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Trapping Oyster Drills In Virginia III. The Catch Per Trap In Relation To Condition Of Bait

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TRAPPING OYSTER DRILLS IN VIRGINIA

III. The Catch per Trap in Relation to Condition of Bait[1]

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INTRODUCTION

In the course of trapping experiments previously described (Andrews 1955, McHugh 1955), a question arose concerning deterioration of bait with time. It is fairly obvious to those who fish the traps that the condition of the bait changes. The smallest oysters die first, through predation by drills, crabs, and other enemies, and through smothering in the muddy bottom. Barnacles and other organisms on the shells also die from various causes. The valves of the dead oysters soon separate, and some are lost through meshes of the trap, so that the volume of bait also decreases. Stauber (1943) found that efficiency of traps decreased as the interval between lifts increased. He found also that the catch increased significantly after rebaiting.

A series of 20 traps was fished from the Virginia Fisheries Laboratory pier from July 1953 to December 1955. Although the traps were not rebaited until early October 1954, the catch per trap was greater during the second summer. If bait does deteriorate, as Stauber (1943) and others have concluded, this increased catch must reflect an increase in abundance or availability of Urosalpinx in 1954. But by October 1954, the bait consisted mainly of isolated valves, and the few surviving oysters were thick-shelled and blunt. It was decided to conduct a controlled experiment with these traps to test the effect of rebaiting. This experiment began in October 1954 and continued through the summer of 1955.

The rebaiting experiment seemed to show that both Urosalpinx cinerea and Eupleura caudata preferred fresh bait to old oysters and shell as Stauber (1943) already has contended. It was realized, however, that the amount of bait in the traps might also influence catch, and that the quantity had not been well controlled in previous experiments. If the catch of drills should be a function of amount of bait rather than kind of bait in traps, then the results of the previous experiment would be open to question. Consequently, in 1955 a more extensive experiment was conducted, in an area offshore from the Laboratory pier, in which both kind and amount of bait were controlled.

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REBAITING EXPERIMENTS

Methods

The traps fished from the Laboratory pier were arranged in two series of ten each, one on each side of the pier, as illustrated by McHugh (1955). Five traps from each series were selected (using a table of random numbers), and these were rebaited with fresh seed oysters from the James River. Bait in the remaining ten control traps was augmented where necessary with old bait discarded from the randomly-selected experimental series, so that volumes of bait in each trap were approximately the same.

Catch in Experimental and Control Traps Prior to Rebaiting

These traps were fished continuously, at intervals of one day to one month, beginning July 9, 1953. On July 29, 1954, the arrangement was altered by moving traps 1 and 2, at the offshore end of each series, to the inshore end of the pier, and renumbering them as 11 and 12. Only catches made after this date were used in estimating performance of the experimental and control traps before rebaiting.

Control traps caught 780 *Urosalpinx* and 21 *Eupleura*; those selected later for rebaiting caught 640 *Urosalpinx* and 28 *Eupleura*. The ratio of the two *Urosalpinx* catches differed significantly from 1:1 (χ^2 = 13.80, P much less than 0.01), therefore this difference was considered in analysing the results of the rebaiting experiment. The ratio of the two *Eupleura* catches did not differ significantly from 1:1 (χ^2 = 1.00, P about 0.6).

Catch in Experimental and Control Traps After Rebaiting

By the end of the second week, rebaited traps had caught 470 *Urosalpinx* and 32 *Eupleura*, whereas the controls had taken only 315 and 2 respectively. Within three weeks, however, the initial advantage had been lost. In experimental and control traps, from November 1954 to April 1955 inclusive, catches of both species maintained approximately the ratios observed before the experiment began. In May 1955, however, both species were caught in larger numbers in rebaited traps, and this superiority was maintained, with occasional deviations, until the experiment was terminated early in December 1955. From May to December, 572 *Urosalpinx* and 54 *Eupleura* were caught in rebaited traps, but only 440 and 17 respectively in controls. By this time bait in all traps was in poor condition.

From October 12, 1954, to December 2, 1955, experimental traps caught about 1.3 *Urosalpinx* for each *Urosalpinx* caught in controls. This catch differed significantly from the expected catch (χ^2 = 105.4, P very much less than 0.001). During the same period experimental traps caught about 4.4 Eupleura for each Eupleura caught in the controls. This differs significantly from the expected ratio of 1:1 ($\chi^2 = 47.2$, P very much less than 0.01).

Sizes of Drills Caught on Old and New Bait

As mentioned previously, new bait caught more drills than old. It would be of value to know whether the sizes of drills caught on the two kinds of bait differed, and the data suggest that new bait caught relatively more small drills (Table 1). Indeed, in the period from October 18 to December 1, 1954, the total catch of Urosalpinx 14 millimeters in length and over apparently did not differ in the two kinds of bait ($\chi^2 = 3.25$, P greater than 0.05), and the excess catch in the rebaited traps was made up of drills 13 mm and smaller ($\chi^2 = 22.08$, P much less than 0.001). The arbitrary division between 13 and 14 mm was chosen because it gave the best separation between yearling and older drills.

From April to November 1955 the total catch on new bait exceeded the catch on old ($\chi^2 = 13.05$, P less than 0.001). This excess catch in rebaited traps was distributed evenly over all sizes, and frequency distributions of shell height of drills from the two kinds of bait were almost identical.

To determine whether placement of rebaited traps was random with respect to shell height of drills available to them, the frequency distributions of shell height of Urosalpinx on the two sets of traps were compared for the period August 12 to October 11, 1954, prior to rebaiting. As shown in Table 1, traps that were later rebaited had been catching fewer large drills than those that were not changed, and this difference was statistically significant ($\chi^2 = 15.72$, P less than 0.001, for Urosalpinx 14 mm in shell height and larger). There was no great difference in frequency distributions of shell height of drills 13 mm and under ($\chi^2 = 0.40$, P greater than 0.5).

The excess catch of small drills in rebaited traps therefore probably has no biological significance. The same traps caught a higher ratio of small to large Urosalpinx before rebaiting, and new bait simply increased the frequency of capture of all sizes.

CONCLUSIONS FROM REBAITING EXPERIMENT

It has been demonstrated that the catch of oyster drills by traps in the York River, Virginia, can be increased substantially by rebaiting traps. New bait apparently maintains its superiority over old for at least a year after rebaiting, and therefore it probably follows that seed oysters are superior to older oysters, and older oysters are superior to shell, for attracting drills. This is not unexpected, in view of the findings of Stauber (1943), Haskin (1950), and others.

Table 1. Frequency distributions of shell height in *Urosalpinx cinerea* caught in experimental and control traps before and after rebaiting

	Experimental (rebaited)		Control (not rebaited)	
	13 mm and less	14 mm and over	13 mm and less	14 mm and over
Before rebaiting 12 Aug - 11 Oct 54	202	427	215	551
After rebaiting 18 Oct - 1 Dec 54	161	379	87	331
April - Nov 55	179	523	130	443

Eupleura seems to respond to new bait more vigorously than Urosalpinx. This could be interpreted in at least two ways, either Eupleura is more destructive of young oysters than its fellow-predator, or it deserts oysters more readily for other food when young oysters are not available. It has been observed repeatedly at Gloucester Point that although Eupleura is not uncommon in eel-grass beds near shore, it does not climb pilings of piers as Urosalpinx does. This may help to explain the relative scarcity of Eupleura in traps, and the large increase in catch when desirable bait is introduced.

For both species the similarity in catches in experimental and control traps in winter and early spring may be primarily a temperature-controlled phenomenon. In other words, although both drills may move about when water temperatures are relatively low, their sensitivity to differences in bait may be repressed. The observations of Janowitz (1957), that rapidity of shell growth rather than age of oysters is the significant factor in attracting drills, are suggestive, for the growth of oysters in Virginia practically ceases in the period December to March.

EXPERIMENTS WITH VARIOUS KINDS AND AMOUNTS OF BAIT

Methods

On July 14, 1955, an experiment was set up to test the relative merits of seed oysters, adult oysters, and oyster shell, each in three different quantities by volume, as bait in chicken-wire traps. Seed oysters were obtained from the James River, adult oysters were taken with tongs in shallow water near the Virginia Fisheries Laboratory pier, where they had been placed at various times during the past two years, shell likewise was tonged from the bottom near the pier.

Volumes of bait were selected to correspond with 6, 12, and 18 adult oysters, which measured about one, two and three quarts respectively. Seed oysters and loose valves of dead adults were measured in these volumes.

Thirty-six traps of galvanized chicken wire, of the usual dimensions, were baited in equal numbers with different combinations of kinds and amounts of bait. Three kinds and three amounts gave nine combinations, thus each combination was given four replications.

Four long stakes were driven in the river bottom to form a right-angled cross around a central stake. Each arm of the cross extended 100 feet on each side of the central stake, and the arms were roughly parallel with and at right angles to the river bank. The center of the cross was about 400 feet from shore and water depth ranged from about five to seven feet at mean low water.

Tarred hemp line, one-quarter inch in diameter, was cut in 100-foot lengths and attached to large wrought-iron rings which were free to move up and down each stake. Traps were attached to these main lines at 10-foot intervals with snoods of three-eights inch tarred hemp line 10 feet long. On each main line the trap nearest the center was attached five feet from the center stake. Placement of various combinations of bait was chosen using a table of random numbers.

Analysis of the Catch

Urosalpinx cinerea. The 36 traps were fished at weekly intervals until September 15, 1955 inclusive. On the next fishing date, September 22, because lines were beginning to rot, one trap was lost. The experiment continued until October 28, inclusive but for the original purpose of the experiment the results were progressively less satisfactory, because bait, particularly seed oysters, deteriorated with time, various traps were lost and replaced, or lost and recovered at a later date, and the catch was declining, probably because water temperatures were dropping.

For these reasons, the experimental observations were separated into three periods for analysis. The results are summarized in Table 2, in which catches have been grouped so that each number represents total catch in four replicate traps over a period of several weeks. The last period includes all observations in which one or more traps were missing. The durations of the first two were chosen to include approximately the same total catch in each.

In the first period, bait was fresh, and it would be expected that differences in attractive power of baits, with respect to kinds and amounts, would be at a maximum. In the second and third periods, differences might decrease or disappear.

The frequency distribution of individual catches was skewed strongly to the right, and more than half the catches contained no drills. A transformation therefore was necessary before the analysis of variance could be applied. The square-root transformation was chosen, but first each individual catch was increased by adding 3/8.

The transformed data for the first period were treated by analysis of variance (Table 3). None of the interactions between factors was significant, and the variance ratios computed for different quantities of bait and successive weeks of fishing were no greater than would be expected by chance. The catches in different kinds of bait, however, differed by amounts greater than usually would be expected by chance ($F = 5.52$, $F_{0.01} = 4.74$). Under the conditions of this experiment, it appears that seed oysters are superior to adult oysters, and adult oysters superior to shell, as bait for Urosalpinx cinerea.

Table 2. Catch of *Urosalpinx* per trap in the period July 21 to October 28, 1955 inclusive, on three kinds and three quantities of bait. The four replicate treatments have been grouped, and catches have been grouped by periods according to the condition of the bait. Traps were fished weekly.

Inclusive dates	Number of weeks	Amounts of bait	Kinds of bait			Totals
			Seed	Adults	Shell	
21 July to 18 Aug.	5	1	10	12	13	35
		2	29	8	5	42
		3	38	22	8	68
	Totals		77	42	26	145
27 Aug. to 15 Sept.	4	1	18	19	19	56
		2	18	12	7	37
		3	22	21	16	59
	Totals		58	52	42	152
22 Sept. to 28 Oct.	6	1	8	20	28	56
		2	20	16	5	41
		3	32	18	24	74
	Totals		60	54	57	171

Table 3. Summary of analysis of variance of the transformed catch of Urosalpinx per trap in the period July 21 to August 18, 1955, inclusive.

Nature of effect	Source of variation	Sum of squares	Degrees of freedom	Variance estimate
Main factors	Weeks (W)	0.98	4	0.24
	Amounts (A)	1.11	2	0.56
	Kinds (K)	2.77	2	1.38
First order interactions	K x W	0.60	8	0.08
	A x W	2.05	8	0.26
	K x A	1.93	4	0.48
Second order interaction	K x A x W	2.73	16	0.17
Residual	Replication	35.45	135	0.26
	Total	47.62	179	---

The data for the second period showed evidence of heterogeneity only with respect to the catches of successive weeks (Table 4). The relatively large catches of August 27 following Hurricane Hazel were primarily responsible for this result. Catches in traps commonly increase substantially after storms. There was no evidence that catches on different kinds of bait, or on different quantities of bait, differed significantly in the second period.

Catches on missing traps in the last period were each assumed to be zero for purposes of analysis. Most of the lost traps were recovered at a later date by careful searching with a hooked pole, and catches on recovery were never inconsistent with the assumption that catches in missing weeks were zero. Records of the catch show that during the period in question about half the catches contained no drills, 32 per cent contained one, and about 18 per cent contained two or more. There was no significant difference in distribution of catches on seed oysters, adults, or shell, nor on the three quantities of bait. Therefore, the assumption that all missing catches were zero has an even chance of being correct, and there is no evidence that any other distribution of estimated catches would fit the facts better. As illustrated in Table 5, there was no good evidence of heterogeneity in catches recorded for the third period.

Eupleura caudata. Only 15 Eupleura were caught during the entire experiment. Catches were too small to justify an analysis of variance, but it is interesting that the largest total catch (9) was made in traps baited with seed oysters, and the smallest (2) on shell. Catches on different quantities of bait were similarly inconclusive.

Deterioration of Bait

If it be assumed that the characteristics of shell as bait did not change during the experiment, catches on shell can be used to test rates of deterioration of seed and adult oysters. The total catches of Urosalpinx per week on shell in the three periods were 5.2, 10.5 and 9.5 respectively. The increase from the first to the second period was caused by an increase in abundance of drills by recruitment of young born in the summer of 1955. The increased availability persisted through September and early October, but catches declined again, probably influenced by falling temperatures, toward the end of the third period.

In the first period, both seed (χ^2 = 100.0, P very much less than 0.01) and adult oysters (χ^2 = 9.85, P much less than 0.01) were superior to shell. In the second period, seed oysters probably were still superior (χ^2 = 6.10, P less than 0.02) but catches on adult oysters could not with any great confidence be said to exceed catches on shell (χ^2 = 2.38, P about 0.2). In the third period catches on seed, adults, and shell did not differ significantly (χ^2 = 0.16, P about 0.7).

Table 4. Summary of analysis of variance of the transformed catch of *Urosalpinx* per trap in the period August 27 to September 15, 1955, inclusive.

Nature of effect	Source of variation	Sum of squares	Degrees of freedom	Variance estimate
Main factors	Weeks (W)	7.38	3	2.46
	Amounts (A)	0.66	2	0.33
	Kinds (K)	0.44	2	0.22
First order interactions	K x W	0.52	6	0.09
	A x W	2.84	6	0.47
	K x A	0.39	4	0.10
Second order interaction	K x A x W	2.61	12	0.22
Residual	Replication	25.22	108	0.23
	Total	40.06	143	---

Table 5. Summary of analysis of variance of the transformed catch of *Urosalpinx* per trap in the period September 22 to October 28, 1955, inclusive.

Nature of effect	Source of variation	Sum of squares	Degrees of freedom	Variance estimate
Main factors	Weeks (W)	3.63	5	0.73
	Amounts (A)	1.09	2	0.54
	Kinds (K)	0.00	2	0.00
First order interactions	K x W	1.58	10	0.16
	A x W	0.80	10	0.08
	K x A	2.91	4	0.73
Second order interaction	K x A x W	5.71	20	0.28
Residual	Replication	28.23	162	0.17
	Total	43.95	215	---

Deterioration of bait with time is illustrated in Figure 1. Formulae for the two lines, computed by the method of least squares, were as follows: for seed oysters log Y = 0.662 - 0.00812X, for adult oysters log Y = 0.236 - 0.00287X. Both lines intersect the axis Y = 1 in the vicinity of 82 days after the experiment began. This signifies that on October 4, under the conditions of this experiment, seed oysters and adult oysters were no longer superior to shell as bait for Urosalpinx. For practical purposes, of course, bait becomes inefficient long before it loses its potency completely. Consequently, it might be worth while to compute the period in which bait loses half its attractive power. For seed oysters the half-life was about 27 days, and for adults about 36 days.

It is interesting also to compare these results with results of the rebaiting experiment at the Laboratory pier. Control in the pier experiment was established by retaining old bait in half the traps. For purposes of comparison, this old bait can be considered as adult oysters. The lower regression line in Figure 2 was fitted by the method of least squares to points representing the ratio of total weekly catch on new bait to total weekly catch on old. The upper regression line represents the ratio of catches on seed and adult oysters, computed from data illustrated in Figure 1. The lower level, and greater slope of the line representing the pier experiment probably reflects the relatively greater numbers of drills near the pier, and decreasing water temperature. New bait no longer exhibited a significant advantage over old bait after about 40 days, and the half-life under these conditions was about 19 days.

Variation in Catches of Individual Traps

Some traps consistently caught more drills than others with similar bait. For example, trap number 17 took 47 drills during the experiment, and the weekly catches of this trap included the three largest catches of all traps. Trap number 7, on the other hand, contained the same amount and kind of bait, but caught only seven drills altogether.

Because kind of bait influences the catch, comparisons of individual catches are legitimate only within replications. Testing against expected catches based on average catch in each of the replications of four, the pooled chi-square values summarized in Table 6 were computed. Although tests at the lowest level did not always produce evidence that the variation was greater than would be expected by chance, the summed chi-squares for the three kinds of bait all showed evidence of heterogeneity at the one per cent probability level or better, two of the three amounts of bait produced equally conclusive results, and one gave less than one chance in twenty that a larger value of chi-square could result by chance. The sum of all chi-square values also strongly favored the view that chance was not the only factor influencing the catch in replicate traps.

Such undue variation could come about through uncontrolled variations in the attractability of the traps themselves, but it would

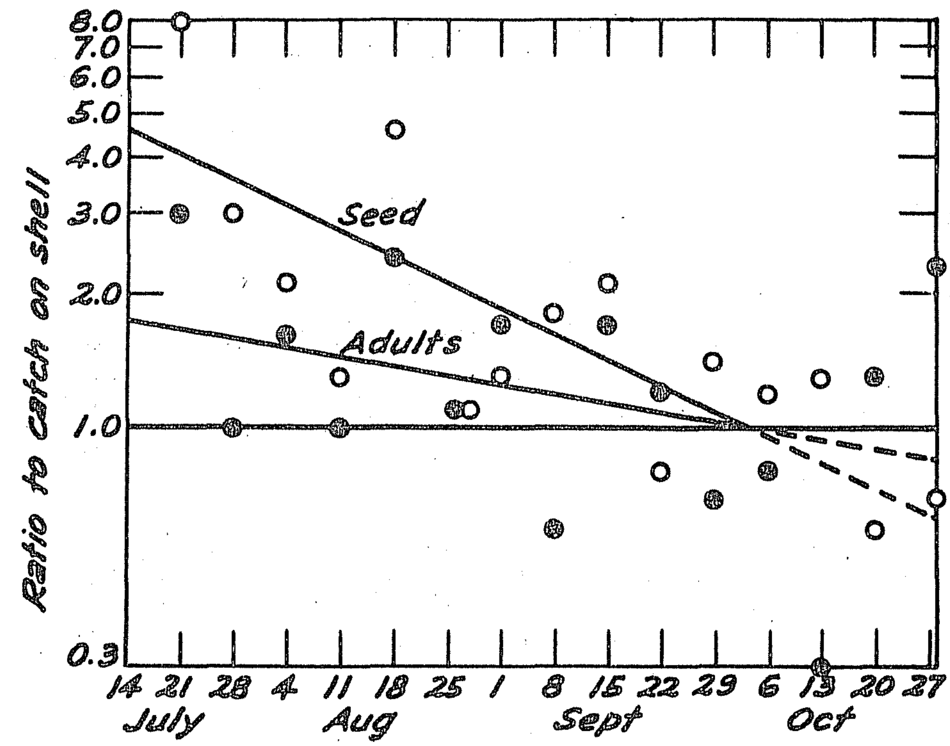

Fig. 1. The ratio of the catch on seed and adult oysters to the catch on shell in the offshore experiment of 1955. Open circles: seed-shell ratio; black circles: adults-shell ratio.

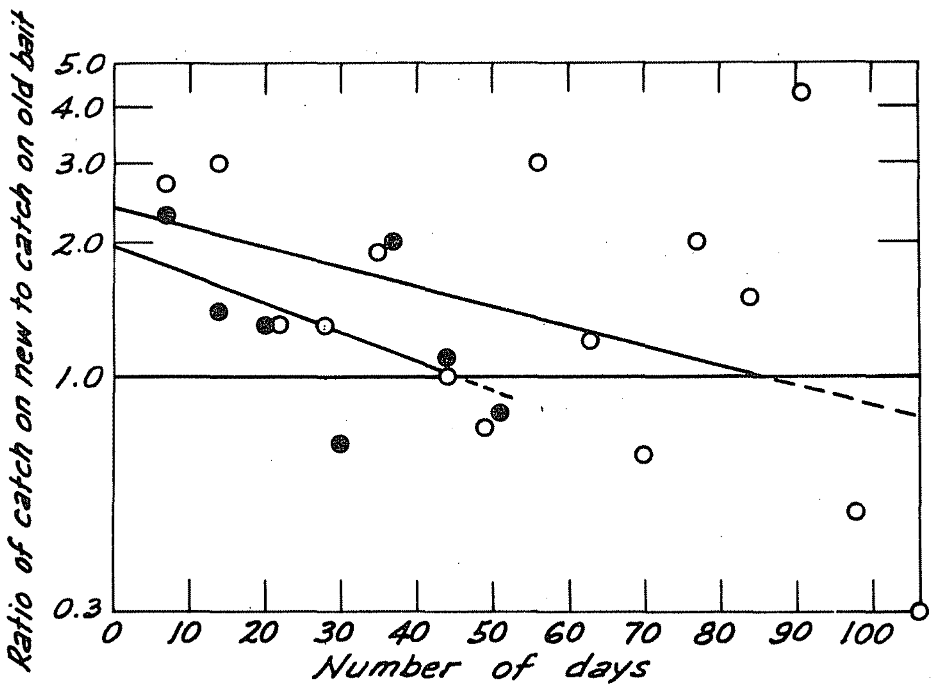

Fig. 2. The ratio of the catch on seed oysters to the catch on adult oysters at the Virginia Fisheries Laboratory pier in 1954 and in the offshore experiment of 1955. Open circles: offshore experiment; black circles: Laboratory pier.

seem logical to search first for evidence of non-random distribution of drills over the trapped area. The two lines of traps were oriented parallel to shore and at right-angles to it, and depth of water and character of bottom fluctuated. As shown in Figure 3 catches tend strongly to decrease in an offshore direction. In constructing Figure 3, allowance was made for differences in catch by the three kinds of bait by adjusting catches by appropriate factors.

Parallel to shore, smallest catches seemed to occur at the two ends of the line, highest near the center. The two ends respectively were not far from the Laboratory pier and a pier on adjacent residential property downriver. The proximity of these piers, the pilings of which harbored a rich community of fouling organisms, may have constituted a disturbing element. The trend was quite irregular, and perhaps not biologically significant.

Sizes of Urosalpinx Caught on Different Kinds of Bait

In view of the previous conclusion that no differences of biological significance appear to exist in the frequency distribution of shell height of drills caught on new and old bait, it is worthwhile to examine the shell height distribution of Urosalpinx caught on the three kinds of bait used in these experiments (Table 7). It is interesting that the difference in total catch on the three kinds of bait is confined entirely to adult drills ($\chi^2 = 26.70$, P much less than 0.001). Total catches of Urosalpinx 13 mm in height or smaller (58, 58, and 59 drills respectively) were essentially identical.

This experiment suggests that although adult Urosalpinx are sensitive to differences between seed oysters, adult oysters, and shell, young drills are not. This may indicate a difference in food preference between young and adult drills. Or, as Dr. Thurlow Nelson has suggested, young drills are inveterate climbers, and this favors their wide distribution on materials that are moved across the bottom by currents. This could account for their relatively greater abundance on shells and adult oysters.

SUMMARY AND CONCLUSIONS

Ten traps, of a series of 20 that had been fished for about a year without replacing or augmenting bait, were selected at random and rebaited with seed oysters in October 1954. The catch of Urosalpinx and Eupleura increased significantly immediately, but the superiority of new bait over old declined steadily on successive fishing dates. Nevertheless, rebaited traps remained more attractive to drills for more than a year, except for a six-month period in winter and early spring, when the catch of Urosalpinx was about equal in new and old bait. There is no evidence that drills caught on the two kinds of bait differ in size. Eupleura responded more vigorously to new bait than did Urosalpinx.

Table 6. Tests of variations in the catch of individual traps, represented by summation of chi-square values at the various levels. Figures in parentheses represent the numbers of degrees of freedom.

Amount of bait	Kind of bait			Pooled χ^2
	Seed	Adults	Shell	
1	1.10 (3)	7.26 (3)	11.48** (3)	19.84* (9)
2	25.85** (3)	14.00** (3)	2.53 (3)	42.38** (9)
3	37.91** (3)	2.55 (3)	9.16* (3)	49.62** (9)
Pooled χ^2	64.86** (9)	23.81** (9)	23.17** (9)	111.84** (27)

* Probability of a larger value of chi-square 0.05 or less.
** Probability of a larger value of chi-square 0.01 or less.

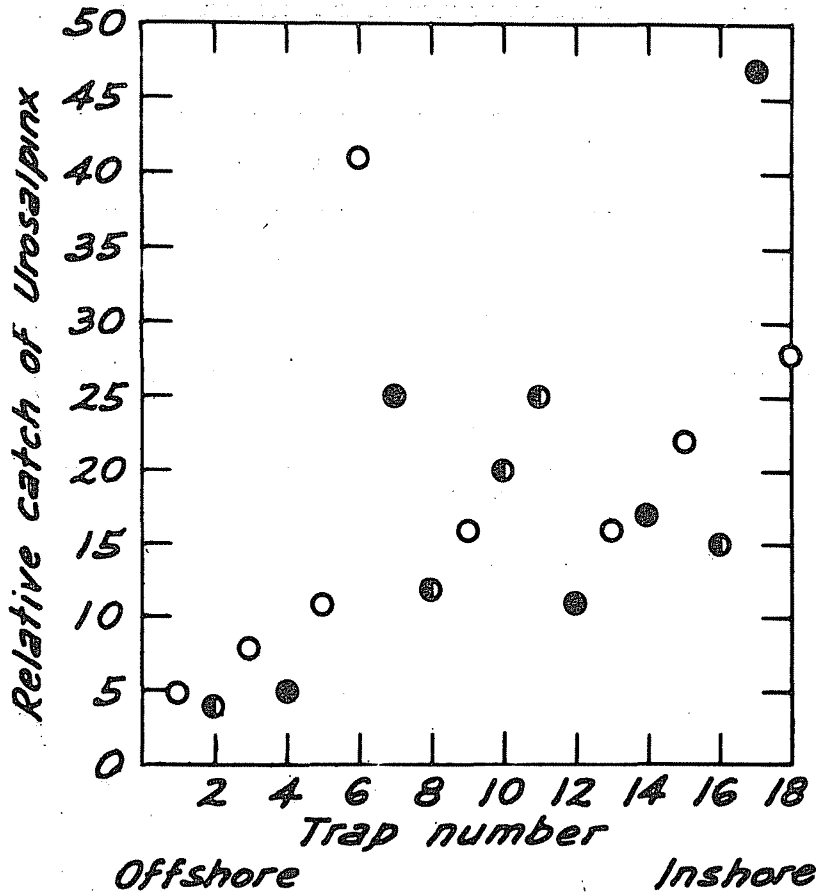

Fig. 3. The total catch of Urosalpinx in a series of traps arranged in a line at right angles to the shoreline in the York River at Gloucester Point. Black circles: seed oysters; divided circles: adult oysters; open circles: shell. The catches on adults and shell were weighted by appropriate factors so that the average catch per unit of effort was equal to that on seed oysters.

Table 7. Numbers of small and large *Urosalpinx cinerea* caught on seed, adult oysters, and shell in 1955.

Shell height	Kinds of bait		
	Seed	Adults	Shell
13 mm and less	58	58	59
14 mm and over	137	90	66
Grand totals	195	148	125

Thirty-six traps were set out in July 1955 to test the relative catching power of seed and adult oysters and oyster shell, and to measure the relative merits of different amounts of bait. In the first five weeks the greatest catch of Urosalpinx was made on seed oysters, and the smallest on shell, and odds were less than one in 100 that these differences could occur by chance. For the next ten weeks also, the greatest catch was made on seed and the least on shell, but these differences were not significant statistically. There was no evidence, at any time during the experiment, that quantity of bait affected the catch. Only a few Eupleura were taken, and catches on the different kinds of bait did not differ significantly, but total Eupleura catch followed the sequence demonstrated for Urosalpinx greatest on seed and least on shell.

The rate of deterioration of bait can be expressed as the time in days during which it loses half its power of attraction. In the experiments described here this was determined in relation to catch on shell, and gave values ranging from 19 days at the Laboratory pier to 36 days for adult oysters in the offshore experiment. Undoubtedly rate of deterioration is a function of the abundance of drills, kind of bait, water temperature and salinity, and many other things. Ignoring environmental effects for the moment, the results here obtained apparently fit a logical pattern, for the relatively short half-life of new bait at the pier is linked with a greater abundance of drills, and the greater half-life of adult oysters as compared with seed oysters in the offshore experiment matches the greater attraction of seed for drills. On the other hand, it must be noted that both experiments, but especially that conducted at the pier, covered periods in which water temperatures declined appreciably from the late summer maximum, and declining catches probably were hastened by falling temperatures. This is confirmed by increased catches on new bait at the Laboratory pier in the summer of 1955.

Available evidence suggests very strongly that catches of individual traps in the offshore experiment varied to a degree much greater than chance alone would allow. Apparently distribution of drills over the trapped area was non-random, and the pattern of catches suggests that abundance decreased rather regularly from the inshore to the offshore part of the experimental area. This is consistent with previous observations that beds of eelgrass near shore harbor a large natural population of drills.

With respect to shell height of Urosalpinx caught on seed, adults, and shell, the results of the offshore experiment are at variance with those of the experiment at the pier. Catches of drills 13 mm or less in height were identical on the three kinds of bait, but larger drills were most strongly attracted to seed, and least strongly to shell. This suggests seasonal or local differences in habits of young and adult Urosalpinx, possibly related to food or depth preferences, and reactions to gravity.

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