	30
82	14	11	25	17	11	28	12	13	25	7	10	17	2	-	2	52	45	97
83	10	13	23	18	19	37	10	13	23	9	9	18	4	8	12	51	62	113
84	14	9	23	13	17	30	13	22	35	14	11	25	3	4	7	57	63	120
85	12	16	28	16	15	31	13	15	28	13	11	24	3	10	13	57	67	124
86	16	16	32	14	9	23	18	22	40	11	13	24	6	6	12	65	66	131
87	19	15	34	26	21	47	15	12	27	8	19	27	6	9	15	74	76	150
88	12	11	23	15	17	32	18	13	31	10	7	17	2	10	12	57	58	115
89	25	17	42	9	9	18	13	13	26	13	12	25	4	8	12	64	59	123
90	17	25	42	14	19	33	11	22	33	13	9	22	7	5	12	62	80	142
91	18	14	32	13	25	38	13	11	24	5	3	8	5	8	13	54	61	115
92	20	19	39	18	15	33	18	15	33	5	4	9	3	6	9	64	59	123
93	16	8	24	15	17	32	13	9	22	6	3	9	2	7	9	52	44	96
94	16	12	28	15	18	33	17	19	36	7	1	8	4	5	9	59	55	114
95	12	11	23	19	10	29	11	6	17	4	4	8	-	3	3	46	34	80
96	5	5	10	6	7	13	8	1	9	1	2	3	-	-	-	20	15	35
97	6	4	10	10	6	16	1	1	2	1	-	1	-	1	1	18	12	30
98	4	2	6	5	3	8	4	3	7	3	1	4	-	-	-	16	9	25
99	4	2	6	-	1	1	2	2	4	-	1	1	-	-	-	6	6	12
100	3	1	4	2	3	5	1	-	1	-	-	-	-	1	1	6	5	11
101	1	-	1	1	1	2	2	-	2	-	-	-	-	-	-	4	1	5
102	1	-	1	1	1	2	1	-	1	-	-	-	-	-	-	3	1	4
103	-	1	1	1	1	2	-	1	1	2	-	2	-	-	-	3	3	6
104	-	-	-	2	4	6	-	3	3	-	-	-	-	1	1	2	8	10
105	-	-	-	1	-	1	-	1	1	2	-	2	-	-	-	3	1	4
106	-	-	-	2	1	3	1	-	1	-	-	-	-	-	-	3	1	4
107	-	-	-	-	1	1	-	2	2	-	-	-	-	-	-	-	3	3
108	1	2	3	3	1	4	-	-	-	-	-	-	-	-	-	4	3	7
109	1	-	1	2	-	2	-	-	-	-	-	-	-	-	-	3	-	3
110	1	2	3	1	2	3	1	2	3	-	-	-	-	1	1	3	7	10
111	2	-	2	2	-	2	-	2	2	-	-	-	-	-	-	4	2	6
112	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	2	-	2
113	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
114	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	1
115	1	-	1	-	-	-	1	-	1	-	-	-	-	-	-	2	-	2
116	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
117	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	1	1
118	-	-	-	1	1	2	-	1	1	-	-	-	-	-	-	1	2	3
119	-	1	1	1	-	1	-	1	1	-	-	-	-	-	-	1	2	3
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
124	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1
125	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	257	223	480	268	262	530	220	230	450	136	124	260	52	93	145	933	932	1865

Table 5. — Carapace length frequencies from cluster samples of lobsters, compiled by sex, month, and year, 1966 (partial year) through 1970. — Continued.

1967

Carapace length (mm)	January			February			March			April			May			June		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	-	-	-	-	1	1	-	-	-	-	-	-	3	4	7	6	-	6
82	-	-	-	1	4	5	1	1	2	-	-	-	11	16	27	7	10	17
83	8	17	25	5	3	8	6	4	10	3	4	7	13	14	27	13	11	24
84	4	10	14	3	8	11	4	5	9	4	3	7	21	15	36	10	14	24
85	4	7	11	10	7	17	2	3	5	1	5	6	9	20	29	14	9	23
86	1	2	3	1	3	4	5	-	5	4	4	8	9	13	22	7	8	15
87	7	12	19	3	7	10	2	3	5	3	1	4	16	11	27	11	8	19
88	4	6	10	4	4	8	1	1	2	-	2	2	11	13	24	5	4	9
89	5	3	8	2	5	7	3	4	7	2	-	2	4	12	16	10	4	14
90	5	1	6	6	4	10	4	3	7	2	2	4	7	9	16	8	15	23
91	6	7	13	2	1	3	2	1	3	1	1	2	9	14	23	10	17	27
92	5	4	9	1	1	2	4	4	8	1	-	1	18	4	22	7	6	13
93	4	3	7	1	2	3	3	1	4	2	3	5	4	4	8	9	3	12
94	4	5	9	1	-	1	2	2	4	2	2	4	6	4	10	10	7	17
95	3	3	6	3	1	4	3	1	4	-	1	1	2	2	4	6	3	9
96	1	-	1	-	-	-	-	-	-	-	-	-	1	2	3	1	2	3
97	1	2	3	-	-	-	-	-	-	1	1	2	2	3	5	3	1	4
98	3	1	4	-	-	-	-	-	-	-	1	1	-	-	-	1	2	3
99	-	2	2	-	-	-	-	1	1	-	1	1	-	-	-	1	-	1
100	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
101	1	-	1	-	-	-	-	-	-	-	-	-	2	-	2	-	2	2
102	-	-	-	-	-	-	1	-	1	-	-	-	4	1	5	1	2	3
103	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	2	-	2
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
105	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1
106	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	1	1	2
107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
108	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
109	-	-	-	1	-	1	-	1	1	1	-	1	-	-	-	-	-	-
110	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1	1	2	3
111	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1
112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
117	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	69	87	156	45	51	96	44	36	80	27	32	59	154	166	320	147	133	280

Carapace length (mm)	July			August			September			October			November			December			Total		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
81	2	-	2	4	4	8	3	3	6	2	2	4	2	1	3	5	4	9	27	19	46
82	3	3	6	9	11	20	4	4	8	11	10	21	9	9	18	8	6	14	64	74	138
83	4	6	10	10	17	27	8	7	15	9	7	16	7	7	14	11	12	23	97	109	206
84	6	6	12	9	12	21	13	8	21	10	5	15	9	14	23	7	11	18	100	111	211
85	5	4	9	11	11	22	10	17	27	12	9	21	11	19	30	11	14	25	100	125	225
86	3	5	8	11	12	23	8	9	17	8	8	16	9	10	19	11	17	28	77	91	168
87	5	10	15	12	8	20	11	9	20	2	9	11	10	14	24	10	17	27	92	109	201
88	3	5	8	8	4	12	11	8	19	12	10	22	8	8	16	12	12	24	79	77	156
89	3	6	9	6	7	13	15	10	25	8	8	16	8	9	17	4	12	16	70	80	150
90	-	6	6	9	10	19	21	8	29	7	7	14	12	20	32	14	19	33	95	104	199
91	-	2	2	7	8	15	7	13	20	11	4	15	10	15	25	10	8	18	75	91	166
92	10	2	12	10	4	14	12	6	18	12	13	25	10	13	23	6	5	11	96	62	158
93	2	3	5	5	4	9	9	5	14	8	6	14	6	7	13	6	5	11	59	46	105
94	5	6	11	8	5	13	9	1	10	6	4	10	2	5	7	2	2	4	57	43	100
95	6	2	8	3	2	5	12	4	16	7	1	8	4	2	6	2	1	3	51	23	74
96	1	2	3	5	1	6	1	-	1	2	1	3	3	1	4	1	-	1	16	9	25
97	-	-	-	1	-	1	1	1	2	1	1	2	-	1	1	-	-	-	10	10	20
98	2	-	2	2	-	2	-	2	2	1	-	1	-	-	-	1	1	2	10	7	17
99	-	-	-	-	2	2	-	2	2	1	-	1	1	-	1	-	1	1	3	11	14
100	-	-	-	1	1	2	-	-	-	-	1	1	-	-	-	-	1	1	2	3	5
101	1	1	2	-	-	-	-	2	2	3	-	3	1	2	3	-	1	1	8	8	16
102	-	2	2	1	2	3	-	-	-	1	1	2	-	-	-	-	1	1	8	9	17
103	2	1	3	-	-	-	1	1	2	1	-	1	-	-	-	-	-	-	7	3	10
104	1	-	1	-	-	-	1	-	1	1	2	3	-	-	-	-	-	-	4	3	7
105	2	2	4	1	-	1	1	1	2	-	-	-	2	1	3	-	-	-	7	5	12
106	-	-	-	-	1	1	1	-	1	-	-	-	1	-	1	-	1	1	3	5	8
107	1	2	3	-	-	-	-	1	1	-	1	1	-	1	1	-	-	-	1	6	7
108	-	-	-	-	-	-	2	1	3	-	-	-	-	-	-	-	-	-	2	2	4
109	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1	4	1	5
110	2	-	2	-	-	-	2	-	2	-	1	1	1	-	1	-	-	-	8	3	11
111	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	3	4
112	1	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	2
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1
114	1	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	2	-	2
115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
116	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	1	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	-	2
120	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	2	-	2
121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	1	-	1	-	-	-	-	1	1	-	-	-	1	1	2
126	1	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	2	-	2
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	74	76	150	133	126	259	166	124	290	137	113	250	128	162	290	122	152	274	1246	1258	2504

Table 5. — Carapace length frequencies from cluster samples of lobsters, compiled by sex, month, and year, 1966 (partial year) through 1970. — Continued.

1968

Carapace length (mm)	January			February			March			April			May			June			July			August			September			October			November			December			Total		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	1
81	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	4	6	10	7	5	12	3	1	4	12	11	23	22	23	45	2	1	3	-	-	-	50	48	98
82	1	2	3	-	2	2	2	4	6	6	4	10	4	8	12	9	6	15	19	12	31	8	3	11	12	12	24	17	12	29	6	8	14	-	-	-	84	73	157
83	3	1	4	2	2	4	-	3	3	6	9	15	5	3	8	9	9	18	9	5	14	13	7	20	11	22	33	21	9	30	2	6	8	-	-	-	81	76	157
84	-	1	1	1	2	3	2	3	5	9	16	25	14	10	24	7	12	19	17	9	26	12	14	26	14	7	21	12	17	29	6	10	16	-	-	-	94	101	195
85	2	6	8	1	2	3	-	2	2	10	12	22	11	15	26	13	13	26	17	16	33	15	23	38	11	10	21	18	24	42	7	11	18	-	-	-	105	134	239
86	1	1	2	2	-	2	-	3	3	13	9	22	12	12	24	9	10	19	7	13	20	12	17	29	12	14	26	23	17	40	4	4	8	-	-	-	95	100	195
87	-	-	-	1	2	3	2	2	4	6	4	10	13	16	29	5	14	19	13	14	27	17	6	23	17	14	31	17	18	35	4	4	8	-	-	-	95	94	189
88	1	2	3	2	1	3	3	3	6	5	4	9	7	5	12	7	5	12	11	12	23	16	19	35	21	16	37	11	14	25	3	6	9	-	-	-	87	87	174
89	-	-	-	-	1	1	1	-	1	10	5	15	10	9	19	10	7	17	13	8	21	12	13	25	12	12	24	8	13	21	3	2	5	-	-	-	79	70	149
90	2	5	7	1	1	2	1	1	2	7	8	15	5	6	11	13	4	17	17	9	26	25	24	49	10	13	23	17	23	40	7	7	14	-	-	-	105	101	206
91	1	1	2	-	-	-	3	1	4	6	2	8	10	6	16	8	11	19	11	8	19	22	19	41	13	16	29	11	19	30	3	5	8	-	-	-	88	88	176
92	1	2	3	2	2	4	1	3	4	4	4	8	12	9	21	11	10	21	11	4	15	13	17	30	8	10	18	11	16	27	2	2	4	-	-	-	76	79	155
93	1	-	1	2	-	2	1	-	1	2	5	7	1	5	6	4	5	9	7	6	13	13	8	21	6	12	18	6	8	14	4	1	5	-	-	-	47	50	97
94	1	-	1	-	1	1	-	-	-	3	6	9	4	2	6	8	5	13	11	7	18	17	6	23	8	8	16	6	3	9	3	2	5	-	-	-	61	40	101
95	-	-	-	1	-	1	-	1	1	2	1	3	3	6	9	4	4	8	3	8	11	9	3	12	7	3	10	5	4	9	2	2	4	-	-	-	36	32	68
96	-	-	-	-	-	-	-	1	1	-	-	-	1	-	1	4	-	4	3	1	4	3	2	5	5	4	9	4	3	7	-	1	1	-	-	-	20	12	32
97	-	1	1	-	-	-	-	-	-	1	-	1	1	1	2	-	2	2	1	1	2	-	2	2	2	1	3	1	2	3	-	1	1	-	-	-	6	11	17
98	-	-	-	-	1	1	-	1	1	1	-	1	-	-	-	2	-	2	5	1	6	2	1	3	2	1	3	-	2	2	-	1	1	-	-	-	12	8	20
99	-	-	-	1	1	2	-	-	-	-	1	1	1	1	2	1	2	3	3	2	5	2	2	4	-	1	1	1	-	1	-	-	-	-	-	-	9	10	19
100	-	-	-	-	1	1	-	-	-	1	-	1	-	-	-	2	3	5	3	1	4	1	-	1	3	2	5	-	1	1	1	1	2	-	-	-	11	9	20
101	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1	-	-	-	-	-	-	-	1	1	1	2	3	1	-	1	-	-	-	-	-	-	3	4	7
102	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	2	4
103	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	2	1	-	1	-	2	2	-	3	3	-	1	1	-	-	-	-	-	-	1	9	10
104	-	-	-	-	1	1	-	-	-	1	-	1	-	-	-	-	3	3	-	-	-	-	-	-	1	1	2	1	-	1	2	-	2	-	-	-	5	5	10
105	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2	2	4	1	1	2	-	2	2	-	-	-	1	-	1	-	1	1	-	-	-	5	6	11
106	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	1	1	2	-	1	1	1	-	1	-	1	1	1	1	2	-	1	1	-	-	-	5	5	10
107	-	-	-	-	2	2	-	-	-	-	-	-	1	-	1	-	-	-	2	-	2	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	4	2	6
108	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	1	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	3	4
109	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1	-	-	-	1	-	1	1	-	1	-	-	-	-	-	-	4	1	5
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	1	-	1	-	-	-	1	2	3
111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	3	-	3
112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
115	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	4
116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
117	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-	1	1	-	-	-	-	1	1	1	-	1	-	-	-	-	-	-	1	4	5
118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	1	2
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	(132)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Totals	15	22	37	16	24	40	16	28	44	93	93	186	120	116	236	139	139	278	198	149	347	216	194	410	191	199	390	219	231	450	62	78	140	-	-	-	1285	1273	2558

Table 5. — Carapace length frequencies from cluster samples of lobsters, compiled by sex, month, and year, 1966 (partial year) through 1970. — Continued.

1969																																							
Carapace length (mm)	January			February			March			April			May			June			July			August			September			October			November			December			Total		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
81	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	5	6	11	5	2	7	12	11	23	3	7	10	5	5	10	-	1	1	-	-	-	32	32	64
82	2	1	3	2	1	3	1	-	1	-	5	5	3	7	10	6	17	23	8	9	17	30	17	47	11	11	22	11	19	30	2	1	3	3	1	4	79	89	168
83	4	5	9	-	1	1	-	-	-	7	11	18	7	7	14	9	15	24	9	7	16	30	15	45	12	12	24	24	10	34	4	7	11	4	6	10	110	96	206
84	5	7	12	3	4	7	-	-	-	9	9	18	3	10	13	8	5	13	13	10	23	31	26	57	19	12	31	11	12	23	4	8	12	9	6	15	115	109	224
85	1	7	8	2	5	7	-	-	-	3	4	7	10	9	19	10	12	22	16	15	31	27	26	53	9	14	23	21	20	41	4	9	13	8	11	19	111	132	243
86	1	1	2	2	2	4	-	-	-	8	6	14	6	11	17	13	9	22	10	14	24	21	18	39	19	20	39	12	15	27	6	8	14	5	10	15	103	114	217
87	3	2	5	-	3	3	-	1	1	2	10	12	5	9	14	10	13	23	11	15	26	29	25	54	13	14	27	9	17	26	2	9	11	6	5	11	90	123	213
88	2	5	7	-	4	4	-	-	-	5	3	8	3	10	13	10	10	20	11	9	20	21	21	42	12	10	22	11	18	29	2	5	7	5	5	10	82	100	182
89	-	2	2	1	2	3	-	-	-	10	6	16	7	8	15	8	11	19	15	11	26	21	25	46	17	17	34	14	14	28	2	5	7	6	3	9	101	104	205
90	4	4	8	-	1	1	-	2	2	2	4	6	5	7	12	12	13	25	16	15	31	23	24	47	24	12	36	28	15	43	6	8	14	3	10	13	123	115	238
91	3	1	4	-	2	2	-	1	1	6	1	7	1	4	5	9	7	16	9	7	16	13	20	33	12	15	27	13	18	31	4	7	11	1	7	8	71	90	161
92	2	2	4	1	1	2	2	2	4	3	6	9	6	5	11	12	8	20	8	7	15	18	12	30	12	12	24	20	12	32	4	2	6	7	4	11	95	73	168
93	3	-	3	-	1	1	1	-	1	4	2	6	3	9	12	7	12	19	4	10	14	21	11	32	9	10	19	12	12	24	1	2	3	4	5	9	69	74	143
94	-	-	-	2	3	5	-	-	-	3	2	5	2	4	6	5	7	12	12	11	23	13	9	22	8	10	18	20	10	30	1	8	9	1	5	6	67	69	136
95	-	2	2	1	2	3	-	-	-	1	2	3	2	3	5	5	6	11	4	7	11	9	1	10	6	10	16	9	10	19	1	5	6	2	4	6	40	52	92
96	-	-	-	-	1	1	-	-	-	2	1	3	-	3	3	1	5	6	5	3	8	6	6	12	7	3	10	7	1	8	-	1	1	3	4	7	31	28	59
97	-	-	-	-	-	-	-	-	-	1	1	2	-	1	1	1	3	4	2	4	6	3	1	4	5	1	6	-	2	2	1	-	1	1	2	3	14	15	29
98	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	2	1	1	2	2	1	3	-	2	2	1	-	1	1	-	1	-	1	1	6	7	13
99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	2	-	1	1	-	1	1	-	-	-	-	3	3	-	8	8
100	-	-	-	-	-	-	-	-	-	-	1	1	1	3	4	2	1	3	2	1	3	3	4	7	-	1	1	-	2	2	-	-	-	-	2	2	8	15	23
101	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	1	3	-	1	1	1	1	2	2	-	2	-	-	-	1	2	3	7	5	12
102	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2	-	2	-	1	1	2	2	4	-	-	-	-	1	1	1	-	1	7	4	11
103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	1	-	1	-	-	-	-	-	-	1	-	1	4	-	4
104	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	1	1	2	1	1	2	1	-	1	-	-	-	1	-	1	1	-	1	1	1	2	7	4	11
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	2	1	3	-	1	1	1	-	1	-	-	-	1	-	1	-	-	-	6	2	8
106	-	-	-	-	1	1	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1	-	-	-	2	-	2	1	-	1	-	-	-	-	-	-	5	1	6
107	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	1	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	1	3	4
108	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2
109	-	-	-	-	1	1	-	-	-	-	-	-	1	-	1	1	1	2	1	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	3	3	6
110	-	-	-	-	1	1	-	-	-	-	-	-	1	-	1	1	1	2	2	-	2	-	-	-	1	-	1	-	1	1	-	1	1	1	-	1	6	4	10
111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
112	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	1	1	-	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	2	2	4
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	1	2	-	-	-	-	-	-	-	-	-	2	1	3
114	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1	2
115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	2	1	3
116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	1	-	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	2	2	4
117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1	-	-	-	-	-	-	2	-	2
122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	1
124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	2	-	2
126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	31	39	70	14	36	50	4	6	10	66	74	140	75	113	188	143	166	309	175	163	338	340	281	621	208	202	410	235	215	450	47	89	136	73	97	170	1411	1481	2892

Table 5. — Carapace length frequencies from cluster samples of lobsters, compiled by sex, month, and year, 1966 (partial year) through 1970. — Continued.

1970

Carapace length (mm)	January			February			March			April			May			June		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80										-	-	-	-	-	-	-	-	-
81										1	3	4	1	2	3	-	-	-
82										-	2	2	-	1	1	2	1	3
83										4	7	11	5	11	16	10	9	19
84										4	11	15	5	8	13	17	10	27
85										10	7	17	7	9	16	6	11	17
86										13	3	16	9	7	16	7	4	11
87										7	6	13	7	3	10	10	7	17
88										6	11	17	3	2	5	2	6	8
89										3	9	12	6	11	17	3	6	14
90										6	8	14	2	6	8	7	3	10
91										3	13	16	9	7	16	4	5	9
92										5	5	10	4	10	14	10	10	20
93										-	3	3	4	8	12	4	4	8
94										2	5	7	6	4	10	5	6	11
95										-	4	4	2	3	5	8	5	13
96										2	2	4	1	2	3	4	3	7
97										1	2	3	3	5	8	1	-	1
98										-	3	3	4	-	4	1	1	2
99										2	1	3	-	-	-	-	-	-
100										1	1	2	-	1	1	-	2	2
101										-	-	-	1	-	1	-	-	-
102										-	-	-	1	1	2	-	-	-
103										-	-	-	-	-	-	1	-	1
104										-	1	1	1	-	1	-	1	1
105										-	-	-	1	-	1	1	2	3
106										-	-	-	-	-	-	1	-	1
107										-	-	-	-	-	-	1	-	1
108										-	1	1	-	-	-	-	-	-
109										-	-	-	-	-	-	1	-	1
110										2	-	2	-	2	2	-	-	-
111										-	-	-	-	-	-	-	-	-
112										-	-	-	-	-	-	-	-	-
113										-	-	-	-	-	-	-	-	-
114										-	-	-	-	-	-	-	-	-
115										-	-	-	-	-	-	-	-	-
116										-	-	-	-	-	-	-	-	-
117										-	-	-	-	-	-	-	-	-
118										-	-	-	-	-	-	-	-	-
119										-	-	-	-	-	-	-	-	-
120										-	-	-	-	-	-	-	-	-
121										-	-	-	-	-	-	1	-	1
122										-	-	-	-	-	-	-	-	-
123										-	-	-	-	-	-	-	-	-
124										-	-	-	-	-	-	-	-	-
125										-	-	-	-	-	-	-	-	-
126										-	-	-	-	-	-	-	-	-
127										-	-	-	-	-	-	-	-	-
128										-	-	-	-	-	-	-	-	-
129										-	-	-	-	-	-	-	-	-
Totals										72	108	180	82	103	185	112	96	208

Carapace length (mm)	July			August			September			October			November			December			Total		
	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals	Males	Females	Totals
80	-	-		-	1	1	-	-	-	1	-	1	-	1	1	-	-	-	1	2	3
81	-	-		2	1	3	1	-	1	7	2	9	1	3	4	1	-	1	14	11	25
82	4	6	10	13	15	28	14	8	22	12	9	21	22	14	36	2	1	3	69	57	126
83	11	8	19	24	22	46	21	15	36	5	4	9	12	13	25	3	5	8	95	94	189
84	11	15	26	38	40	78	39	47	86	14	20	34	22	23	45	6	5	11	156	179	335
85	9	12	21	33	30	63	37	27	64	17	12	29	18	20	38	3	9	12	140	137	277
86	12	3	15	30	23	53	32	54	86	13	19	32	13	13	26	5	9	14	134	135	269
87	12	10	22	36	26	62	25	36	61	18	15	23	15	20	35	9	3	12	139	126	265
88	5	8	13	20	13	33	25	23	48	6	7	13	16	14	30	1	6	7	84	90	174
89	9	6	15	32	41	73	38	26	64	10	16	26	20	27	47	5	3	8	131	145	276
90	7	10	17	47	33	80	36	41	77	22	21	43	25	24	49	3	8	11	155	154	309
91	8	8	16	25	22	47	28	35	63	17	14	31	13	17	30	7	1	8	114	122	236
92	8	10	18	30	23	53	44	22	66	9	12	21	15	11	26	2	6	8	127	109	236
93	6	6	12	30	22	52	27	26	53	7	11	18	9	13	22	1	2	3	88	95	183
94	7	8	15	40	33	73	34	31	65	15	14	29	10	14	24	7	5	12	126	120	246
95	7	3	10	25	16	41	23	8	31	5	6	11	6	11	17	1	-	1	77	56	133
96	2	2	4	20	7	27	19	9	28	3	3	6	5	3	8	-	-	-	56	31	87
97	3	1	4	10	9	19	13	6	19	1	2	3	-	6	6	2	-	2	34	31	65
98	2	3	5	9	1	10	8	2	10	1	3	4	3	3	6	-	-	-	28	16	44
99	-	2	2	3	-	3	3	1	4	-	2	2	4	1	5	1	-	1	13	7	20
100	1	1	2	5	2	7	-	3	3	2	1	3	1	1	2	2	-	2	12	12	24
101	-	-		1	-	1	1	3	4	-	-	-	3	2	5	1	-	1	7	5	12
102	-	1	1	1	2	3	2	1	3	2	1	3	2	2	4	-	-	-	8	8	16
103	-	1	1	-	1	1	1	2	3	1	-	1	1	1	2	-	-	-	4	5	9
104	1	-	1	-	-	-	1	-	1	1	-	1	-	-	-	-	-	-	4	2	6
105	2	1	3	3	1	4	3	-	3	-	2	2	3	1	4	-	-	-	13	7	20
106	-	1	1	-	-	-	1	-	1	1	-	1	1	3	4	-	-	-	4	4	8
107	-	1	1	1	-	1	-	1	1	1	-	1	2	-	2	1	-	1	6	2	8
108	-	-	-	-	-	-	-	1	1	1	-	1	-	1	1	1	-	1	2	3	5
109	3	1	4	2	-	2	1	2	3	-	-	-	-	2	2	-	1	1	7	6	13
110	-	-	-	4	-	4	2	-	2	1	-	1	1	2	3	-	-	-	10	4	14
111	1	-	1	-	-	-	1	-	1	-	-	-	2	2	4	-	-	-	4	2	6
112	-	-	-	2	-	2	-	-	-	1	-	1	1	-	1	-	-	-	4	-	4
113	-	-	-	1	-	1	2	-	2	-	-	-	-	-	-	-	-	-	3	-	3
114	1	1	2	-	-	-	-	-	-	-	-	-	2	-	2	-	1	1	3	2	5
115	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-	1
116	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
117	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1
121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1
124	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	2	-	2
127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	132	130	262	488	385	873	483	431	914	194	196	390	251	268	519	64	66	130	1878	1783	3661

In addition to the expressed deficiencies, there is a disturbing hypothesis that all lobsters regardless of sex in any given age or molt class may not shed in each year (Wilder, 1953 and Cooper, 1970). It follows then that it would be meaningless to proceed further with estimates from length frequencies of the needed population parameters on age and growth and mortalities. However, if we accept the possibility of a fairly constant percentage of an age or molt class shedding each year over two or more years, then we have not affected the estimates from the 14% groupings that we need. In fact, Taylor (1948) stated a similar premise in connection with converting length groups to age groups.

If the constant percentage premise were not the case, I would expect the 14% increments of carapace length compiled on a monthly and yearly basis to be extremely erratic in relation to each other. Of course, there are other factors which might influence the fluctuations in percentage from period to period, such as sample size, effort, and year class strength. Nevertheless, these fluctuations do not mask certain characteristic patterns in the size composition of the catch (Fig. 6). That is, from year to year there is usually a gradual increase in the percent frequency of the groupings from 81 through 92 mm for males, and for females from August through December in each year. Conversely, these same years and groupings usually display a gradual descendency from April through June. In this case, I believe, the length frequencies adequately portray the pattern of the size or molt composition of the commercial population before and after shedding.

In fact, the section on catch and effort supports the concept of shedding and resultant recruitment influencing the length composition of the catch. That is, as the monthly catch-per-unit-of-effort values decline (April through June) with increasing effort, the length frequencies by 14% groupings from 81 through 92 mm also decline by month until shedding and resultant recruitment occurs in July and subsequent months; then the catch-per-unit-of-effort values increase as usually does the percentage of carapace lengths from 81 through 92 mm.

We are also able to make general statements about the fishery from these length frequencies. For example, in the coastal waters of Maine at least 60% (usually 80% or more) of the catch by size and month occurs from 81- (3-3/16 inches) through 92-mm (3-5/8 inches) carapace length. Even if we accept the possibility of a segment of lobsters not shedding (at least in the legal size range), the lobster industry would be in immediate economic ruin because it appears that most animals are caught soon after recruitment from the sublegal to legal size through shedding.

I am compelled to note here that it is almost inconceivable to work on a commercial, long-lived species whereby over 80% of the *yearly* catch is constrained within ½-inch interval in carapace length.

Analysis by probability paper. — Keeping to the advisability of analyzing length frequencies in different ways, we used probability paper to pick out modes from the accumulative percentages of carapace lengths of lobsters that are captured by commercial and research gear. The combination of the two types of sampling allowed us to subject a wider range of lobster lengths to the probability method described by Harding (1949) and Cassie (1954).

In this method, gear selectivity should be considered for the two types of sampling because this factor alone may have an effect on the location of the modes. Krouse (1971, see footnote 3.) determined that wire traps (1- × 2-inch and 1- × 1-inch mesh) have a selective range down to at least 50-mm carapace length and that lobsters appear to be fully vulnerable between 68- and 70-mm carapace length. As discussed previously, the commercial gear possibly has a selective range below the minimum legal size while the commercial-sized lobsters appear to be fully vulnerable at 85-mm carapace length. This mode might also coincide with an assumed age or molt class. To support this contention, we found a similar mode for the catch from research sampling gear (Krouse, 1971, see footnote 3.) It seems unlikely that this similar mode in length frequencies from research and commercial gear would occur by chance.

The length frequencies by sex of the commercial catch are similar; therefore, we combined these data for the probability analysis. To further examine the assumption regarding the similarity of the size composition between the sexes, we simply plotted the accumulative percent frequencies by sex on probability paper by month and then year. The inflexion points are approximately the same, indicating that the probability method would yield almost identical modes.

At first this situation seems to be in conflict with the expectation that mature females extrude their eggs in one year and usually carry them externally into the next year before these eggs hatch and the female possibly molts. The elapsed time for nonshedding of mature females could be 18 or more months. Therefore, with a certain percentage of males shedding each year and a regulation protecting "v" notched or berried females, there should be a difference in the size composition between males and females. The section on berried female measurements helps to explain this apparent anomaly, in that those length-frequency data lead me to believe that the majority of native females are caught before they extrude eggs. This situation could account for the similarity in the length frequencies by sex in the commercial catch.

The probability method on the length frequencies of the commercial catch by year revealed similar curves for 1967, 1968, 1969, and 1970 (Fig. 7). With this similarity, we should expect the resultant modes in millimeters (carapace length) to be approximately the same from year to year (Table 6).

As mentioned earlier, we calculated an average of 8% per molt from laboratory animals. The consecutive probability modes from the commercial catch do compare favorably with this 8% increment. For example, in 1967 the percent increments between modes are: 7.1%, 6.6%, 8.2%, and 5.7% while in 1970 the percent increments are: 8.3%, 4.4%, 11.6%, and 3.8%.

I am reluctant to postulate that these consecutive increments actually portray the growth pattern between age groups of lobsters in the commercial catch. Still, these consecutive modes may be the result of some situation that I have overlooked. Confounding the problem even more, these modes give logical estimates of mortality and of parameters in the von Bertalanffy Growth Equation.

Comparison of 14% increments with probability modes. — The consecutive modes from the probability analysis do not fall within the successive ranges of 14% groupings in length. However, we reasoned that it is unlikely for the initial sizes of the range in length about the 84- to 85-mm probability mode (assumed age or molt class) to begin at the legal minimum size of 81-mm carapace length. In fact, three standard deviations about the 84- to 85-mm probability mode extends the size well below 81 mm. Coupled with this, there could be a range of sizes of a sublegal assumed age or molt class extending into the protected size range of the probability mode at 85 mm. If this were true, then we would have a conglomerate of assumed age and molt classes in subsequent years in the commercial fishery.

Undaunted by this seemingly incongruous situation, we attempted to follow the 85-mm mode and its protected and unprotected size range by approximate 14% increments from 1967 through 1969. This increase should be the result of shedding. Therefore, the 85-mm mode in 1967 might result in a mode at 97 mm in 1968 while the protected size ranges of this or another assumed molt class might move from the sublegal sizes in 1967 to produce a mode at 91 mm in 1968. The 97-mm mode in 1968 might move to 113 mm in 1969, while the mode at 91 mm in 1968 might move to 102 mm in 1969.

If this were the actual situation, then the modes from the probability analysis do agree with the 14% groupings (listed in parentheses) in the following manner: 85-mm mode (81-92 mm), 97-mm mode (93-106 mm), and 111-mm mode (107-122 mm). The additional modes near 91 and 105 mm could be the result of the minimum size regulation.

Viewing the relationship between the two techniques in another way, we hypothesized that the 14% grouping from 81 through 92 mm includes two probability modes at 85 and 91 mm; the grouping from 93 through 106 mm includes two probability modes at 97 and 105 mm; the grouping, with a small sample size, from 107 through 122 mm includes a probability mode near 111 mm. Then this com-

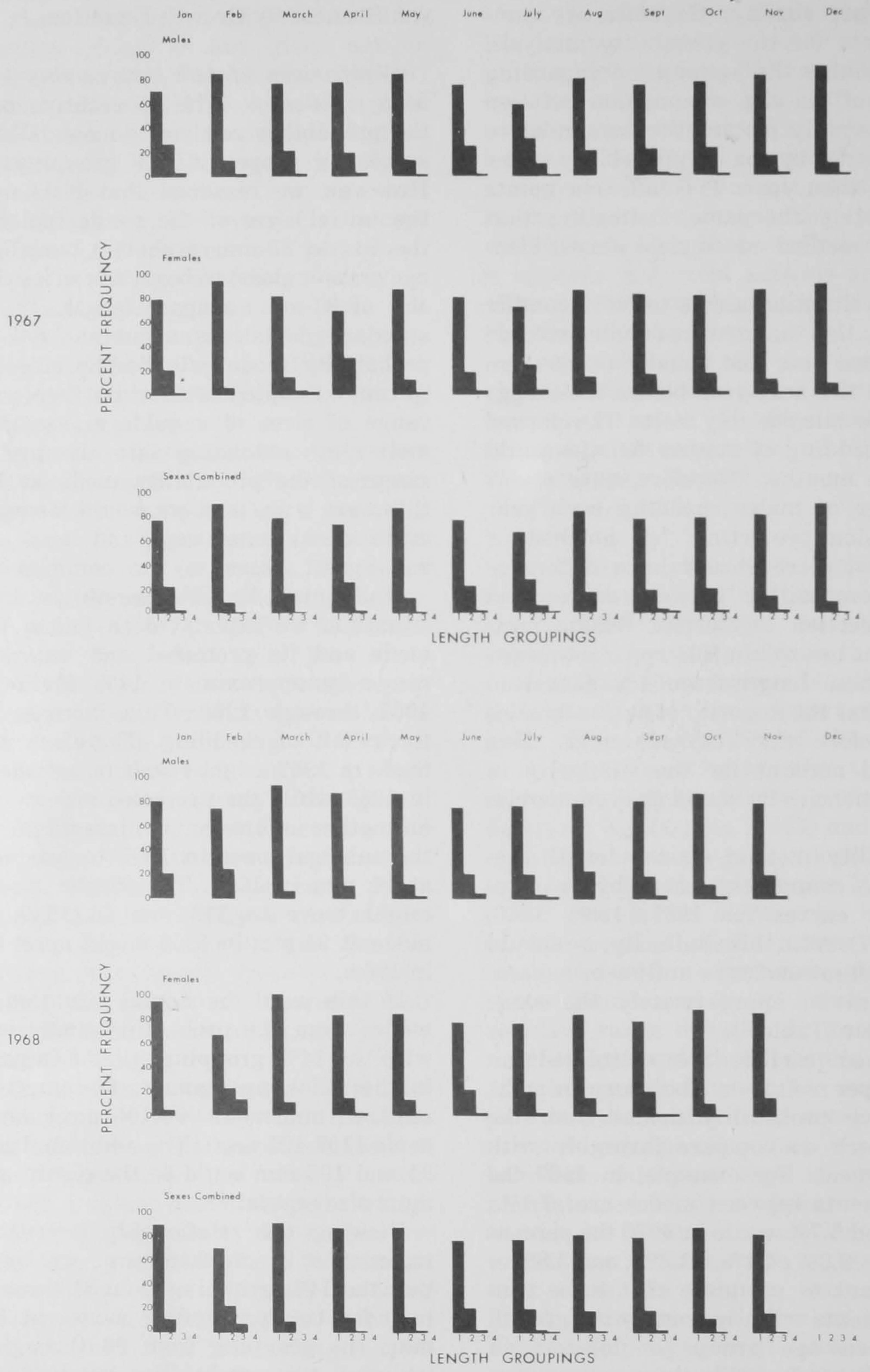
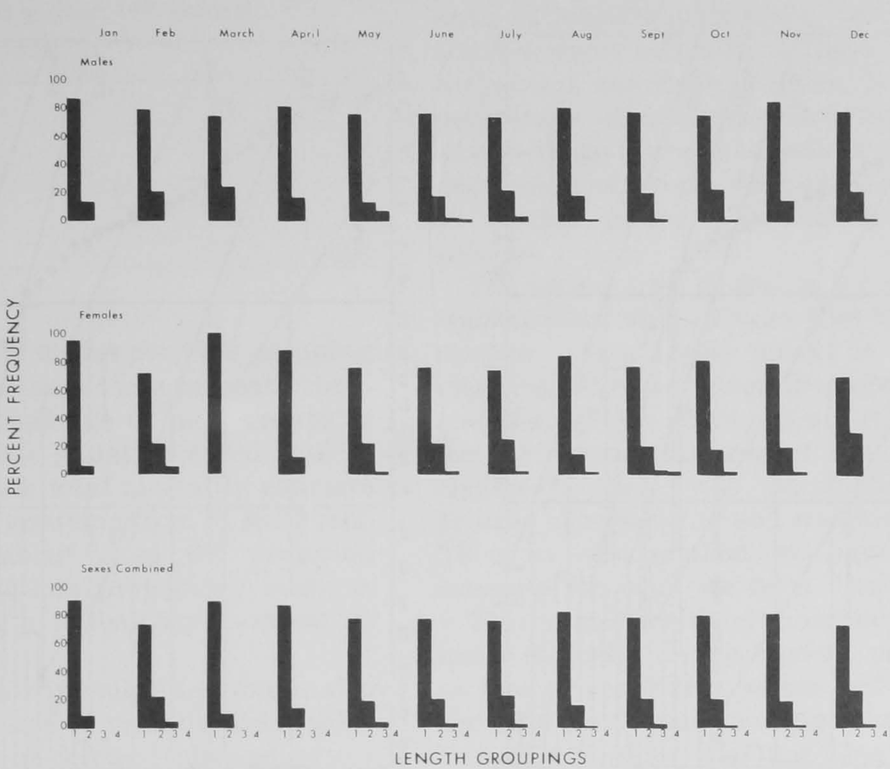
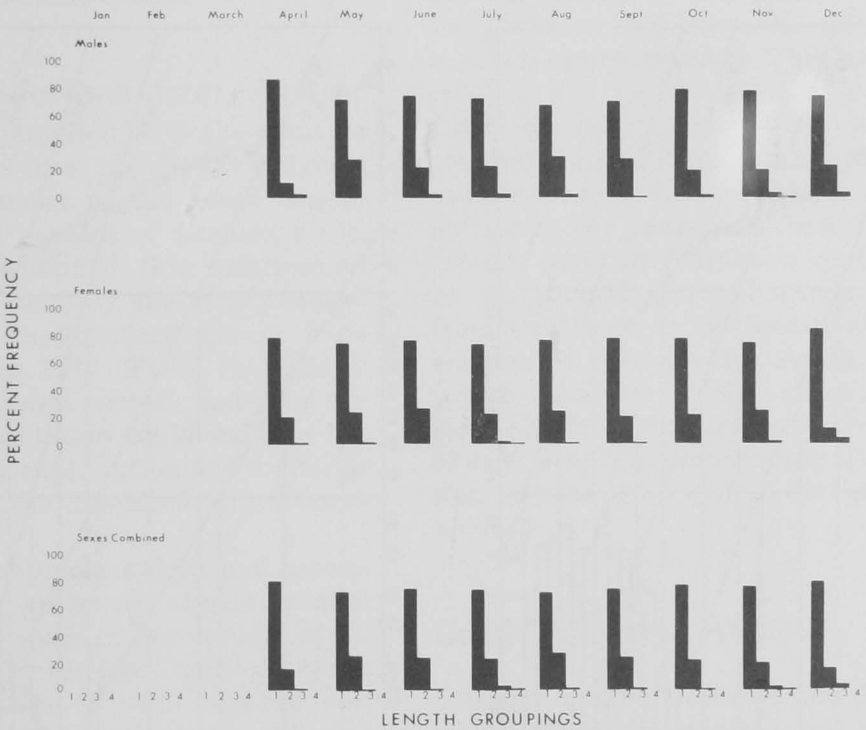


Figure 6. — Carapace length groupings of approximately 14%, compiled on a percent frequency basis by sex, month, and year, 1967 through 1970. The groupings with inclusive carapace lengths in parentheses are: 1 (81-92 mm) and 2 (93-106 mm), this page; 3 (107-122 mm) and 4 (123-127 mm), opposite page.

1969


Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Males
Females
Sexes Combined
PERCENT FREQUENCY
0
20
40
60
80
100
1 2 3 4
LENGTH GROUPINGS

1970


Jan
Feb
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Oct
Nov
Dec
Males
Females
Sexes Combined
PERCENT FREQUENCY
0
20
40
60
80
100
1 2 3 4
LENGTH GROUPINGS

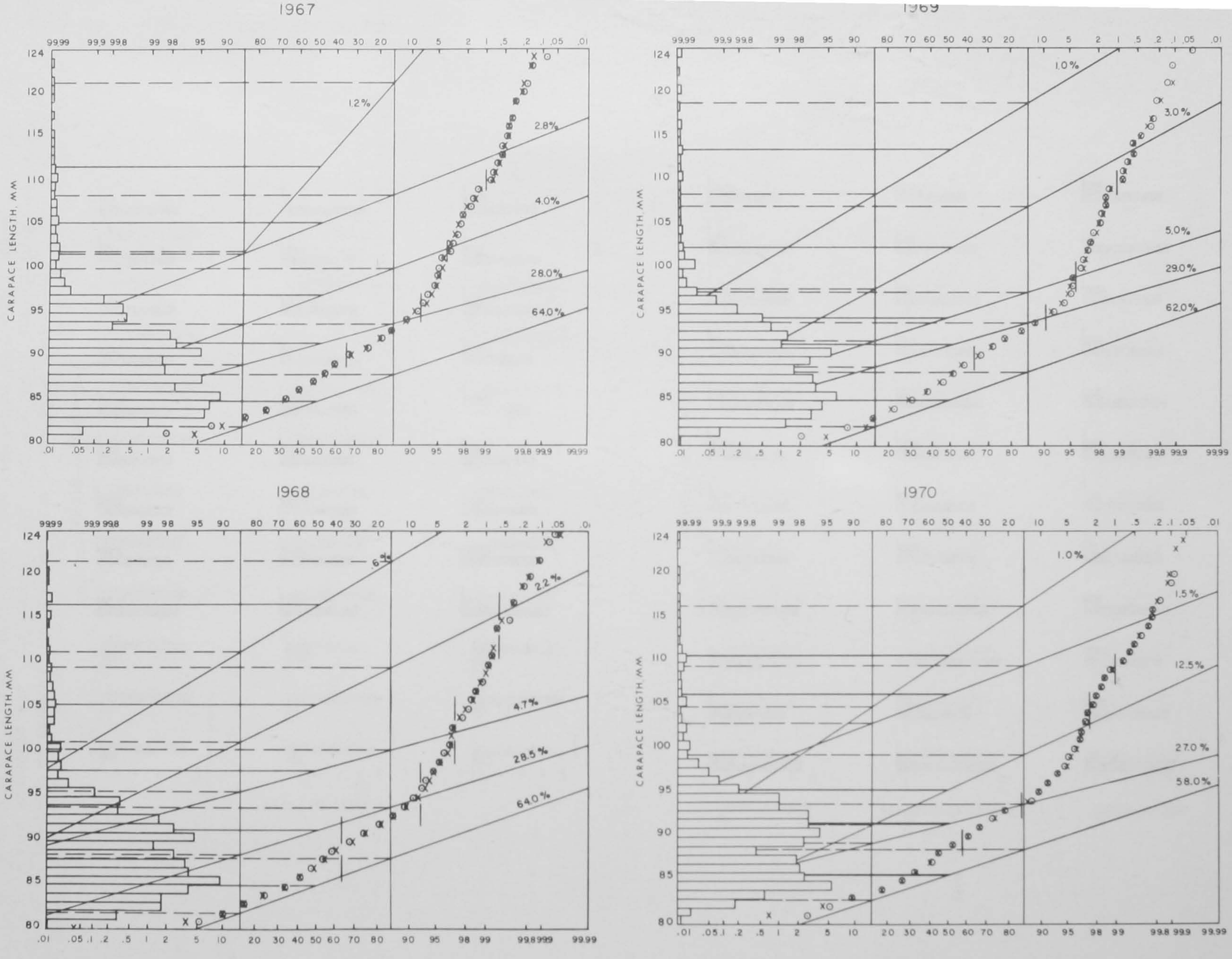

Figure 7. — Accumulative percentages of lobster length plotted on probability paper by year, 1967 through 1970. Solid lines from the length frequencies on the ordinate to the oblique line crossing the 50 accumulative percent line on the abscissa designate the modes while the dash lines represent the standard deviation about this mode.

Table 6. — Modes from probability analysis of length frequencies, compiled by year, 1967 through 1970.

Number of modes	1967	1968	1969	1970
1.	85	85	85	84
2.	91	91	91	91
3.	97	97	94	95
4.	105	105	102	106
5.	111	116	113	110

bination of probability modes per 14% grouping supports the premise that these percent groupings represent assumed age or molt groups in a year. However, this situation could lead to some anomalies in the total mortality estimate within years for the grouping from 81 to 92 mm. This could come about from the protected size range of the 85-mm probability mode in one year producing a probability mode at 91 mm in the next year.

This combination of possibilities would also account for the absence of visually discernable modes after 85 mm of the monthly and yearly percent frequencies because the size ranges about the succeeding modes would overlap each other to a considerable extent.

Other determinations from cluster samples. — In conjunction with the analysis on length frequencies from the cluster samples, we also made estimates of the mean length and weight and the percent of females, culls, and shedders. We compiled this information by sample-day, with monthly and yearly means and percentages with standard errors from August 1966 through 1970 (Table 7). Usually the mean lengths by day, month, and year are quite similar; this situation could indicate the possibilities of heavy exploitation and a similar selectivity range of the described trap dimensions.

To be expected, the mean weight and associated percentages of culls are closely related and help to explain some of the variability in mean weight related to the same mean carapace length. The percentage of culls between and within areas and years could be a valuable asset in determining ways of improving the catch in pounds (the important item to fishermen). Some fishermen and biologists have postulated that the rough handling of prerecruit sizes of lobsters (sublegals) in traps leads to either a heavy mortality of these lobsters before they enter the fishery or an increase in the percentage of culls when lobsters reach legal size. Perhaps it would be well for administrators and industry people to consider lath spacing as another means of increasing the catch in pounds.

The actual time available for sampling each boat and its catch dictates that the estimate of shedder percentages must be a subjective measure. We determined if a lobster was hard- or soft-shell by a slight amount of hand pressure on the lateral surfaces of the carapace and chelipeds. This was accomplished in the process of measuring and weighing the lobster. Then by this method we have a subjective estimate for what we term "recent shedders."

This subjective determination is made even more difficult by the dealers usually buying at two prices (hard- versus soft-shell) during the months of peak molting. Their determination of a shedder does not always agree with ours, but we are stymied by the dealers separating the hard- and soft-shell lobsters. Therefore, the estimation of the percent of shedders in the commercial fishery can only be considered a rough approximation. This estimate in some months was so inexact that we eliminated it from the tabulations. As a consequence, we concluded tentatively that: (1) lobsters in the southwestern section of the State begin ecdysis earlier in the year than those from the northeastern part; this situation could be influenced by the general seasonal warming of the ocean from southwest to northeast, and (2) the percentage of shedders by month gives us additional evidence of the effect of ecdysis on recruitment during August through November of each year; the importance of this determination will be discussed in the catch and effort section.

Catch and Effort Analysis

Ricker (1958), Beverton and Holt (1957), and many others have discussed the importance of the relationship of catch to effort. In the lobster fishery this has become increasingly important because Dow (1961) and Dow and

Trott (1956) have quite convincingly demonstrated that the catch in numbers or pounds per trap is not a valid index of stock density. Therefore, when this survey started, we knew that we would have to determine a different effort value than had been considered previously.

Initially we hoped that the catch in numbers per trap-haul would satisfy the need to find, at least, an indicator of stock density. We collected this type of information from August 1966 through August 1967. Upon analysis of these data, we found that while this catch-per-unit-of-effort value does approximate the condition in the fishery at least for May through July, it is not adequate for most other months. Evidently there are other factors influencing even this catch-per-unit-of-effort value. Also, these unknowns are apparently constant for May through July and quite variable in other months. A factor that could account for these situations is the number of set-over-days in association with availability.

In addition to the established interview questions, we added one more regarding the number of set-over-days for the group of traps hauled per boat. This additional information began in September 1967. A preliminary analysis, as the data were collected, looked promising. Then, with a monthly and yearly backlog of survey data for 1968 through 1970, we determined the following specific relationships for each of these years:

(1) The catch in numbers per trap-haul as it is related to surface water temperature;
(2) The catch in numbers per trap-haul-set-over-day as it is related to surface water temperatures;
(3) The catch in numbers per trap-haul-set-over-day as it is related to the number of boat-days.

In 1968, these relationships segregated themselves into three distinct periods during the calendar year:

Period 1: (January-April) Covers those months when availability could be a major factor; i.e., water temperature in association with metabolic rates, leading to vulnerability in a trap fishery; also considering accessibility (moving from deeper to shallower water).

Period 2: (May-July) Includes those months when effort and the assumed molt- or year-class strength from the preceding year could be a major determinant.

Period 3: (September-December) Encompasses those months when recruitment through molting with increased vulnerability during the current year in association with the defined effort could have the greater effects. We hypothesize that after several days, new shell lobsters actively seek food thereby increasing their vulnerability to the baited trap (personal observations from laboratory studies).

Ideally, in all of these periods and relationships we should use the bottom ocean temperatures either by area or coastwide. Again, limited manpower and money made this an impossibility. As a result, we used the surface temperatures that we collected at the dealer locations during the survey (Fig. 8).

In considering the catch in numbers per trap-haul with surface water temperature (Fig. 9), we deduced the following:

Period 1: (January-April) As the mean surface water temperature increases by month, the catch in numbers per trap-haul generally decreases. This situation conflicts with the premise that availability should be increasing with the warming ocean waters.

Period 2: (May-July) The downward convex curve possibly indicates that even though the monthly mean ocean temperature is increasing, the age- or molt-class strength is reduced prior to recruitment. However, the convex reduction might indicate that availability is still a factor rather than age- or molt-class strength from the preceding year.

November

Dealer code	Mean: length	weight	Percent: females	culls	shedders
W-21	86.8	485.5	48.7	8.2	1.8
S-4	90.1	528.4	57.0	10.0	4.8
C-8	87.6	508.7	52.7	11.5	0
C-14	86.7	470.5	46.9	9.5	0
L-5	88.0	507.4	39.9	0	4.1
Y-5	89.5	509.6	42.6	20.0	0
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
Monthly mean	88.1	500.6	48.0	9.9	1.8
Standard error	.6	10.2	2.7	2.3	.9

Dealer code	Mean: length	weight	Percent: females	culls	shedders
K-30	87.0	500.0	70.0	0	-
K-11	90.2	592.0	60.0	0	-
Y-6	89.3	504.7	47.3	10.4	-
S-2	89.9	549.0	56.1	8.8	-
H-30	88.3	518.1	47.4	0	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
Monthly mean	88.9	532.8	56.1	3.8	-
Standard error	.6	16.9	4.3	2.4	-

Dealer code	Mean: length	weight	Percent: females	culls	shedders
S-6	90.1	587.6	75.2	2.6	30.0
K-7	88.6	515.2	53.7	7.3	31.7
H-2	89.2	591.8	60.0	11.9	7.0
Y-3	85.6	456.6	60.7	31.6	10.0
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
Monthly mean	88.4	537.8	62.4	12.1	19.7
Standard error	.9	42.1	4.5	6.6	6.5

Dealer code	Mean: length	weight	Percent: females	culls	shedders
K-11	91.8	598.2	82.0	4.0	37.9
C-20	88.9	544.3	60.0	4.0	34.6
S-2	86.8	488.0	70.0	0	40.0
W-11	88.5	501.5	78.8	22.5	0
Y-8	88.4	503.9	49.6	4.6	20.8
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
Monthly mean	88.9	527.2	68.1	7.1	26.7
Standard error	.8	20.1	5.9	3.9	7.5

Dealer code	Mean: length	weight	Percent: females	culls	shedders
S-2	87.4	494.4	63.7	1.2	45.9
S-1	85.5	494.0	40.0	0	60.0
H-27	89.0	528.8	48.3	3.9	48.7
K-6	90.8	562.6	44.8	6.2	91.2
C-13	89.2	519.0	50.0	0	100.0
K-25	93.2	621.2	54.2	3.4	22.4
C-10	90.8	552.0	60.0	10.0	60.0
W-8	89.1	529.3	57.8	5.8	15.8
-	-	-	-	-	-
-	-	-	-	-	-
Monthly mean	89.4	537.7	52.4	5.5	55.5
Standard error	.8	14.7	5.3	1.7	10.4

Dealer code
Y-14
S-7
H-11
K-9
-
-
-
-
-
-
Monthly mean
Standard error

Dealer code
C-15
C-19
H-22
L-15
K-9
-
-
-
-
-
Monthly mean
Standard error

Dealer code
-
-
-
-
-
-
-
-
-
-
Monthly mean
Standard error

Dealer code	
W-20	
K-22	
W-15	
-	
-	
-	
-	
-	
-	
-	
Monthly mean	8
Standard error	

Dealer code	
W-15	9
H-19	8
C-8	8
-	
-	
-	
-	
-	
-	
-	
Monthly mean	89
Standard error	

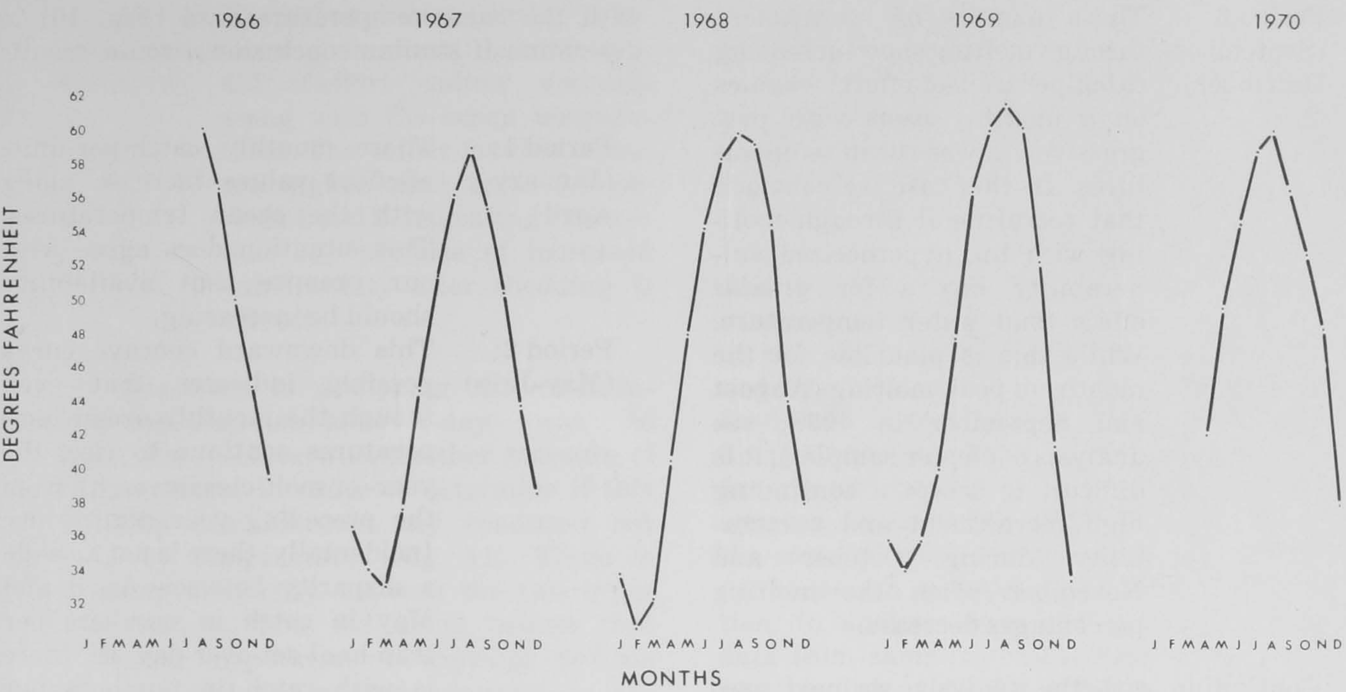

Figure 8. — Mean surface water temperatures, recorded from 10 dealer locations each month of the survey, 1966 (partial year) through 1970.

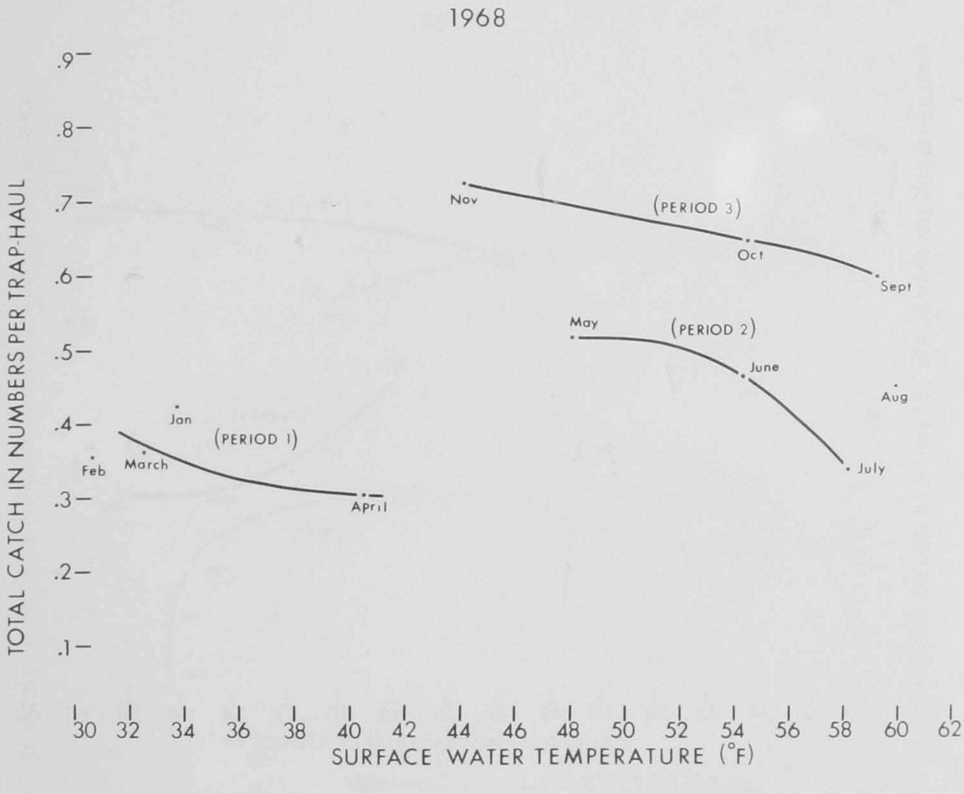

Figure 9. — The relationship between mean ocean surface temperature and catch in numbers per trap-haul by month for 1968.

Period 3: (September-December) These months of recruitment through molting show increasing catch-per-unit-of-effort values on a monthly basis with progressively lower ocean temperatures. In this case we conclude that recruitment through molting with the hypothesized vulnerability has a far greater effect than water temperature. While this is plausible for the months of peak molting (August and September in 1968; see analysis of cluster samples), it is difficult to accept a continuing high recruitment and vulnerability during October and November when the molting percentages decrease.

Continuing with the analysis, we next used catch-in-numbers-per-trap-haul-set-over-day with the same temperature data (Fig. 10) to determine if similar conclusions would result:

Period 1: (January-April) These monthly catch-per-unit-of-effort values increase along with the ocean temperatures. This situation does agree with our premise that availability should be increasing.

Period 2: (May-July) This downward concave curve possibly indicates that even though the monthly ocean temperatures continue to rise, the year- or molt-class strength from the preceding year diminishes. Incidentally, there is not as wide a disparity between April and May in catch in numbers per trap-haul-set-over-day as there is with catch in numbers per trap-haul.

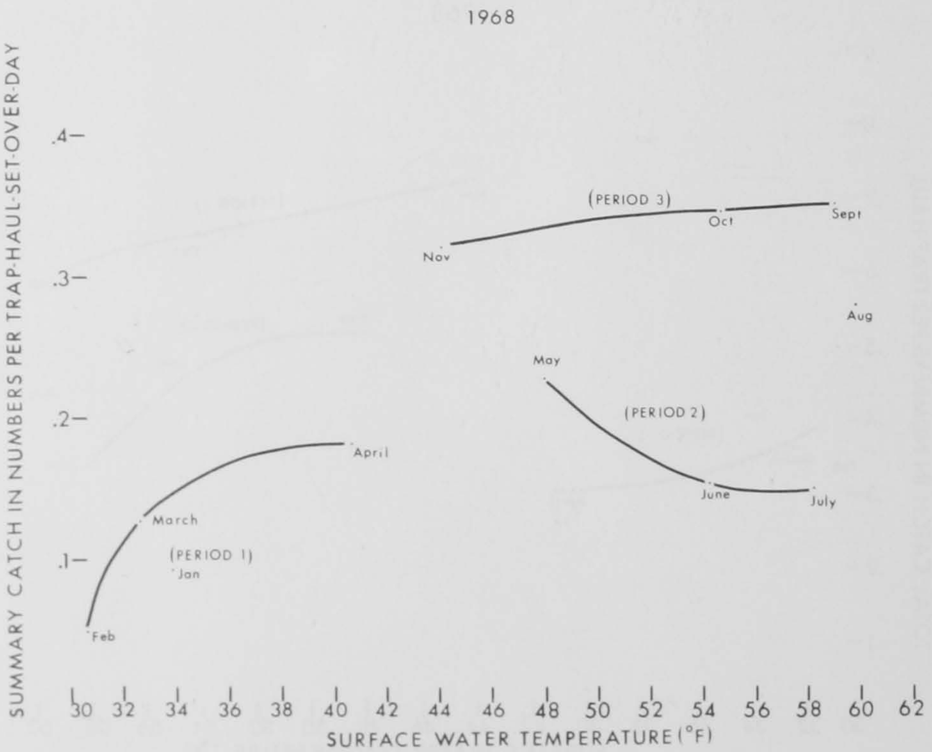

Figure 10. — The relationship between mean ocean surface temperature and catch in numbers per trap-haul-set-over-day by month for 1968.

Period 3: (September-December) Even though recruitment is occurring, the monthly catch-per-unit-of-effort values decrease along with the ocean temperatures. The values for this period are higher than those for periods 1 and 2, indicating perhaps that our premise of increased vulnerability after shedding is correct.

Our next step in analyzing the catch-in-numbers-per-trap-haul-set-over-day was to compare these values with another measure of effort (boat-days) in order to determine if this relationship demonstrates any condition not revealed by temperature (Fig. 11). There is an amazing similarity between the two types of relationships. This led us to believe that our original hypotheses concerning periods of the year and the related assumptions are greatly strengthened. Therefore, in the face of this evidence we concluded that the relationship of catch-in-numbers-per-trap-haul-set-over-day with boat-days is the more important consideration after the ocean water temperature warms above a certain level.

These same types of relationships appeared to hold true for 1969 (Fig. 12). However, as usually happens with hypothetical concepts, something somewhat different obviously occurred in 1970 (Fig. 13).

By way of explanation for the omission of data from January through March 1970, the sampling in that year began in April because of the demonstrated reduction in the catch and effort categories for January through March from 1967 through 1969 (Table 4). The reasons for the reduction might be an evolving shrimp fishery which usually concentrates its effort between January and March of each year and the ease by which lobster boats and fishermen are converted to fishing for shrimp. This situation, in addition to a tremendous backlog of data from sampling the lobster catch in other months, led us to the decision to discontinue the lobster survey during this period of the year.

Returning to the months that we sampled in 1970, there is an abrupt increase in the catch in numbers per trap-haul-set-over-day in

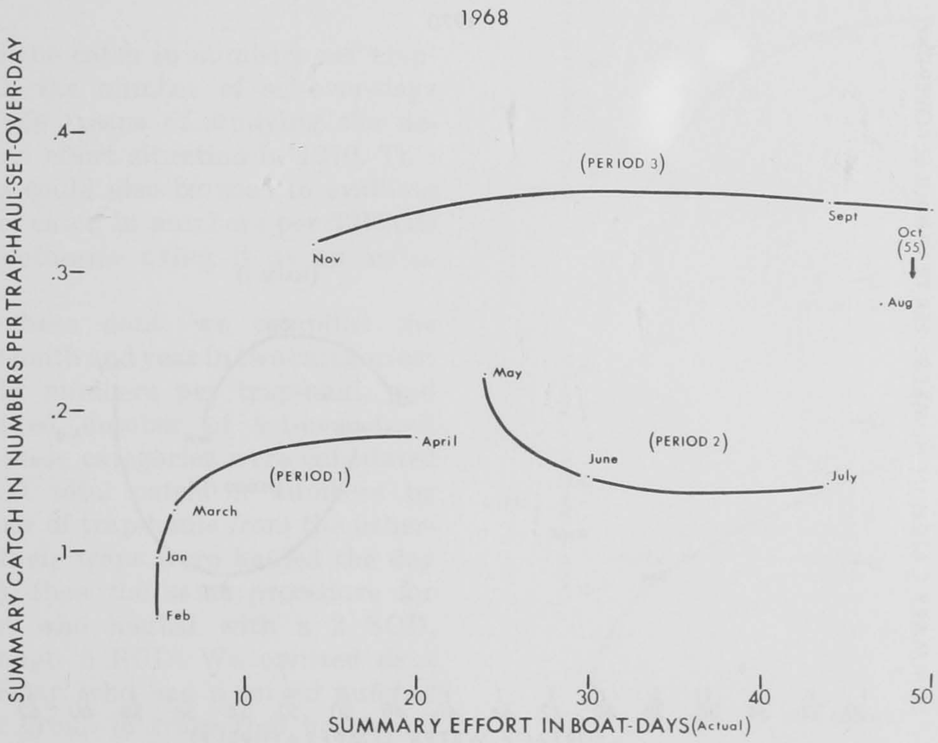

Figure 11. — The relationship between catch in numbers per trap-haul-set-over-day and boat-days by month for 1968.

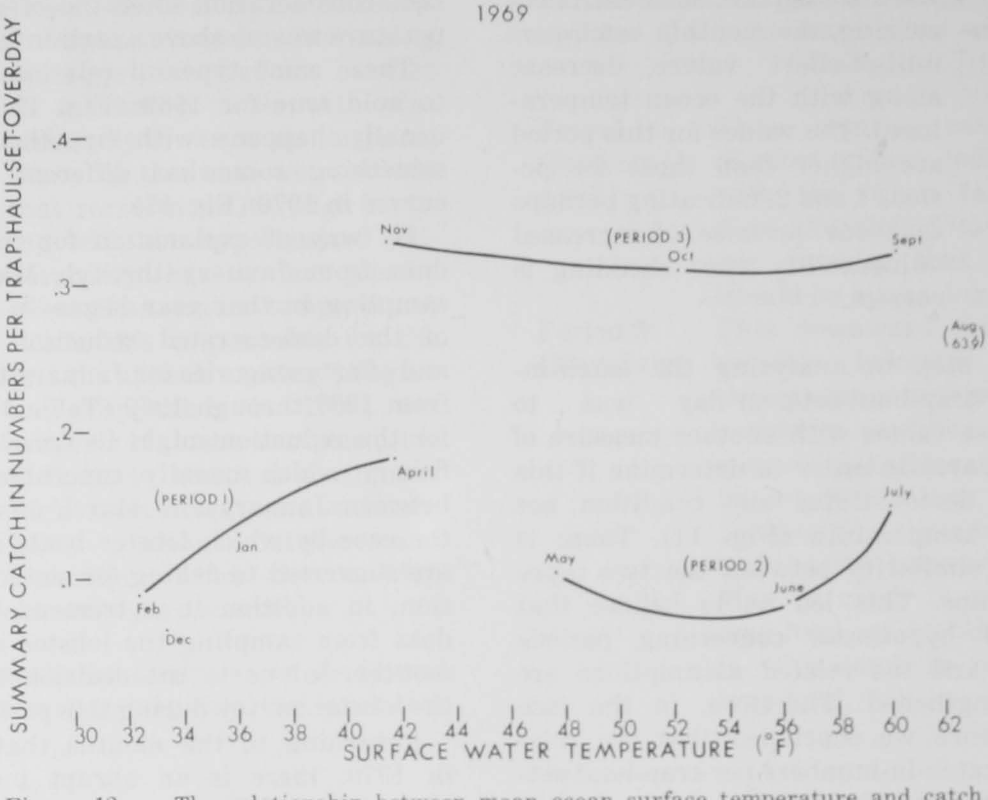

Figure 12. — The relationship between mean ocean surface temperature and catch in numbers per trap-haul-set-over-day by month for 1969.

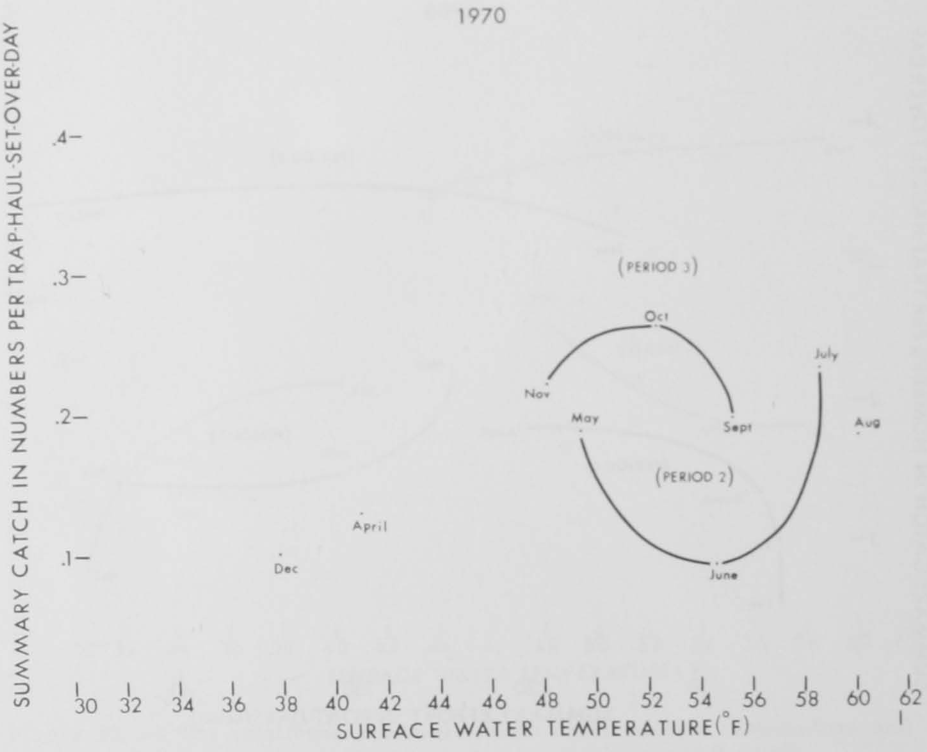

Figure 13. — The relationship between mean ocean surface temperature and catch in numbers per trap-haul-set-over-day by month for 1970.

July. This appears even more pronounced because the values in April through June 1970 are smaller in comparison to the values in these same months of 1969 and 1968.

Surprisingly, this catch-effort value in August 1970 is smaller than the one for July of that year. This is the first year during the sampling survey for this to occur. A partial explanation is the tremendous increase in trap-hauls and trap-haul-set-over-days in July and August 1970 as compared to these months in 1969 and 1968 (Table 4). In addition, the peak shedding percentages by month were later in 1970 than in previous years.

This combination of factors, different from 1969 and 1968, could account for the changed relationship by month between catch in numbers per trap-haul-set-over-day and water temperature in 1970.

I reasoned that other than a shift of specific months between the three periods of 1970, we have not destroyed the hypotheses that we had developed for each of these periods in 1969 and 1968.

Relationship Between Catch in Numbers per Trap-Haul and Set-Over-Days

We compared the catch in numbers per trap-haul (TH) with the number of set-over-days (SOD) as another means of studying the described catch and effort situation in 1970. This type of analysis could also be used to evaluate the intricacies of catch in numbers per THSOD because we hypothesize using it as an index of stock density.

To analyze these data, we compiled the information by month and year in two categories: (1) the catch in numbers per trap-haul, and (2) the associated number of set-over-days. The values for these categories were calculated by dividing that total catch in numbers by that total number of trap-hauls from the fishermen who said their traps were hauled the day before (1 SOD), then the same procedure for those fishermen who hauled with a 2 SOD, and so on through 5 SOD. We omitted data from any fisherman who had a mixed number of SOD for the group of traps that he hauled for the day; such as a fisherman who hauled 300 traps for the day and of those, 150 had been set-over for 1 day, while the remaining 150 traps had been set-over for 2 days. These modified data were compiled by month and year from 1968 through 1970 (Table 8).

The relationship between the catch in numbers per trap-haul and the number of set-over-days in 1970 reveals a higher increasing trend line than for 1969 and 1968 (Fig. 14): I attribute this to the same reason that I have already discussed: that is, an earlier and higher percent of shedders starting in June 1970, resulting in higher recruitment and vulnerability starting in July and continuing through

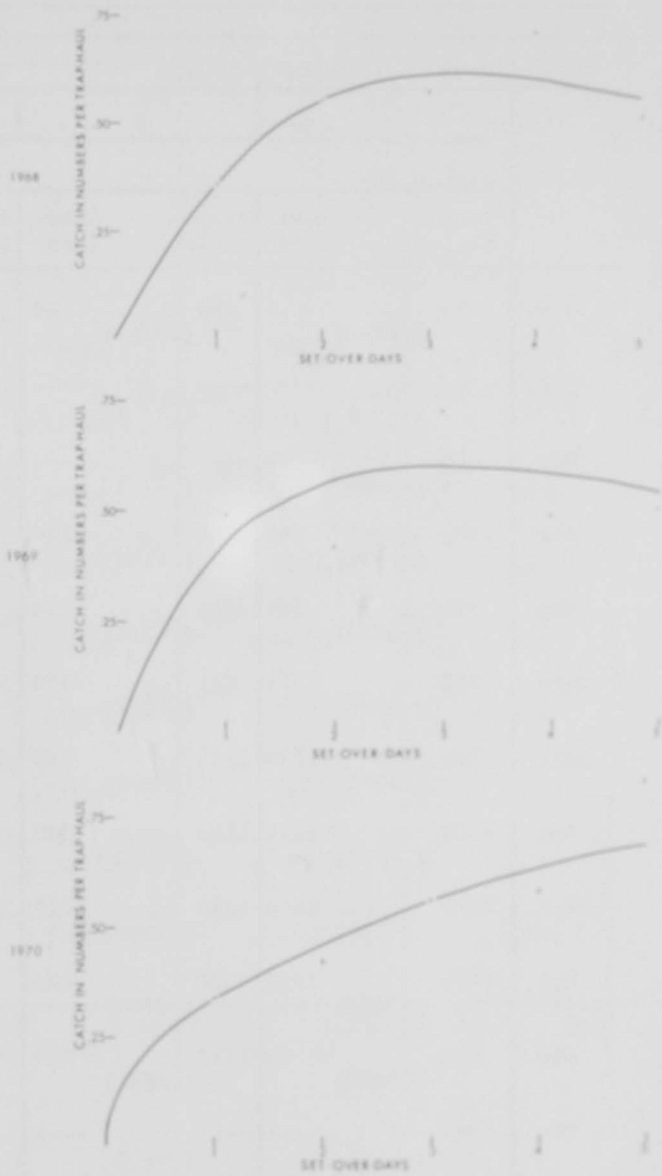

Figure 14. — The relationship between catch in numbers per trap-haul and set-over-days by year, 1968 through 1970.

most of the remaining months of 1970 as compared to the situation in 1969 and 1968.

This combination of factors could also explain the slightly higher value of catch in numbers per THSOD in 1970 than in 1969, although the total catch in pounds is slightly higher in 1969 than in 1970 as reported in "Maine Landings." I concluded that while catch in numbers per THSOD is a much better indicator of stock density than any other known ratio, it must be carefully analyzed each year. Such a continued treatise will be valuable in future years.

Relationship Between Catch per Unit of Effort and Effort

Gulland (1968) discussed the usefulness and expected type of curve between the relationship of catch per unit of effort plotted against

Table 8. — The compilation of the catch in numbers per trap-haul and the number of set-over-days by month and year, 1968 through 1970. The ratios are enclosed by parentheses.

1968															
Month	Number of set-over-days:														
	1			2			3			4			5		
	Number of:														
	trap-hauls	lobsters		trap-hauls	lobsters		trap-hauls	lobsters		trap-hauls	lobsters		trap-hauls	lobsters	
Jan.	40	7	(.1750)	150	49	(.3267)	125	51	(.4080)	----	----	(--)	----	----	(--)
Feb.	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)	150	15	(.1000)
Mar.	520	234	(.4500)	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)
Apr.	1145	341	(.2978)	295	134	(.4542)	100	10	(.1000)	250	78	(.3120)	35	6	(.1714)
May	330	226	(.6848)	2315	1094	(.4726)	585	394	(.6735)	240	106	(.4417)	120	52	(.4333)
June	262	71	(.2709)	617	309	(.5008)	700	257	(.3671)	80	117	(1.4625)	532	321	(.6033)
July	796	179	(.2249)	2495	996	(.3872)	1280	392	(.3062)	----	----	(--)	120	23	(.1917)
Aug.	4524	2159	(.4772)	1155	386	(.3342)	653	363	(.5559)	668	334	(.5000)	----	----	(--)
Sept.	2722	1568	(.5760)	1943	1212	(.6238)	64	30	(.4687)	----	----	(--)	----	----	(--)
Oct.	1735	1220	(.7032)	1520	867	(.5704)	970	984	(1.0144)	164	189	(1.1524)	----	----	(--)
Nov.	100	82	(.8200)	1212	834	(.6881)	705	536	(.7603)	30	28	(.9333)	----	----	(--)
Dec.	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)
Totals	12,174	6,087	(.5000)	11,702	5,881	(.5026)	5,182	3,017	(.5822)	1,432	852	(.5950)	957	417	(.4357)

Table 8. — The compilation of the catch in numbers per trap-haul and the number of set-over-days by month and year, 1968 through 1970. The ratios are enclosed by parentheses. — Continued.

Month	1969														
	Number of set-over-days:														
	1			2			3			4			5		
	Number of:														
	trap-hauls		lobs-ters	trap-hauls		lobs-ters	trap-hauls		lobs-ters	trap-hauls		lobs-ters	trap-hauls		lobs-ters
Jan.	156	.4487)	70	----	(--)	----	----	(--)	----	236	(.6780)	160	120	(.9917)	119
Feb.	----	(--)	----	----	(--)	----	----	(--)	----	----	(---)	----	----	(--)	----
Mar.	200	(.8000)	160	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)	----
Apr.	748	(.3516)	263	45	(.8667)	39	410	(.3488)	143	500	(.6960)	348	86	(.6977)	60
May	----	(--)	----	330	(.3182)	105	415	(.4361)	181	867	(.4002)	347	----	(--)	----
June	75	(.1867)	14	1237	(.2514)	311	472	(.1780)	84	765	(.3752)	287	521	(.2630)	137
July	1372	(.3878)	532	1147	(.2842)	326	718	(.3510)	250	480	(.3729)	179	30	(.2667)	8
Aug.	3213	(.4199)	1349	3995	(.4471)	1786	1716	(.6923)	1188	120	(.4500)	54	----	(--)	----
Sept.	626	(.8818)	552	1923	(.5091)	979	1372	(.6822)	936	----	(--)	----	310	(.5258)	163
Oct.	3581	(.5658)	2026	863	(.5574)	481	155	(.8516)	132	80	(.2625)	21	----	(--)	----
Nov.	295	(.8305)	245	----	(--)	----	902	(1.1463)	1034	150	(.6400)	96	----	(--)	----
Dec.	----	(--)	----	----	(--)	----	40	(.5000)	20	320	(.6781)	217	100	(.5900)	59
Totals	10,266	(.5076)	5,211	9,540	(.4221)	4,027	6,200	(.6403)	3,970	3,518	(.4858)	1,709	1,167	(.4679)	546

Table 8. — The compilation of the catch in numbers per trap-haul and the number of set-over-days by month and year, 1968 through 1970. The ratios are enclosed by parentheses. — Continued.

1970															
Month	Number of set-over-days:														
	1			2			3			4			5		
	Number of:														
	trap-hauls	lobsters		trap-hauls	lobsters		trap-hauls	lobsters		trap-hauls	lobsters		trap-hauls	lobsters	
Jan.	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)
Feb.	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)
Mar.	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)	----	----	(--)
Apr.	600	140	(.2333)	300	133	(.4433)	1521	785	(.5161)	----	----	(--)	150	43	(.2867)
May	492	166	(.3374)	940	431	(.4585)	515	174	(.3379)	----	----	(--)	----	----	(--)
June	400	69	(.1725)	150	32	(.2133)	1990	628	(.3156)	305	169	(.5559)	460	273	(.5935)
July	804	332	(.4129)	425	303	(.7129)	290	154	(.5310)	105	42	(.4000)	160	18	(.1125)
Aug.	2672	846	(.3166)	5067	1915	(.3779)	4035	2296	(.5690)	960	529	(.5510)	456	362	(.7938)
Sept.	3430	1194	(.3481)	6327	2243	(.3545)	1225	653	(.5331)	1026	612	(.5965)	110	44	(.4000)
Oct.	1379	474	(.3437)	1052	632	(.6008)	550	336	(.6109)	870	651	(.7483)	100	70	(.7000)
Nov.	305	215	(.7049)	1125	905	(.8044)	1283	1466	(1.1426)	900	604	(.6711)	570	859	(1.5070)
Dec.	----	----	(--)	----	----	(--)	83	54	(.5696)	568	183	(.3222)	----	----	(--)
Totals	10,082	3,436	(.3408)	15,386	6,594	(.4286)	11,492	6,546	(.5696)	4,734	2,790	(.5894)	2,006	1,669	(.8320)

effort for a long series of years, preferably with a wide range in effort. Because we have data for only four full years, we cannot hope to demonstrate the expected theoretical curves. Nevertheless, we did calculate this relationship for the months within each of these years of the survey.

An interesting comparison came to light between catch in numbers per trap-haul and catch in numbers per trap-haul-set-over-day by month and year plotted against the respective effective effort (Fig. 15). The relationship of catch in numbers per trap-haul-set-over-day and its effective effort are similar with only slight changes in the slope from year to year. This occurred even with a tremendous increase in trap-hauls and trap-haul-set-over-days in 1970 (Table 4). On the other hand, the relationship between catch in numbers per trap-haul and effort shows a similar curve to the preceding relationship for only 1968 but with a much higher trend line. However, in 1969 and 1970 this relationship is entirely different. I attribute this difference to an increase in the set-over-days for 1969 and 1970. We already have demonstrated how this variable affects the catch in numbers per trap-haul.

Turning to the fairly consistent relationship of catch in numbers per trap-haul-set-over-day and its effective effort, we can see that the trend line for 1968 is higher than that for 1969 or 1970. This situation indicates that the catch in 1968 is better than the following 2 years, and that 1969 and 1970 are close to the same total poundage. Indeed, "Maine Landings" demonstrates that this is true.

Thus we have, to some extent, again substantiated the premise that catch in numbers per trap-haul-set-over-day is a better index of stock density than any other known ratio. At the same time, this value must be scrutinized more fully than most indices of stock density in other fisheries.

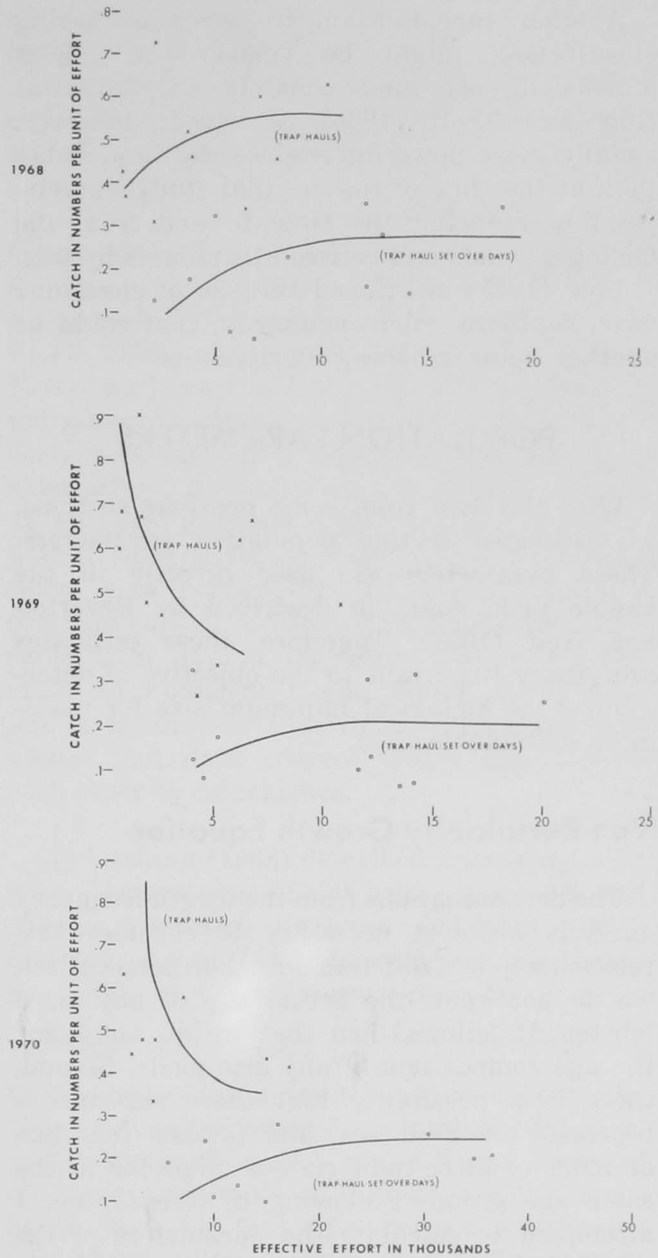

Figure 15. — Comparison of catch in numbers per trap-haul and catch in numbers per trap-haul-set-over-day with respective effort by month and year, 1968 through 1970.

Consideration of Effectiveness of Fishing

A factor that has been overlooked in the literature, is a possible change in fishing effectiveness with the advent of the hydraulic hauler in the early 1960's. This gear possibly enables fishermen to use and haul more traps in the same amount of time than is required to haul a lesser amount of gear with a mechanical hauler. The sampling for the present survey began in 1966, after most of the conversion to hydraulic haulers occurred. Therefore, it is impossible to compare the change in fishing intensity in terms of trap-hauls or time spent fishing from before to after the conversion.

Another consideration in terms of fishing effectiveness might be vessel speed. Boat dimensions are approximately the same as Dow and Trott (1956) described; however, usually more powerful engines are used today than at the time of the original study, thereby possibly reducing the time to and from the fishing grounds and between trap-hauls by trip.

Dow (1955) mentioned the use of electronic gear, depth recorders primarily, that could be another factor in fishing effectiveness.

POPULATION PARAMETERS

With the data from some previous sections, we estimated certain population parameters. These parameters are used directly in the simple yield equation described by Beverton and Holt (1957). Therefore, these estimates are vitally important to the objective of determining the biological minimum size for maximum sustainable yield.

Von Bertalanffy Growth Equation

The determinations from the length frequency analysis make it necessary to consider this relationship in a different way than usual. First, we do not know the actual age of any sized lobster. It follows then that we do not know the age composition of any size mode. Second, there is a possibility that these size modes represent molt classes, and further that one or more of these molt classes might be in the same age group. Following this reasoning, I attempted to calculate the parameters of the von Bertalanffy Growth Equation by combining probability modes to correspond to 14% increments as hypothesized in the probability analysis. The estimated parameters, determined by the method of Tomlinson and Abramson (1961), are obviously incorrect; for example, the maximum expected carapace length is 13.0 mm.

As an alternative, I used the consecutive modes from the probability analysis of the length frequencies. This might constitute a molt group-length relationship rather than the usual age-length correlation.

This information was used in the method of Tomlinson and Abramson (1961). The pertinent estimates and standard errors are:

$$\hat{l}_\infty = 266.77 \pm 59.04$$
$$\hat{k} = 0.04785 \pm 0.01566$$
$$\hat{t}_0 = -0.77250 \pm 0.43685$$

where:

$\hat{l}_\infty$ = maximum expected length
$\hat{k}$ = constant proportional to catabolic rate
$\hat{t}_0$ = hypothetical age at zero length.

These growth parameters are much more logical; leading to the dilemma of deciding whether we are dealing with molt or age groups. To resolve this, I reasoned that the intent of the use of the von Bertalanffy Growth Equation is to demonstrate the growth pattern for lobsters which intuitively (comparison of calculated parameters) is better reflected by using consecutive size modes from the probability analysis.

Weight-Length Relationship

We fitted a logarithmic transformation of the basic equation $W = aL^b$ by the method of least squares. There were 336 males and 391 females used in these calculations. The following real values by category are:

$W = 0.001669\,L^{2.82781}$ (males)
$W = 0.001657\,L^{2.83377}$ (females)
$W = 0.001682\,L^{2.82826}$ (sexes combined).

A t test on the b values revealed no significant difference between the sexes; therefore, the sexes were combined (Fig. 16). The 95% confidence limits on the slope or b value for the sexes combined placed the upper limit at 2.86099 and the lower limit at 2.79554. The 95% confidence limits on this intercept or a value placed the upper limit at 0.001889 and the lower at 0.001509.

We also calculated the weight-length relationships by the same method for the commercial sizes only. While there still is no significant difference between males and females, the confidence intervals about the slopes bracketed "3" in each case. We surmise that there is a change in the weight-length relationship after lobsters reach legal size. This situation might have importance in the section on yield.

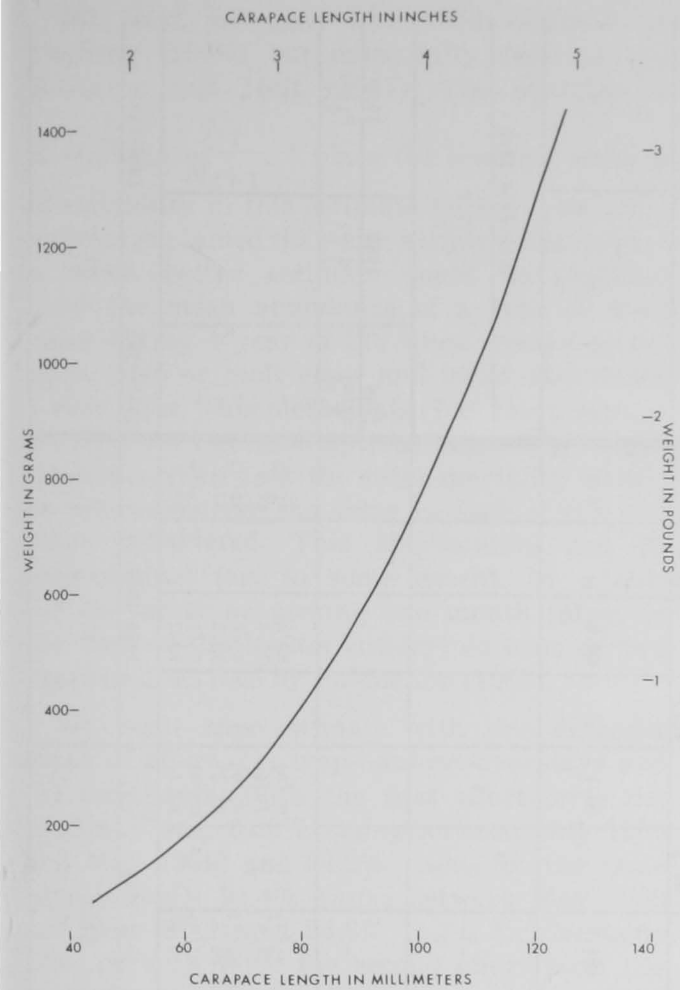

Figure 16. — The weight-length relationship of lobsters (sexes combined), $W = .001682\ L^{2.82826}$.

Mortality Rates

The implications from the length frequency section concerning age or molt groups create some imponderables for estimating survival or mortality. A reasonable alternative would be to estimate the desired parameters by 14% groupings and then by selected size modes from the probability analysis, realizing the discussed assumptions in each category. With this approach, we can compare estimates and then, in certain situations, explain why there are differences or similarities. Of course, even if these estimates were similar, they would be tentative because of the uncertainties concerning the age composition of the catch. To circumvent this situation to some extent, we present corroborative estimates, whenever possible, from different techniques of other investigations on lobsters.

In accordance with this reasoning, we listed the methods and reported all estimates in annual rates (Table 9) as follows:

(1) We used the method of Robson and Chapman (1961) with 14% increments of growth for the commercial-sized lobsters within calendar years. The estimates are: 90.0% (1967), 91.4% (1968), 92.2% (1969), and 92.9% (1970). These authors explained that the method is not adequate when estimating survival by age class between years because it does not consider effort. Nevertheless, the authors devised an unbiased estimate of survival and mortality within years if the age and growth considerations were correct. R. A. Cooper (personal communication) estimated approximately the same total annual mortality from a tagging study off Monhegan Island, Maine. In my opinion, it is unlikely that the two separate techniques and data sources would approximate each other by coincidence.

(2) Cushing (1968) described a method which does incorporate effort with assumed age classes. However, Beverton and Holt (1957) maintained that it is seldom efficient to estimate an index of instantaneous abundance as is required in $Z = \log_e \dfrac{N_t}{N_{t+1}}$. Nevertheless, this equation (after conversion) represents the usual method of estimating total annual mortality. We used it with two different types of effort: (1) trap-hauls-set-over-days and (2) trap-hauls. With the first effort term the estimates are: 87.0% (n_1/n_2 between May 1968 and May 1969) and 83.5% (n_2/n_3 for the same time period). With the second effort term the estimates are: 85.8% (n_1/n_2 between May 1967 and May 1968) and 90.8% (n_2/n_3 for the same time period); 74.8% (n_1/n_2 between May 1968 and May 1969) and 68.1% (n_2/n_3 for the same time period); 64.6% (n_1/n_2 between May 1969 and May 1970) and 94.1% (n_2/n_3 for the same time period).

Also, we used this method of Beverton and Holt (1957) to estimate the annual natural mortality for the prerecruit sizes of lobsters. These estimates are: 29.3% (n_1/n_2 between May 1968 and May 1969) and 19.2% (n_1/n_2 for May 1969 and 1970).

Table 9. — A summary of mortality estimates and methodologies between and within years, 1967 through 1970.

Methodology references	Equations	Determination of assumed age groups	Estimates of total annual mortality 1967		1968		1969		1970	Estimates of annual natural mortality 1968-1969	1969-1970	
Robson and Chapman (1961)	$S = \frac{T}{n+T-1}$ $a = 1-S$	(a) 14% increments of commercial sizes in each year	90.0		91.4		92.2		92.9	-	-	
Cushing (1968)	$Z = \log_e \frac{N_t}{N_{t+1}}$ (Converted to annual rates)	(a) 14% increments of commercial sizes following assumed age classes with trap-haul-set-over-days in May of each year	-		-	n_1/n_2 87.0	-	n_1/n_2 29.8	-	-	-	
			-		-	n_2/n_3 83.5	-	n_2/n_3 88.3	-	-	-	
		(b) 14% increments of commercial sizes following assumed age classes with trap-hauls in May of each year	-	n_1/n_2 85.8	-	n_1/n_2 74.8	-	n_1/n_2 64.6	-	-	-	
			-	n_2/n_3 90.8	-	n_2/n_3 68.1	-	n_2/n_3 94.1	-	-	-	
		(c) probability modes of pre-recruit sizes following assumed age classes with trap-haul-set-over-days in each year	-		-		-		-	n_1/n_2 29.3	n_1/n_2 19.2	
	$Z = \log_e \frac{\bar{N}_t}{N_{t+1}}$ (Converted to annual rates)	(d) probability modes of commercial sizes following assumed age classes with (1) trap-hauls and (2) trap-haul-set-over-days in May of each year	-	(1) n_1/n_2 94.1	-	(2) n_1/n_2 94.5	-	(2) n_1/n_2 94.4	-	-	-	
			-	(1) n_2/n_3 94.3	-	(2) n_2/n_3 94.2	-	(2) n_2/n_3 94.6	-	-	-	
Beverton and Holt (1957)	$Z = \frac{\hat{k}(\ell_\infty - \bar{\ell})}{\bar{\ell} - \ell'}$ (Converted to annual rates)	(a) probability modes for growth parameters from length frequencies of commercial sizes in each year	88.9		90.1		88.9		76.6	-	-	
	$y = a+bx$ (Converted to annual rates)	(a) 14% increments of commercial sizes with Z plotted against trap-haul-set-over-days following May in each year	-		-		-		-	1968-1969-1970: 7.7		
Ricker (1958)	Catch curves $\log_e n_t - \log_e n_{t+1}$ (Converted to annual rates)	(a) probability modes of pre-recruit sizes in each year	-		-		-		-	1968: n_1/n_2 7.7	1969: n_1/n_2 2.0	1970: n_1/n_2 4.0
		(b) 14% increments of commercial sizes in each year	n_1/n_2 78.8		n_1/n_2 79.6		n_1/n_2 75.8		n_1/n_2 67.9	-	-	-
			n_2/n_3 89.8		n_2/n_3 91.1		n_2/n_3 92.2		n_2/n_3 92.7	-	-	-
			n_3/n_4 88.6		n_3/n_4 92.1		n_3/n_4 90.7		n_3/n_4 93.7	-	-	-
Silliman (1943)	$\log_{10}(1-a) = \log_{10}S_2 - \log_{10}S_1$	(a) 1/2-inch increments of commercial sizes and numbers of traps by year from historical data	1942-1943: 58.0				1946-1947: 83.0			1942-1943 - 1946-1947: 22.9		

(3) Next we used a method outlined by Cushing (1968), but more fully described by Beverton and Holt (1957). The equation is $\bar{Z} = \log_e \frac{\bar{N}_t}{\bar{N}_{t+1}}$. I place the greatest amount of reliability in this estimate because the latter authors explained that with a continuous fishery, a much better estimate could be expected from the mean abundance of a year or molt class during 1 year of life when related to the same year or molt class and mean abundance 1 year later. This method also has shortcomings (other than our assumptions regarding length frequencies) in that the total mortality should be approximately the same in each of the two years considered. This shortcoming can be compensated for, to some extent, by a correction factor or picking one month (May, in the case of the lobster fishery) in each of two years as described by Paloheimo (1961).

We made this estimate with two different types of effort, (1) trap-haul-set-over-days and (2) trap-hauls. With the first effort term the estimates are: 94.5% (n_1/n_2 between May 1968 and May 1969) and 94.2% (n_2/n_3 for the same time period); 94.4% (n_1/n_2 between May 1969 and May 1970) and 94.6% (n_2/n_3 for the same time period). With the second effort term the estimates are: 94.1% (n_1/n_2 between May 1967 and May 1968) and 94.3% (n_2/n_3 for the same time period).

(4) Beverton and Holt (1957) described another method of estimating total mortality from the combination of (1) parameters from the von Bertalanffy Growth Equation and (2) the mean length and the size when lobsters are fully vulnerable in the commercial fishery. The equation is $Z = \frac{\hat{k}(l_\infty - l')}{\bar{l} - l'}$. The estimates by year are 88.9% (1967), 90.1% (1968), 88.9% (1969), and 77.6% (1970).

(5) Again Beverton and Holt (1957) described a method which involved the use of the total mortality estimates from $Z = \log_e \frac{\bar{N}_t}{\bar{N}_t + 1}$ plotted against the effective fishing effort (in this case trap-haul-set-over-days). Because we collected these effort data from 1968 on, it is only possible to use three years of data. The authors caution that we should have a long series of years; nevertheless, we estimated an annual natural mortality of 7.7% for lobsters of commercial size.

(6) Ricker (1958) presented a detailed discussion on the use of "catch curves" along with the methodology. For use in this method, we organized the length frequencies of the commercial and prerecruit sizes of lobsters into either 14% groupings or numbers at selected modes from the probability paper determinations, all within years. A plot of the natural logarithm of the frequency of numbers of prerecruit and commercial sizes with effort reveals a dome-shaped curve with a somewhat sinuous descending right limb (Fig. 17). In addition to the contributive causes for this type of curve described by Ricker (1958), we must add our technique of estimating the assumed age or molt groups by 14% increments or by probability modes. It then follows that the descending right limb which is concave suggests that the fishing mortality has increased on the larger sizes (positively the case from prerecruit to recruit sizes), but variable recruitment from shedding frequencies might affect these estimates, as could a changing natural mortality or vulnerability to the trap in association with SOD. The latter consideration seems plausible, but then we should expect either larger sizes in the population to be readily apparent or a good carry-over of commercial sizes of lobsters from December to May of the following year. The conclusion from sampling the natural population with different types of gear, including scuba observations, refutes this carry-over contention; therefore, it appears that either a decreasing natural mortality (some of our estimates indicate this is true) or as Ricker (1958) pointed out, the shape of the curve could also be affected by the assumed age or molt groups not being uniform in size increments. In this case the probability modes between and within years do not lend support to this premise, at least for the commercial sizes.

While we included in Table 9, under the catch curve section, only the total annual mortality estimates from the number of lobsters at consecutive probability modes, we also

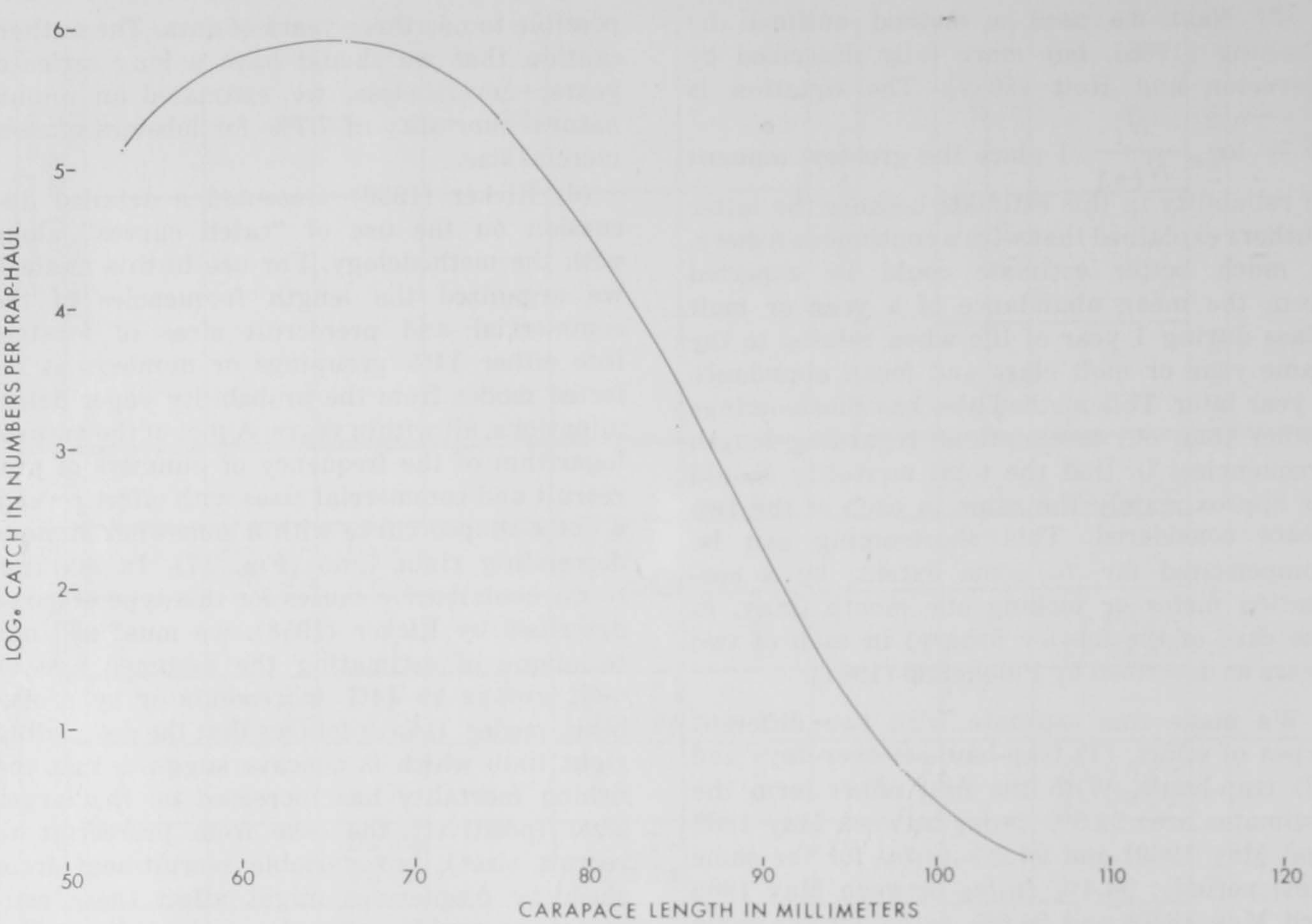

Figure 17. — A simple catch curve calculated from the number of lobsters between consecutively numbered probability modes starting at 53-mm carapace length.

calculated this estimate from the arrangement of probability modes as hypothesized in the section on length frequencies.

The estimates by year with probability modes in parentheses are: 1967, 91.1% (numbers at modes 85 and 97), 92.8% (numbers at modes 91 and 105); 1968, 91.6% (numbers at modes 85 and 97), 93.7% (numbers at modes 91 and 105); 1969, 44.0% (numbers at modes 85 and 94), 93.2% (numbers at modes 91 and 102); 1970, 60.3% numbers at modes 84 and 95), 96.6% (numbers at modes 91 and 106).

These estimates are higher than those from the consecutive probability modes and closer to the estimates from some other methods of estimating mortality. The two aberrancies (1969 and 1970) for the first two modes could be caused by using only the number of lobsters at the specific modes. The high degree of consistency of the estimates from the other modes strengthen the working hypothesis that we developed in the section on length frequencies.

Estimates of the annual natural mortality for the prerecruit sizes (modes from probability paper) from sampling the prerecruit sizes with wire traps are: 7.7% (n_1/n_2 in 1968), this estimate is identical with the natural mortality estimate of 7.7% from the commercial sampling; 2.0% (n_1/n_2 for 1969); and 4.0% (n_1/n_2 for 1970).

(7) Silliman (1943) described a method that requires a series of years at two different levels of effort to separate natural from fishing mortality. Because of the short series of years in the present study on lobsters, we turned to historical data in order to use the method. The length frequencies for the available years were separated by ½-inch increments and the effort was simply an estimate of the number of traps by year as reported in "Maine Land-

ings." The selected years were 1942-1943 and 1946-1947. The estimates of total mortality for each of these periods are 58.0% for 1942-1943 and 83.0% for 1946-1947. The assumed constant annual natural mortality between these periods is 22.9%. The total mortality estimates are logical, whereas the natural mortality is suspect because it is more dependent on an effective effort determination. The estimate of the number of traps fished in a year without trap-hauls or trap-haul-set-over-days should not satisfy the requirement for estimating natural mortality with this method.

The next series of estimates were made by earlier investigators who used or modified existing methodologies.

(8) Dow et al. (1953) estimated an annual natural mortality of 7 to 8% for the years 1949 through 1952. Their modification of a catch curve was unique and entailed considerable assumptions; nevertheless, their estimate still could be correct.

(9) Dow (1964) used these and more recent length frequencies, organized in a different manner, but still essentially a catch curve, to estimate a total annual mortality of 83 to 86% with a natural mortality of 28 to 33% from 1948 through 1963. This range of total mortality estimates closely approximates the estimate from Silliman's method of 83% for 1946-1947.

(10) Skud (1969), with the use of our length-frequency data, estimated a total annual mortality of 90%. This estimate, based upon the method of Thomas (1955), requires the use of the ratio of the number of females to males by length. The ratios that Skud used are biased because there are no subtotals by size and sex of the total number of lobsters that we counted by boat. As described earlier, the length-frequency data in this report are from the cluster samples of 10 lobsters per boat. This situation could seriously affect Skud's estimate.

Substantiation of certain estimates of natural mortality. — I believe the lower natural mortality estimates are closer to the actual value for the following reasons:

(1) A low $\hat{k}$ value from the von Bertalanffy Growth Equation indicates a low M as explained by Gulland (1965).

(2) From the preceding sections, the more acceptable methods yield consistently lower estimates of M.

(3) The greater average size and magnitude in numbers of lobsters that have been lightly exploited from some canyon areas offshore might indicate a low natural mortality (Skud and Perkins, 1969).

(4) D. G. Wilder (personal communication) estimated an annual natural mortality of 10% in at least one district in the Maritime Provinces.

(5) R. A. Cooper (personal communication) estimated an annual natural mortality of 6% from his tagging work on lobsters near Monhegan Island.

Fishing mortality estimates. — The combination of estimates of total instantaneous mortality (Z) and instantaneous natural mortality (M) led to a simple solution for estimating instantaneous fishing mortality (F) as follows:

$$Z = F + M$$

so that $F = Z - M$.

A more desirable method for estimating instantaneous fishing mortality involves the relationship between the catchability coefficient (q) and fishing intensity (f). This equation is

$$F = qf.$$

Because of the discussed problems in estimating the catchability coefficient, a reasonable alternative is to use the first procedure. To do this, we used estimates of instantaneous total mortality which range from 1.1363 (67.9%) to 2.9188 (94.6%) and the estimates of instantaneous natural mortality which range from 0.0202 (2%) to 0.3467 (29.3%). Therefore, the estimates of the instantaneous fishing mortality range from 0.7896 (54.6%) to 2.8986 (94.5%).

Again, all of the data from the survey of this commercial fishery overwhelmingly supports the higher estimates of fishing mortality.

Other factors associated with mortality estimates. — Paloheimo (1961, 1963) discussed catchability coefficients in association with population estimates for lobsters. He demonstrated inconsistencies in the catchability estimates when derived from temperature, catch, and effort (trap-hauls per day fished per square nautical mile). While his shortcut method appears reliable, we do not have a long enough series of yearly catch and effort data to complete the estimates.

Because of the complexities of availability and recruitment in the stock of lobsters along the Maine coast, it appears futile to estimate this catchability coefficient. However, if we hold before us the goal of establishing precise population parameters, in particular the estimates of fishing and natural mortality from the relationship $F = qf$, where q = catchability coefficient and f = fishing intensity (weighted effort), then the first approximation of the catchability coefficient makes a step toward this objective. Also, this coefficient might explain the deviation in the catch-per-unit-of-effort values from the true density (provided we use the effective effort term), and changes in this coefficient from year to year or period to period might indicate changes in availability.

Armed with these concepts and the techniques of Beverton and Holt (1957), and Cushing (1968), we attempted estimates of the catchability coefficient from the survey data. In order to do this, we compiled the required data by month and year.

The first attempt was made by plotting the instantaneous mortality (y) for May of 1968, 1969, and 1970 (calculated from the equation of $Z = \log_e \frac{N_t}{N_{t+1}}$, using 14% increments as assumed age or molt groups) against the corresponding number of THSOD (x). The linear regression, solved by the method of least squares, is:

$$y = 0.079857 + 0.000168x \ (r = 1.00).$$

The estimate of the catchability coefficient is 0.000168. In this case the total annual natural mortality estimate is 7.7%. This estimate is identical to two estimates that we made in the mortality section.

Next we plotted the instantaneous total mortality (y) for May of 1968, 1969, and 1970 (calculated by the method of Robson and Chapman (1961) for all assumed age or molt groups of 14% increments) against the corresponding number of THSOD (x). The linear regression, solved by the method of least squares, is: $y = 0.579137 + 0.000168x$ ($r = 0.99$).

The estimate of the catchability coefficient is 0.000168. In this case the total annual natural mortality is 0.43962. The estimate of the catchability coefficient is identical with the preceding estimate. This higher natural mortality estimate may be attributed to the different methodology for calculating the total mortality estimates.

Other attempts to calculate the catchability coefficient led to negative natural mortality estimates. It appears then that the best estimate we can make of the catchability coefficient is 0.000168 for the month of May in each year.

Consideration of Trap Limitations

Some legislators and fishermen have proposed a trap limitation. The objective of their proposal is not clearly defined. I believe the general intent is to lessen the fishing pressure (effective effort) on lobsters.

Fisheries biologists deal with this concept in a different way. We are concerned with the effect of fishing effort on fishing mortality. This report has dealt with such effort categories as numbers of: (1) traps, (2) trap-hauls, and (3) trap-haul-set-over-days. In the mortality section, we demonstrated limited success in correlating the trap-hauls, and trap-haul-set-over-days with fishing mortality while Dow and Trott (1956) had none at all with the number of traps. In the case of the latter two categories, I believe that the problem is due to the magnitude of the effective effort so that fairly large changes in these categories have relatively little effect on the actual fishing mortality.

Then the proposal at hand should be considered with the coalescence of the concepts of fishermen and biologists. This should enable us to reach a determination as to whether these proposals would accomplish the objective. The united concept assumes that a limit on the number of traps per boat will lessen the fishing effort and therefore the fishing mortality.

We concluded from the sections under catch and effort that the effective effort is related to the number of trap-hauls in association with the number of set-over-days rather than simply the number of traps.

To supplement the above concept, we compiled the average number of traps per boat with the minimum and maximum range of traps for all boats for a sample-day. This information was taken from the survey of the commercial fishery and was compiled by month and year (Table 10).

We considered all of this information in relation to two specific proposals: (1) a limit of 400 traps per boat and (2) a minimum limit of 200 traps to a maximum limit of 600 traps per boat. In both proposals, no limitation on the total number of fishermen was considered.

In the case of the 400 trap limit, we should understand that it is possible for a crew of two men with a hydraulic hauler, fishing 8 to 10 traps in a string, to haul 400 traps in a day. If these men fished 800 traps before the proposed limitation, then possibly the regulation would reduce the number of set-over-days with the trap limitation but not the number of trap-hauls for each fishing day because quite possibly these men would haul these same traps each fishing day, provided they receive a profit from this undertaking. We have already demonstrated that the catch does not increase arithmetically with more set-over-days; therefore, fewer set-over-days for hauling the same traps might not reduce the catch in numbers per trap-haul during the months of peak shedding.

The minimum-maximum proposal would result in a similar situation for the catch and effort. The compilation of average number of traps per boat with the range of number of traps from all boats brought out another important fact for consideration, that in all likelihood the proposal would not reduce the number of traps by more than a small percentage, if at all, compared to the present level. This could come about by an increase in the number of traps to 200 or more by so called "punt" fishermen, while only a small percentage of the "full-time" fishermen would reduce their number of traps to 600.

Use of Population Parameters to Estimate Mean Length of Catch

Beverton and Holt (1957) devised an equation for estimating the mean length of the catch by using certain population parameters. We substituted the values from the study on lobsters into the following equation:

Table 10. — Mean number of traps per boat by month and year, 1967 through 1970.

	1967			1968			1969			1970		
	Number of traps:			Number of traps:			Number of traps:			Number of traps:		
	range	mean	standard error	range	mean	standard error	range	mean	standard error	range	mean	standard error
Jan.	34-500	200	± 4	40-300	210	± 85	80-325	204	±42	-	-	-
Feb.	50-240	155	±28	240-600	345	±128	114-200	150	-	-	-	-
Mar.	90-300	168	±56	250-350	302	± 2	200-200	200	-	-	-	-
Apr.	50-350	237	±73	35-500	155	± 31	80-280	175	±18	150-400	294	±20
May	72-500	292	±38	15-400	212	± 25	75-600	258	±40	40-500	175	±39
June	125-525	261	±40	48-500	187	± 35	60-500	233	±15	50-1400	391	±165
July	85-500	292	±22	30-1200	194	± 58	30-550	197	±40	30-600	169	±23
Aug.	30-640	271	±70	40-800	247	± 47	8-900	187	±37	25-600	275	±25
Sept.	25-800	252	±62	42-450	192	± 28	10-600	242	±51	30-660	250	±21
Oct.	40-300	172	±13	22-800	238	± 56	40-650	220	±24	40-500	246	±24
Nov.	50-500	245	±30	85-700	321	± 17	64-400	218	±34	30-600	240	±18
Dec.	30-1000	280	±75	-	-	-	35-500	186	±25	70-400	222	±36
Totals	25-1000	245	±14	15-1200	219	± 16	8-900	211	±13	25-1400	252	±12

$$\overline{L}_y = l_\infty \left[1 - \frac{(F+M)\,(1-e^{-(F+M+k)\lambda})}{(F+M+k)\,(1-e^{-(F+M)\lambda})} \times e^{-k(t'_\rho - t_0)} \right]$$

The values are:

$$\begin{aligned} F+M &= 2.4700 \\ l_\infty &= 266.77 \\ k &= 0.04785 \\ t'_\rho &= 7.0 \\ t_0 &= -0.77250 \end{aligned}$$

The estimate of this mean length is:

$$\overline{L}_y = 85.58 \text{ mm carapace length.}$$

This value is close to the estimates of mean length calculated from the length frequencies in the cluster samples of the commercial catch (Table 7).

Of course this similarity does not indicate that any or all of the calculated parameters are correct. Certainly, I feel more confident with these estimates due to the favorable comparison of mean lengths by this method and those from the cluster samples.

YIELD ESTIMATES

The primary objective of the preceding analyses was to estimate parameters that can be used in a yield equation so that we might determine the biological minimum size for maximum sustainable yield.

We have calculated yield estimates from the simple yield equation of Beverton and Holt (1957) by two methods of expansion:

(1) bionomial, as outlined by Norman J. Abramson (personal communication), California Department of Fish and Game:

$$Y_{w/r} = W_\infty F e^{-m\rho} \left[\frac{1}{F+M} - \frac{b}{F+M+k}\, e^{-k(t'_\rho t_0)} + \frac{b(b-1)}{2(F+M+2k)}\, e^{-2k(t'_\rho - t_0)} - \frac{b(b-1)\,(b-2)}{6(F+M+3k)}\, e^{-3k(t'_\rho - t_0)} + \frac{b(b-1)\,(b-2)\,(b-3)}{24(F+M+4k)}\, e^{-4k(t'_\rho - t_0)} \right];$$

(2) cubic, as described by Gulland (1965):

$$Y_{w/r} = Fe^{-M(t_c - t_r)}\, W_\infty \sum_0^3 \frac{U_n e^{-nk(t_c - t_0)}}{F+M+nk}.$$

The symbols in each of the preceding equations are defined as follows:

- F = instantaneous fishing mortality
- M = instantaneous natural mortality
- W_∞ = maximum expected weight
- k = constant proportional to catabolic rate
- t_0 = hypothetical age at zero length
- t_c = assumed age at first capture
- t_r = assumed age at recruitment
- t_p = $t_c - t_r$
- t_ρ = assumed age when first on fishing grounds
- t'_ρ = assumed exploited ages of fish
- ρ = $t'_\rho - t_\rho$.

It is inherent in the cubic expansion that growth is isometric or that b from the weight-length relationship is "3." If this value were significantly different from "3," then it should affect the yield estimates from this type of expansion.

On the other hand, the binomial expansion uses the actual value of b so that these yield estimates are not affected by this assumption on growth.

It follows then that we should use the binomial expansion for lobsters ($b = 2.8283 \pm 0.0167$). We must reiterate that the commercial sizes did yield a slope value ($b = 3.10584 \pm 0.13224$) not significantly different from "3." Therefore, we included the methodology by Gulland for this reason and the fact that his method is much more comprehensive than the binomial expansion by Abramson. That is, we can determine yield values not only for different assumed ages at first capture (t_c) of the same assumed age or molt class but also for different instantaneous fishing mortalities (F). Therefore, if we use both methods, we should be able to determine how much the value of b influences the yield estimates and whether the more inclusive method has any application.

Gulland (1965) has defined the various yield categories, but it might be beneficial to restate these terms as follows:

(1) P'/R = exploited population weight in grams per recruit; that is, F times the average total weight of lobsters divided by the number of recruits in the exploited phase.

(2) Y/R = yield in weight per recruit; that is, the yield in grams per lobster entering the fishery under a different F or t_c.

(3) N'/R = numbers per recruit in the exploited population; that is, the average number in the exploited phase; so that, if there were one million lobsters caught and $N'/R = 0.5$ at a specific F or t_c, then this population size is two million.

(4) C/R = catch in numbers per recruit; that is, the fraction of the stock caught for a specific F or t_c; so that, as F increases so does the fraction of the numbers caught. Conversely, as t_c increases, the fraction of the stock caught decreases.

(5) $\bar{W}$ = mean weight of individual lobsters; so that, as F increases, the mean weight per lobster decreases. Conversely, as t_c increases so does the mean weight.

With either type of expansion, there usually is agreement at least in the increasing or decreasing trend (other parameters constant) of the yield in weight per recruit with assumed age at first capture t_c (Table 11). Therefore, we included with the binomial expansion the values from the cubic expansion in order to demonstrate their use and potential value in lobster management.

Because of the range in natural mortality estimates, we decided to plot the yield estimates with at least two different instantaneous values. I chose (1) 0.2664 and (2) 0.1000 so that we could determine the effect this change has on the yield estimates.

With this reasoning, if the instantaneous natural mortality (M) were 0.1000 with all other parameters as estimated, then the cubic and binomial methods demonstrate an increasing yield in weight per recruit with the older assumed age groups of the same assumed age class (trend line [F] for both expansions, Fig. 18). Conversely, if M were 0.2664 with identical other parameters, then the best yield with the cubic expansion would still be at the older assumed age or molt groups (trend line [C] cubic, Fig. 18) while the binomial expansion shows a better yield at the younger assumed age or molt groups (trend line [D] binomial, Fig. 17).

As discussed earlier, I believe the lower natural mortality estimates approximate the actual value. Therefore, the information under [F] for both expansions should be the more logical to use in terms of selecting the correct size or assumed age or molt class for maximum sustainable yield.

For this reason, I strongly advocate raising the minimum size to at least some convenient measure near t_{c+1}. The size for this assumed age or molt group is 91-mm carapace length (3-9/16 inches). For the convenience of all concerned parties, it would be logical to set the new minimum size at 3-½-inch carapace length. This size would be much more compatible with the size at maturity for females and logically should eliminate the maximum size regulation.

This proposed size could increase the catch by about 18%. For example, if the catch were 20 million lb. with the 3-3/16 inch regulation, with the size limit set at 3-½ inches, the catch would have increased 3.6 million lb. over the 20 million lb. In value, the fishermen would receive an estimated increase of $3,312,000.

The increase to 3-½ inches could be achieved by raising the minimum size one-sixteenth of an inch each year until the desired size is reached. This would delay the net benefit of 18% for at least this period of years.

I must reiterate that if recruitment varies from its present level (numbers shedding into the legal size range each year), this percentage of yield increase would be over what the yield *would have been* without the change in minimum size. That is to say, if a catch of 20 million lb. occurred last year and a catch of 18 million occurs this year with the 3-3/16 inch size limit, these same years with a size limit of 3-½ inches would have produced a catch of 23.6 and 21.24 million lb. respectively.

Table 11. — Estimates of the yield by defined category from the cubic and binomial expansion of the simple yield equation.

					CUBIC									BINOMIAL	
Parameters	F	P'/R	Y/R	N'/R	C/R	$\bar{W}$	Tc	P'/R	Y/R	N'/R	C/R	$\bar{W}$	Parameters	Tc	Y/R
A $M = .2664$	.5	548	274	.999	.499	549	tc	129	284	.310	.683	416	A $F = 2.2036$	tc	358
$W_\infty = 12,235$	1.0	284	284	.605	.605	470	tc+1	130	286	.238	.524	547	$M = .2664$	tc+1	351
$K = .04785$	1.5	189	284	.434	.650	437	tc+2	127	280	.182	.401	698	$b = 2.82826$	tc+2	336
$t_o = -.77250$	2.0	142	284	.338	.676	418	tc+3	121	267	.139	.307	868	$W_\infty = 12,235$	tc+3	314
$t_c = 7.0$	2.5	114	284	.277	.692	412	tc+4	113	249	.107	.235	1058	$K = .04785$	tc+4	287
$t_r = 6.0$	3.0	94	282	.234	.703	407	tc+5	102	225	.082	.180	1247	$t_o = -.77250$	tc+5	258
													$\rho = 1.0$		
B $M = .1000$	.5	919	459	1.508	.754	609	tc	165	364	.393	.866	420	B $F = 1.0000$	tc	494
$W_\infty = 12,235$	1.0	401	401	.822	.822	487	tc+1	196	432	.355	.783	551	$M = .1000$	tc+1	564
$K = .04785$	1.5	254	381	.565	.848	449	tc+2	227	500	.322	.709	706	$b = 2.82826$	tc+2	628
$t_o = -.77250$	2.0	184	368	.431	.862	427	tc+3	255	562	.291	.641	876	$W_\infty = 12,235$	tc+3	684
$t_c = 7.0$	2.5	144	360	.348	.870	414	tc+4	279	615	.263	.580	1060	$K = .04785$	tc+4	732
$t_r = 6.0$	3.0	120	360	.292	.876	411	tc+5	299	659	.238	.525	1255	$t_o = -.77250$	tc+5	772
													$\rho = 1.0$		
C $M = .2664$	.5	322	161	.587	.293	549	tc	76	167	.182	.401	417	C $F = 1.0000$	tc	404
$W_\infty = 12,235$	1.0	167	166	.355	.355	470	tc+1	77	169	.140	.307	549	$M = .1000$	tc+1	462
$K = .04785$	1.5	111	166	.255	.382	437	tc+2	75	165	.107	.235	701	$b = 2.82826$	tc+2	514
$t_o = -.77250$	2.0	83	166	.198	.397	418	tc+3	71	157	.082	.180	869	$W_\infty = 12,235$	tc+3	560
$t_c = 7.0$	2.5	67	167	.163	.406	412	tc+4	66	146	.063	.138	1057	$K = .04785$	tc+4	600
$t_r = 4.0$	3.0	56	168	.138	.413	407	tc+5	60	133	.048	.107	1254	$t_o = -.77250$	tc+5	632
													$\rho = 3.0$		
D $M = .2664$	.5	57	28	.587	.293	97	tc	12	27	.182	.401	67	D $F = 2.2036$	tc	161
$W_\infty = 12,235$	1.0	28	28	.355	.355	79	tc+1	13	29	.140	.307	94	$M = .2664$	tc+1	158
$K = .02392$	1.5	19	28	.255	.382	73	tc+2	13	29	.107	.235	124	$b = 2.82826$	tc+2	151
$t_o = -.77250$	2.0	14	27	.198	.397	69	tc+3	13	28	.082	.180	158	$W_\infty = 12,235$	tc+3	141
$t_c = 7.0$	2.5	11	27	.163	.406	68	tc+4	12	27	.063	.138	196	$K = .04785$	tc+4	129
$t_r = 4.0$	3.0	9	26	.138	.413	64	tc+5	11	25	.048	.106	240	$t_o = -.77250$	tc+5	116
													$\rho = 4.0$		
E $M = .2664$	.5	290	145	.587	.293	494	tc	67	148	.182	.401	369	E $F = 2.2036$	tc	210
$W_\infty = 12,235$	1.0	148	148	.355	.355	418	tc+1	69	152	.140	.307	496	$M = .2664$	tc+1	206
$K = .04785$	1.5	99	148	.255	.382	389	tc+2	68	151	.107	.235	641	$b = 2.82826$	tc+2	197
$t_o = -.38625$	2.0	74	148	.198	.397	374	tc+3	66	144	.082	.180	802	$W_\infty = 12,235$	tc+3	184
$t_c = 7.0$	2.5	59	147	.163	.406	362	tc+4	62	136	.063	.138	982	$K = .04785$	tc+4	173
$t_r = 4.0$	3.0	49	147	.138	.413	355	tc+5	56	124	.048	.106	1173	$t_o = -.77250$	tc+5	152
													$\rho = 3.0$		
F $M = .1000$	.5	752	376	1.235	.617	609	tc	135	297	.322	.709	420	F $F = 2.2036$	tc	373
$W_\infty = 12,235$	1.0	328	328	.673	.673	487	tc+1	161	355	.291	.641	553	$M = .1000$	tc+1	440
$K = .04785$	1.5	207	310	.463	.694	447	tc+2	186	410	.263	.580	706	$b = 2.82826$	tc+2	489
$t_o = -.77250$	2.0	150	300	.353	.706	425	tc+3	209	461	.238	.525	877	$W_\infty = 12,235$	tc+3	539
$t_c = 7.0$	2.5	118	295	.285	.712	414	tc+4	228	502	.216	.475	1058	$K = .04785$	tc+4	582
$t_r = 4.0$	3.0	98	294	.239	.717	410	tc+5	245	540	.195	.430	1256	$t_o = -.77250$	tc+5	618
													$\rho = 3.0$		

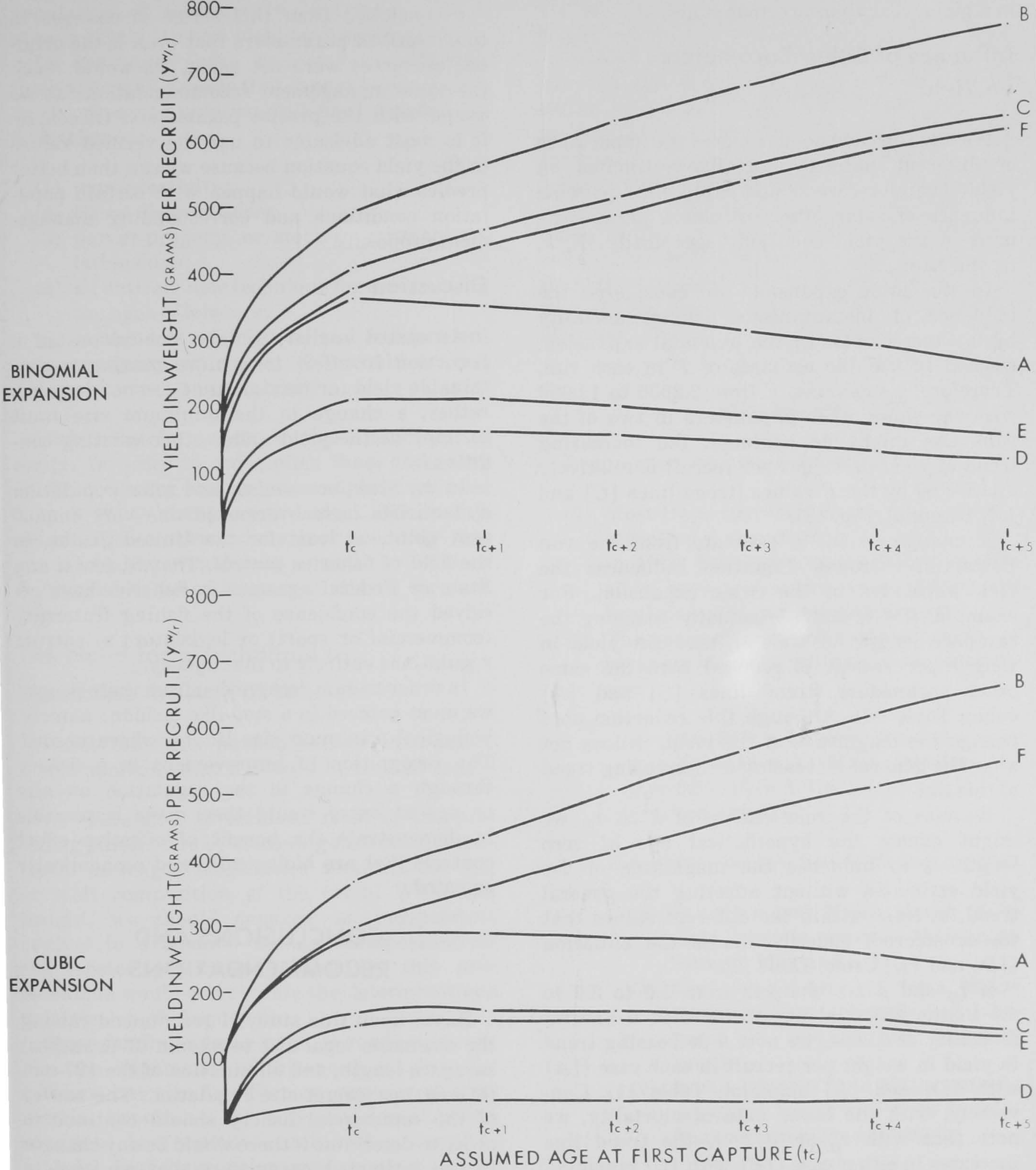

Figure 18. — The relationship between the calculated yield in weight (grams) per recruit and assumed age at capture (t_c) from binomial and cubic expansions of the simple yield equation.

Therefore, with the new size limit, it would still be possible to have a smaller total poundage in a given year than previous years.

Influence of Other Parameters on Yield

We have already demonstrated the importance of different natural mortality estimates on yield. Therefore, we should explore the possible influence of some other estimated parameters used in the yield equation: specifically, F, k, t_0, and t_p or ρ.

In the cubic expansion, we considered the influence of instantaneous fishing mortality by 0.5 increments. In the binomial expansion, we had to use one estimate of F in each run. Therefore, we changed F from 2.2036 to 1.0000 with the same other parameters in two of the runs. As might be expected, the increasing trend of yield in weight per recruit is relatively unaffected by the F values (trend lines [C] and [F] binomial, Fig. 18).

A change in the k estimate from the von Bertalanffy Growth Equation influences the yield estimates in the cubic expansion. For example, if k is halved (actually reducing the carapace length for time t), then the yield in weight per recruit is reduced with the same other parameters (trend lines [C] and [D] cubic, Table 11). Although this reduction does change the magnitude of the yield, it does not alter the general increasing or decreasing trend of this line.

Because of the relationship of k to t_0, we might expect the hypothetical age at zero length t_0 to influence the magnitude of the yield estimates without affecting the general trend, at least within the different values that we considered. Indeed, this is the situation ([D] and [E] cubic, Table 11).

If t_p and ρ are changed from 1.0 to 3.0 to 4.0 in the binomial expansion with a natural mortality of 0.2664, we note a decreasing trend in yield in weight per recruit in each case ([A] with [D] and [E] binomial, Table 11). Conversely, with the lower natural mortality, we note that with t_p or $\rho = 1$, the trend line increases in either case ([B] with [C] binomial, Table 11). I reasoned that only in the unrealistic situation of t_p or $\rho = 1$ with the also unlikely high natural mortality, would there be a discrepancy in the increase or decrease of the trend in the yield estimates.

I concluded from this series of changes in the described parameters that even if the original estimates were not exact, we would reach the same management recommendations as we would with the precise parameters. Of course, it is most advisable to use the verified values in the yield equation because we can then better predict what would happen with certain population conditions and corresponding management proposals.

Discussion

As stated earlier, I have not advocated a reduction in effort to achieve maximum sustainable yield (or maximum net economic gain), rather, a change in the minimum size limit to improve the yield under other existing conditions.

In my view, economists and some population dynamicists have overlooked one very important point, at least for the United States, in the field of fisheries control. That is, few if any State or Federal agencies in fisheries have received the confidence of the fishing fraternity (commercial or sport) or legislators to entrust regulations entirely to that agency.

In order to gain recognition from these people, we must proceed in a step-like fashion: namely, biological minimum size limits, where needed. The recognition of improvement in a fishery through a change in the regulation on size or age at entry would then make it possible to demonstrate the benefit of effective effort controls that are biologically and economically oriented.

CONCLUSIONS AND RECOMMENDATIONS

Based upon this study, I recommend raising the minimum legal size to 89-mm (3-½ inches) carapace length, and elimination of the 127-mm (5 inch) maximum size regulation. The survey of the commercial fishery should continue in order to determine if there would be any changes in the estimated parameters that we used in the yield equation. Indeed, if there were changes in the critical parameters, then we should adjust the minimum size accordingly.

Really, we must abandon the concept of static, unchanging regulations in a dynamic, changing population of lobsters. In this way we can always obtain the best yield for fishermen.

In any study with budgetary restrictions there are many aspects that cannot be examined. In the present study we still need detailed information on:

(1) trap selectivity;
(2) larval distributions;
(3) parent-progeny, or stock-recruitment relationships;
(4) an entirely new technique for determining the ages of lobsters;
(5) movements of lobsters and independent mortality estimates; this would be best suited to a tagging study.

Unfortunately, most of these studies are costly. In order to accomplish them and carry on the necessary commercial sampling, we need 2 to 3 times the present budget. While this sounds like a tremendous increase, this new annual budget would only amount to 1.5% of the landed value of lobsters in Maine for each year.

The Need for a Technique to Determine the Age of Lobsters

I feel that this particular recommendation is so important that it should be treated separately.

We were able to estimate most of the preceding parameters by assuming that the manipulation of length frequencies revealed the age or molt composition of the catch. With this insight, we should consider an independent method to determine the age composition of the lobster population. Hopefully, this new technique would corroborate the determinations from the length frequencies.

Some funding agency must be made to recognize the importance of this need not only for lobsters, but also for other crustaceans of commercial importance. This type of investigation would be best suited to universities (medical schools) that have prior experience with the genetic-biochemical aging process in humans. Paradoxically, in this situation, humans would be the test species.

For those who would say this limitation in the length frequencies should delay implementation of the recommendations in this report, I would remind them that the regulations now in effect are largely a result of intuition and convenience. While this type of management might suffice in a lightly exploited fishery, it is foolhardy to continue it in such a valuable resource as lobsters, especially when the most cursory examination of the length frequencies reveals that the size ranges of the exploited phase of the stock have been reduced practically to one-half inch in carapace length. Further, this one-half inch in size range does not include the size at maturity for most female lobsters.

SUMMARY

In summary we have determined:

(1) Most traps currently in use have parlors, reflecting a change from an earlier study in 1948. Further, present-day traps possibly have a selection range below the legal size of 81-mm carapace length.
(2) The premolt-postmolt relationships in carapace length in millimeters by category are:

$y = 0.64986 + 1.07578x$ (males)
$y = -0.46448 + 1.09612x$ (females)
$y = 0.59543 + 1.07619x$ (sexes combined)

(3) Based upon berried female measurements:

(a) Canadian and Maine stocks of female lobsters extrude their eggs between May and July;
(b) most female lobsters from Maine stocks mature (extrude eggs) between 90- and 100-mm carapace length;
(c) female lobsters from Maine extrude eggs at a larger size than females from certain parts of Canada.

(4) The maximum size regulation of 127-mm (5 inches) carapace length is biologically unsound.

(5) Probability modes and 14% groupings of length are comparable and possibly indicate age or molt groups.

(6) The cluster samples show (a) fairly uniform mean lengths by day, month, and year; this mean length is approximately 89-mm (3.5 inches) carapace length, (b) the mean weight is more variable but is explained, to some extent, by the percentage of culls, (c) the percentage of females is usually around 50% on a monthly and yearly basis, (d) the subjective measure of the percent shedders shows a proportionate increase usually from July through October in each year.

(7) The catch in numbers per trap-haul-set-over-day is a better indicator of stock density than any other known ratio, provided it is carefully analyzed.

(8) Fishing effectiveness has increased from 1955 to 1970.

(9) Trap limitations as proposed by some fishermen and legislators will not diminish the effective effort.

(10) The solved von Bertalanffy Growth Equation is:

$$\hat{l}_t = 266.77 \left[l - e^{-0.04785\,(t+0.77250)} \right].$$

(11) The solved weight-length relationship for the sexes combined is:

$$W = 0.001682\ L^{2.82826}.$$

(12) Depending on the methodology, the instantaneous total mortality ranges from 1.1363 (67.9%) to 2.9188 (94.6%) while the instantaneous natural mortality ranges from 0.0202 (2.0%) to 0.3467 (29.3%). Therefore, the estimates of the instantaneous fishing mortality range from 0.7896 (54.6%) to 2.8986 (94.5%). An instantaneous natural mortality of 0.1054 (10%) and an instantaneous fishing mortality of 2.3026 (90%) are more plausible.

(13) By using the binomial and cubic expansion of the simple yield equation with reasonable parameters, the legal minimum size should be raised to at least 89-mm (3-½ inches) carapace length.

ACKNOWLEDGMENTS

I find it a pleasure to commend others who have played an integral part in an investigation.

Specifically, I would like to thank the fishermen and dealers who allowed, often at an inconvenience to themselves, "bug-hunters" to gather the information for this report.

The sampling crew, Paul J. DeRocher (who worked from 1966 to 1970), Clarence C. Burke, Gary A. Robinson, and Louis M. Kazimer, has my deepest appreciation. These men not only traveled great distances but also worked many overtime hours including weekends and holidays to collect the data. They were also instrumental in the compilation and summarization of this material at the laboratory.

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I sincerely thank everyone who assisted me and hope that this paper justifies their endeavors.

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