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FACTORS INFLUENCING PRODUCTIVITY OF METAL AND WOODEN LOBSTER TRAPS

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INTRODUCTION

Although metal lobster traps have been in existence for at least two decades and fishermen in Maine have been using them in large numbers since 1974, the desirability of changing to such traps remains in doubt. Many fishermen feel that metal traps are vastly more efficient; other fishermen, equally experienced, argue that the construction material of a trap has little effect on lobster catches in comparison with other factors; still other fishermen argue persuasively that certain types of metal traps are inferior to the traditional wooden traps. The object of this paper is to analyze the factors influencing lobster catches with a view toward determining the relative importance of each. The influence of trap construction material on catches is of particular interest.

In order to evaluate these factors, two different studies were conducted. In the first, fishermen in Muscongus Bay and John's Bay helped researchers obtain data on 7,716 trap hauls during 1977-1978. Most of the data presented in this paper come from this study. In the second study conducted in the fall of 1978, three fishermen from Pemaquid Harbor allowed researchers to gather data on a smaller number of traps to address issues concerning metal traps which were not examined in the first study. The number of traps hauled was large enough for statistical reliability and the data were collected under conditions which allowed for control of a number of significant factors influencing lobster catches. The issue of controls is critical. One cannot compare the catches of various types of wooden and metal traps unless one takes into account other factors such as season, the type of bait used, the position of the trap, head type, etc.

It is assumed that the readers will be familiar with the most elementary aspects of the lobster industry. Descriptions are included on aspects of the industry unique to Maine (e.g., local laws), but no pretense has been made to describe the boats, traps, daily round, the territorial system, etc. Those who are unfamiliar with the Maine lobster industry may first wish to consult the articles listed in the bibliography.

When trying to assess various kinds of gear and catches of different types of traps only a statistical analysis will do. Impressions will not replace hard data on exactly what was caught from various traps or the worth of those catches. It is, therefore, necessary to express these finding in numbers. An attempt has been made, however, to present all data in terms that shed light on the problems, not obscure them. Throughout the paper a clear distinction is made between the facts (data on what came up in the traps) and the analysis of those facts. It is possible, of course, that experienced fishermen may accept this information but have a different interpretation.

In analysing together all of the factors which influence lobster catches, a statistical tool known as regression analysis was used. Although this is of immense practical value to social scientists, it is an advanced statistical technique which relies on sophisticated mathematical concepts. It is hoped that the explanation of the techniques used as well as the results are readily understandable to any reader who knows lobster fishing.

METHODOLOGY

In the first study to obtain information on the relative efficiency of different kinds of metal traps, five University of Maine employees rode lobster boats owned by eighteen fishermen from five towns in the Muscongus Bay region of Maine. They recorded data on 7,716 traps which were hauled while team members were onboard. The data were obtained in July/August of 1977, November/December of 1977, and April/May of 1978.* The information was coded, keypunched, and analyzed by computer. It was then incorporated into a preliminary article on trap catches which was shown to several fishermen for their comments. Generally, the fishermen who read the paper agreed with the results but pointed out one serious deficiency: it had been assumed that all galvanized and aluminized traps were alike. Several fishermen claimed that traps made of wire which is impervious to corrosion fish better than those made of wire which corrodes. Accordingly, to test this hypothesis data were obtained on another 2,135 traps pulled by three Pemaquid Harbor fishermen in the fall of 1979. During this second study all of the original information was recorded plus data of the condition of the wire on the metal traps pulled. It should be noted the only data on the corrosion issue comes from the 1979 fall samples. In 1977 and 1978 the vast majority of the traps pulled had not corroded.

All of the data appearing in this paper were obtained by six people from the research team who were either permanent or temporary University employees; none were obtained by fishermen, state employees, or anyone else.

During the months when the trap samples were conducted, the researchers listened to the evening news for the weather report and then called fishermen who had agreed to help for permission to accompany them in the morning. The researchers would get up between 3:00 a.m. and 6:00 a.m., depending on the season, and meet the fishermen at some designated place, usually the dock of the cooperative or dealer to whom that fisherman sells his lobsters. Each researcher would spend the day on a different boat recording data on every trap pulled during the day. One set of data was recorded for every string** of traps that was pulled: the name of the fisherman, the date, the string position, the type of bottom, the depth of the string, the harbor from which the man fished, the type of bait being used, the number of layover days, and the distance of that string to strings owned by other fishermen. For each trap in the string, note was made of whether it was a metal or wooden trap, any unusual features of the trap, size of the legal lobsters caught, and the number of notch-tailed lobsters if any.*** Since fishermen are paid only for pounds of legal-size lobsters caught, no attempt was made to record data on the short lobsters. A trap

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*During the summer of 1977, the trap sample was obtained by James Acheson, John Thorvaldsen, and William Acheson. The winter 1977 sample was obtained by James Acheson and John Bort. The spring 1978 sample was obtained by James Acheson, John Bort, and Jayne Lello, while the 1979 fall sample was obtained by James Acheson and Terry Cucci.

**Lobster traps are normally laid in clusters or strings.

***Under current Maine law, only lobsters which measure between 3-3/16 and 5 inches on the carapace may be legally taken. Also, it is illegal to take females with eggs or those which have ever had eggs on them. When a female lobster with eggs is caught, she must be marked by cutting a v-shaped notch out of one of her tail flippers. Such notch-tailed lobsters cannot be legally taken by any fisherman again since they are proven breeding stock.

catching mostly shorts is of very little interest to fishermen. Moreover, it should be noted that no attempt was made to weigh the lobsters caught since scales would be inaccurate on a moving boat. The carapace lengths of legal lobsters were measured using a standard scientific caliper, and the results were recorded in millimeters. The weight of lobsters was obtained later by converting length measurements into pounds using a simple mathematical formula. Ordinarily there was ample time to record these data. In the area where this project took place, fishermen pull between 150 and 350 traps per day or a trap every two to three minutes on the average. (A sample data sheet used to record this information is included at the end of this report.) Usually researchers returned to the dock between 1:30 p.m. and 3:00 p.m. and arrived home by 4:00 p.m. On some highline boats, one might leave the dock at 5:00 a.m. and not land until 5:30 p.m.

No attempt was made to obtain data on lobster catches along the entire coast. Fishermen fishing out of four adjacent harbors were carefully selected in order to control for a number of ecological and technological factors. Since the issue of controls is so critical, some explanation of this aspect of the methodology is called for.

A large number of factors influences lobster catches. The number of lobsters a man obtains varies enormously depending on season of the year, the number of traps employed, and the area he is fishing. Lobstermen state that in any area, at any given season, catches will vary depending on the skill of the fisherman, the position of the trap, the depth at which it is placed, the type of bait used, the type of heads, the length of the trap, and what the trap is made of. One cannot accurately assess how well metal traps fish compared to wooden ones if one compares the catch of four-foot wooden traps baited with alewives in the Stonington area in the spring with three-foot vinyl-covered metal traps baited with bagged herring from the Kittery area in mid-winter. If one wants to compare metal and wood, one must control for all these extraneous factors. This could only be done by carefully selecting the people and conditions under which the data were collected.

Several important comments need to be made in this regard:

1) It is necessary to control for the time the trap has been in the water. One cannot compare a metal trap and a wooden one if one trap has been in the water for three days and the other for only half an hour. Consequently, in measuring the output of traps, researchers used as a measure <u>pounds of lobster produced per trap per layover day</u>. This is the standard measurement used throughout this paper. The number .333 lb/trap/LOD means 1/3 pounds per trap per layover day.

2) Only fishermen who were using both metal and wooden traps were asked to participate in this project. These men did not have the same number of metal and wooden traps, but they all had some of both types. This allowed for comparing catches from metal and wooden traps taken by the same man in the same day.

3) There is substantial evidence that some men are much better fishermen than others (Acheson, 1977). This is generally acknowledged by everyone in the industry. In order to control for skill, men were chosen who had been in the lobster business full-time for a least five years. There were no part-timers or new fishermen in the sample. This attempt at control was of some help, but proved to be inadequate. A great deal of the variation in catches can be accounted for only if a vastly more sophisticated indicator of skill is used. It is naive to assume that all people with five years experience are equally skilled fishermen.

4) Some fishermen stated with great vehemence that there would be a strong variation in the performance of wooden and metal traps according to the season. Such a hypothesis was generally phrased in terms of predicting that either wooden or metal traps would fish better at different times of year. In order to obtain information on such factors, data were gathered at three different times of the year: just after shedding in July and August; in the middle of the productive fall fishing season (November and December); and in the spring, when catches are generally lower.

5) There is a good deal of evidence suggesting that men fishing from some areas do better than men fishing from others due to differences in concentrations of lobsters, variation in fishing effort along the coast, and other ecological factors not understood (Acheson, 1975). For this reason the investigation was limited to fishermen from only Pemaquid, New Harbor, Bremen, and Friendship. Even this attempt at control proved to be inadequate. While Muscongus Bay is relatively small, it is not a uniform body of water. Some areas of the bay are far more productive of lobsters than others. These differences show up most dramatically in the case of Bremen fishermen who had been doing unusually well the past few summers when they were fishing far up Muscongus Bay. Fishermen from Friendship and New Harbor, fishing further down the bay, were catching far fewer lobsters during this season. For this reason, it is impossible to compare catches (particularly during the summer) without controlling for the specific territory in this bay where men from particular towns fish (Acheson, 1972, 1975).

6) Lobster fishermen believe the type and construction of traps strongly influences catch. The majority build their own traps, rig them, and constantly make minor changes in design. Thus, not only do trap styles differ from one man to another, but the same man might have several different styles which differ (at least in his mind) in important respects. At the lobster trap factory run by James Davidson in Round Pond, Maine, fishermen can choose between forty different models.

Controlling for the type of trap is not as difficult as it might at first sound, since all fishermen in the area under study use only a lmited number of types of traps. All traps used are either three-foot or four-foot models, with either three or four heads made of nylon or some other synthetic twine. In this area the vast majority of the traps are fitted out with either hake mouth heads (string heads where the opening for the lobster is made very narrow by pressure from guy strings) or hog ring heads (heads with openings held open with metal rings about five inches in diameter). In this area there are two different kinds of metal traps in use: traps made of aluminized wire and traps made of vinyl-coated wire. All of the wooden traps are the traditional bow trap (half-round) covered with oak laths. In order to control for type of trap, fishermen were selected who used metal and wooden traps, three or four feet in length with hake mouth or hog ring heads or a combination of these two types of heads. If men pulled any other type of trap during the data collection period, the information was not recorded.

While it took two faculty members and three research assistants along with twenty lobstermen over a year to collect the data on these thousands of traps, the results can be expressed in very few tables.

In the following pages, three different types of tables are presented. Each one approaches the issue of comparing metal and wooden traps from a different perspective and gives different information.

SEASONAL VARIATIONS AND TRAP TYPES

Table I summarizes all of the data obtained during the first study on pounds per trap per layover day for all seasons in which information was collected.

TABLE I

Pounds/Trap/Layover Day for Vinyl, Aluminized, and Wooden Traps Over the Annual Cycle*

Season	Trap Type	Pounds per Trap** per Layover Day	Number of Trap Pulls
Summer 1977	vinyl	0.306	250
	wood	0.515	1102
	aluminized	0.850	466
Winter 1977-78	vinyl	0.381	270
	wood	0.265	1757
	aluminized	0.577	851
Spring 1978	vinyl	0.258	686
	wood	0.260	1119
	aluminized	0.267	917

*All data in Table I were obtained in the first study (1977-78). The metal traps were in good condition and were not corroding.

**There are two commonly used ways to measure the output of a trap: 1) pounds of lobster per trap hauled, and 2) pounds of lobster per trap hauled per layover day. In this case, pounds per trap per layover day has been used since this measurement takes into account the working time of the bait.

Statistical Note #1

Season	Comparison	Value of t	Degrees of Freedom	Level of Significance
Summer 1977	vinyl vs. wood	0.0251	328	P=.50 (not significant)
	vinyl vs. aluminized	-9.929	712	P=.001 (significant)
	wood vs. aluminized	11.813	550	P=.001 (significant)
Winter 1977-78	vinyl vs. aluminized	0.139	325	P=.50 (not significant)
	vinyl vs. wood	0.156	510	P=.50 (not significant)
	wood vs. aluminized	7.257	1277	P=.005 (significant)
Spring 1978	vinyl vs. wood	-1.220	1602	P=.20 (not significant)
	vinyl vs. aluminized	-1.559	1549	P=.10 (not significant)
	aluminized vs. wood	-0.396	1978	P=.50 (not significant)

Several critical facts stand out clearly in Table I. First, Table I underlines the fact that a good deal of seasonal variation exists in the lobster fishery. In general, traps do best after shedding season in the summer and worst in the spring. Wooden traps, for example, caught .315 lb/trap/layover day in the summer; .265 lb/trap/layover day in the winter; and .260 lb/trap/layover day in the spring. The same downward trend can be seen in the figures for the aluminized traps. There is nothing surprising in this. Everyone in lobster fishing has known for years that spring fishing has been very bad in comparison with shedder season and fall fishing.

More importantly, this table points out that there is no single type of trap which consistently outfishes all others, nor any type of trap that always does worse than the others.

These figures, however, give very little reliable information about which traps fish best at any given season or over the course of the year. For example, it might appear that one could conclude that vinyl traps did worse that either aluminized traps or wooden traps in the summer, but did significantly better than aluminized or wooden traps in the winter. In the spring, they were again outfished by the aluminized and wooden traps. Unfortunately almost none of these conclusions can safely be made given the statistical probabilities involved. In the spring of 1978 aluminized traps caught .267 lb/trap/layover day and wooden caught .260 lb/trap/layover day; while the vinyl caught .238 lb/trap/layover day. However, these differences are not statistically significant. The difference in average catches (lbs/trap/layover day) is small enough that they could have occurred by accident. Moreover, in the winter of 1977-78, there was no statistically significant difference in the catches of vinyl and aluminized traps. The vinyl traps caught .381 lb/trap/layover day and the aluminized traps caught .377 lb/trap/layover day, but the results of the test of significance again demonstrate there is a high probability this could have occurred purely by accident.

Of course, tests of significance are not always reliable indicators of what is going on. These figures indicate that in the summer of 1977 aluminized traps outfished both vinyl and wooden traps by a wide margin. Moreover, the differences in mean catches are highly significant statistically.* In fact, there is only one chance in 1000 that these results could have occured by accident (those who know some statistics can verify this by looking at the P figures in Statistical Note #1). From these figures, obtained in the summer of 1977, it might appear that the aluminized traps are clearly superior, and that there is not much difference between the vinyl and wooden traps. These conclusions are not warranted. A great deal of the aluminized fishing gear in the summer of 1977 sample was used by Bremen fishermen and, for reasons no one can figure out, catches have been very high in the headwaters of Muscongus Bay and the Medomak River where Bremen fishermen place their traps in shedder season (summer). The critical question then is: are the promising results of the aluminized traps (recorded in Table I) due to the traps or to the fact the fishing in certain areas is especially good? The information in Table I does not provide an answer to this question.

It should be noted that wooden traps are outfished by both vinyl traps and aluminized traps. In no season of the year do they clearly do better. Those who know statistics, however, will immediately recognize that Statistical Note #1 demonstrates the difference in means between wooden and vinyl and aluminized traps is not always significant so that nothing conclusive can be drawn from Table I. Nevertheless, there is strong reason to believe that wooden traps do not do as well as metal traps as long as the metal is not corroding. This is indicated, though not proven, by the information in Table I.

FISHING SKILL AND CATCHES

All of the men who allowed researchers to gather catch data on their boats had at least five years experience, were full-time fishermen with inboard-powered boats, and fished throughout the year. It was hoped this would control for skill. It did not. The men who helped are clearly of different skill levels. There is a great difference in the lbs/trap/layover day produced by men of different skill levels using the same type of traps from the same harbor. For example, in New Harbor (which provided a particularly large trap sample) there is a marked difference in the mean lbs/trap/layover day between the <u>most</u> highly skilled men and the highly skilled men for every type of trap. As one can see from Table II, highly skilled men using vinyl traps caught .266 lb/trap/layover day, whereas the most highly skilled men caught .353 lb/trap/layover day. Highly skilled men using wooden traps got .255 lb/trap/layover day, while the most highly skilled men got .334 lb/trap/layover day. With the aluminized traps the same difference can be observed: highly skilled men in New Harbor got .303 lb/trap/layover day, whereas the most highly skilled got .513 lb/trap/layover day. Statistical Note #2 demonstrates that all of these differences in means are highly

*There is no statistically significant difference in the catches of vinyl and wooden traps.

significant (at the .05 level or .001 level).

The data in Table II, however, tell very little about productivity of different kinds of traps used by men of a given skill level. For example, if one compares the traps used by highly skilled men, the vinyl traps caught .266 lb/trap/layover day; the wooden traps caught a little less, .255 lb/trap/layover day; and the aluminized traps caught .303 lb/trap/layover day.

TABLE II

Pounds per Trap per Layover Day by Harbor by Skill
New Harbor 1977-78

Fishing Skill	Trap Type Vinyl	Wood	Aluminized
Intermediate	---	---	---
High	.266 (n=599)	.255 (n=1668)	.303 (n=120)
Highest	.353 (n=87)	.334 (n=949)	.513 (n=177)

n = no. of trap hauls.

Statistical Note #2

A set of t tests was run to determine whether the differences in means observed in Table II were significant statistically. T tests were run to determine the level of significance of different types of traps at the same skill level and for different skill levels controlling for traps.

Comparison	t Value	Degrees of Freedom	Significance Level
High Skill: vinyl vs. wood	t = .666	1166	p = .50
High Skill: vinyl vs. aluminized	t = .959	155	p = .20
High Skill: wood vs. aluminized	t = 1.290	135	p = .10
Highest Skill: vinyl vs. wood	t = .450	103	p = .50
Highest Skill: vinyl vs. aluminized	t = 2.903	224	p = .005
Highest Skill: wood vs. aluminized	t = 4.473	214	p = .001
Vinyl Traps: high vs. highest skill	t = 2.065	107	p = .05
Wood Traps: high vs. highest skill	t = 5.169	1459	p = .001
Aluminized Traps: high vs. highest skill skill	t = 4.003	289	p = .001

The differences in these means are not statistically significant, however (see Statistical Note #2). The output of traps used by the most highly skilled men produced better results. The aluminized traps these men used caught .513 lb/trap/layover day whereas the vinyl traps got only .353 lb/trap/layover day, and the wood .334 lb/trap/layover day. (Statistical Note #2 demonstrates that only two of the three comparisons are significant. The difference in means between vinyl and wooden traps is insignificant.)

The data in Table II strongly suggests two things. First, the skill of the fisherman is a critical factor influencing catches of all kinds of traps. This table demonstrates clearly that the initial assumption of all full-time fishermen with five years experience being essentially equal is absolutely wrong. Second, the information in this table suggests the aluminized traps do better than the vinyl or the wooden. There is a good deal of other evidence that tends to buttress both of these conclusions.

VINYL, WOODEN, AND ALUMINIZED TRAPS: A CONTROLLED COMPARISON

Far more conclusive information can be obtained about the effectiveness of metal vs. wooden traps by comparing the lbs/trap/layover day figures for each trap type, controlling for season of the year, fishing area, and skill of the fisherman. That is, one can tell much more about the catches of these various types of traps if one compares catches of wooden, aluminized, and vinyl traps pulled by men of the same level of skill, in the same season, who are fishing in the same fishing area, which is usually designated by the town or hamlet name.

To be sure, some of the information collected cannot be used in a controlled comparison, but a very large amount of it can. The results are expressed in Table III.

TABLE III

Controlled Comparisons on Lbs/Trap/Layover Day for Aluminized, Vinyl, and Wood Traps*

Season	Town	Skill Level	lbs/trap/LOD One Type Trap	lbs/trap/LOD Second Trap	Value of t	Degrees of Freedom	Significance Level	
1. Summer	Bremen	High	Vinyl .265 (n=9)	Alum. .323 n=140	2.753	12	P=.02	aluminized better than vinyl
2. Summer	Bremen	Highest	Vinyl .315 (n=9)	Wood .452 n=121	.768	10	P=.20	wood not clearly better than vinyl
3. Summer	Bremen	Highest	Vinyl .315 n=9	Alum. .999 n=302	3.788	10	P=.005	aluminized better than vinyl

Season	Town	Skill Level	lbs/trap/LOD One Type Trap	lbs/trap/LOD Second Trap	Value of t	Degrees of Freedom	Significance Level	
4. Summer	Bremen	Highest	Wood .452 n=121	Alum. .999 n=302	6.720	376	P=.001	aluminized better than wood
5. Summer	New Harbor	High	Vinyl .174 n=85	Wood .332 n=552	.348	138	P=.50	wood not clearly better than vinyl
6. Summer	New Harbor	Highest	Wood .319 n=256	Alum. .453 n=24	1.206	26	P=.20	aluminized not clearly better than wood
7. Summer	Friendship	Intermed.	Wood .176 n=172	Vinyl .148 n=23	.621	35	P=.50	wood not clearly better than vinyl
8. Winter	Pemaquid	Highest	Vinyl .428 n=68	Wood .276 n=411	2.681	78	P=.01	vinyl better than wood
9. Winter	Bremen	Highest	Wood .210 n=43	Alum. .378 n=742	3.250	51	P=.005	aluminized better than wood
10. Winter	New Harbor	High	Vinyl .353 n=172	Wood .237 n=715	4.669	231	P=.001	vinyl better than wood
11. Winter	New Harbor	High	Vinyl .353 n=172	Alum. .348 n=43	.076	54	P=.50	Vinyl not clearly better than aluminized
12. Winter	New Harbor	High	Wood .237 n=715	Alum. .348 n=43	1.788	44	P=.10	aluminized not clearly better than wood

Season	Town	Skill Level	lbs/trap/LOD One Type Trap	lbs/trap/LOD Second Trap	Value of t	Degrees of Freedom	Significance Level	
13. Winter	New Harbor	Highest	Vinyl .430 n=30	Wood .297 n=566	1.883	31	P=.20	vinyl not clearly better than wood
14. Winter	New Harbor	Highest	Vinyl .430 n=30	Alum. .382 n=66	.608	46	P=.50	vinyl not clearly better than aluminized
15. Winter	New Harbor	Highest	Wood .297 n=566	Alum. .382 n=66	2.158	80	P=.05	aluminized better than wood
16. Spring	Pemaquid	Highest	Vinyl .261	Wood .395	2.771	334	P=.01	wood better than vinyl
17. Spring	Pemaquid	Highest	Vinyl .261 n=137	Alum. .203 n=121	1.077	250	P=.50	vinyl not clearly better than aluminized
18. Spring	Pemaquid	Highest	Wood .395 n=292	Alum. .203 n=121	3.769	277	P=.001	wood better than aluminized
19. Spring	New Harbor	High	Vinyl .244 n=342	Wood .180 n=401	2.809	266	P=.005	vinyl better than wood
20. Spring	New Harbor	High	Vinyl .244 n=342	Alum. .278 n=77	.707	102	P=.50	aluminized not clearly better than vinyl
21. Spring	New Harbor	High	Wood .180 n=401	Alum. .278 n=77	2.098	91	P=.05	aluminized better than wood
22. Spring	New Harbor	Highest	Vinyl .312 n=57	Wood .529 n=127	3.291	139	P=.002	wood better than vinyl

Season	Town	Skill Level	lbs/trap/LOD One Type Trap	lbs/trap/LOD Second Trap	Value of t	Degrees of Freedom	Significance Level	
23. Spring	New Harbor	Highest	Vinyl .312 n=57	Alum. .629 n=87	3.967	141	P=.001	aluminized better than vinyl
24. Spring	New Harbor	Highest	Wood .529 n=127	Alum. .629 n=87	1.308	157	P=.20	aluminized not clearly better than wood
25. Spring	Friend-ship	Inter-med.	Vinyl .177 n=144	Wood .121 n=205	.1888	242	P=.50	vinyl not clear-ly better than wood

*These data were obtained in the 1977-78 study. The aluminized traps in this sample were in good condition and were not corroding.

Table III necessitates some explanation. In this table is assembled all the data collected in a way which controls for season, town, and skill level of the fishermen involved. Moreover, the necessary statistical values are included. This table appears to be more complicated than it is. Each case should be read across the page. In controlled comparison #1, the lbs/trap/layover day of vinyl traps is being compared with lbs/trap/layover day of aluminized traps which were pulled by highly skilled men from Bremen in the summer season. The t value and the degrees of freedom are statistical devices used to indicate whether the difference in means is statistically significant or not. In this case, they indicate that the aluminized traps caught more than the vinyl traps pulled by men from the same town in the same season and that this difference is significant. The P value indicates that there is only a .02 or 2% chance that this difference in lbs/trap/layover day could have occurred by accident. With this level of significance, one can safely conclude that these noncorroded aluminized traps owned by highly skilled Bremen fishermen in the summer of 1977 outfished vinyl traps hauled under the same conditions.

Controlled comparison #2 compares the lbs/trap/layover day of vinyl traps with the lbs/trap/layover day of wooden traps pulled by the most highly skilled fishermen in Bremen during the summer of 1978. In this case the t test indicates that there is a .20 or one in five chance of these results occurring by accident. A one in five chance is generally considered too high to prove anything. Thus, one can conclude the wooden traps pulled by these men are not clearly superior to the vinyl traps pulled by the same men under the same circumstances.

One need not be fooled by the statistics. They are really much easier to understand than they may appear. The important thing to recall is the researchers were trying to find out whether one type of trap pulled by men under certain conditions does better than another type of trap pulled by the same men under the same conditions. A t test is merely a standard statistical test used to find out whether differences in the mean or average lbs/trap/layover day are significant or not. The results are always phrased in terms of some percentage. Normally, anything over a one in twenty chance ($P = .05$) is considered statistically insignificant, since the results could have occurred by accident in one out of twenty cases.

The results of these controlled comparisons are summarized in Table IV. (Note that Table IV does not contain anything that cannot be extrapolated from Table III. It merely pulls together information on the results of controlled comparisons of a particular type.) The first comparison in Table III is one in which highly skilled fishermen in Bremen in the summer caught .323 lbs/trap/layover day from aluminized traps and .265 lbs/trap/layover day from vinyl traps. The difference in these two means is highly significant (at the .02 level). In Table IV, this information appears as one of the four cases where the mean lbs/trap/layover day of aluminized traps exceeds vinyl traps. It is also one of the three statistically significant cases where the lbs/trap/layover day of aluminized traps exceeds the lbs/trap/layover day of vinyl traps.

The information on the statistically significant cases tells a good deal about the relative superiority of one type of trap over another.

There are three controlled comparisons with statistically significant results where lbs/trap/layover day of aluminized traps exceeds the lbs/trap/layover day of vinyl. There are no statistically significant cases where the mean catches of vinyl traps exceed the aluminized. This is very strong evidence suggesting that aluminized traps in good condition are superior to vinyl in general.

There are four statistically significant cases where the catches of aluminized traps exceeds those of wooden trap, and only one statistically significant case where lbs/trap/layover day of wooden traps exceeds the lbs/trap/layover day of aluminized traps. This is strong evidence that aluminized traps are also superior to wooden ones.

TABLE IV

Summary of Controlled Comparisons*
on Lbs/Trap/Layover Day for Various Types of Traps

Case Description	No. of Cases	No. of Statistically Significant Cases
lbs/trap/layover day aluminized traps exceeds lbs/trap/layover day vinyl traps	4	3
lbs/trap/layover day aluminized traps exceeds lbs/trap/layover day of wooden traps	7	4
lbs/trap/layover day of vinyl traps exceeds lbs/trap/layover day of wooden traps	5	3
lbs/trap/layover day of vinyl traps exceeds lbs/trap/layover day of aluminized traps	3	0
lbs/trap/layover day of wooden traps exceeds lbs/trap/layover day of vinyl traps	5	2
lbs/trap/layover day of wooden traps exceeds lbs/trap/layover day of aluminized traps	1	1

The situation with wooden and vinyl traps is not clear. There are three statistically significant cases where the lbs/trap/layover day of vinyl traps exceeds the lbs/trap/layover day of wooden traps and two cases where it is the other way around. From this, the only thing to be concluded is that the catches of vinyl traps and wooden traps are approximately equal, with a slight edge going to the vinyl traps.

Perhaps the most important thing to be gained from Table III and IV is an appreciation for the complexity of the situation. Even in situations comparing catches of different types of traps pulled by men from the same town with approximately the same level of skill at the same season, there is no single type of trap that clearly outfishes all others, and none that is outdone by all others all of the time. The results of these controlled comparisions indicate that aluminized traps are generally superior to vinyl and wood; and that vinyl traps are, perhaps, a little superior to wood. There are, however, a few instances noted here where wooden traps outfished vinyl and even one case where very highly skilled men got more from wooden traps than aluminized traps (see Table III, controlled comparison #18).

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*These data were obtained in the first 1977-78 study. The aluminized wire traps were generally in good condition.

FACTORS INFLUENCING TRAP CATCHES: A REGRESSION ANALYSIS

All data from this study were analyzed using stepwise multiple regression. Regression analysis is a very powerful statistical tool. It is not the purpose of this report to explain it although those who have a background in statistics will understand. For those who do not, it is important to realize several things about the analysis which is to follow. 1) Regression analysis allows researchers to take into account a very large number of variables. In the previous sections, the factors taken into account were lbs/trap/layover day, season, type of trap, skill level, and fishing area or town. This regression analysis includes factors such as bait, depth of the trap, length of the trap, type of bottom, head type, and fishing practices of individual men. It allows all of these factors to be taken into account <u>all at once</u>. 2) In regression analysis, an attempt is made to separate out the effects of a whole cluster of independent variables on a dependent variable. In this case, the dependent variable, the thing being accounted for, is pounds of legal-sized lobsters in a trap. The independent variables are such items as type of trap, type of bait, season, depth, type of bottom, etc. Thus, this regression analysis analyzes what effect items like those just mentioned have on lbs/trap caught. This regression analysis strongly reinforces many observations made earlier in this report. It also provides some additional observations.

In regression analysis, it is standard procedure to give the formula. In this case, giving the formula would be very difficult since some sixty variables were used in the regression equation. It would be more meaningful to list the types of variables used. This has been done in Figure I.

Figure 1

List of Variables in Lobster Catch Regression Analysis

Type of Variable	Variable Labels
Head type	1. Metal (all hog rings) 2. Hake mouth 3. Hog rings and hake mouth 4. Unknown
Trap construction material	1. Vinyl 2. Wood 3. Galvanized or aluminized
Trap length in feet	1. Actual length (in feet) used
Number of heads in trap	1. Actual number of heads used

Figure 1 (cont.)

Bait used in trap	1. Bagged herring 2. Redfish 3. Pogies 4. Miscellaneous 5. Alewives 6. Whiting, and/or other dragged fish 7. Bagged and stringed fish
Depth of water where trap is set	1. 0-5 fathoms 2. 6-10 fathoms 3. 11-15 fathoms 4. 16-20 fathoms 5. 21-25 fathoms 6. 26-30 fathoms 7. 31-35 fathoms 8. 36-40 fathoms 9. 41-45 fathoms 10. 46-50 fathoms
Type of ocean bottom	1. Hard 2. Mud 3. Gravel 4. Sand 5. Edge of hard bottom
Topography of ocean bottom	1. Hole 2. Large area of hard bottom 3. Shoal 4. Next to shore 5. Channel
Protected vs. unprotected position	1. Unprotected 2. Protected
Fishing area	1. Pemaquid 2. Bremen 3. New Harbor 4. Friendship
Fisherman	18 variables involved. Each fisherman assigned a variable number going from no. 1 to no. 18
Season	1. Summer of 1977 2. Late fall of 1977 3. Spring of 1978
Length of lobsters caught	12 variables allocated for length of lobsters caught in each trap
Weight of lobsters caught	12 variables were allocated for weight of lobsters caught in each trap

Figure 1 (cont.)

Layover days/season	1. Layover days for summer 2. Layover days for fall 3. Layover days for spring
Pounds per layover day	1. lbs. per layover day
Estimated availability of lobsters on bottom	1. Est. availability of lobsters
Computational variables	

In stepwise regressions, one variable is fed into the computer and analyzed, then another is fed in and analyzed, etc. The last step allows one to see the effect of all factors working together simultaneously. Accordingly, this report concentrates on analyzing the last step of the regression analysis alone so does not focus on the reams of computer output which led up to these results. In the last step of this analysis, fifty-three dependent variables printed out. Some are interesting because they are so significant, others because they have so little influence on catches. There is a great deal of information in this regression analysis; the remainder of this section is devoted to explanation and interpretation of its results.

Seasons

As one might expect from the controlled comparisons which preceded this, variables connected with seasons are the most highly significant.

TABLE V

Regression Analysis: Season Variables

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Spring	-0.8951936	-0.29389	0.39859	5.004	P = .05
Late Fall	0.1542285	0.05116	0.32003	0.232	not signif.
Availability	-0.9268357	-0.22724	0.44631	4.312	P = .05

The standard regression coefficient of -.29389 for the spring season is the highest in Table V along with the standardized regression coefficient of -.2273 for the

The standard regression coefficient of -.29389 for the spring season is the highest in Table V along with the standardized regression coefficient of -.2273 for the availability factor,* which is closely connected with season. (Both are significant at the .05 level.) These figures reinforce again the theory that nothing influences catch as powerfully as the season of the year. All other factors being equal, catch clearly drops dramatically between shedding time in August and spring. The regression coefficient figures indicate that in the spring of the year, a trap will catch .89 lbs/trap less than it caught in the summer, a phenomenally large drop.

These figures indicate there is no significant difference between summer catches and fall catches, all other factors being equal. Note that the standardized regression coefficient for late fall is .05116 which suggests that fall traps do slightly better than summer traps of the same type, but this difference is not statistically significant. All this does is reinforce the idea that August and November-December are some of the best months of the year for lobstering and that there is no significant difference between these seasons.

Trap Size

The next most important factor influencing lobster catches is the size of the trap. As can be seen from Table VI, the standardized regression coefficient for trap size is .18089, and the standardized regression coefficient for the closely related variable of number of heads is -.15019.** Both of these results are significant above the .001 level. These figures indicate that four-foot traps catch far more lobsters than three-foot traps. The regression coefficient figures on trap size indicate that a four-foot trap catches .536 lbs/trap pulled more than the three-foot trap.

TABLE VI

Regression Analysis: Trap Size Variables

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Trap Size	0.5357639	0.18089	.09907	29.245	P = .001
N Heads	0.4156289	0.15019	.07815	28.288	P = .001

*The availability factor needs some explanation. Approximately 93% of all lobsters that molt into the legal size range in July and August are caught before the next shedding season. Thus, there are more lobsters available to be caught in August than the following May. In order to take into account the availability of lobsters, a variable was constructed that assumed that 100% of the lobsters were available in August and that there was a 10% drop in legal-sized lobster population every month thereafter, so that in May only 10% of the lobsters remained.

**It should be noted that three-foot traps usually have three heads and four-foot traps have four heads. Thus, the number of heads is not generally independent of trap size.

Many men in the industry have long argued that the four-foot trap outfishes the three-footers. These results will come as no surprise to them.

Bait

TABLE VII

Regression Analysis: Bait Variables

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Pogies	0.7996427	0.13881	0.13597	34.589	P = .001
Bagged Herring and Stringed bait	0.2033606	0.04852	0.07425	7.502	P = .005
Alewives	0.2694326	0.08827	0.12571	4.593	P = .05
Miscellaneous	-0.3508594	-0.05700	0.10185	11.868	P = .001
Whiting	-0.2940270	-0.04364	0.11465	6.579	P = .02
Redfish	-0.2099449	-0.04324	0.08034	6.828	P = .01
Bagged Herring	Baseline variable				

All of the information concerning type of bait used is contained in Table VII. There are two critical pieces of information. First, if one can judge by the standardized regression coefficient there is a great variation in the importance of various kinds of bait on lobster catches. The standardized regression coefficient for pogies and alewives is relatively high, which indicates they are significant in influencing catch figures, although they are not as critical as season, trap size, or skill. The standardized regression coefficients for the other kinds of bait are relatively low, indicating these variables have relatively little influence on catches when compared with the whole set of data under consideration.

Second, bagged herring was used as the baseline variable, so that the effectiveness of different kinds of bait is judged in terms of its effectiveness relative to bagged herring. The regression coefficients indicate bagged herring is more effective than some fish and less effective than others. The negative figures for whiting and redfish indicate that bagged herring is slightly more effective as a bait than either of these. The fact that the regression coefficient for alewives is .269 and that of bagged herring combined with stringed bait is .203 indicates these two kinds of baits are a little better than bagged herring used alone. The regression coefficients for pogies is .800, which indicates it is a much better bait than bagged herring.

These results are very difficult to interpret, particularly since various kinds of baits are not used all year. Two figures in the data particularly demand some comment. The regression coefficients for pogies indicate they catch .800 lb/trap/layover day more than bagged herring. However, pogies are used only in the late summer when fishing is generally very good, whereas herring are used throughout the fishing season, even in the spring when fishing is generally bad. Thus, the high regression coefficient for pogies might reflect the generally good summer fishing conditions as much as anything about the bait itself. It is difficult to explain the fact that alewives show up as better bait than bagged herring. Alewives are used exclusively in the late spring and early summer when fishing generally is very bad so one might have thought a bait used exclusively in the spring would not have done well. A great many fishermen insist that lobsters in the spring will take only fresh bait and alewives are usually fresh. Fishing may be generally bad in the spring, but alewives may be so effective as bait that they show up better than bagged herring despite the poor fishing conditions under which they are used.

Fishing Practices and Skill

Many of the regression coefficients for individual men are quite large and statistically significant, as can be seen in Table VIII which summarizes the regression output on fishermen. It is important to note that the variable concerning men is really a residual variable. That is, a great deal of fishing skill is knowing the size of the trap to use, the bait, the place to put the trap, the type of heads to use, etc. These variables have already been handled in this regression equation. Thus, the variable on each man is indicative of fishing practices over and above the ones already taken into account in the analysis. A high standardized regression coefficient on a fisherman variable indicates this man is doing something important to influence the output of traps which cannot be explained by looking at heads, trap size, trap type, and all of the other factors explicitly handled here.

TABLE VII

Regression Analysis: Fishing Practice and Skill Variables

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Fisherman #12	0.4148997	0.07443	0.10700	15.035	P = .001
Fisherman #9	-0.9967670	-0.09767	0.21146	22.220	P = .001
Fisherman #7	0.1665962	0.03936	0.08605	3.749	P = .1
Fisherman #15	0.4461531	0.04331	0.14336	9.685	P = .002
Fisherman #3	0.0527552	0.01149	0.08858	0.355	not signif.
Fisherman #17	-0.8374076	-0.08762	0.13672	37.515	P = .001
Fisherman #14	-0.8441483	-0.09400	0.13226	40.736	P = .001

Table VIII (cont.)

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Fisherman #11	-0.6043286	-0.10637	0.12290	24.180	P = .001
Fisherman #8	-0.5286158	-0.04571	0.16475	10.296	P = .002
Fisherman #4	-0.3982837	-0.07449	0.10231	15.154	P = .001
Fisherman #10	-0.8933552	-0.08481	0.21050	18.011	P = .001
Fisherman #18	-0.4954385	-0.08735	0.12722	15.167	P = .001
Fisherman #5	-0.4396956	-0.09376	0.12853	11.703	P = .001
Fisherman #6	-0.3033652	-0.04553	0.15226	3.970	P = .05
Fisherman #16	-0.2507777	-0.02219	0.16683	2.260	not signif.
Fisherman #13	-0.1806167	-0.01775	0.15627	1.336	not signif.
Fisherman #2	0.05547563	0.0062	0.15149	0.134	not signif.

A large number of the standardized regression coefficients are moderately high. In eight out of the eighteen cases reported, the coefficients were .08 to .10; the remainder are below that figure. This indicates the fishing practices of a large number of men are moderately important in influencing catch. These coefficients suggest these residual skills and practices are not as important as season, trap length, etc., but they are far more influential than other factors such as topography of the bottom, and so on.

Although all of the men who helped in this project are full-time, experienced fishermen, there are differences in their fishing practices and levels of skill. This shows up quite plainly in the regression coefficients which compare the pounds/trap each fisherman caught with the catch of fisherman #1 who served as a baseline for measuring fishing practices and skills. Since fisherman #1 was very highly skilled, few men (e.g., fishermen #12, #15) caught more lbs/trap (where the measurements were statistically significant) than man #1. Most of the other fishermen have a negative regression coefficient which indicates they caught fewer lbs/trap than fisherman #1. Some of these men caught significantly less. For example, fisherman #14 has a regression coefficient of -.837 which indicates that he caught .84 lbs/trap less than man #1. Numbers 10 and 14 did about the same.

While it is clear from these figures that fishing practices and skills of individual men are very important in influencing catch, it is not at all clear exactly what those skills and practices are. As anyone in the business knows, a great deal of thought goes into fishing and fishermen are constantly modifying gear and techniques. Moreover, successful fishermen are not prone to talk about these skills, so it is difficult to pinpoint exactly what is being done. Some of the factors making certain men more successful than others are clearly conscious; some are almost unconscious, or at least difficult for fishermen to describe (even when they want to) and are the results of long years of experience. A previous study, which focused specifically on lobster fishing skills, demonstrated that the most important kinds of skills concern placement of traps (Acheson, 1977: 111-138). That is, the most important factor distinguishing very good fishermen is the fact they have, as one man put it, "an advanced degree in ocean bottom." By this he meant that very good fishermen know the bottom very well, know how to place traps at different seasons on bottom where concentrations of lobsters will be. This kind of skill makes a great difference in catch levels. It is probably this kind of knowledge and skill being measured in the differing regression coefficients for various fishermen. There may be other factors involved. Unfortunately, this kind of statistical analysis gives no conclusive idea of what exactly is being measured in these fishermen variables beyond the fact that certain residual practices and skills do exist.

Depth of Water and Bottom Topography

Since fishermen seem concerned with the depth of water their traps are in, one might assume depth would be a critical factor influencing catches. This is not so. While in any given season or week fishermen may obtain more lobsters at certain depths than others, over the course of the annual cycle there is no single depth that is strongly associated with high productivity. This can be seen clearly in Table IX which summarizes the regression information on depth and on bottom topography.

TABLE IX

Regression Analysis: Depth and Bottom Variables

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Hard bottom	Baseline variable				
Mud	-0.1243054	-0.03803	0.06272	3.928	P = .05
Gravel	-0.3021396	-0.04393	0.09417	10.293	P = .002
Sand	-0.3720884	-0.04969	0.09888	14.160	P = .001
Edge of Hard	0.02589977	0.00465	0.08184	0.100	not signif.
0-5 fathoms	Baseline variable				
6-10 fathoms	0.1216492	0.03501	0.05754	4.470	P = .05
11-16 fathoms	0.0383904	0.00706	0.08252	0.216	not signif.
16-20 fathoms	0.1203541	0.02039	0.10140	1.409	not signif.
21-25 fathoms	-0.007365116	-0.00115	0.10568	0.005	not signif.
26-30 fathoms	0.3036022	0.06830	0.09760	9.676	P = .002
31-36 fathoms	0.06304481	0.01385	0.10866	0.337	not signif.
37-40 fathoms	0.2071612	0.03500	0.11849	3.057	not signif.
41-45 fathoms	0.1546614	0.02189	0.13491	1.314	not signif.
46-50 fathoms	0.2267935	0.02302	0.15180	2.232	not signif.

These results will come as no surprise to people familiar with the fishing industry. They strongly reinforce the idea that one must keep moving traps from one depth to another with the season of the year, etc. One cannot leave traps in the same depth for long periods of time without moving them and expect to do well.

For bottom topography, all types of bottom are compared to the figures for hard bottom which serves as the baseline variable. Since the regression coefficients for mud, gravel, and sand are negative in comparison to hard bottom and the level of significance is relatively high, it can be concluded that hard bottom is more productive of lobsters than these other types of bottoms and that there is a very small probability of these results happening by accident. For example, since the regression coefficient for mud bottom is -.1243054, one can conclude that traps on mud bottom produce .124 lb/day less than traps on hard bottom. Since these results are significant at the .05 level, there is only one chance in twenty of these results happening by accident. Since the regression coefficient for edge of the hard bottom is insignificant, one can conclude that edge and hard bottom are equally productive of lobsters. Furthermore, it is obvious the edge is significantly more productive than mud, sand, or gravel bottom.

These data indicate depth of water has less influence on catches than type of bottom. In studying depth, the zero to five fathoms variable was used as the baseline. Not only are the regression coefficients on depth variables lower than those for bottom variables, but their level of significance is very low as well, indicating that, in most cases, these figures could have occurred by accident. The one exception is the 26-30 fathoms depth variable. Here the standardized regression coefficient is .06830, suggesting that this depth has some influence in determining catches in comparison with all other variables. The regression coefficient of .304 indicates that traps at this depth catch .304 lb/day higher than traps in zero to five fathoms. These results are highly significant (at the .002 level).

Head Type

Fishermen pay special attention to the type of head used in their traps. They have as many theories and ideas about the type of heads used as any other aspect of lobstering. For this reason, it was thought that the figures on type of head used would be of special significance. This does not prove to be the case. In fact, head type proved to be one of the least significant variables in the entire equation, as can be seen from Table X.

TABLE X

Regression Anaylsis: Head Type Variables

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Hog ring heads	Baseline variable				
Hake mouth heads	-0.1243684	-0.04269	0.19276	0.416	not signif.
Hog rings and hake mouth	-0.1224263	-0.04130	0.18750	0.426	not signif.

The level of significance indicates there is no statistically significant difference between the amount of lobster produced by traps with these different kinds of heads. Moreover, the regression coefficients are very low (i.e. -.04), which strongly suggests that, in comparison with other variables, heads play a relatively unimportant role in determining catch levels. The researchers feel very uneasy about these results, since so many outstanding fishermen are convinced that heads do make an important difference. It should be noted that while fishermen feel strongly about the importance of head type, they do not agree often on what type of head fishes best. These data suggest they may have real cause for disagreement. Certainly the data support no single school of thought on heads or even the idea that heads are important.

Trap Construction Material

The regression data concerning the trap constuction material is very interesting. The data from the first study are statistically significant and reinforce the conclusions reached through the controlled comparisons. As can be seen from the data in Table XI, wooden traps and non-corroded aluminized traps are being compared to vinyl traps, which serve as the baseline variable.

TABLE XI

Regression Analysis: Trap Construction Material

Variable	Regression Coefficient	Standardized Regression Coefficient	Standard Error	F	Significance Level of F
Vinyl traps	Baseline variable				
Wooden traps	-0.2767385	-0.09448	0.07508	13.584	P = .001
Aluminized traps	0.1546972	0.04821	0.07886	3.848	P = .05

The regression coefficient figures indicate wooden traps catch .277 lb/trap less than vinyl traps while the aluminized traps get .155 lb/trap more. Even though these differences in poundage caught are quite small, the difference in catches is statistically significant, so one can be reasonably certain these results did not happen by accident.

It should be noted these results were obtained on the data collected in 1977-78 when researchers were studying traps with no corrosion problems. In the fall of 1979, information was obtained on traps which were in good condition as well as traps which were corroding. The 2,135 traps pulled in 1979 were added to the 7,716 of the 1977 and 1978 sample. Table XII contains figures on pounds/trap/layover day for the 9,782 traps in the sample on which there was information.

TABLE XII

Pounds/Trap/Layover Day by Trap Construction Material:
Other Factors Uncontrolled

Trap Construction Material	Lbs/Trap/Layover Day	Sample Size
Aluminized (good condition)	.421	2567
Aluminized (rusted)	.300	208
Vinyl	.292	1589
Wood	.270	5011
Aluminized (corroding)	.263	456

These figures indicate aluminized traps in good condition caught more pounds of lobsters per day than traps made of any other kind of material. Aluminized traps with all of the prospective metal coating rusted off produced .300 lb. of lobster for every day they were in the water. The least productive were the aluminized traps which were in the process of corroding; these produced only .263 lb. of lobster per day in the water. In between are the wooden and vinyl traps. These results on lbs/trap/layover day must remain tentative since they do not reflect all of the other factors which influence catches. A much better indication of trap productivity comes from the regression analysis which takes a large number of factors into account. That is, it compares the productivity of different kinds of traps (i.e., aluminized, wooden, vinyl) as though factors such as bait, season, skill, etc. were all held constant. The results of this regression analysis are summarized in Table XIII.

TABLE XIII

Productivity of Types of Traps: The Regression Analysis

Trap Construction Material	Regression Coefficient*	t	Significance Level of t	Adjusted Pounds/Trap/ Layover Day
Aluminized (good condition)	0	--	--	0.314
Aluminized (rusted)	-0.0359	1.09	0.14	0.278
Vinyl	-0.050	3.11	0.002	0.264
Wood	-0.111	8.15	0.0001	0.203
Aluminized (corroding)	-0.0685	2.75	0.01	0.242

* R^2 = .141
Adjusted R^2 = .138

Several things need to be explained about this table. First, the regression coefficients compare the catches of all other kinds of traps to those of the aluminized traps in good condition. These figures again indicate the aluminized traps in good condition catch the most; the same kind of traps with all the coating rusted off catch .0359 lb/trap/layover day less. The vinyl traps catch .050 lb/trap/layover day less than the aluminized traps in good condition.

The figures on the adjusted pounds per trap per layover day indicate that under typical conditions encountered in the sample, aluminized traps in good condition catch .314 pound of lobster every day the trap is in the water. Under the same controlled conditions, the aluminized traps with all the coating rusted off catch .278 lb/trap/layover day, followed by the vinyl traps with .264 lb/trap/layover day. According to the regression analysis, the aluminized traps which are corroding catch only .242 lb/trap/layover day. The least productive traps, all other factors controlled, are the wooden ones. It should be noted Table XIII indicates the corroding aluminized traps do worst. However, the more powerful regression analysis indicates the wooden traps are least productive, all other factors being equal.

A series of standard statistical t-tests were run to see if differences in trap productivity are statistically significant. The figures on the t-tests and level of significance in Table XIII indicate the aluminized traps in good condition do significantly better than the vinyl, wooden, and corroding aluminized traps. No significant difference could be found between the aluminized traps in good condition and the aluminized traps where all the coating had corroded off. These results suggest something rather strange: aluminized traps do well if the coating stays on and after it has completely corroded off. Traps in the process of corroding are clearly not as productive.

These results clearly indicate trap construction material influences productivity. The reasons for this are not clear, though a number of fishermen and scientists have suggested several plausible explanations. Many fishermen believe metal traps stay on the bottom better, while wooden traps, even when weighted, have a tendency to float and move somewhat due to the action of waves, wind, and tide. Lobsters, so the story goes, prefer to crawl into more stationary traps. In support of this theory, several fishermen who have observed lobsters in pounds report that lobsters will crawl all over a baited stationary trap. If the trap moves, even slightly, these fishermen say the lobsters will scatter. Also, some fishermen believe lobsters are repelled by the smell emanating from the vinyl-coated wire and corroding traps. Still other men believe lobsters can see fairly well and prefer the bright, shiny metal wire of the non-corroded aluminum traps over the duller wooden and vinyl traps. Another hypothesis posed by a scientist at Woods Hole Oceanographic Institute is that lobsters may be attracted or excited by the ions emanating from the aluminized traps and, consequently, crawl into them in greater numbers than into the other types of traps.

All or none of these hypotheses may be correct. None of the data presented in this paper support or negate any of these suppositions. In short, this study tells a good deal about what comes out of the traps, but nothing about the reasons why a lobster prefers traps made of one construction material over another. All that is known for sure is that lobsters in Muscongus Bay did crawl into some types of traps in greater numbers than others.

More important, however, is that the trap construction material is relatively unimportant in determining catches in comparision with other variables. This is indicated by the regression coefficient figures which are summarized in the next section.

Summary of Results: Regression Analysis

One of the exceptional characteristics of regression analysis is that it not only allows comparisons of variables of a given type but also allows one to assess the importance of all variables in the equation. The regression coefficient figures, for example, allow for the comparison of the effectiveness of one type of bait to other types of bait. The standardized regression coefficients, by way of contrast, tell how important various types of bait are in explaining catch, in comparison with depth of water, season, head type, etc. It is useful to pull together all of the information on the standardized regression coefficient figures from Tables V to XI to compare and discuss the importance of various factors influencing catches.

TABLE XIV

Regression Analysis: Importance of Factors Influencing Lobster Trap Production

Variable Name*	Standardized Regression Coefficients***
Spring	.295**
Availability of lobsters	.227
Trap size	.180
Number of heads	.150
Pogies	.138
Fisherman #11	.106
Fishermen #9, 14, and 5	.090
Wooden traps	.094 (negative figure)
Alewives	.088
Fishermen #17, 10, and 18	.087
Fishermen #12 and 4	.075
Bagged and stringed bait	.074
26-30 fathoms depth	.068
Sand	.049
Aluminized traps	.048 (positive figure)
Fishermen #15, 8, and 6	.045
Whiting	.043
Redfish	.043
Gravel bottom	.043
Mud bottom	.043
Hake mouth heads	.042 (insignificant statistically)
Hog ring and hake mouth heads	.041 (insignificant statistically)

*All variables with levels of significance over .05 have been excluded from this table except for those concerning head type. Nothing definite can be said about them since the results reported could have occurred by accident.

**The last two digits on the standardized regression coefficient figures and the sign have been left out since they are irrelevant and including them would make the table more difficult to read.

***All these figures stem from the 1977-1978 sample. The data from the fall of 1979 (Table XIII) are not included.

Again, the season variables are unquestionably the most significant. This shows up in both the *spring* variable and the *availability of lobster* variable, which is an estimate of lobsters still on the bottom in any given month. Nothing is more important in influencing catch than the month the trap is placed in the water. Next in importance are trap size and number of heads, which, as has been said, are closely related variables. Next in influence is a type of bait (i.e., pogies). The fact that pogies show up so high is probably because they are used exclusively in the warm summer months when fishing is very good. Most other kinds of bait show up as relatively low in the scale, indicating the kind of bait used is relatively unimportant in influencing lobster catches. The *fisherman* variables show up as moderately important. This variable is a residual variable and probably reflects skill in trap placement as much as anything else. Such skills and practices, while difficult to pinpoint, cannot be ignored in any analysis of factors influencing lobster catches.

On the bottom of the list are items such as depth, material on the bottom, type of heads, and some kinds of bait. Several things need to be stressed about these unimportant variables. First, it should be noted the number of heads used is very significant, but whether those heads are hake mouth or hog ring, etc. has little influence on catches. No pretense has been made to explain these results, but this is clearly what the figures show. Second, these figures probably indicate traps do have to be moved, however, there is no depth which is usually productive of lobsters over the course of the entire year.

Most important, there clearly is a difference in types of traps. The vinyl traps, which have served as a basis for comparative purposes, are significantly better than wooden traps and just a little less productive than non-corroded aluminized traps. This is indicated both by the controlled comparisons and the regression analysis (see pages 15, 27, and 28 for explanation). The standardized regression coefficient figures do not reflect a comparison of trap types to each other, but to all other variables. In this regard it is important to note that the trap construction material is relatively unimportant in influencing catch in comparison to variables to variables such as season, size of trap, etc. Wooden traps in this 1977-78 sample have a standardized regression coefficient of .094 and aluminized .048, while variables such as *trap size* and *availability of lobsters* are .180 and .227 respectively.

These figures indicate something very important: trap construction material does make a difference, but is not as important in influencing lobster catches as factors such as seasons, trap size, and the practices of the fisherman using those traps. All other things being equal, the figures in Table XI indicate a man with vinyl or aluminized traps will outfish a man with wooden traps. However, they also demonstrate a man with vinyl or aluminized traps who is unskilled and uses his traps in March will be badly beaten by a more skilled man who uses wooden traps in August. (For those familiar with the fishing industry, this is merely stating the obvious.)

The regression analysis provides insight for understanding the factors influencing lobster catches and the relative importance of those factors. It should not, however, be thought that this analysis tells everything there is to know about the factors influencing catches--quite the contrary. There is a great deal left to be explained. This is indicated most importantly by the fact that the R^2 for the last step in the equation is only 0.14327, which indicates that all of the variables being considered together explain only 14% of the total variance in lobster catches on which there is information. This is not to say the results are completely false or inadequate, only that there is still a good deal about lobsters, traps, and fishermen not explained. Of course, no regression analysis explains 100% of the variance, but this R^2 figure is considered to be on the low side.

There are two reasons which might explain why so little of the variance is able to be explained. First, some factor or set of factors critically important for understanding catch results may have been ignored. Second, a great deal of lobster behavior may be highly unpredictable or there might be a highly random component in placing traps where losters are. It is the author's belief the second explanation is far more likely than the first. There are literally hundreds of factors which might influence lobster catches which may not have been considered, but it is believed most of the major ones were. It is possible that age of the trap or height of the head or number of worm holes or mesh size of head, etc. is a critically important variable. It is believed that much of the unexplained variance is due to lobsters being highly unpredictable creatures. Most of the reasons they crawl into one trap over another are unknown and likely to remain so. Jim Thomas, an experienced marine biologist, has noted cases where tagged lobsters are released in the eastern part of Maine only to be caught in waters near the New Hampshire border (Thomas, 1979). Such lobsters passed literally thousands of traps before they finally crawled into one several hundred miles away from the place they started. What was it about the one trap, if anything, which distinguished it from all the rest? If these suspicions about lobster behavior are correct, any analysis of lobster catches is apt to have a very high unexplained variance.

ECONOMIC ISSUES

From the point of view of the fisherman, one of the critical questions is whether or not it is advisable to invest in aluminized, vinyl, or wooden traps. The regression analysis indicates trap construction material has far less influence on catches than other factors. Are those differences in trap productivity so small that they can be safely ignored in considering various kinds of traps? Are they large enough to substantially influence income? There is some evidence that differences in trap productivity are substantial enough to be considered when a fisherman is contemplating buying new traps.

One cannot answer questions about the desirability of investing in various kinds of traps by looking at the figures on physical productivity of various types of traps. Several factors complicate the issue. First, metal traps are far more expensive than wooden traps. In 1977, some four-foot aluminized traps cost $27.50; a pair of these traps equipped with warp line, toggles, and buoy ran about $65.00. A single three-foot oak trap could be bought for $12.00 and a pair of them fully rigged cost about $25.00. Moreover, the wooden traps, it is estimated, last five to seven years, while an aluminized or vinyl trap lasts about three or four years. In addition, investment in lobster traps lasts over a period of years, so the discount rate of time value of money must be taken into account. Finally, the physical output of a trap varies dramatically over the course of a year, along with the price the fisherman receives for lobsters. All of these factors make it impossible to automatically assume that a trap which fishes better during one month is the trap to buy. In order to be able to tell which trap is the better investment, one needs catch and cost figures over the entire lifetime of a large number of various types of traps. Unfortunately, such information does not exist. One fisherman did volunteer information of this kind on twenty traps: ten wooden and ten non-corroded aluminized. While this is not an adequate sample by any means, this information will allow some tentative statements about the advisability of investing in wooden and aluminized traps to be made. Unfortunately, there was no access to similar data on vinyl traps, corroding wire traps, etc.

The most widely used techniques accountants, bankers, and businessmen use to evaluation investment options is to compare the *Net Present Values* on the investments in question. Information on internal rates of return allows one to ascertain whether an amount of money invested in one project will bring a higher or lower return than the same amount of money invested in another. The available data will certainly allow this comparison for the wooden and non-corroded aluminized traps. The internal rate of return is that interest rate which returns the following formula to zero.

$$\text{Net Present Value} = \sum_{t=1}^{N} \frac{NCF_t}{(1+i)^t} - C$$

Here, NFC is Net Cash Flow; i is the interest rate; c is the initial cost of the project; and N is the expected life of the project.

In order to obtain information on the NPV of an investment in wooden and aluminized traps, detailed information on costs, interest rates, catches, and revenues for ten metal and wooden traps was made available by this fisherman for the period from June 15, 1977, to April 1, 1978. Given the available information, the following assumptions are made in calculating the NPV of wooden and aluminized traps:

1) the interest rate is 8.75% (this is the interest rate the fisherman actually was charged in the summer of 1977 on a secured loan to buy traps);
2) an aluminized trap cost $32.50 and a wooden trap cost $17.50, fully rigged (these are the actual costs he paid during the spring of 1977);
3) a metal trap will last four years and a wooden trap will last six years;
4) the Net Cash Flows will remain constant over the course of the investment;
5) a fisherman already has a boat, dock, pickup truck, workshop, etc. so the only decision he is currently making concerns the traps themselves.

In order to obtain Net Present Value figures for investment in these wooden and aluminized traps, one needs to have data on Net Cash Flows or the gross revenue minus cash costs associated with each type of trap. To this end, data on prices paid for lobster was obtained for the New Harbor Co-op from June 1977 to April 1978, along with data on pounds of lobster caught by the local fisherman in his ten wooden and ten aluminized traps. The results are summarized in Table XV.

There are, of course, enormous costs involved in the lobster business. This particular fisherman (see Table XV) pays about $5,200.00 for bait during the year and another $3,200.00 for gas. It cost him another $500.00 cash (to say nothing of his time) to maintain the traps he already has. Since he has approximately 500 traps and his annual variable costs are $8,900.00, his cost per trap is $17.80.*

The ten wooden traps yielded $947.13, therefore the gross revenue for one trap per year was $94.71. Since ten aluminized traps in good condition yielded $1,476.00, one trap produced a gross revenue of $147.60. If variable costs per trap are $17.80, then the Net Cash Flow for a wooden trap is $76.91 per year and the Net Cash Flow for an aluminized trap is $129.60 per year.

If the Net Cash Flow per year for an aluminized trap is $129.00, the interest rate is 8.75%, the trap lasts for four years, and the initial cost of the investment is $37.50 then the Net Present Value is as follows:

NPV (Aluminum Traps) good condition

$$= \sum_{t=1}^{N} \frac{NCF_t}{(1+i)^t} - C$$

$$= \sum \frac{\$129.00}{(1+.0875)^4} - \$32.50$$

$$= \$387.75$$

*Only variable costs, or costs connected with actually putting traps out, have been included. Payments on boat, pickup truck, and insurance (fixed costs) would have to be paid whether a man put any traps in the water or not. Since such fixed costs have nothing to do with traps, they have been excluded.

TABLE XV

Revenue Produced by a Sample of Wooden and Aluminum Traps

Month	price received (15th of the month)	lbs. (total lobsters caught in wooden traps) (10)	lbs. (total lobsters caught in aluminized traps) (10)	Total Revenue (wooden traps)	Total Revenue (aluminized traps)
June 1977	$1.90/lb.	26	40	$ 49.40	$ 76.00
July 1977	$1.30/lb. (soft shell) $2.30/lb. (hard shell)	6	37	9.33	61.10
August 1977	$1.40/lb. (soft shell) $2.00/lb. (hard shell)	55	86	86.40	133.00
Sept. 1977	$1.40/lb.	83	129	116.20	180.60
Oct. 1977	$1.50/lb.	96	155	144.00	232.50
Nov. 1977	$1.80/lb.	104	171	187.00	307.80
Dec. 1977	$2.40/lb.	62	85	148.80	204.00
Jan. 1978	$2.75/lb.	28	33	77.00	90.75
Feb. 1978	$3.00/lb.	19	30	57.00	90.00
March 1978	$3.00/lb.	24	33	72.00	99.00
April 1978	$3.60/lb.	?	?	?	?
TOTALS		502 lbs.	799 lbs.	$947.13	$1,476.75

If the Net Cash Flow on a wooden trap is $76.91, the trap lasts six years, the interest rate if 8.75%, then the Net Present Value is as follows:

$$\text{NPV (Wooden Traps)} = \sum_{t=1}^{N} \frac{NCF_t}{(1+i)^t} - C$$

$$= \sum \frac{\$76.90}{(1+.0875)^6} - \$17.50$$

$$= \$340.05$$

The figures on the Net Present Value of aluminized and wooden traps support the idea that the aluminized traps are a better investment. The NPV for these aluminized traps is $387.75, while the NPV of the wooden traps is $340.05. This comparison takes into account the differences in physical productivity, life of the traps, and initial costs.

These figures, however, do not prove the superiority of aluminum wire traps in good condition over all other traps. First, the Net Present Value figure for these wooden traps is very close to that for the aluminum traps. Second, the sample of twenty traps is too small for statistical reliability. Third, there is no economic information on vinyl lobster gear or aluminum traps which are corroding. What these figures do suggest is that if one could get the proper kind of aluminum wire traps (non-corroding), one would probably do well economically. More important, these figures suggest the trap construction material has a strong enough effect on income that it should not be ignored when one is considering investment in lobster traps.

CONCLUSIONS

Lobster fishing is a very complicated business and, as every fisherman knows, there is a wide variation in catches not only among different fishermen, but among traps pulled by the same fisherman. In an effort to sort out the factors affecting catches--particularly the effect of the trap construction material on catches--detailed information was obtained on 7,716 traps hauled by eighteen fishermen working in the Muscongus Bay and John's Bay area of the central Maine coast in 1977-78 and on another 2,135 traps in 1979. These different data were analyzed in three different ways. First, it was demonstrated that trap catches varied considerably according to layover day, season, fishing area, and fishing skill. Since all these factors obviously affected catches, a set of controlled comparisons was used to assess the effect of trap construction material on catches. When comparing the lbs/trap/layover day of aluminized (non-corroded), vinyl, and wooden traps pulled by men of equal skill in the same area in the same season, the aluminized traps appear to do best, followed by the wooden traps. This analysis also pointed out, however, that there was no trap construction material which consistently surpassed all others and no material which was always inferior. That is, in many cases, men from one area in the same season and of the same skill using aluminized traps beat men using wooden traps. But there are cases where men from the same harbor in the same season and of the same skill using wooden traps beat men using aluminized traps and vinyl ones. More than anything else, these controlled comparisons underline the complexity of the phenomena being dealt with and the fact that a good many factors including the material of which the trap was made strongly affected lobster catches.

Second, all of the variables collected were analyzed using stepwise multiple regression analysis; an advanced and complicated, but very powerful statistical tool. While the intricacies of regression analysis may not be fully understood by the layman, the results are worth heeding. This analysis strongly documents the fact there is a statistically significant difference in catches of different types of traps. In the discussion of the data in Table XI and Table XIII, it was demonstrated that the regression coefficients on trap style indicate the aluminized traps in good condition caught the most lobsters followed by the vinyl traps, and that wooden traps caught the least. It also demonstrated that while trap construction material did affect catch levels, other factors were far more important. The most important variables were connected to season of the year, followed by the size of the trap. Next in importance were the fisherman variables,which are proxy variables for fishing skill and fishing practices. The next important variables were bait and trap construction material. The least important factors influencing catch were type of bottom, depth, and type of heads used. This is not to say that where a man places traps is not critical, but only that there is no one type of bottom or depth that is productive of lobsters all year long. In short, one must move traps as everyone knows. I am suspicious of the data on head type, since most men in the fishing industry believe that heads are critically important. Heads may be important, but this regression analysis strongly suggests it does not make an iota of difference if the heads are hog ring, hake mouth, or mixed type heads. The R^2 on this regression indicates that all of the variables in our regression equation are explaining only 14% of the total variance. I believe this is primarily due to the erratic behavior of lobsters and/or a random component in placing traps where lobsters are.

Third, to assess the desirability of investing in each type of trap, cost and income data was analyzed (provided by one fisherman on a small sample of wooden and aluminized traps in good condition). The Net Present Value figures for non-corroded aluminized traps exceeded the NPV for wooden traps, indicating aluminized traps in good condition are a better investment even though they cost more and last half as long. Though no accurate economic data on vinyl and corroding traps exists, these results suggest trap construction material is one of the factors which should be considered when a fisherman is contemplating buying new traps.

From the results of this study it might appear advisable for fishermen to purchase large metal traps, assuming the proper kind of metal can be purchased. After all, four-foot metal traps made from non-corroding aluminum wire appear to catch more lobsters than anything else. Recently, we have cause to wonder about the advisability of such a switch.

As one wise old fisherman recently explained the broader implications: "The first fishermen who get them [i.e. big aluminum traps] are going to do well. But after everyone gets them, everyone is going to be equal again. All that will be accomplished is that everyone will have a lot more invested in gear and the pressure on the lobster will be increased so that the chances of a disaster occurring [e.g., stock failure] are much better. If everyone stuck to the older traps, we would all be better off. Of course, the hogs won't do it, so we'll all have to go to the damn things." We believe this warning bears a lot of thought.

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Name

Date

Harbor

String Location

Depth

Bottom

Bait

Layover Days

Trap Description(Head, chambers, Length)

String Position

Trap No.	Metal Wood	Length of Lobsters							Comments