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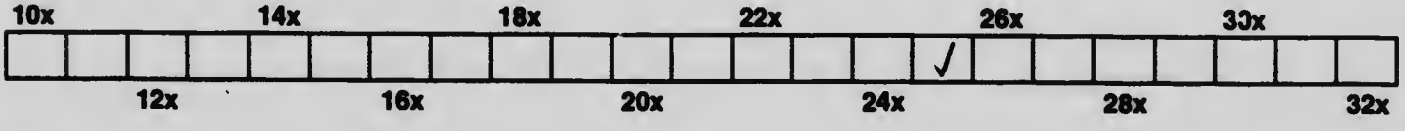

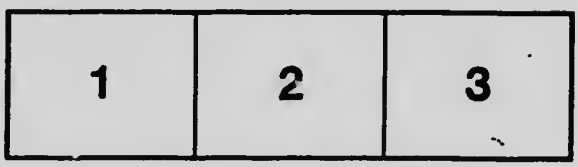

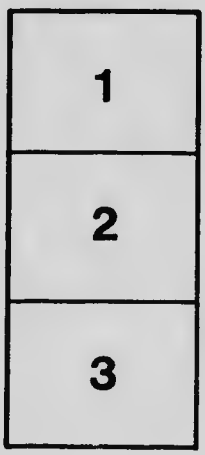

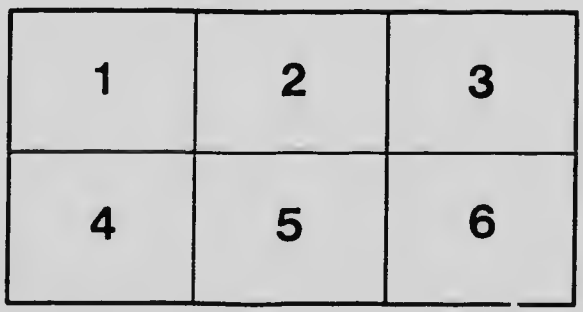

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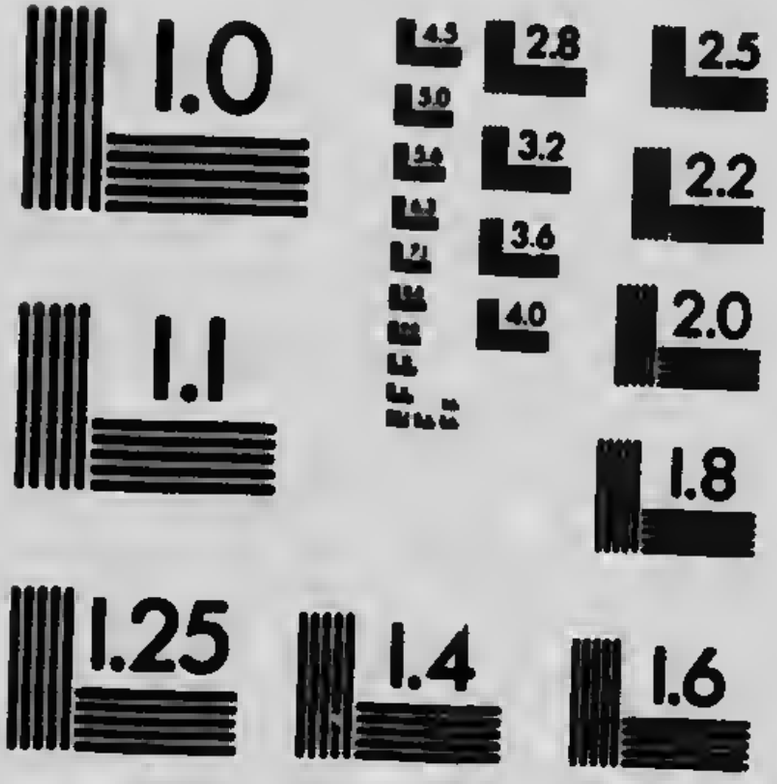

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SUPPLEMENT
TO THE
ANNUAL REPORT OF THE FISHERIES BRANCH
DEPARTMENT OF NAVAL SERVICE
1917-18

REPORT UPON

LOBSTER INVESTIGATIONS

AT

LONG BEACH POND, NOVA SCOTIA

DURING

THE SUMMER OF 1915

BY

A. P. KNIGHT, M.A., M.D., F.R.S.C.

Professor of Animal Biology, Queen's University, Kingston, Ont. Member of the Biological Board of Canada.

Being t[illegible] of Investigations carried on under the Biological Board, with [illegible] Officers instructed by the Department of Naval Service

OTTAWA
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1918

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LOBSTER INVESTIGATIONS AT LONG BEACH POND, N.S.

RECOMMENDATIONS.

1. That the rearing operations hitherto conducted by the Board at Long Beach pond be discontinued.

2. That the executive committee consider the advisability of securing from the Fisheries Branch of the Department of Naval Service full control over the operation of one of the present lobster hatcheries, in which to conduct a series of experiments on the rearing of lobster fry, using warm sea-water, as suggested by Professor Macallum.

3. That the executive committee confer with the Department as to the best method of collecting statistics regarding the relative numbers of male and female lobsters trapped next season, and also the percentage of females carrying fertilized eggs.

4. That several more enclosures be built at a moderate cost, by either the Board or by the Fisheries Department at different points along the maritime coast, for the purpose of determining more definitely the percentage of commercial lobsters which extrude eggs in July and August.

ACKNOWLEDGMENTS.

Acknowledgment is due the Department of Naval Service for furnishing a plentiful supply of both berried and commercial lobsters for the purpose of carrying on the experiments described in the following report; also for placing at the disposal of the Board the services of Mr. Andrew Halkett. Mr. Halkett gave us every assistance. More particularly, he kept an accurate count of the lobsters received at the pond, allotted to the various enclosures, and returned to the sea.

The Board is also indebted to the department for moving the rearing plant from the southwest end of the pond, and placing it within the cement pound.

POUND AND POND.

In the following report the reader must distinguish carefully between the natural pond of some 5 acres, and the artificial pound of about three-fourths of an acre, enclosed by cement walls and forming the northeast part of the pond.

Fig. 1.—Long Beach Pond viewed from the northeast end. In the foreground can be seen first the mess-house; beyond this, the cement pound; further away is the larger part of the pond. In the distance can be seen the engine house and plant for rearing lobsters.

Last year, 1914, because of the excessive leakage of water from the pound, tho Board approved of the location of an experimental rearing plant of four boxes at the southwest end of the pond, and my report upon the operations of that year has been already published.

LEAKAGE.

On December 18, 1914, the Board was notified that the leakage, which had persisted throughout the previous summer, had been stopped, and that there was at that date a depth of 6½ feet of water in the pound at low tide. During the winter of 1915, however, the leakage again developed and was again reported stopped on June 26, 1915. At this date there was said to be a depth of 5 feet 8 inches of water at low tide.

On my arrival, July 3, 1915, the pound was again leaking, not copiously, it is true, but sufficiently to show that in the course of a few days or weeks the rearing boxes, 4 feet in depth, would likely be resting in the mud. As a precaution, therefore, against possible injury to our larvæ, the boxes were reduced in depth to 2½ feet. On the assumption that there would be, as intimated, 6½ feet of water at low tide, a space of 4 feet would intervene between the bottom of our shallow boxes and the mud beneath.

At Wickford, R.I.—the original home of the plant—the depth of water below the boxes is 12 feet at low tide, excepting at one corner, where it is only 5½ feet. At Long Beach it was hoped that a depth of 4 feet might suffice to test the scheme. Last year at low tide there were only between 20 and 22 inches of water below our boxes; this year, after operating our plant for seventeen days, the boxes were resting in the mud, so great was the leakage.

Fig. 2.—West side of cement pound showing leakage of water. Over the ironrods at the upper left hand corner of the illustration can be seen the gearing of the rearing apparatus inside of the cement pound.

At the extreme low water of August 7, two of the boxes were resting 5 inches in the mud. Measurements at eleven different points around our apparatus gave the

following depths of water, 21 inches, 22, 17, 20, 17, 19, 19, 23, 24, 26, 24, or an average of 21 inches, in which to float our apparatus. It can scarcely be expected that an apparatus, which requires at least 10 feet of water in which to operate, can be made to operate successfully in a depth of 21 inches.

FIRST HATCHING.

Our first hatching began July 12, and in two days we had about 40,000 larvæ in the four boxes. While only an odd diatom could be found on the fry during the first day, large numbers were visible by the fifteenth. As the diatoms increased, the fry became "fuzzy" to the naked eye. Both last year and this the effect of the diatoms was largely, if not solely, mechanical. Feeding was interfered with, the animals became exhausted with the effort of swimming, sank to the bottom, and soon died.

The remarkable thing about this mortality was that last year it was caused by the diatom *Synedra investiens*, whereas this year it was caused by *Licmophora Lyngbyei*. Why the principal destructive organism should have been different in the two years is difficult to understand, unless it were due to the fact that in 1914 the sea-water reaching our boxes came through the sand, gravel, and mud of the sea-wall, whereas, in 1915 it came through an earthenware pipe from the open sea.

As soon as it became apparent that this season's fry were likely to share the same fate as those of last year, the contents of two of the boxes were transferred to St. Mary's bay, in order, if possible, to save their lives. Meanwhile the leakage steadily grew worse. On the 19th the average depth of water below the boxes was only 10 inches. As a result, good ventilation became impossible, because the water drawn in through the bottom windows gradually became muddy. It was resolved, therefore, not to use more than two boxes for rearing purposes for the remainder of the season. The other two were fitted up with shelters, or nests, for adult lobsters, so that more accurate observations could be made upon them than was possible in the compartments of the pound.

DETENTION DEVICES.

It should, perhaps, be explained that we employed five different devices, or enclosures, for impounding adults. The smallest was the crate, about 3 feet by 2 feet by 2 feet, which floated on the water, and could be used for temporary purposes only. The second was our rearing boxes, 10 feet by 10 feet by 2½ feet, with revolving paddles inside, so as to aerate the water, as described in the report of last year. The third was the compartment, 20 feet by 10 feet by the varying depth of the water at high and at low tide. The wooden slats of which it was constructed were only about 4½ feet high. As can be seen from the illustration, there were six of these compartments within the cement pound. The fourth enclosure was the pound, and the fifth, the pond, but these two latter were so large that is was impossible to use them for observation purposes. The compartments could be used for observation purposes only at low water. The real purpose of their construction was to serve as sub-divisions of the pound, in which lobsters could be kept for experimental and observational purposes.

FAILURE.

We had even worse luck this season than last. Of the 20,000 fry which we tried to rear in the two remaining boxes, beginning July 12, only twenty-one remained alive on the 30th of July, and they were all in the second stage of development. Not one had moulted a second time, and they had taken thirteen days before moulting even

once. Of the 20,000 to 22,000 fry which we tried to rear at a second trial, beginning August 2, only 146 were alive on August 17, and these also were all in the second stage.

In the August rearing the larvæ were shaded from the sunlight by heavy painted canvas screens lying close over the boxes; in July they were not. The effect of the shading appeared to be to reduce the first stage from thirteen days to nine days, and to lessen the number of diatoms; but the larvæ died just the same.

It is, of course, true that the warmer water in August (about one degree) may have had more to do with the shortening of the first stage than the exclusion of light. Indeed, the influence of direct sunlight upon larvæ is still an open question. To be sure, the fry, when left to themselves, swim straight into the light, but it does not follow that because they do so, the result to themselves is necessarily beneficial.

Fig. 3.—Showing the interior of the cement pound. The six latticed compartments are for retaining lobsters so that they can be studied at close range.

Leaving out for the present the influence of light, it may well be asked: "What favourable conditions exist at Wickford, that enable the operators there to raise 40 per cent. of their fry to the crawling or fourth stage, which do not exist at Long Beach pond?" And the answer is: first, too slight a depth of water under our rearing boxes, thus favouring the entrance of mud and diatoms from the bottom; secondly, the presence in the water of an unusual number of diatoms not generally found in open sea-water;* thirdly, too low a temperature of water. While the temperature at Wickford varies during the rearing season from 68° to 75°, the mean average temperature at Long Beach this season was only 58·09° for July, and 58·9° for August. The two following tables give the daily temperatures at Long Beach for July and August, respectively:—

* Professor McClement's Report "Diatoms and Lobster Rearing"—Contributions to Canadian Biology, 1915-16. Supp. 6th Ann. Rep. Dept. Naval Service (Fisheries), Ottawa, 1917.

SESSIONAL PAPER No. 38a

TEMPERATURES and kind of weather at Long Beach Pond, during the month of July, 1915.

Date.	Wind.	Temperature of Pound Water.			Temperature air outside.	Weather.
		Maximum.	Mean.	Minimum.		
		°	°	°	°	
July 12...	SW.	.. ..	55·5	....	not taken.	Foggy.
" 13..	SW.	.. ..	58·0	....	"	Fair.
" 14...	calm.	Temp. in St. Mary's Bay 56.8.	56·0	..... .	"	Fair.
" 15 ..	SW.	....	59·8	.....	67·0	Foggy.
" 16...	S.	.....	57·3	... .	56·5	Foggy.
" 17...	SW.	....	58·0	.....	59·8	Foggy and rainy.
" 18...	SW.	. .....	56·0	.....	61·0	Foggy.
" 19 ..	SW.	....	58·0	.....	not taken.	Fair to rainy.
" 20...	SW.	.....	56·0	....	55·7	Foggy.
" 21...	NE.	. .. .	58·5	.....	not taken.	Raining.
" 22...	NE.	60 8	58·4	56·0	"	Cloudy.
" 23...	N.	62·0	60·2	57	63·0	Fair.
" 24. .	SW.	62·0 65·0	.....	60 59·0	not taken.	Fair.
" 25...	E.	63·0 61.5	61·5	59·0 57·0	"	Fair.
" 26...	SW.	64·5 60·8	60·5	59·0 56·5	54·8	Foggy.
" 27...	SW.	60·5 59·0	59·2	59·0 58·0	58·0	Rainy and foggy.
" 28...	SW.	57·0 58·0	55·8	55·0 53·0	54·0	Foggy.
" 29...	SW.	61·5 61·0	58·0	59·0 55·0	60 0	Fair.
" 30...	S.	58·5 57·5	57·5	55·5 55·0	64·0	Foggy.
" 31...	SE.	61·5 61·5	58·5	60·0 56·7	63·0	Foggy.
	Totals..		1161·8	. ...	716·8	

Mean average temperature of water = 58·09°. Mean average temperature of air = 59·7°.

TEMPERATURE and kind of weather at Long Beach Pond during the month of August, 1915.

Date.	Wind.	Temperature of Pound Water.			Temperature air outside.	Weather.
		Maximum.	Mean.	Minimum.		
		°	°	°	°	
Aug. 1...	S. Faired	62·3	60·5	57·0	78·0	Foggy.
	10 A.M.	65·5	.....	57·3		
" 2...	Calm and Cloudy	64·7	61·3	58·0	72·0	Foggy.
		63·6	.....	59·0		
" 3...	N. Sun shining.	61·0	58·5	55·0	54·8	Fair.
		64·0	.....	54·7		
" 4...	S.	61·0	56·5	52·0	59·8	Fair.
" 5...	NE.	61·0	58·1	55·0	58·8	Cloudy.
		61·5	.....	55·0		
" 6...	NE.	61·0	60·0	56·5	59·8	Fair.
		66·0	.....	56·5		
" 7...	S.	65·0	60·5	57·0	66·5	Fair.
		63·0	.....	57·5		
" 8...	SW. changed to N.	63·0	60·0	57·0	58·5	Foggy.
" 9..	Calm.	64·0	59·3	57·0	62·0	Foggy.
		59·5	.....	57·0		
" 10...	SW.	60·0	58·0	57·5	65·0	Foggy.
		59·5	.....	56·0		
" 11...	NE.	60·5	59·9	57·5	60·0	Fair.
		64·7	.....	57·0		
" 12...	SW.	63·0	60·0	57·0	59·0	Fair.
" 13...	S.	61·5	58·7	56·0	61·0	Foggy.
" 14...	S.	55·5	56·5	55·0	55·5	Foggy.
		59·5	.....	55·0		
" 15...	NE.	59·5	58·0	56·5	64·0	Foggy.
		60·0	.....	56·0		
" 16...	SW.	61·0	58·8	56·3	63·0	Foggy.
		60·5	.....	57·3		
" 17...	SW.	60·0	57·7	55·5	62·0	Foggy.
	Totals.....		1002·3		1059·7	

August Mean average temperature of water=58·9° Mean average temperature of air=62·3°
July Mean average temperature of water=58·09° Mean average temperature of air=59·7°.

On this subject the Rhode Island Commission remarks:—

> The temperature of the water is of paramount importance in order to obtain the best results. Although it is possible to rear lobsters with some success in cold water, the best results will be obtained with water at a temperature of 65° to 75° F. This higher temperature results in a more rapid development of the lobsters. This more rapid development results, first, in a reduction of the expenses of operating the plant, because of the less time required, and, second, in a greater proportion of fry reared to the fourth stage, because in the shorter time there is less chance for death from cannibalism, parasites and injury.

Prof. A. B. Macallum has suggested that, in order to overcome the handicap of cold water, we should use sea-water that has been heated to 68° or 70°. This appears to be a good suggestion, unless its adoption would increase to too great an extent the cost of operating our plant. At a moderate calculation, about 2 cubic feet of water per minute enters, and, of course, leaves each rearing box. To heat this quantity of

water from 55°, which is our average temperature, up to 70° will require the combustion of about 250 pounds of coal per day of twenty-four hours.

As the enlarged Wickford plant is composed of fifty-two boxes, the total consumption of coal for the rearing season of two months would amount to about 300 tons. Accordingly, to the regular expense of running a Wickford plant of fifty-two boxes, namely, wages of five men, gasoline, oil, food for the larvæ, wear and tear, there would have to be added in Canada the wages of an extra engineer and fireman, besides the cost of the 300 tons of coal.

WINTERING IN THE POUND

Next to the leakage of water, the feature which attracted most attention at Long Beach during the early season of 1915 was the pitiable condition of the lobsters which had wintered in the pound. They were simply covered with growths of green, brown, and orange coloured algæ. The green measured from 1 to 3 inches in length, the brown from several inches to three feet, and the orange-coloured ones about one-quarter to one-half inch. These latter grew not alone on the body, but over the eyes, and rendered them blind, at least for the time being. Their gills varied in colour from grey to almost black, strongly suggesting that the function of these organs was impaired by a coating of the black mud in which they were compelled to live during the year.

The animals which had passed the winter in the pond were distinctly better. They were not so much infested with algæ, but the effects of their confinement became very apparent when they were compared with the commercial lobsters which were placed in the pond between May 10 and June 15. In the former the natural colours of the body were completely hidden by the grey mud and copious growth of weeds which they carried, whereas the latter showed the bright colours characteristic of the normal lobster. Moreover, the commercial ones were free from algal growths, and their gills exhibited the well-known flesh colour. The difference between pond and pound lobsters, on the one hand, and commercial lobsters, on the other, was comparable to the difference between the dirt and rags of a tramp and the cleanliness and dress of a gentleman.

CONFINEMENT.

The fundamental conditions for a healthy life are very much the same for lobsters as for other animals. They must have plenty of food, well-ventilated water, adequate exercise alternated with rest, and diffused sunlight. How many of these conditions can be said to be freely supplied to a lobster that passes all of its time in a crate, car, box, compartment of the pound, or even in the pound itself? One has but to think of the ill effects of confinement upon wild animals, or even upon domesticated animals, to realize how harmful it is. Human beings, whose occupation confines them much in factories, shops, or offices, and those who are confined in jails, asylums, or detention camps—all suffer more or less from their confinement. Is not the spread of tuberculosis among cattle largely due to their confinement in ill-ventilated stables? Do not zoological gardens also show instances of deterioration in health, due to the violation of the fundamental laws of biology? Lobsters can be no exception to the rule. When kept in confinement we cannot expect to find them in the same condition of health and vitality as when they live in the open sea. No wild animal flourishes so well in confinement as in the open. Liberty of movement is essential to health. It matters not whether lobsters are retained in small or large enclosures, or, for that matter, in the whole pond, the ill-effects upon the lobsters soon become apparent. In the case of the smaller crates and cars, the animals soon die. In the

larger compartments of the pound, or pond, the ill-effects may not become apparent for several months, but slowly and surely the lobsters' health and vitality are undermined and they finally succumb to the adverse conditions.

No doubt, by a long course of breeding and artificial selection, it might be possible, in the case of the lobster, just as in the case of our domesticated animals, to breed a stock that would be less sensitive to the ill-effects of confinement, but, until we have bred such a strain, the nearer we can make the conditions of confinement approximate to the conditions in which the animal lives in the sea, the lower will be the mortality.

MUDDY BOTTOM.

Next to the copious growth of weeds, blinding and encumbering the lobsters which had wintered at Long Beach, perhaps the next most unfavourable condition was the mud. There is, of course, mud and mud. Every lobster fisherman knows perfectly well that during winter and early spring the largest catches are made off shore, on muddy or sandy bottom. In late spring or early summer the fishermen move their traps towards the shore and find the best fishing on rocky bottom along the side of kelp or other kinds of sea-weed. But, while the lobster finds a congenial home on a soft sea-bottom, it does not follow that the animal, when compelled to pass the winter in Long Beach pound, necessarily finds the mud therein equally congenial. The mud of the pound has a disgusting odour, largely due to the gas, sulphuretted hydrogen. Every one who is familiar with this gas knows its characteristic odour, and the characteristic odour could be obtained anywhere in the central area of the pound by simply driving a wand down into the mud. For example, at low water on the morning of August 8 a spruce wand six-sixteenths by seven-sixteenths was pushed 5½ feet into the mud by the mere pressure of the hand. This was at the north end of our engine house. At the south end, 3 feet were found. At the south end of our hatching boxes, 5 feet. At all points, on withdrawing the wand, the characteristic odour of sulphuretted hydrogen was experienced, and the adherent mud had all the appearance of a sulphide precipitate.

That the gas was really sulphuretted hydrogen became evident in another way. The gas-ladened mud blackened any board, oar, or boat that was painted with white lead, and which remained in contact with the mud for a few hours. Moreover, it precipitated soluble salts of silver, copper, iron, etc., and there is no doubt that the surface of the gill filaments were darkened and their function partially destroyed by sulphides or other particles of mud. In this way it is easy to understand how the gills of lobsters in the pound gradually turned, first, to a grey colour, and finally became almost black.

Dr. McGill, chief analyst of the Inland Revenue laboratory, Ottawa, made an examination of the mud, the super-natant sea-water, and the gills of an adult lobster which had died in the pound. He reports as follows: "The mud is chiefly silica, with a considerable amount of inter-mixed sulphide of iron. The gills of the lobster contained iron and phosphates, with a possible trace of sulphur."

Dean Goodwin, D.Sc. of the Kingston School of Mining, reports a similar finding to that of Dr. McGill.

MORTALITY.

The severe conditions under which the animals passed the winter seem to have affected their general health and caused a rather high death-rate. Of course, it is quite impossible to estimate the death-rate among lobsters in their natural habitat. In the sea, allowance must be made for those that die of hunger, or are killed by enemies. In the pond and pound the adults have no enemies, and, consequently, should show a low rate of mortality, otherwise there would be no reason for placing them in sanctuaries. We can only form an idea of the rate of mortality in sanctuaries

by keeping track of those which die from year to year, and ascertaining, if possible, the cause of death. For example, of 167 lobsters left in the pond and pound last season (1914) only 134 could be found this season, thus showing a loss of 33. Of the 312 placed in the pond and pound this season (1915) all have been accounted for, the loss by death being a total of thirty-eight. But, just as thirty-three in the one case does not represent the true loss by death (because some of last year's lobsters may yet be recovered from the pond), so thirty-eight does not show the true mortality this year, that is, the mortality due to the ill-effects of detention in the pound or pond. The loss this year must be reduced to twenty, because eight of the thirty-eight were poisoned by the accidental use of red paint on the paddles in one of our hatching boxes, and ten others died in the course of transportation to the pound. The real loss, therefore, this year is only 6 per cent of the total, whereas, the loss on last year's numbers (if no more can be found in the pond) was nearly 20 per cent. The greatly decreased mortality this season is, undoubtedly, due to the great care exercised by the department in collecting, feeding, and distributing them, and the shorter detention period in the pond and pound. No one, who appreciates the facts, will advocate the retention of lobsters in either pond or pound for more than a few months at a time.

EGG-LAYING.

Egg laying at Long Beach this season had two peculiarities. The first was that about half the females extruded only a few hundred eggs in place of many thousands, and the second was that the eggs on probably 80 per cent of the mothers were unfertilized.

In explanation of the former fact (noticed last year also) we at first assumed that the mothers had been interrupted in the act of egg-laying by being dipped up in the net. Subsequent facts, however, showed that this was not the case, because, when such lobsters were confined in crates or cars for a few weeks, the number of eggs was never increased. Secondly, when (as happened on a few occasions) such a lobster died, *post mortem* examination showed that the beast had extruded all the ripe eggs in her ovaries, excepting perhaps half a dozen or so. This great reduction from the full complement of eggs had to be explained on some other ground. As this peculiarity in egg-laying was limited, so far as the writer can remember, to females which had spent the winter in the pond or pound, the reduction in the number of eggs would seem to be due to the unfavourable conditions under which the animals had lived throughout the winter—crowding in a small compartment, lack of adequate food, excessive growth of algæ upon them, and the uncongenial mud of the bottom. In illustration of this subject, the following facts may be quoted. In one compartment of the pound were fifty females which had hatched their eggs in the summer of 1914 and been retained in the pound all winter. Whether they had extruded eggs last autumn and lost them during the winter or early spring is not known, but, at any rate, they were all found without eggs on April 8, 1915. On July 19 an examination of the 50 resulted, as follows:—

22 had no eggs on them.
21 had new eggs on them, but none with the full complement. Within a week 4 of these 21 had lost the few eggs which they had.
1 only had a full complement of eggs.
2 had died.
1 male only was present throughout the winter with these females.
3 were unaccounted for.

It is probable that few if any of the eggs carried by these twenty-one females were fertilized, because there was only one male present in the enclosure to mate with the fifty females. It happened, unfortunately, at the time of this examination that the rearing apparatus absorbed all my attention, and, consequently, no examination of the eggs was made to see whether they were fertilized or not. Nor must it be supposed that the loss of eggs by four of these females out of the twenty-one was the only instance of the kind which came under our notice this season. On another

occasion a female, which was known to carry a few eggs, was later found to be without any. In a third instance two females, both with eggs, were placed in a crate and a few days afterwards one of them was found to have lost her eggs.

Here, then, we have records of three different occasions on which lobsters lost their eggs a short time after extruding them. If unfertilized eggs "go bad" and drop off within a few weeks or even months after extrusion, it is easy to understand how our fishermen find not more than an average of 20 per cent (according to one member of the Shell Fish Commission of 1912-13) of the females carrying eggs. It may be, too, that mothers, when pressed by hunger, eat their eggs, whether fertilized or not fertilized. I have myself watched a female tearing off unfertilized eggs from her swimmerets, passing them forward and transferring them to her mouth with her maxillipedes. On examining her abdomen, the egg clusters could be seen ragged and torn on each side and partly removed. It could not be said in this instance that the eating of her eggs was the result of hunger, because all the lobsters in the pound this summer were well cared for and regularly fed.

The fourth instance of the loss of eggs was the most remarkable of all. In this case none of the eggs adhered to the abdomen. The first intimation we had that eggs were being laid was seeing them floating around in the current on the floor of one of our rearing boxes. These were all soft and jelly-like, and undoubtedly, diseased and unfertilized.

Fig. 4.—Mother lobsters carrying newly extruded eggs. These are attached to the paired swimming feet on the under surface of the abdomen. When carrying eggs, the mothers always bend the latter part of the abdomen and tail under the body so that the eggs are as well protected as if carried in a covered cup. In the illustration the abdomen is extended so as to expose the eggs to view.

MOULTING.

We had opportunities of witnessing several successful moults and also several failures to moult, followed by death. The act is too well known to require description. In healthful surroundings and under the stimulus of adequate food, the act cannot be a critical one for a vigorous animal, but, if conditions are not favourable, as in the pound, then the act may well be fraught with danger. There can be but little food in winter, especially, within the limited area of the compartments, and considering the leakage, the supply of fresh sea-water at low tide must also have been scanty. The slimy mud that covered their gills was an ever-present menace, so that the animals were weakened by their long confinement, and some of them, therefore, unfit to store materials in the body for the manufacture of the new shell or the excretion of waste material from the body. What more likely thing could happen than that some of them would succeed in moulting, while others would fail and die?

BLIND LOBSTERS.

On noticing the blind lobsters, the first question that occurred to me was to ask whether the sight would be restored after moulting. The question was generally answered in the affirmative, but not always. In the case of a female which had spent a year at least, and possibly more, in the pond, it was found that she was still blind. The algal growths had penetrated too deeply into the substance of the eye and had destroyed the underlying tissue. In one other case, the sight was impaired, but not lost; but, generally speaking, the process of moulting restored the sight.

NUMBERS OF EGG-BEARING FEMALES.

It is greatly to be regretted that statistics in regard to the relative numbers of egg-bearing lobsters are not available. The following table from Herrick's book is valuable so far as it goes. Facts of a like kind are given by Vinal Edwards for No Man's Land. Similar facts do not appear to be available in Canada, so far as the writer knows.

RECORD of the Total Catch of Lobsters at Woodshole, Mass., from December 1, 1893, to June 30, 1894, showing the number and size of egg-bearing females.

Length.	No. Males.	No. Females	Females with eggs.	Totals.	Length.	No. Males.	No. Females	Females with eggs.	Totals.
in.					in.				
6	3	4	.....	7	10¼	0	1	1	1
6¼	1	.....	.....	1	10½	62	71	17	133
6½	3	4	.....	7	10¾	79	103	28	182
6¾	5	0	.....	5	10⅞	1	.....	.....	1
7	45	47	1	93	10¾	18	18	2	36
7¼	.....	1	.....	1	11	31	62	20	93
7½	10	4	.....	14	11¼	10	11	.....	21
7¾	66	47	.....	113	11½	11	30	4	41
8	20	9	.....	29	11¾	2	2	.....	4
8¼	168	140	2	308	12	9	14	3	23
8½	.....	1	.....	1	12¼	1	.....	.....	1
8¾	44	29	.....	73	12½	4	7	.....	11
8⅞	143	115	7	258	12⅝	.....	1	1	1
9	26	27	1	53	13	4	4	.....	8
9¼	170	166	13	336	13½	1	.....	.....	1
9½	.....	1	1	1	14	1	.....	.....	1
9¾	32	38	4	70	14½	1	2	.....	3
9⅞	148	169	24	317	15	.....	3	.....	3
10	27	29	3	56					
	167	184	36	351	Totals	1,313	1,344	168	2,657

Percentage of females which carry eggs, 12.

Percentage of females with eggs at No Man's Land, 63·7, but that was over twenty years ago, when lobsters were more abundant than now.

These figures indicate that a much higher percentage of females are berried along the Massachusets coast than in St. Mary's bay or the Bay of Fundy. Inquiries made among the lobster fishermen, both last summer and this, go to show that out of every 1,000 to 2,000 adults, only from two to three are found to carry eggs. Is it not time that other statistics besides measurements of length should be collected and published in our annual reports?

In collecting statistics, the important points are: (*a*) the relative numbers of males and females caught during a season; (*b*) the percentage of females that carry mature, or ripe, eggs during the open season; (*c*) the percentage of females which extrude new eggs during July, August, and September; (*d*) and especially, the proportion of these eggs which are fertilized and unfertilized.

With such statistics before us for a few years we should soon know whether we are making good the wastage of lobsters or not. At present we do not know. In a vague way we conclude that, because millions of newly hatched fry are being planted annually in the sea, therefore, we must necessarily be increasing our lobster supply, or, at least, keeping the supply up to the numbers annually trapped by the fishermen. The fallacy of this reasoning is clearly realized by the Shell Fish Commission (1912-13) page 27: "The annual returns, though showing a very large increase in the money value, are really misleading, because, while the supply of lobsters is declining, the price has so materially advanced that the total value is greater to-day than at any previous period."

The results of all our hatching and all our egg-planting, therefore, has not sufficed to replenish our depleted waters: that they have increased the numbers is pure guess work. The same criticism precisely may fairly be made about rearing the fry. We are working away in the dark, increasing the chances of survival, no doubt, but without demonstrable proof of any increase in the numbers of animals which grow to maturity.

Can we not be a little more accurate in our methods? Let us first of all collect for a few years the statistics for which I am pleading. With these as a basis for comparison, let us erect, say, fifty enclosures, 20 feet by 20 feet, at a cost not exceeding $200 each, or $10,000 in all. Impound in these during July and August, twenty-five males and twenty-five females—all carefully chosen and fully mature, and I am confident that we shall get a very large increase in the number of eggs. And after all, the greatest aid in preventing the extinction of the lobster will be to increase the egg bearers. Mother ocean will feed the fry, if we protect the egg producers. But, if we continue to hatch, as has been done in the past, we never know what increase results from our efforts, but we do know that frequently we are feeding fish.

Much desirable information can probably be obtained by circularizing canners and fishermen and explaining clearly to them the objects which the department has in view.

In fact, Mr. W. S. Trask, a canner at Little River gladly gave me such information as he had at his disposal. From May 10 to June 15 he bought 7,151 adult lobsters from fishermen. He did not take the time (nor did the fishermen) to distinguish males from females, but he was confident from some observations which he had made a few years before, that there were generally more females than males. Out of the 7,151 adults which he had purchased, only thirty-five carried eggs, that is, 1 per cent, on the assumption that the sexes are equal in numbers. How can the lobster industry be kept up, if only one mother out of every 100 bears ripe eggs?

Probably few females are ever sterile. When eggs are not fertilized, one cause will probably be lack of facilities for mating. This, at least, was apparently the

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NOTE.—Mention should be made of the information collected by Mr. Halkett at Baker's Pond, C.B., showing the relative percentage of males and females there to be about 46 males to 54 females per hundred.

cause this year at Long Beach. Up to to August 2, forty-three females had extruded eggs, and careful examination of twenty-eight of these showed that only five carried fertilized eggs. The reason of this seem clear enough. With the fifty females which wintered in the pound, there was, as already stated, only one male. Whether this one male could fertilize the eggs of forty-nine females is certainly open to question.

It is true that the department placed thirty males and thirty females (commercial) in the pond or pound for experimental purposes this season, but, unfortunately, eight of the males were poisoned, several of them were undersized, and six others died from causes unknown. It will thus be seen that, if we take into account the relatively small proportion of males to females, and the unfavourable conditions in which both sexes were confined in the pound—I refer to the mud, not to feeding, which was carefully done,—it is not much wonder that many of the extruded eggs remained unfertilized, then softened and dropped off.

ANNUAL SPAWNING.

It was intimated in my report for 1914 that some females which had extruded eggs in August of that year were to be retained in the pound all winter, and might throw some light upon the subject of annual spawning. Of forty-seven females placed in the pound in midsummer, 1914, thirty had extruded eggs by the end of September. There were confined with these females, fifteen males. Leaving out of consideration ten females which were under 10 inches in length, the proportion of full-grown males to females was 15 to 37, or nearly 1 male to 2 females. The result was that on the 8th of April, 1915, when these thirty females were again examined, all bore fertilized eggs. In other words, 64 per cent of the females placed in the pound last June carried fertilized eggs to June of this year. As a matter of fact, most of the eggs were "laid" in August, but the important point is the large number of berried females which resulted from the experiment. These animals were not examined again until July 7, 1915, when the following results were found:—

12 had no eggs on them, being probably hatched off in the interval between April 8 and July 7.
12 were in the act of hatching their eggs.
2 had newly extruded eggs upon them.
1 was dead.
1 was lost off the dip net in removing it from the compartment.
2 could not at that date be accounted for, probably hidden in the mud.

30

The twelve which had old eggs upon them on April 8, but were without eggs on July 7, were placed in a compartment by themselves and re-examined again on July 29, when seven of them were found to be carrying newly extruded eggs.

These seven females with the two which bore new eggs on July 7 make a total of nine, which had carried eggs in 1914, and again extruded eggs in 1915. The remaining five of the twelve escaped from the enclosure in which they were confined, and, as a consequence, it became impossible to identify them from others in the pound, but so far as these nine lobsters are concerned, annual spawning is an undoubted fact.

One female, at least, of these seven, bore "bad" eggs, and one other, though the eggs appeared normal and of the usual number, nevertheless, carried unfertilized eggs, as shown by microscope examination.

MORE FERTILIZED EGGS.

The problem of problems in the lobster industry is not how to rear fry to the crawling stage, but how to increase the number of females which carry fertilized eggs.

The artificial hatching of lobster eggs may be important, though many doubt it; the artificial rearing of lobster fry to the fourth or fifth stage may be important, though this remains to be proved, at any rate in Canadian waters; but the biggest of all lobster problems is how to increase the number of fertilized eggs. Unfertilized eggs are probably produced in vast numbers, if biennial spawning is the rule; in vaster numbers still, if annual spawning is the rule.

Reverting again to the 7,151 adults bought by Mr. W. S. Trask this season, among which he found only thirty-five berried females, and to Mr. J. W. Tidd's catch of 3,000 lobsters in 1913, among which he found only three berried females, we are faced with the problem of explaining how it happens that there were not about 3,500 berried females among Mr. Trask's purchases, if lobsters spawn annually, or 1,750 if lobsters spawn biennially, similarly with Mr. Tidd's catch, and with the catch of every lobster fisherman in the Maritime Provinces.

We have no knowledge of the extent to which the sexes mingle with each other in the sea. Conclusions based upon the tagging of lobsters and their subsequent liberation and capture may be misleading. Tagging does seem to indicate, however, that they are strongly local in their habits, and, if so, they may meet each other only at intervals and solely by accident. How different conditions are to-day for mating, compared with what they were in early colonial days when lobsters were so abundant along the Atlantic coast that after every storm they were found lying along the shore in windrows!

If the facilities for mating are lacking, this may be the reason why so few females carry fertilized eggs. If there is no mating, the mothers will extrude their eggs annually or biennially, as the case may be, but the eggs, being unfertilized, will "go bad" and subsequently drop off.

It must not be supposed, therefore, that the eggs found in June, July, August, and September on berried females are necessarily "good eggs." For breeding purposes they may be as useless as those of a pullet with which no cockerel has cohabited. As illustrating the truth of this statement, it is only necessary to point out that of twenty-eight females which extruded eggs in Long Beach pond this season, only five were found to carry fertilized eggs. These results are quite different from those of last year, but the conditions were different in the two years. In 1914 the mating lobsters were placed in a compartment specially located near the entrance of fresh sea-water from the intake pipe, and by the end of the season, as already stated, 64 per cent of the females carried fertilized eggs, as compared with 1 per cent reported by fishermen. In the case of the mating lobsters of this year, 1915, some of them, were placed at first in the pond and others of them in the pound. Subsequently they were transferred to two of our rearing boxes, and later again to the third compartment of the pound. Considering, too, that there were only 26 males to 109 females and that the transfer from one enclosure to another was unnatural; considering also the unfavourable conditions under which they lived in the pound, one can readily understand that copulation took place less frequently than under the more natural conditions of 1914. But afte. making every allowance for the conditions which militated against the extrusion and fertilization of eggs, we find that 44 out of 109 females extruded eggs in the summer of 1915, or over 40 per cent.

When it is remembered that the Shell Fish Commission estimated from their inquiries that the percentage of berried females ranged from 2 per cent to 40 per cent,* and that this latter percentage existed only where fishing is permitted in June and July, as in Northumberland strait, and when it is considered also that in these months some lobsters are carrying old eggs and others are carrying ne.. ones, it will readily be seen that the 40 per cent does not represent the true proportion of newly extruded eggs at all. Let us find out, if possible, the correct proportion of hen-lobsters which carry new eggs, or of those which carry mature eggs, but not a combination of the two.

* These figures were obtained not from the Commission but by correspondence with only one member of the Commission.

MATING GROUNDS.

So few facts are known in regard to the mating of lobsters that special attention should be given to this subject next year. While the pound has proved to be useless this season as a suitable place in which to rear fry or retain adults, the southwest end of the pond, as stated in last year's report, could be made very useful, both as a sanctuary for berried females and as a mating ground for commercial lobsters. If the compartments at present in the pound were removed to the southwest end of the pond, and the cost of doing this need not exceed $200, there would then be ample space for both sanctuary and mating ground and better conditions than prevailed this past summer.

It cannot be stated too often that the great problem is how to increase the number of fertilized eggs. The hatchery cannot add a single fry to those which the mother will hatch out. On the contrary, the hatchery often starts them upon their ocean life, infected with diatoms, as shown by Professor Gorham. The rearing plant guards and feeds the fry for a brief three or four weeks, and then liberates them to take their chances in wind and tide and among a multiplicity of voracious enemies. In contrast with the uncertainty of hatching and rearing fry, an increase in the number of females carrying fertilized eggs would mean an incalculable increase in the number of fry, and consequently, a better chance of survival until they become adults.

Fig. 5.—Two lobsters resting in their shelters.

To realize how greatly the number of berried lobsters may be increased, as they were actually increased in the pound in 1914 from 1 per cent to 64 per cent, we have only to consider how rapidly a farmer could increase his poultry if he bred from sixty-four hens out of a hundred, instead of from one hen. He might use a hatching apparatus (as we do for lobsters) and a rearing apparatus also, if there is such a thing for chickens, but the increase in his poultry would be slow indeed, compared with what it would be if he bred from sixty-four mothers in place of from one. If we could come anything near increasing our berried lobsters from 1 per cent to 64 per cent, we might burn down our lobster hatcheries and never notice the loss, so far as the lobster industry is concerned.

Of course, there may be other causes at work, besides lack of facilities for mating, to account for the small number of berried females. If so, these causes must be studied and, if possible, removed. But, at any rate, no one can he blind enough to overlook the significance of the mating experiments of last year and this.

THE EVERYDAY LIFE OF THE LOBSTER.

While our lobster-rearing experiments at Long Beach pond, both last year and this, resulted in failure, it cannot be said that the two seasons' work was entirely barren of results. Apart from the observations which have been made on mating, and which, it is hoped, may prove even more useful to the lobster industry than any success which might have been achieved in lobster rearing, we have been able to make some contributions to our knowledge of the every day life of the lobster.

Very early in our operations of this year it was decided to use but two rearing boxes, instead of four. The other two were fitted up with shelters, or nests, for the study of adults.

Obeservations were made every day from July 20 to August 6, when the animals had to be removed. The excesive leakage from the pound left our boxes resting in the mud, and contributed not a little to bring about the death of several adults, through the lack of properly aerated water.

POSTURES.

When performing certain functions, for example, cleaning themselves, egg-laying, fighting, etc., the adults took up certain appropriate postures. One of these, which may be spoken of as the cleaning posture, was first observed among lobsters which had wintered in either pond or pound. Within a week after these animals had been placed

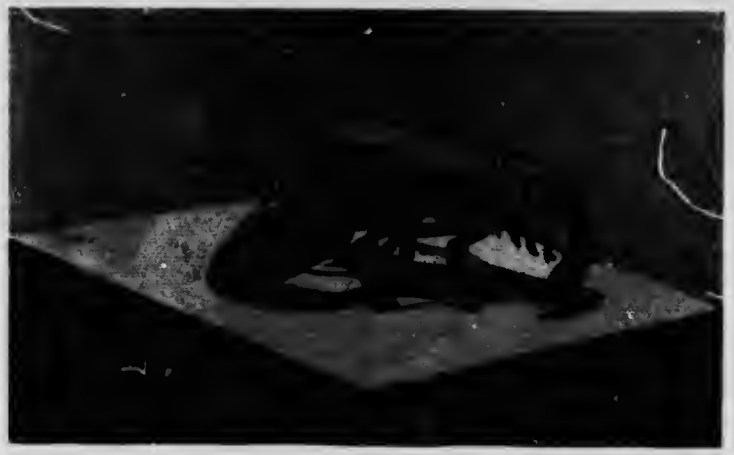

Fig. 6.—This illustration is from a lobster cast which has been shaped to resemble the posture of a mother lobster when hatching her eggs. The swimmerets are visible under the abdomen and these are moved gently backwards and forwards in the water so as to assist in liberating the young from the "shell". This same posture is taken when the animal is cleaning itself.

in the rearing box, their appearance had changed very much for the better. No lady in the land could spend more time on her toilet than these lobsters did in cleaning themselves. They did not, of course, wash, mussage, paint or powder their faces, nor did they curl their hair, but they did spend days and days in attempts to free themselves from the excessive growth of algæ, which covered almost every part of their body.

At first they ate voraciously; later on, much more moderately. Their only toilet instruments were the opposable thumb and finger (pincers) of their walking legs. Every part of their body which could be reached by those appendages was carefully gone over. It was no uncommon thing to see a lobster raise the first pair of walking legs over the great claws and use them in cleaning the rostrum and antennules. The antennæ (feelers) would be grasped by the pincers and drawn through between the thumb and finger, thus stripping off algæ and dirt, in much the same way as a person might strip off the excess of dirt from a string by drawing it through between his thumb and finger.

When thus cleaning themselves, the animals rest almost entirely upon the tips of their great claws and the telson which is bent at right angles to the long axis of the body. The middle region is arched slightly upward, and the walking legs are thus left almost completely free for cleaning movements.

THE HATCHING POSTURE.

This posture has often been described and does not differ from the cleaning one, excepting that the animal rests on its walking legs as well as on its great claws and telson. The movements are limited to a gentle swaying backwards and forwards of the swimming feet, evidently for the purpose of assisting the fry to liberate themselves from the egg capsule (shell).

EGG-LAYING POSTURE.

The egg-laying posture, as we saw it, was different from that described by Anderton. The general position is that of a more or less erect frog. The abdomen is bent completely under the body, and the broad tail is well spread out on each side, so as to form an almost perfect cup. The anterior part of the body is inclined at an angle of nearly

Fig. 7.—The egg-laying posture.

45°, on account of the animal resting on the tips of the great claws. The posture is such as to allow the eggs, as soon as they leave the orifice of the oviduct, to fall by gravity over the receptaculum seminis and drop easily and naturally into the abdominal cup already described. After the eggs have filled the cup, the female turns upon her back for 15 or 20 minutes and remains almost motionless, the walking legs alone swaying backwards and forwards at intervals of a minute or two. During this quiet period the egg glue is apparently hardening so as to fix the eggs to each other and to the hairs of the swimmerets.

That the egg glue requires time to harden in the water was demonstrated by the fact that one female, which was lying on her back after egg-laying, was dipped up too soon from the box and righted in position. As a result, nearly all her eggs dropped off on the board on which the observer was standing.

THE RESTING POSTURE.

This is the posture which an animal naturally adopts when left to itself in a crate, box, or other enclosure, and usually after being fed. If there are many animals

Fig. 8.—The resting posture. From a photograph of an animal under water.

together, they will often take up this posture in one corner and lie one on top of the other. It is their usual posture in shelters.

FIGHTING POSTURE.

There is nothing new to describe about this posture. Most people who have watched lobsters when removed from the water have seen them elevate their great claws, open their scythe-like jaws, and otherwise adopt a threatening or defensive attitude. It is the regular pose of female lobsters, in defence of their eggs, and of the male lobsters towards each other. Time after time have we seen two males pass females without adopting any belligerent attitude, but as soon as they approached each other "squared off" for a fight. Though the males are generally restless, the larger ones chasing the smaller from place to place, we never actually saw one injure the other.

BIENNIAL SPAWNING.

It remains to say a few words on the subject of biennial spawning. The fact that nine lobsters spawned in 1914, and again in 1915, is beyond all question. It is also equally beyond question that out of 50 lobsters which hatched their eggs in July, 1914, and moulted in the autumn of 1914 (according to the testimony of the caretaker of the pond) twenty-two did not spawn this summer at all. If lobsters spawn biennially, then these females should have extruded new eggs in July and August of 1915, but they did not.

From the evidonce which we have collected thus far at Long Beach, it is quite clear that some lobsters spawn annually, some biennially, and some do not spawn even biennially. Of course, it is only fair to point out again that the conditions in both pond and pound are unnatural, and, therefore, we need not be surprised when we meet with departures from the normal habits of the animal, whether the habit be annual or biennial spawning.

A REVIEW.

In looking over the operations of the pound for the past two years, let it be frankly acknowledged at the outset that the main purpose for which it was built has not been realized. Can it be fairly said, then, that the money spent in the purchase of the pond and the construction of the pound has been wasted? I think not.

In addition to being a sanctuary for berried females, the pound has brought about the discovery that the numbers of lobsters may be increased by bringing the sexes together. This, of course, was not the primary object for which the pound was built. So far as can be judged from public reports and from the Board's correspondence with the Fisheries Branch, the discovery was made by accident. Sixty-two commercial lobsters were sent to the pound in 1914 for the purpose of observing whether lobsters spawn annually or biennially. Long before a conclusion could be reached on the subject, it was discovered that 64 per cent. of the forty-seven females in the pound had extruded fertilized eggs—a most astonishing fact, when every fisherman in Digby County knows that only about one female in every hundred carries eggs. This opinion of the fishermen is corroborated by Mr. Andrew Halkett. In his report upon the Baker Lobster pound, Cape Breton, 1909-10, page 16, he mentions a trip which he took with Rafuse & Son, fishermen, to seventy-five traps, containing altogether fifty-six males and sixty females. Only one of the females was berried.

Why this great difference in egg-bearing between open-sea lobsters and those in Long Beach pound? One obvious explanation is that it is due to the close intercourse between male and female lobsters in a compartment 20 feet long by 10 feet wide. The fact that 40 per cent. of the females at Long Beach this summer (1915) extruded eggs under most unfavourable conditions appears to corroborate the discovery. At any rate, the results of the two years' observations, in my judgement, amply justify the department in building a few more enclosures at different points along the maritime coast in order to test still further the extent to which egg-bearing may be artificially promoted.

Surely the expenditure of money on industrial and economic problems is one of the functions of Government. If it is not, then much of the expenditure on Experimental Agricultural Stations and on investigations into our peat and other mineral resources is unjustifiable. Far, however, from the money hitherto spent upon such scientific investigations being wasted, it is money well spent. Similarly, I trust it will be realized in a few years that the money spent upon Long Beach pond will have been amply justified either by the direct or indirect scientific results that have been achieved.