EFFECTS OF TRAP SELECTIVITY AND SOME POPULATION PARAMETERS ON SIZE COMPOSITION OF THE AMERICAN LOBSTER, *HOMARUS AMERICANUS*, CATCH ALONG THE MAINE COAST[1]

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ABSTRACT

Information collected aboard commercial lobster boats along the Maine coast (1971-73) revealed, among other things, high numbers of sublegal lobsters (<81 mm carapace length) being handled by fishermen while sorting their catches. Throw-back ratios of illegal to legal lobsters (1.8 to 12.4:1) varied in association with lath spacing. Traps with spacings of 1⅝ to 1¾ inches accounted for markedly fewer sublegals than those traps with 1¼- to 1½-inch spacings.

Selectivity curves calculated for research traps with escape ports of 1½, 1⅝, and 1¾ inches and a trap escapement study demonstrate that a spacing of 1¾ inches is large enough to allow escapement of most sublegals yet small enough to retain legal lobsters. A regression of carapace length on carapace width shows that only an insignificant percentage of legal lobsters could physically squeeze through a 1¾-inch opening. Thus, results of this study led us to recommend that with a minimum legal length of 81 mm, traps should have 1¾-inch escape vents.

While riding aboard commercial lobster boats along the Maine coast (1971-73) to collect detailed catch and effort information, we frequently observed lobster fishermen sort and throw back from their traps excessive numbers of sublegal lobsters (<81 mm carapace length). When one considers that Maine lobstermen presently haul their traps more than 20 million times each year, the magnitude of this sorting becomes apprent. Lobstermen not only lessen the efficiency of their fishing operations by needlessly handling sublegal lobsters but they also inadvertently increase the lobsters chances of becoming a cull (missing claw[s]) or a victim to predatory fish while descending to the ocean floor (D. G. Wilder, pers. commun.), which in either case represents an economic loss to the industry.

A solution to this detrimental fishing practice became apparent to us after a cursory analysis of data from our earlier boat trips revealed an inverse relationship between lath spacing and numbers of sublegal lobsters. Templeman (1939) and Wilder (1945, 1948, 1954) also reported the same relationship based on size composition of catches from traps of various lath spacings. Although these Canadian scientists have long advocated the use of wider latch spacings to allow sublegals to escape, presently only Newfoundland has a lath spacing regulation of 1¾ inches.

Because of the management implications of this association between lath spacing and size composition of the catch, we undertook this investigation to quantitatively assess this situation with several independent approaches, namely: 1) selectivity curves; 2) trap escapement study; and 3) certain morphological dimensions of lobsters. Certain facets of this study were also valuable in corroborating some previously estimated population parameters such as natural mortality rates, sex ratios, and spawning stock structure and size.

These analyses have become increasingly important because we have recommended raising the legal minimum size from the present 81 mm ($3^3/_{16}$ inches) to 89 mm (3½ inches) carapace length. Then this study not only has application for the present situation, but also provides pertinent information for management of lobsters in the future.

METHODS

Samples from Commercial Gear

From 1971 through 1973, we spent 21 days riding aboard nine different commercial lobster boats (three boats were sampled more than once) from

[1]This study was conducted in cooperation with the Department of Commerce, National Marine Fisheries Service, under Public Law 88-309, as amended, Commercial Fisheries Research and Development Act, Project 3-153-R.

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Manuscript accepted December 1974.
FISHERY BULLETIN: VOL. 73, NO. 4, 1975.

four coastal areas. These boats were selected on a nonrandom basis because not all vessel-captains could or would accommodate us, nor could we reallocate committed time from our ongoing surveys of the natural lobster population and the commercial catch. While aboard these vessels we recorded the following: 1) numbers of sublegal and legal lobsters for each trap haul; 2) carapace length and sex of lobsters from a systematic sample of the catch, along with the corresponding measurements of lath spacings in these traps; 3) time expended in actual fishing as well as fishing time for each trap (number of set-over-days); 4) whether the fisherman was hauling one trap at a time (singles) or two attached traps with one buoy (pairs), or three or more attached traps (trawls) with two buoys, one at each end of the string; and 5) amount and kind of bait used.

Carapace lengths were measured in millimeters from the posterodorsal edge of the eye socket to the posterior margin of the carapace. In most cases, we attempted to measure all the lobsters in every nth trap (depended on whether traps were set as singles, pairs, or trawls); however, sometimes with two samplers, we were able to measure and record all the lobsters in each of the total number of traps hauled for the day.

Length compositions of the catches for each boat trip were used to calculate what we refer to as retention curves. These curves are simply an accumulative percentage of the number of lobsters by 1-mm carapace increments that were retained in the systematic sample of the traps hauled, along with measurements of the lath spacings of these traps. Because lath spacings were not uniform for each of the traps hauled per boat, the term "modal spacing" was used to imply that at least a majority of the traps per boat had a spacing more frequently measured by us than any other.

Samples from Research Gear

Since 1968 we have recorded the carapace length, weight, sex, condition (hard or soft shell, lost appendages) of individual lobsters caught in our research traps. Our research gear consisted of: 1) modified wooden traps, with plastic escape vents of 1½, 1⅝, and 1¾ inches (Figure 1), and 2) 1×1 inch wire meshed traps especially designed to catch sublegal lobsters. The modified commercial gear was fished from July 1972 through 1973, while the wire traps were used since 1968.

We also conducted a trap escapement study

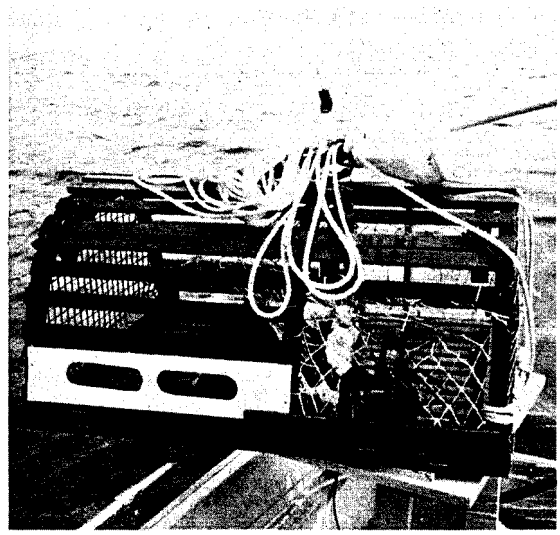

FIGURE 1.–Modified commercial lobster trap equipped with a plastic escape vent.

whereby lobsters of known sizes were placed in wooden traps with vents of 1¼, 1½, 1¾, and 2 inches. Because the heads or entrances were sealed, any escapement should have been accomplished between the laths. Through a 2-wk period traps were usually checked daily for escapement.

Comparison of Samples from Commercial and Research Gear

Following the methodologies of Beverton and Holt (1957), Pope (1966), and Gulland (1969), we calculated selectivity curves which were based upon carapace lengths of lobsters retained in the commercial gear with modal lath spacings of 1¼, 1⅝, and 1¾ inches. These data were proportioned with the same range of lengths retained in the 1×1 inch wire meshed research traps. Both sets of data, commercial and research, were weighted by trap-haul-set-over-days (THSOD). These comparisons were from the same general area, but not with the same groups of traps nor necessarily during the exact same period of time.

In addition, we used the cited methods to make selectivity determinations from the modified commercial traps that had specific lath spacings of 1½, 1⅝, and 1¾ inches. These spacings were proportioned with the data from the wire research traps (1×1 inch mesh). In this case, the modified commercial and wire research traps were fished

simultaneously with the same spatial and temporal arrangements.

Body Proportions of Lobsters

To circumvent the spatial and temporal problems between commercial (boat trips) and research gear to a certain extent, we took body measurements of 217 lobsters, specifically carapace length, width, and height for sizes between 70 and 90 mm carapace length. These measurements should enable us to reach a more objective determination concerning the retention and escapement potential of various sized lobsters through different lath spacings.

RESULTS AND DISCUSSION

Samples from Commercial Gear

For the 21 boat trips with commercial fishermen, we counted their entire catch of 12,071 lobsters of which there were 2,311 legal lobsters (Table 1). This catch resulted from 4,026 trap hauls for a catch of 0.57 legal lobsters per trap haul or 0.22 legal lobsters per THSOD.

There are omissions in some of the data categories per boat trip because the sampling procedure evolved from successive trips aboard vessels; thus samplers learned by experience and observation what could or could not be accomplished under different physical conditions in each vessel. Nevertheless, subtotals can be gleaned from the boat trips with the more complete information. For example, there were 156 berried and/or "V"-notched females from 18 of the 21 boat trips. Even though this is a subtotal, it is an alarmingly low number. Of course, such things as season of year, area fished, and availability of berried females could affect this number. Still, we continue to be concerned about the possibility of a precarious limit of an adequate spawning stock (Thomas 1973; Krouse 1973).

The percent females is another estimate related to the reproduction potential of the exploited population of lobsters. For those lobsters that we measured and determined sex, 52.9% were females (sublegal and legal). This estimate is close to the 49.0 to 53.8% females that we estimated by year (1966-73) from the survey of the commercial (legal lobsters) and natural (mostly sublegal) population of lobsters.

These estimates are in conflict with the expectation that there should be more males than females in the commercial catch because berried and/or V-notched females must be returned to the ocean by law. Again, this situation points to a low number of sexually mature females.

To reach definite conclusions concerning the stock-progeny-recruitment relationships, we should follow the procedures of Beverton and Holt (1957) and Ricker (1958). This will be possible with continued support of this program and continued surveys on the commercial and natural populations of lobsters.

Length Frequencies

We measured the carapace length of 3,595 lobsters; the sex ratio (male:female) was 1:1.2. A histogram of these length frequencies (Figure 2) portrays the same situation that we have demonstrated from the commercial and natural surveys. That is, there are relatively large numbers of lobsters (2,937 or 81.7%) under the legal minimum size, while there are considerably fewer lobsters (658 or 18.3%) at and above the legal minimum size of 81 mm ($3^3/_{16}$ inches) carapace length. In fact, 94.0% of the legal catch is constrained within a ½-inch size range immediately above the legal minimum size. These conditions confirm the high exploitation rate of 0.86 that can be calculated from Thomas (1973).

Considering the modal lath spacings of traps used in each boat trip, there is a marked difference in the number of sublegal- and legal-sized lobsters.

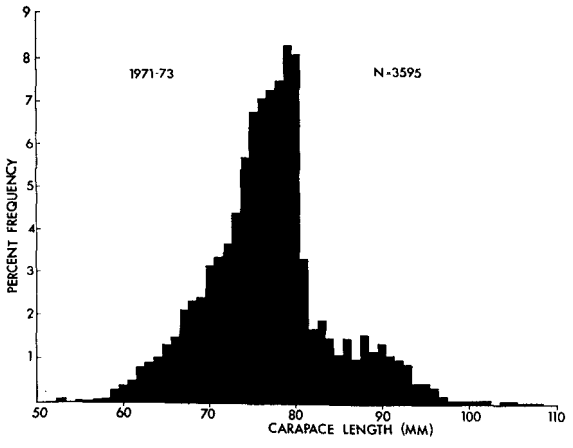

FIGURE 2.—Length-frequency distributions of lobsters caught in traps several lath spacings) used by commercial fishermen (1971-73).

TABLE 1.–Catch and effort statistics of 21 daily lobster catches for nine commercial fishing boats, September 1971 through September 1973.

Area / Boat trip (Date of trip)[1]	Catch, counted: Total no.	Illegals: legal	Females: Berried V notch	Females: non Berried V notch	Females: Non-berried V notch	Females: Sub-total	Catch, measured: Total no.	Catch, measured: Females (%)	Catch-effort: Legals per trap haul	Catch-effort: Sub-legals per trap haul	Catch-effort: No. of trap hauls	Catch-effort: No. of set-over-days	Catch-effort: Boat hours	Trap specifications: No. of parlors	Trap specifications: Modal vent spacing (inches)	Bait: Amount (bu)	Bait: Type
Boothbay:																	
1. (Sept. 71)A	434	10.4:1	0	3	1	4	—	—	0.29	2.97	132	3	7.5	1	1.25	2	redfish
2. (Oct. 71)A	298	8.3:1	0	2	4	6	55	61.8	0.27	2.22	117	5	6.0	1	1.25	2	redfish
3. (Aug. 72)B	642	2.4:1	0	2	2	4	144	46.5	0.56	1.37	329	2	6.5	1	1.62	—	—
4. (Aug. 72)C	109	8.1:1	0	0	1	1	109	39.4	0.41	3.31	29	3	3.0	1	1.25	1	flatfish
5. (Aug. 72)B	696	2.6:1	0	3	3	6	134	57.5	0.62	1.61	310	—	6.5	1	1.62	5	redfish
6. (Sept. 72)A	428	12.4:1	0	3	0	3	204	52.0	0.13	1.58	248	3	7.3	1	1.25	2	redfish
7. (July 73)B	624	1.8:1	0	5	7	12	136	56.6	0.74	1.28	303	4	7.0	1	1.62	6	redfish and menhaden
8. (Aug. 73)B	637	2.9:1	0	2	25	27	128	50.8	0.65	1.79	250	2-4	8.0	1	1.62	4	redfish
9. (Sept. 73)A	340	8.7:1	0	0	6	6	245	57.6	0.27	2.32	129	5	7.0	1	1.25	2	redfish
Medomak:																	
10. (Sept. 71)D	1,247	5.6:1	0	3	12	15	—	—	0.76	4.18	249	3-4	12.5	1-2	—	6	redfish
11. (Nov. 71)D	1,606	3.5:1	4	3	9	16	347	[2]	1.34	4.62	267	6	11.0	1-2	—	6	redfish
12. (Sept. 72)D	1,234	4.5:1	3	6	8	17	260	57.7	0.96	4.22	235	4	12.0	1-2	1.25-1.50	6	redfish
13. (Sept. 73)D	926	3.6:1	0	4	12	16	56 / 145	[2] / 59.3	1.32	4.70	151	3	7.3	1-2	1.25-1.50	3	redfish
Jonesport:																	
14. (July 72)E	277	7.2:1	—	—	—	—	57	54.0	0.17	1.23	198	—	8.0	—	—	—	—
15. (Aug. 72)F	244	5.8:1	—	—	—	—	43	44.2	0.24	1.40	149	—	7.0	—	—	—	—
16. (Sept. 72)G	291	3.3:1	—	—	—	—	72	44.4	0.45	1.49	150	—	—	—	1.25	—	—
Newagen:																	
17. (Aug. 72)H	441	11.6:1	1	1	5	7	441	51.5	0.27	3.04	131	1-2	—	1	1.13-1.25	2	herring
18. (June 73)H	186	8.3:1	0	0	4	4	180	54.1	0.18	1.45	112	2-5	5.0	1	1.13-1.62	2	pollock
19. (July 73)H	329	4.9:1	0	5	1	6	327	51.7	0.43	2.05	130	1	5.0	1	1.13-1.62	1	herring
Cundy's:																	
20. (Sept. 72)I	554	9.7:1	0	0	4	4	232	54.7	0.30	2.91	171	2-3	7.3	1-2	1.75	4	redfish
21. (Sept. 73)I	528	3.2:1	0	2	0	2	280	51.4	0.53	1.69	236	2-3	7.3	1-2	1.75	4	redfish
Total	12,071	4.2:1	[3]8	[3]44	[3]104	[3]156	[3]3,595	[3]52.9	0.57	2.39	4,026	[3]1-6	[3]141.2	[3]1-2	[3]1.13-1.75	[3]58	

[1]Letters (A, B, etc.) represent boat trips with the same or different fishermen.
[2]Sex not determined.
[3]Data omissions.

For example, the catches of boat trips numbered 3, 5, 7, 8, 20, and 21 (modal lath spacings of 1⅝ or 1¾ inches) consisted of a low number of sublegal lobsters compared to the high number of sublegals in catches of boat trips numbered 2, 4, 6, 9, 17, 18, and 19 (modal lath spacings of 1¼ to 1½ inches) (Table 2).

Effects of Throw Backs on the Fishery

The throw-back ratios of illegal (sublegal plus berried and/or V-notched females) to legal lobsters which ranged from 1.8 to 12.4:1, confirmed our earlier observations that a considerable number of lobsters are being handled needlessly (Table 1). It is not difficult to envision sublegal, V-notched, or berried female lobsters spending a portion of their lives airborne. One of the important considerations in this situation is whether these lobsters suffer a higher natural mortality than those lobsters less than 51 mm (2 inches) carapace length which are seldom caught because of their possible secretive behavioral patterns and the selectivity of lobster traps. However, we might reach some tentative conclusions from the lengths of lobsters collected in the present study along

TABLE 2.—Length-frequencies by 1-mm increments for lobsters collected in 21 commercial boat trips, September 1971 through September 1973 (successive boat-trip numbers are identical to those in Table 1).

Carapace length (mm)	Successive boat trips																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Totals
≤59	(1)	—	—	2	—	—	—	—	1	(1)	—	—	—	—	—	—	9	4	11	—	1	28
60		—	—	—	—	—	—	—	—		—	1	—	—	—	—	5	1	5	1	1	14
61		—	1	—	—	2	1	—	2		2	—	1	—	—	—	4	1	4	—	—	18
62		1	—	2	—	1	—	—	3		—	1	—	—	—	2	10	7	2	1	—	30
63		2	—	1	—	1	—	—	1		—	1	1	3	—	2	9	3	6	3	—	33
64		—	—	1	1	2	—	1	2		2	1	1	2	3	—	8	2	10	1	—	37
65		—	—	1	—	4	—	—	3		2	3	1	—	3	2	10	6	9	1	—	45
66		1	—	2	—	6	—	1	10		2	—	2	1	1	1	10	3	12	3	—	55
67		—	—	4	—	4	1	—	5		3	3	4	1	1	1	23	6	18	1	—	75
68		1	1	4	—	5	—	1	2		7	5	2	3	4	2	15	10	16	5	—	83
69		6	1	3	—	3	2	1	12		2	3	6	3	2	3	14	9	10	6	—	86
70		1	—	7	—	4	1	—	8		11	13	9	1	4	2	22	7	14	5	3	112
71		2	2	2	1	8	1	2	8		13	8	10	—	2	—	21	8	13	8	8	117
72		5	1	6	1	9	1	2	12		10	7	3	1	1	3	20	11	15	11	9	128
73		—	2	7	3	7	4	4	21		16	6	6	2	5	8	20	6	14	15	10	156
74		7	2	2	7	18	10	6	9		11	21	10	1	1	1	33	9	18	20	16	202
75		3	7	8	11	20	9	6	14		29	14	14	1	1	6	29	12	22	23	11	240
76		5	11	7	11	14	10	7	14		29	18	15	3	3	5	34	13	10	20	22	251
77		2	13	8	13	11	14	8	23		23	15	13	2	2	—	35	10	14	21	31	258
78		2	15	6	12	23	10	12	18		31	20	15	2	2	7	11	14	15	23	29	267
79		6	13	11	14	16	19	18	13		31	31	20	1	1	1	27	11	14	17	29	293
80		2	17	5	14	19	7	14	19		33	32	15	3	1	3	30	7	10	18	40	289
81		1	12	7	5	8	9	3	10		12	7	11	—	—	4	3	2	8	3	15	120
82		2	4	2	3	1	5	4	2		5	3	6	1	—	1	4	1	5	3	8	60
83		1	10	1	8	1	3	5	7		3	2	2	2	—	1	6	2	9	2	5	70
84		—	3	2	3	1	5	5	4		7	2	4	4	1	—	5	2	5	—	1	54
85		—	5	2	2	2	3	4	—		1	5	4	1	—	—	—	1	2	2	6	40
86		2	2	—	4	5	2	4	2		4	4	6	3	—	4	2	—	2	2	7	55
87		—	4	—	1	1	5	1	1		2	4	1	1	—	—	4	1	4	1	6	37
88		—	3	—	4	2	4	5	5		8	4	4	—	—	1	2	2	5	3	5	57
89		—	3	1	2	1	3	3	2		9	1	4	3	—	1	1	1	3	3	2	43
90		1	1	2	2	2	2	2	3		11	3	2	3	—	3	4	—	4	2	5	52
91		1	2	1	3	1	2	4	—		5	5	—	—	1	—	1	1	5	2	4	38
92		—	2	—	1	—	1	2	1		5	3	2	—	—	2	2	2	5	2	4	34
93		—	2	—	3	2	2	2	—		3	2	1	1	2	—	5	1	3	3	1	33
94		—	2	—	—	—	—	—	2		6	2	2	1	—	—	—	—	1	—	—	16
95		—	2	—	1	—	—	—	1		3	2	3	1	—	—	1	1	1	—	1	17
96		—	—	—	1	—	—	—	1		2	2	—	5	—	1	—	—	1	—	—	13
97		—	—	—	1	—	—	—	1		—	1	—	1	2	—	1	—	—	—	—	7
98		—	—	—	—	—	—	—	—		—	1	—	—	—	1	—	1	1	—	—	4
99		—	1	—	—	—	—	—	—		—	—	—	—	—	1	—	2	—	—	—	4
100		—	—	—	—	—	—	—	1		1	1	1	—	—	—	—	—	1	—	—	5
101		—	—	—	—	—	—	1	—		—	—	—	—	—	2	—	—	—	—	—	3
102		—	—	—	—	—	—	—	—		—	1	—	—	—	—	—	—	—	1	—	2
104		—	—	—	—	—	—	—	—		—	1	—	—	—	1	—	—	—	—	—	2
105		—	—	1	—	—	—	—	1		1	—	—	—	—	—	—	—	—	—	—	3
106		—	—	—	—	—	—	—	—		1	—	—	—	—	—	—	—	—	—	—	1
107		1	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	1
108		—	—	—	—	—	—	—	—		—	1	—	—	—	—	—	—	—	—	—	1
≥110		—	—	1	2	—	—	—	1		1	—	—	—	—	—	1	—	—	—	—	6
Totals		55	144	109	134	204	136	128	245		347	260	201	57	43	72	441	180	327	232	280	3.595

[1]No lengths taken.

with those from the commercial and natural surveys (Thomas 1973; Krouse 1973). The commercial survey shows that about 6% of the yearly catch are culls (one or both claws missing). Because most of the legal catch is recently recruited, this may indicate that frequent removal from traps of sublegal lobsters is, in part, responsible for this percentage of culls in the commercial catch. This could occur because the claws of those sublegals might grasp laths, knitted heads and parlor entrances, hands of fishermen, and the like. When such lobsters are pulled from the traps by fishermen, the claws are occasionally broken off. Another contributing factor might be that sublegal and legal lobsters sometimes extrude their claws through the lath spacings as the trap is hauled aboard the vessel. In this way, claws could be broken off. The design of the proposed "vented" trap, discussed later, takes this situation into consideration.

In order to evaluate more fully the possibility of a higher natural mortality due to handling, we used three independent approaches as follows:

1. Our observations aboard vessels show that the percentage of culls of sublegals is between 5 and 10%. This might indicate that natural mortality has not increased due to handling because of the similarity of the percentage of culls in the sublegal and legal size range of lobsters. Autotomy of the lobster could also confound the percentage of culls; however, we theorize that this particular percentage should not be different from the sublegal to legal sizes that we are studying.
2. Another insight on the effect of natural mortality would be the length frequencies of the sublegal lobsters caught by research gear in the sampling of the natural population (Figure 3), as well as the length frequencies from sampling aboard commercial vessels (Figure 2), although gear selectivity is a factor in this case. We should expect a higher mortality due to handling to show a significant decline in the number of sublegal lobsters as the size range increases by 1-mm increments from 70 (fully vulnerable size) to 81 mm (legal minimum size). Then the number of lobsters at, say, 80 mm should be less than those at 70 mm, not only due to the higher incidence of handling this larger size, but also because of the natural mortality that would occur without handling. These numbers at the specific sizes do not show this decline that could be attributed to a higher mortality due to increased handling (Figure 3).
3. As a supplement to the incidence of handling lobsters and the resultant natural mortality, we feel that our observations on the storage of lobsters in "pounds" (this procedure is described in Thomas 1973) might give information on the amount of natural mortality in the natural population and that mortality due to handling. The pound owners, stocking at the rate of one to two lobsters per square foot, tell us that a reduction of around 5% in numbers is normal for legal lobsters stocked to those reclaimed 3 to 5 mo later. Under these adverse conditions of crowding and handling in the pound as opposed to the situation in the natural environment, we infer that the annual natural mortality is low in the ocean (5 to 15%) and that handling has a minimal effect.

   The loss in lobster pounds is sometimes much higher than 5%, but in most of these situations the higher loss can be attributed to disease, adverse environmental conditions, and escapement.

Despite these speculative premises concerning the negligible effects of handling on natural mortality, the fishermen should still eliminate this needless sorting of large numbers of sublegal lobsters to reduce: 1) the time spend sorting sublegal from legal lobsters in traps, and 2) the eventual number of culls in the legal catch. Culls not only lessen the total poundage of the commercial catch but possibly the growth rate of culls may be slower than that of nonculls; Stewart and Squires (1968) suggest that molting of unduly stressed lobsters may be inhibited. The section on selectivity will

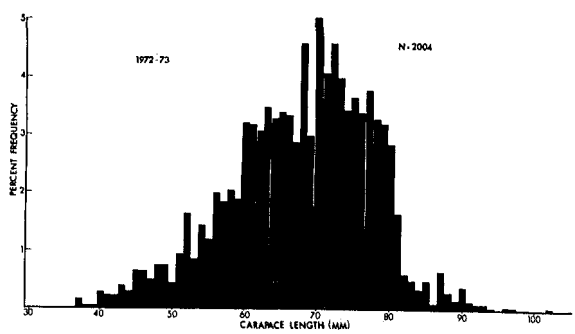

FIGURE 3.—Length-frequency distributions of lobsters collected with wire traps (1×1 inch mesh) at Boothbay Harbor (1972-73).

demonstrate the potential benefit of proper lath spacing.

Retention Curves

The accumulative length frequencies by 1-mm increments from two selected boat trips reflect a characteristic sigmoid curve (Figure 4). Snedecor (1956) and others caution that although these curves are characteristic of normal distributions, other types of distributions could result in a sigmoid curve. For our purposes, we assume that these data represent normal distributions.

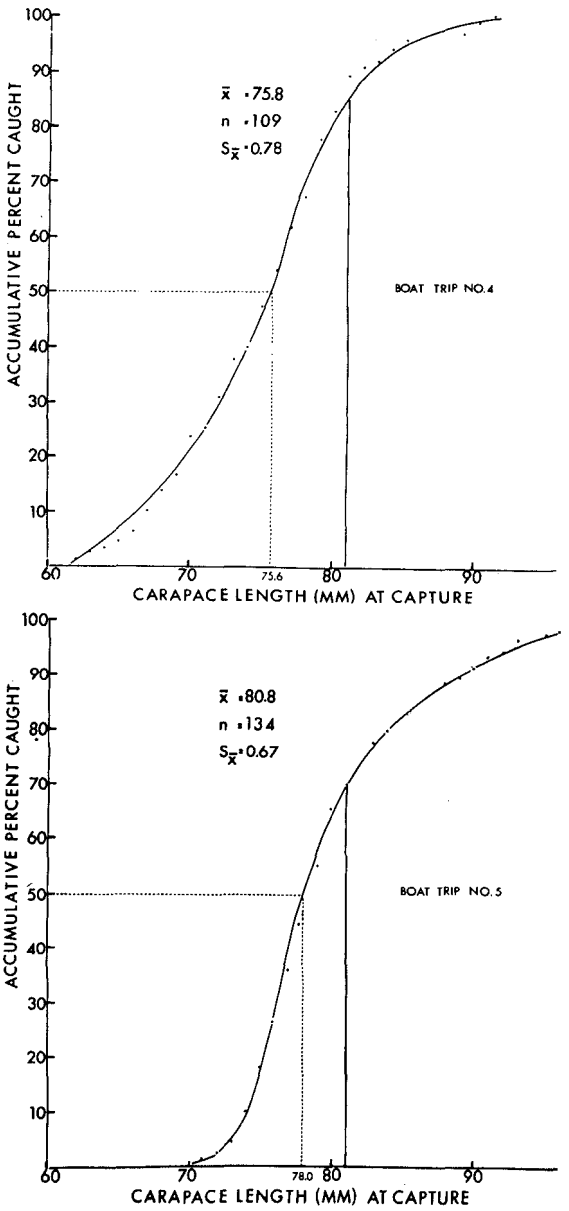

FIGURE 4.–Retention curves for two commercial boat trips (refer to boat trips 4 and 5 in Tables 1 and 2) in Boothbay Harbor (1972). Boat trips 4 and 5 had modal vent spacings of 1¼ and 1⅝ inches, respectively.

These curves are interesting in themselves because the 50% accumulative point demonstrates the influence of different lath spacings on the size, composition of the catch. For instance, boat trips 4 (1¼-inch vent) and 5 (1⅝-inch vent) had 50% accumulative points of 75.6 and 78.0 mm, respectively; thus demonstrating that traps with 1¼-inch vents are more selective for smaller lobsters (85% of catch ≤81 mm) than traps with 1⅝-inch vents (70% of catch ≤81 mm); while we are not advocating using these curves in place of selectivity curves, however we do suggest that these "retention curves" could be used as a quick, preliminary approximation of the influence of different lath spacings (gear selectivity) on the size composition of the catch in a trap fishery.

Selectivity Curves

Based upon the length composition of our catches with modified commercial traps equipped with escape ports (plastic vents) of 1½, 1⅝, and 1¾ inches and the 1×1 inch wire meshed traps, we calculated selectivity curves in accordance with the methodology of Beverton and Holt (1957). These catch data by 1-mm increments were weighted by THSOD and then the resultant values for each of the three vents (lath spaces) were proportioned with those of the wire traps over the same range of carapace lengths.

Traps with the same lath spacings had similar selectivity curves for the 1972 and 1973 catches while conspicuous differences are evident between the various size vents (Figure 5). In both years the 1½-inch vent was selective for the smaller sizes (50% retention ranged from 68.2 to 68.6 mm carapace length), the 1⅝-inch vent for the intermediate sizes (50% retention ranged from 71.4 to 73.5 mm carapace length), and the 1¾-inch vent for larger sizes (50% retention ranged from 75.4 to 78.8 mm carapace length). Contrary to most selectivity studies the important consideration in this study is not the mean selection length (50% point at which half the lobsters escape and half are retained); but rather, the proximity of the curve to the minimum legal size (81 mm carapace length) and whether or not the 100% retention point occurs below or above the minimum legal size. According

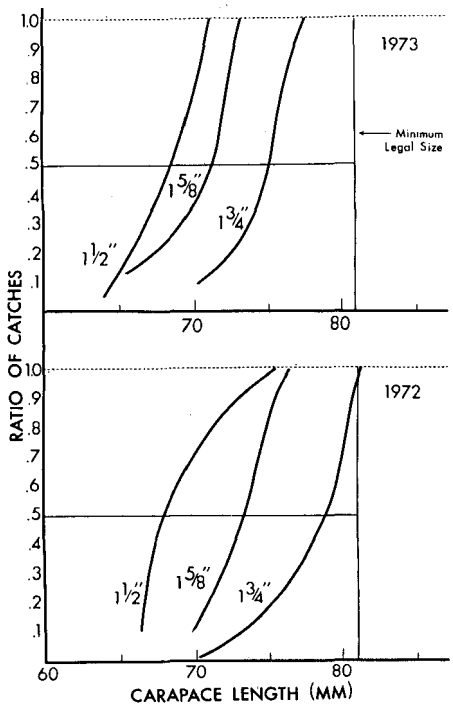

FIGURE 5.—Selectivity curves for each of the three vent sizes (1½, 1⅝, and 1¾ inches) of the modified commercial traps compared to wire (1×1 inch mesh) traps for 1972 and 1973.

to the selectivity curves, all three vents would prohibit the escapement of legal-sized lobsters. However, the 1¾-inch curve falls closer to the 81-mm line, thus demonstrating that this size vent allows a greater percentage of sublegal lobsters to escape than the 1⅝- or 1¼-inch vents.

Effects of Vent Size on Trap Efficiency

Catches with modified commercial traps reveal an inverse relationship between vent size and the ratios of sublegal to legal lobsters (Table 3). Overall catches with traps having a 1¾-inch vent always consist of more legal than sublegal lobsters

TABLE 3.—Ratios of sublegal to legal lobsters captured with wire (1×1 inch mesh) and modified commercial (1½-, 1⅝-, and 1¾-inch vents) lobster traps, 1972 through 1973. Actual numbers of sublegal and legal lobsters appear in parentheses.

	Vent size (inches)			
Year	1 × 1 (wire)	1½	1⅝	1¾
1972	11.73:1 (962:82)	3.94:1 (71:18)	2.60:1 (78:30)	0.75:1 (21:28)
1973	28.09:1 (927:33)	5.86:1 (164:28)	1.44:1 (133:92)	0.76:1 (104:136)

while this size composition is reversed in the catches from traps with smaller vents. This further substantiates our contention that excessive handling of short lobsters in the lobster fishery can be minimized with the addition of a 1¾-inch vent to all lobster traps.

Throughout this study, traps with 1⅝- and 1¾-inch vents not only retained fewer sublegal lobsters but seemed to capture proportionally more legal-sized lobsters than did those traps with 1½-inch vents. To assess this situation, we calculated separate catch-effort values (numbers of lobsters per THSOD) for legal-sized and all-sized lobsters combined for each of the three vent sizes (Figure 6). Indeed, our data indicate that traps with larger vents (1⅝ and 1¾ inches) are more successful in retaining greater numbers of legal lobsters than traps with smaller vents. However, because of our limited field sampling, we cannot validly conclude that this disparity in efficiency between vents is conclusive evidence, but rather that our data strongly suggest this possibility.

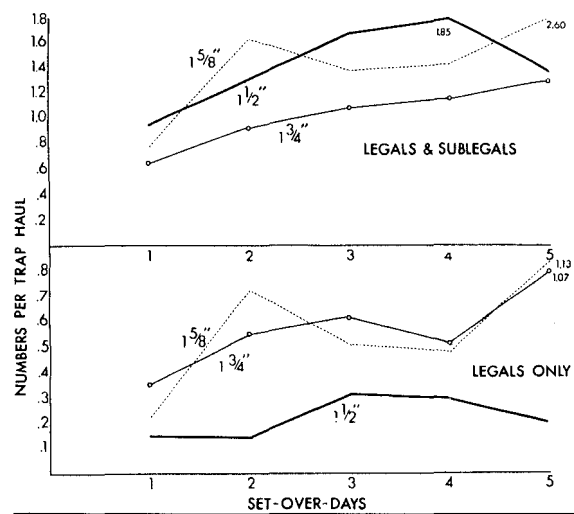

FIGURE 6.—Comparisons of the number of lobsters (legals, sublegals, and legals combined) per trap-haul-set-over-day for modified commercial traps with vents of 1½, 1⅝, and 1¾ inches (1972-73).

Body Proportions of Lobsters

The escapement of lobsters of given sizes from traps with varying lath spacings depends upon certain morphological dimensions such as carapace length, width, and height. We contend that the width of the carapace is more important than the height because we observed in the laboratory that

lobsters, attempting to escape through different lath spacings, would twist on their sides when encountering a tight fit between laths. This, coupled with the fact that the width is always smaller than the height for any carapace length, led us to the opinion that the relationship between carapace length and width in association with lath spacing is the important consideration for gear selectivity studies. We calculated the regression of carapace length (X) on width (Y) for 217 lobsters (114 females and 103 males) by the method of least squares. The calculated equation was $Y = -4.367 + 0.649X$ (Figure 7). Data for sexes were combined because analysis of covariance on the regression coefficients (Steel and Torrie 1960) showed that carapace length-width ratios of males and females did not differ significantly.

According to this relationship, lobsters at the minimum legal size of 81 mm carapace length would be expected to have a mean carapace width of 48.2 mm + 0.18 with individual widths within the 95% prediction interval ranging from 45.6 to 50.9 mm. The magnitude of these measurements relative to a 1¾-inch (44.5-mm) lath spacing suggests that only a very small percentage of legal-sized lobsters might escape through that size vent.

We should mention that some compression of the shell, particularly if the lobster is newly molted, is possible as a lobster struggles to get through the lath spacing of a trap. However, based upon our laboratory observations, we would not expect this compression to exceed 2 to 3 mm for soft-shelled lobsters (1 to 2 wk since ecdysis) and 1 mm for a hard-shelled lobster. Because this soft-shelled condition is of rather brief duration and the frequency of trap hauls is greatest during the shedding season (a shorter period of time for escapement), these situations should minimize escapement.

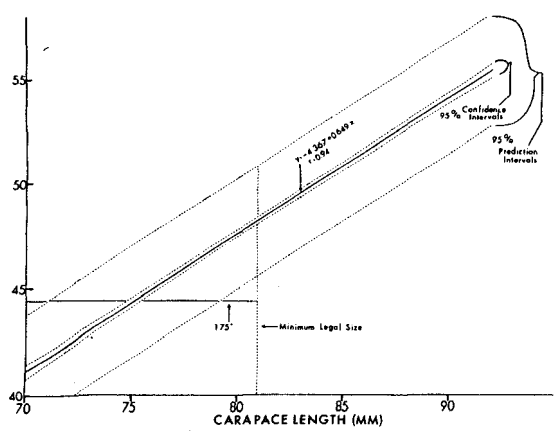

FIGURE 7.—Carapace length-width relationship for lobsters with 95% confidence and prediction intervals.

Trap Escapement Study

Retention curves, based on the escapement of lobsters of known lengths from traps with lath spacings ranging from 1¼ to 2 inches, graphically display the pronounced effect escape vent size has on lobster escapement (Figure 8). Retention of sublegal lobsters was high for the 1¼- and 1½-inch traps while most sublegals were able to escape from traps with the 1¾- and 2-inch vents. With the present minimum size of 81 mm ($3^3/_{16}$ inches), a 2-inch vent would be unsatisfactory as many legal lobsters could escape, whereas escapement of legals through a 1¾-inch vent would be extremely minimal. Although the curve for the 1¾-inch vent did show some escapement, we believe this escapement is exaggerated by the methodology (plotting midpoints) employed in the derivation of this curve. This contention is further substantiated by the fact that only one of seven lobsters with a carapace length of 82 mm escaped and there was no escapement for lobsters larger than 82 mm.

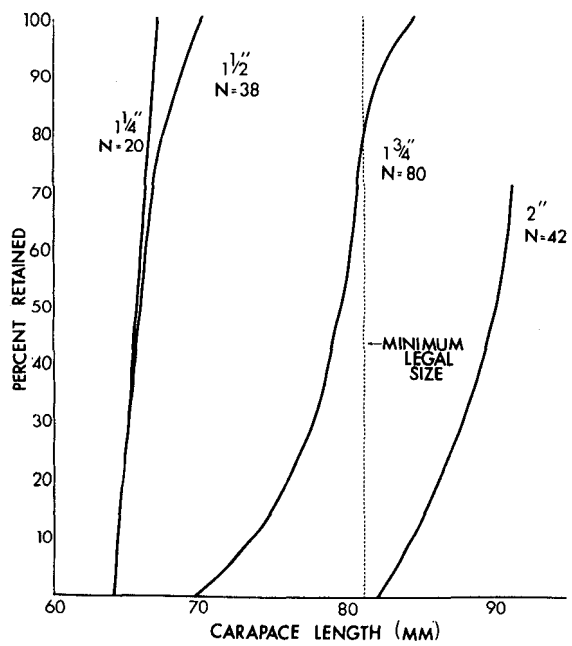

FIGURE 8.—Retention curves for lobsters placed in modified commercial traps with 1¼-, 1½-, and 1¾-, and 2-inch vent dimensions.

RECOMMENDATIONS

Based on the foregoing analysis of the effects different lath spacings have on the size composition of lobster catches, we recommend that all lobster traps fished along the Maine coast have an escape vent of 1¾ inches. Of course, if the minimum legal size (81 mm) is increased then the vent size should be altered accordingly.

We emphasize that it is not necessary for the entire trap to consist of the desired lath spacing; but rather, only one lath spacing either on the side or end (preferably near the bottom) of the parlor section of the trap. The remaining laths could be spaced at the fisherman's discretion.

We believe an escape port (vent) fabricated from some type of durable material and manufactured to our specifications could be incorporated into any conventional lobster trap (Figure 1). Merits of this vent would be: 1) easy installation in both new and old traps without requiring drastic modification; 2) modest cost to the fishermen; and 3) retention of its original dimensions over time (unlike wooden laths which eventually wear, causing a larger opening, thus permitting escapement of legal lobsters).

If this recommendation of venting traps is adopted as a conservation measure, we would expect reductions in: 1) the number of culls (which in turn would increase the weight of the total landings) and, if of consequence, the natural mortality; 2) time expended by lobstermen in sorting their catches; 3) perhaps the illicit trade of sublegal lobsters (shorts) which is considered by some dealers and fishermen to be of an alarming magnitude; and 4) if a real problem, the number of lobsters imprisoned in lost traps.

ACKNOWLEDGMENTS

We thank the fishermen who allowed us, often at inconvenience to themselves, to accompany them on their fishing trips. Cecil Pierce, a fisherman from Southport, Maine, designed the plastic vent. Gary Robinson, Louis Kazimer, Curt Crosby, Andrew Dolloff, and William Sheldon of the Maine Extension Service made many of these trips. Their comments and experience aided greatly in collecting meaningful data. We express gratitude to Gareth Coffin, formerly with the Northeast Fisheries Center, National Marine Fisheries Service, West Boothbay Harbor, Maine, for his photographic work.

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