TRANSLATIONS OF FOREIGN LITERATURE CONCERNING LOBSTER CULTURE AND THE EARLY LIFE HISTORY OF THE LOBSTER.

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 6

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

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No. 6

TRANSLATIONS OF FOREIGN LITERATURE CONCERNING LOBSTER CULTURE AND THE EARLY LIFE HISTORY OF THE LOBSTER

Edited by

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INTRODUCTION

During the past few decades, fish culturists and fishery biologists have expended a considerable amount of time and effort to rear artificially the larvae of the lobsters (*Homarus americanus* and *H. vulgaris*) which dwell in the North Atlantic Ocean. These attempts are being continued in Europe and North America. As both the European and American lobsters are closely related anatomically and physiologically and have a similar life history, the results of experimental lobster culture on either species are of almost equal value to those continuing the propagation activities on both sides of the Atlantic.

Much of the scientific literature in which the lobster culture experiments are reported is in languages other than English. A great deal of the information recorded in foreign publications is of interest to those who have difficulty in understanding a foreign language and have been unable to secure the required translations. The editor was engaged in a study of lobster rearing during the period 1939 and 1944 and obtained translations of most of the more important lobster culture articles. In view of the continuing interest in artificial rearing, it seemed logical to assemble those translations and make them available to all.

Unless otherwise noted, the Norwegian articles have been translated by Borghild Wiencke of Oslo, Norway; the Dutch publications, by Louise Pinard Dekker of Palo Alto, California; and the French and German articles, by the editor. The translations have not been rigorously edited, but it is believed that the meanings of the passages are clear, although at times perhaps somewhat awkward.

The complete tables and graphs have not been included with the translations, but the legends which will explain these data have been presented. It was not considered as worthwhile to copy all the tables and duplicate all the figures. To those who wish to study the publications at greater length and refer to the illustrations, all the articles listed in this report are available in the United States and inter-library loans can be arranged at most large libraries.

The editor believes that a better understanding of the problems of lobster rearing should be realized by those reading the following pages. If such is accomplished, then the task of compiling the translations will have been well worth the effort. Furthermore, duplication in translating these same articles will have been avoided in the future.

To Fish and Wildlife Service librarians Isabel C. Dean and Ida K. Johnson, the editor would like to express his gratitude for their diligence in making the literature available to him.

Leslie W. Scattergood
Fisheries Research Biologist.

October, 1949

Appellöf, Dr. A.
1909 Untersuchungen über den hummer. Bergens Mus. Skrifter, Ny raekke, bd. 1, no. 1, 79 p., illus.

(page 39)

The growth during the first growth period. I mentioned above briefly, under the characteristics of the various larval stages, the growth rates. Already in these stages one notices individual differences as much in relation to the duration of the various stages as also in the magnitude of their growth. In an earlier publication (3) I indicated closer boundaries within which the duration of the various stages fluctuates and these data can only be completed by later experiments. During the rearing experiments which I made in the middle of the nineties at the local Biological Station, I found in relation to the duration of the various stages the following figures. The first stage lasted normally 6-7 days, it could however extend even to 8-9 days; the second normally 9-10 days, a minimum of 7 and a maximum of 12 days; the third normally 10 days, yet probably also individual differences occurred here. In regard to the fourth stage I could only work on two individuals at that time. One of these spent 23, the other 28 days in this stage. Yet, as was mentioned earlier this last stage can no longer be considered as belonging to the larval life but is to be regarded as the first lobster stage.

Already in 1892, however, Dannevig (2) had made experiments at the Fløddevigen fish hatchery which showed that growth and casting of the larvae were dependent to a high degree on the temperature of the sea water, a fact that was further clarified and confirmed later by the experiments of other workers. Dannevig proved that during the course of nine days at a temperature of 8-10° C. no casting occurs among the larvae of the first stage at a temperature of 12° C. they cast once, at 16-22° C. they had in this time also passed through the second larval stage and entered into the third. Although these experiments were made only with a small number of individuals and consequently give no information concerning possible individual variations and their extent they are however of interest as they prove directly the influence that temperature exerts on the metabolism of the larvae and thus on their growth.

I had occasion in my experiments at Kvittingsø that were made in boxes which floated on the surface to follow the moultings and growth of a large number of lobster young from the first larval stage to the end of the first growth period. The shortest time which I observed for the duration of the first larval stage was 4-5 days, instead of the usual 6-7 days. The shortest period of time I observed at the end of July 1903 when the temperature on the surface rose to 14° R. (17.5° C.). It lasted however only during the first two days of the development of the larvae and then sank to 11° R. (13.8° C.); a pair of very warm days are therefore sufficient to accelerate the development. The shortest time for the second stage observed by me in the floating boxes was seven days while the average here amounts to 10-11 days. 1/ Seven days was the minimum

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1/ For the experiments in 1908 the shortest time for the first and second stages was nine days at a mean temperature of approximately 16° C.

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duration of the third stage, the average must be regarded as 10-12 days. Thus we see that the lobster larvae on our West Coast need approximately 26-30 days, or four weeks, to pass completely through the larval stages and to reach the bottom stage.

According to this we find for each of the first three stages or larval stages the following age. First stage: a minimum of 4-5, average 6-7 (8) days, second stage: minimum 11-12, average 16-17 (19) days and third stage: minimum 18, average 26-29 days. These figures are slightly higher than those which Dannevig (1885) found in his experiments at Flødevigen which without doubt is to be attributed to a lower mean temperature prevailing on our West Coast. With especially favorable sea water temperature however the development on our West Coast can also take place somewhat more quickly.

It is therefore clearly seen that temperature exerts a great influence on the period of development this is hindered by a lower temperature and increased by a higher one. I intended now to discover what influence it would have on the development of the larvae if the development took place not in the warmer water layers of the surface but in a few metres of depth. I constructed therefore in 1899 a box of exactly the same construction as the others used as breeding boxes in the surface; it was however fitted with a cover of the same kind of net that was used on the sides. This box was then sunk to a depth of 10 meters. It was regularly hauled up and examined, and the larvae were also fed as regularly as the others held on the surface. The experiments had the following results.

On the 3d August 400 newly hatched larvae were set out in this box. First on the 12th, thus after nine days, one single larva of the second stage was to be seen while amongst the larvae hatched on the same day that were put in the surface box moulting to the second stage had already begun three days earlier, on the 9th. Not until the 5th were most of the larvae in the sunken box in the second stage, some however still in the first, these latter were therefore now 12 days old. On the 21st, five individuals of the surface box were in the third stage (such a one had already been noticed in this stage on the 19th); Of those in the sunken box however not one. Further, on August 23, thus four days after the moulting to the third stage had begun on the surface, among the latter the corresponding shedding had not commenced. Of these only eight larvae remained in the second stage, the others had gradually died; these eight were 20 days old which means three to four days older than the average age of this stage. The experiment was terminated on the same day owing to the large mortality.

It is a pity that not as many temperature measurements were made as I would now wish, the measurements made showed however a pronounced temperature difference between surface and depth, since in a depth of 10 meters it was 1 to $2\frac{1}{2}°$ C. colder than on the surface. That the delayed moulting and also with it the slower growth mainly is to be attributed to a lower temperature and not for example to unsuitable light conditions is evident in that the rearing experiments on the larvae which I undertook under the influence of the various colored lights (by covering the boxes with red, blue or green glass) as well as in complete darkness showed that no definite unfavorable influence from this on the growth was to be proved. 1/ Remarkable also was the great mortality in the larvae

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1/ Hadley believes even to have found for the American species that larvae in boxes in which the light had been dimmed by a cover develop slightly quicker than in other boxes (l.c.204)

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which were held at a depth of 10 metres, however I do not dare to consider this with certainty as the direct cause of the lower temperature since also other circumstances could have contributed to it.

Be it as it may, the fact that the prevailing lower temperature in the somewhat deeper water layers influences unfavorably the development of the lobster larvae indicates therefore with certainty that the natural habitat of the lobster larvae is the upper water layers with the highest temperature. The dimensions of these water layers may indeed differ according to the various years and the various coastal areas. Hydrographical investigations show that often during the summer in a depth of 10-20 metres a distinct boundary occurs for the temperature as well as the salinity when the temperature in the depths sinks suddenly and the salinity increases and we can consider it as probable that lobster larvae which, forced by unsuitable circumstances to remain in these depths for a longer time must eventually die. And that the unusually low temperature at the surface in many years can contribute to a lowering of the lobster larvae stock is probable.

As already evident from the foregoing statements it would however be wrong if one would look for the reason of the difference of growth, which the individuals show, only in the influence of the external environment. All rearing experiments show on the contrary that although all individuals of the same age live crowded together in a relatively small box together where there can be no question of a difference of physical conditions, yet the moulting for one individual may take place at a different time than for the other just as one individual grows more than the other. In other words the lobster is also subjected during the larval stages to such variations which have their basis in the individual itself and not on external influences.

We left the small lobster in its entrance into the fourth stage which means after it had completed all larval stages. In reference to the duration of the fourth stage, it is more difficult to specify definite figures since now a bigger difference becomes evident. The shortest stage that I could ascertain amounted to about 15 days; it may however commonly take 20 days on our West Coast. In an earlier publication (3) I specified two definite periods, namely 23 and 28 days for this stage, on the basis of observations that I made on two individuals reared in the Biological Station at Bergen. Here it must however be noted that it concerned abnormally late hatched larvae (end of August) which therefore spent their first growth period under less suitable external conditions which means at a lower than usual mean temperature. I believe therefore that an average period of 20 days would thus fairly comply with the average conditions. At the age of 45-50 days, thus about after six weeks the fifth stage may be reached on our West Coast. Under especially suitable temperature conditions--it must be mentioned--the period can be much shorter.

In the following stages the variations become always bigger and the moultings more irregular and more difficult to follow so that I cannot give averages with certainty. Both the above named individuals of the Bergen Biological Station showed in this respect very little agreement since the fifth stage lasted five weeks for the one and eight weeks for the other in spite of the fact that they were hatched at the same time, had made their previous moulting at approximately the same time and were kept in the same glass aquarium. 1/ We will therefore not dwell longer on this in order to determine

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1/ I will here give the various times at which the above named small lobsters moulted into the later stages. For one individual it was on the 17th September (4th stage), on 10th October (5th stage), 16th November (6th stage); with this the first growth period was terminated. The second specimen moulted on 19th September (4th stage), 17th October (5th stage), 18th December (6th stage).

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the duration of the various stages in the first year of life, but deal with more general questions that are closely related to the above statements: how many moultings does a lobster larva make during the first growth period and what size does it reach at the same time?

For the first question one must first of all bring into consideration the time at which the larvae hatched. A larva hatched early in the summer, for example, in the middle or end of July, can pass through more moultings than one hatched a month later. I possess no exact observations regarding this and I have made no comparative experiments with certain individuals. I believe, however, that I am allowed, on the basis of my observations to declare as generally accepted five castings during the first period; this means that a larva concludes this period in the 6th stage. But on account of the larger size which certain individuals can attain I also consider it certain that six moultings may also occur and that therefore in a few cases larvae can enter the 7th stage within this period. Both these numbers, five and six, therefore, indicates the lowest and highest number of moultings that a lobster larva on our West Coast passes through in the first year of life, greater variations may hardly occur normally. 2/

2/ Exceptionally, very late hatched larvae can also only attain the 5th stage with four moultings in their first period.

With greater certainty we can answer the question, what size the lobster larvae reach in their first period. As I had the occasion to observe, it varies as a rule between 19 and 22 mm. I have, however, also measured one small lobster that was 26 mm. (1 inch) at the end of the first period; in all probability it was in the 7th stage (Pl. II, Fig. 7). Revenue officer Evertsen reports that he also observed in the rearing boxes in the beginning of winter young lobsters of this size (however this information depends only upon estimates by eye). The first mentioned sizes can be considered as the most common. It can be added that one young lobster that was reared in the Biological Station measured about 19 mm. after the last shedding in the first year and in the 6th stage. A second died on 27th December in its 5th stage, 16½ mm. long.

The first growth period lasts on our West Coast approximately four months, namely from the middle of July when the larvae commence to hatch to the middle of November. Only exceptionally is this time exceeded and oftentimes the period also does not last as long. Meanwhile the growth period for various individuals is of various lengths, since indeed a part of the larvae hatch at the beginning of July, the majority however only at the end of July and beginning of August or still later. For the majority 3-3½ months well represents the normal period; for late hatched larvae it is somewhat shorter and for early hatched larvae slightly longer.

What we have said here on the growth of the lobster larvae in their first growth period may be stated briefly thus: <u>On the Norwegian West Coast the first three stages--larval stages--occupy from 26 to 30 days, on the South and West Coasts in somewhat shorter time (24 days according to Dannevig). With especially suitable temper-conditions the developmental period on our West Coast may also be shorter. After the small lobster has given up the free swimming ways of life and has become a bottom animal, the growth continues until with the beginning of winter, the temperature of the sea water</u>

has become lower with which the first growth period, which means the growth of the first year of life, is terminated. The small lobster is now three to four months old, has moulted five to six times and is now in its 6th or 7th stage. In general it has a length of from 19-22 mm., exceptionally even 26 mm.

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As for the youngest stages the most detailed researches have been made by Ehrenbaum at Helgoland and by English scientists on the British coasts. Ehrenbaum (2) points out that the duration of the first three stages depends in a high degree on the temperature of the water. Hence it is also evident that the larval stages in the Helgoland district, where the mean temperature of the water in August, the month when most of the lobster larvae pass through their development, is approximately 16.8° C. will develop in a somewhat shorter time than on our West Coast where the mean temperature in July and August is approximately 15-16° C. Naturally Ehrenbaum carried on his rearing experiments in the aquarium of the Biological Station where according to his data the temperature rises up to 18-20° C. and the results which he obtained here show consequently a quicker growth also than would have been the case in all probability in the open sea. For all three larval stages in the Helgoland Aquarium 12 days were required in the shortest case and in the longest, 19 days. In earlier experiments, also Helgoland, Ehrenbaum (2, p. 150) has required however a somewhat longer period for the first three stages, namely 19-22 days. In regard to the duration for each stage Ehrenbaum declares the following numbers: 1st stage 4-5, 2d stage 3-5, 3d stage 5-10 days. For the 4th stage, Ehrenbaum found a duration of 17-25 days, according to the season.

On an average therefore the development during the larval stages proceeds more quickly in the southern part of the North Sea than on our West Coast. Also the difference of the later, younger stages is to be noted. Ehrenbaum has had the opportunity to observe an individual during three growth periods. Instead of the average of the lobster larvae on our West Coast in the first period only reaching the 6th or 7th stage with a mean length of 19-22, highest 26 mm., one individual reared at Helgoland reached the 9th stage and a length of 30 mm. In the following growth periods the growth also is much quicker so that the mentioned individual at the end of the 3d growth period had reached the same size of 11.5 cms. that the individual reared at Kvittingsø had at the end of the 4th. It is to be noted that the number of sheddings for each of the three periods was greater than on the West Coast of Norway, namely eight in the 1st, five in the 2d and four in the 3d period. The literature mentions only this single individual which, outside of Norway, had been reared from the larval stage to over so large a number of periods. However, Ehrenbaum has found that also at Helgoland larvae that hatch late from the egg can conclude their first period with the 7th stage.

The time for the beginning of moulting in the second growth period seems to commence several weeks earlier, at Helgoland than on the Norwegian West Coast, which without doubt is related to the temperature conditions of the sea water. Ehrenbaum has indeed observed shedding at the beginning of February and the latter half of March, but he supposes however that these times are abnormal and are caused by the favorable conditions of the aquarium, a view that is undoubtedly correct. The above-mentioned individual reared by Ehrenbaum had on the other hand made its first moulting in the second period on 24th May and the first in the third period on 15th May (3). These times may indeed also come nearer to normal conditions than the first mentioned. On our West Coast I have observed the first moulting among young individuals at the beginning of June, as a rule however it commences later, as mentioned before.

Beyond this stage that was reached by the individual reared by Ehrenbaum, the aforesaid scientist, was not able to observe directly the growth of the lobster at Helgoland. He is therefore dependent upon calculations that have been based on comparisons with individuals of other coasts. Ehrenbaum himself points out (3, p. 198) that his calculations are uncertain indeed if they are regarded as an average. I am also inclined to believe that he has regarded the average growth of the lobster of the southern North Sea somewhat too great. As support for his calculations Ehrenbaum mentions among others a pair of lobsters which the Scottish worker Brook kept in his aquarium at Huddersfield (a city in mid-England). These lobsters were respectively 17.8 and 18.3 cms. long when they were put in. In the course of two growth periods (approximately 1½ years) they each passed through four moultings and thus increased in length over six cms. I believe however that from the conditions under which these individuals were kept, one can conclude nothing on the growth of the lobster, neither for the southern or northern part of the North Sea. In an aquarium in the interior where the renewing of the salt water must necessarily be entirely different than on the coast and where especially temperature conditions must be therefore higher, peculiar physical conditions occur by which the animals--if one also assumes that older individuals will be less influenced than younger ones--will be influenced in quite a different way than if kept in water which is steadily renewed. I assume that the growth under these circumstances is quicker than under normal conditions and that the number of castings especially is increased. While he supposes that the figures for these mentioned individuals also are normal for the lobsters of Helgoland, Ehrenbaum arrives at the result that there the female becomes sex ripe for the first time at the age of seven years (and of a length of approximately 24½ cms.). At an age of five years the lobster should have reached a size of 21 cms.

As uncertain as the calculations on the growth of the lobsters are also on our coasts one cannot hardly expect that one ought to be able to draw from this definite arguments for an estimation of the growth of the lobster in the southern North Sea. Although I however believe that Ehrenbaum in his calculations has reckoned too large numbers so I essentially conclude this from a comparison between Ehrenbaum's tables (1, p. 285) on the growth of the Helgoland lobster and my observations on the growth of the lobster of the Norwegian West Coast. This comparison shows indeed the same variations on both coasts, but in regard to the older individuals no greater average growth is evident for the southerly North Sea. Also no proof is present that the lobster at Helgoland just as little as on the Norwegian West Coast should moult twice a year at a size of 21 cms. and more, which was the case with Brook's specimens. On the contrary Ehrenbaum's example---namely that moulting takes place principally from the beginning of July to the beginning of August (1, p. 289)---indicates thereof that two moultings in the same year cannot readily occur. Under these circumstances however at least one year must be added to the age given by Ehrenbaum for sexual maturity and the latter can commence at the earliest during the 8th growth period (in the 8th year of life). Moreover indeed these same groups with regard to growth would seem to be found in the southern North Sea as on the Norwegian Coast and a definite ratio between size and age might also not be able to be proven.

On the East Coast of Scotland (Aberdeen) Williamson has made investigations on lobster rearing and he declares briefly that the larvae here require one month to six weeks to reach the 5th stage (the stage beyond the Megalops) if the development occurs during the warmer season. The latter time might very nearly correspond, as mentioned above, with that one that is required on the average for the proper development on the Norwegian West Coast. In regard to grown-up individuals, we have statement from Williamson (p. 92) who has investigated the growth of 13 such ones from approximately 24 to 33 cms. To judge from these individuals the growth is generally less than for the lobster on our West Coast: for two individuals it was not noticeable, for seven 0.63 cms., for one 0.8 cms., for one approximately 1 cm., for one 1.3 and for one 1.6 cms.

The experiments in lobster rearing that were made by Chadwick at the Liverpool Biological Station (Port Erin) show in regard to the larval stages about the same duration as on the Norwegian West Coast, since the first three larval stages are passed through in between three and four weeks.

In the Channel, in the vicinity of Falmouth, Cunningham has made rearing experiments. These took place from the end of May to the end of June and he specifies the duration of the first three stages as approximately 23 to 25 days; this rather corresponds therefore with the conditions on our coasts. Cunningham does not specify the water temperature but according to temperature data given in the same work (p. 39) from places in the vicinity the temperature must also correspond rather well with that which the sea water of the Norwegian West Coast reaches during the larval development time, thus in July-August. Owing to the early hatching of the larvae in the Channel one must assume that these have here a longer growth period during the first period and therefore during this time (in the first summer and autumn) reach a bigger size and an older stage than on our coasts. Hereupon the observations of Cunningham indicate, as he found, that larvae hatched out on the 23d to 30th May were on the 5th August (probably) in the fifth stage with a length of approximately 22 mm. There is hardly a doubt that they have reached at least the 8th or 9th stage before the conclusion of the first growth period.

Concerning the growth of the American species in the larval stages as well as in the later stages one has--besides those made by Herrick--now thorough examinations made by Hadley and by Mead. and Williams. I cannot here closely review these interesting works in detail, but I must restrict myself principally to give the conclusions to which the workers have come. Hadley assumes that the average female on the American coast reaches sexual maturity in the 6th year (the 6th growth period) and in the 23d stage. It is therefore supposed to coincide approximately with our category 2 (see p. 53) in regard to the stage number, that is the number of moultings, but in regard to the age it should on the average be considerably younger than this. He also assumes that the females after they have reached sexual maturity grow more slowly than the males. Besides the writer points out that the growth---also for the grown animals--has varied on the different sections of the American coast of the Atlantic Ocean. With regard to the duration of development of the larval stages this coast with its varying physical conditions of the sea water presents interesting variations. While during a few experiments made at Wickford, Rhode Island, at a temperature of approximately $18\frac{1}{2}$-22° C. the three first stages were passed through in 9 to 16 days, at Wood's Hole, Mass. at a temperature 15-$15\frac{1}{2}$° C. 21 to 25 days moreover were required. Furthermore it is related that during development of the first three stages near Orr's Island (Maine), at a temperature which varied between 14 and 17° C., 25 to 26 days were required for the same stages (p. 200), on the more southerly situated Rhode Island at a temperature of 22-24° C. only 9 to 10 days were necessary. Interesting is the agreement in regard to the speed of development which the larvae show on both sides of the Atlantic Ocean as soon as the temperature conditions become somewhat equal. A comparison between these two conditions made at Orr's Island and on our West Coast shows this agreement very clearly. In relation to the growth of the later stages--which, to judge moreover from Herrick and Hadley's tables (see Hadley, Table 13, p. 182), appears to present as strong individual variations as on our coasts--direct comparisons can hardly be made between our species and the American one because we lack direct observations on the latter. Hadley's results in regard to the relationship between age and size have been reached by calculations which are, however, to be regarded likewise as little reliable as those made by Ehrenbaum.

Examinations also made by Mead and Williams (3) on the American species include a large number of individuals from three months to about $2\frac{1}{2}$ years old have no special interest for judging the growth of our species except that they also show exceptionally big individual variations in the former. On account of the extremely different physical conditions of the sea water near Rhode Island and on our coasts, an earlier spawning time in the former place and therefore a longer growth period, the relationship between age and size of the American species is entirely different than for ours.

We will mention briefly a few conditions that are related to the growth and moulting of the lobster. It has been and will continue to be a general belief that shedding is the direct cause of growth because the shell is supposed to burst because of that. Counter to this belief however is the circumstance that exceptionally a moulting is passed through by some individuals without a growth in length being observed afterwards. This was the case with two individuals at Kvittingsø that moulted in 1907, according to what customs officer Evertsen communicates. One of these was 33, another 28 cms. long and one could identify no growth after moulting. Williamson has also found (p. 92) that certain individuals do not increase in length at a shedding. The big variations which even the same individual may show in its various moultings speak against the surmise that growth is supposed to be the direct and only basis for moulting. This same individual can indeed have a larger growth in a younger stage than in a later one and one was still supposed to believe that the larger the shell becomes the more room there would be inside before the shell is burst and all the more indeed was the individual--in any case while it is engaged in growing--supposed to increase in length at each moulting.

This all seems to prove to me that the moulting is caused by entirely different physiological processes than by the growth even if in most cases it goes hand in hand with an increase in size. It is, however, outside the sphere of this paper to go in for a closer examination of these conditions which will likely become the subject of a special study.

As well known the lobster has, as other higher crustacea, the ability to be able to free itself of certain body parts and the first set of feet. In most cases it frees itself of the pincers or first pair of feet which are the most exposed. In order to find out how the growth of these body parts takes place I kept in a floating box one lobster whose pincer was thrown off but for which a new claw formation had begun. At the end of approximately 10 months, the pincer had reached approximately a length of five cms.; it was, however, as is always the case, quite soft and incompletely formed. During casting which occurred 11 months after captivity it reached one half of the normal length and a completely normal form. A similar condition was also observed in another individual. 1/

1/ The information on these regenerative conditions I owe to customs inspector Evertsen who at my request kept the animals in a floating box.

In all probability the pincer of this individual would have reached the full size at the following moulting in correspondence with that which one knows for the regeneration in the American species (Barnes, p. 126). This has been moreover proved by direct observations on young animals at Kvittingsø. In that place such a complete growth took place after two successive moultings.

We will now summarize briefly what we have related above on the development and growth of the lobster and of its habits during the younger stages.

The development of the embryo of the egg requires a period of approximately 12 months on the Norwegian West Coast, a slightly shorter time on the South and East coasts. The development of the embryo takes place principally during the warmer season and stops almost completely during winter. In order that the larvae at hatching from the egg can be free of the membrane that encloses it in the egg, a strong movement of the egg is necessary, a movement which is also caused by the swinging of the female's abdominal feet to which the eggs are fixed. During the first three stages (the larval stages) and at the beginning of the fourth (the first lobster stage) we find the larvae swimming about; but this swimming ability already decreases with the beginning in the second stage and diminishes considerably in the third; the larvae therefore stay much on the bottom during the latter two larval stages without however having the instinct to hide themselves. The swimming is carried on during the first three stages by means of special swimming palps fixed on the last pair of maxillipeds and on the five thoracic feet, in the fourth stage by means of its abdominal feet. Living, as well as dead food is taken and indeed partly on the surface while swimming, partly below on the bottom. In the three larval stages the food is seized with the mouth parts without the help of pincers; in the fourth, pincers are used the first time for that purpose. As soon as the young lobster has taken up his position on the bottom, it remains very stationary. It lives under rocks in shallow water in the vicinity of the coast.

Growth takes place periodically and occurs principally during the warmer season; each such period we shall call a growth period. The first period lasts on our West Coast from the hatching of the larvae from the egg until approximately the middle of November, thus a period of three to four months, it varies however slightly according to the various stretches of coast, still in this respect the difference between the West, South and East coasts is slight. The speed of growth in the first period in any case depends on the temperature of the sea water and varies therefore according to the different coastal sections and the different seasons on these stretches of coast. Under normal conditions the first three stages (larval) on the Norwegian West Coast last 26 to 29 days. On the South and East coasts a few days less (according to Dannevig, approx. 24 days). On other coasts this time may be significantly shorter so that for instance in the southern North Sea near Helgoland it is 15 days on the average. On the West Coast the young lobster reaches in the first period the 6th or 7th stage and has thus passed through five to six moultings, on the South and East Coasts it can reach possibly one stage more owing to the fact that development takes place somewhat earlier. On other coasts with a higher mean temperature (e.g. Helgoland) it can become still older during the first period (9th stage). On the Norwegian West Coast the lobster reaches in the first period a size of approximately 22 mm., exceptionally even 26 mm. On other coasts it can also become somewhat larger (30 mm. at Helgoland) since it passes through more stages. The number of moultings decreases gradually during the following periods (for two reared individuals there were four in the second period, for one of these individuals there were two in the third, fourth and fifth periods), until ultimately they decline to one per period. The normal size that is attained in the second period seems to be 6 to 6½ cms.; later the growth varies more and more not only for different individuals but also for different moultings of the same individual. Shedding of older individuals can entirely fail to appear in one period. The increase in size for each shedding varies between one and two cms. (it is on the average 1.6 cms.), rarely more or less than this measurement. In regard to the growth one can divide the individual lobsters of the Norwegian West Coast into four groups: 1) with shedding in each period and an average increase in size of about 2 cms. per period; 2) with moulting in each period and an average increase in size of about 1.5 cms.; 3) one in which shedding may not take place during a particular period and therefore with a lower average growth (approximately 1.1 cms.) per period; and 4) with an average increase in size of only 0.8 to 0.9 cms. To the second and third groups belong the majority of individuals. As the size for the beginning of sexual maturity of the females on the Norwegian West Coast is 24 to 25 cms., so this will be reached in the 9th year of life by individuals that belong to the first group, by the second group in the 11th year of life by the third group in the 13th, and by the fourth in the 14th or 15th. In order to reach the size permitted to be caught 8 to 10 growth periods would be necessary for the majority. On the South and East Coasts where sex maturity of the females begins at somewhat smaller size and where possibly growth proceeds more quickly during the earlier stages (concerning this there are yet no observations) sex maturity as well as the legal size limit is reached correspondingly earlier yet the difference should not amount to more than one to two years.

If we calculate the growth of the assumed average size of all individuals (1.5 to 1.6 cms.) sex maturity is reached in the 11th growth period and the legal fishing size in the 9th. (p. 85)

Appellöf, Dr. A.
1909 Undersøkelser over hummeren (Homarus vulgaris) med saerkskilt, hensyn til dens optraeden ved Norges kyster. Aarsberetn. Norg. Fisk. 1909, hefte 1, pp. 1-185, illus.

The following is a partial translation by Miss Borghild Wiencke

p. 110

The decrease in the lobster population, which started in the last part of the 1880s and later on continued for years, raised the question whether anything could be done to increase the lobster population and the steadily decreasing profit of the fisheries. For this reason the Stavanger Branch of the Association for Promotion of Norwegian Fisheries in 1891 asked for a grant of kr. 2,000 in order to build a so-called lobster park at Kvitingsø, so that a larger number of mother lobsters could be put in there every year to hatch their spawn. One assumed that the brood would grow up in the park, then be put out in larger districts and thereby contribute to an increase of the lobster population. After the necessary money had been granted, the park was started, and in 1892 it was ready for use. It is built in such a way that five larger or smaller rocks are combined by walls which consist of big stones. At the beginning there were two larger openings, covered with a net, in the walls, in order to let water pass through into the park. These were, however, soon removed, as it appeared that there was sufficient water circulation between the park and the ocean outside through the holes in the walls. The bottom of the park is partly ledge, covered with brown algae (Fucus and Laminaria), partly mud, grown with eel-grass (Zostera). The depth is between three and four meters at the most.

The first year (1892) there were put into the park about 450 mother lobsters with external eggs which should be hatched the same year, and in 1893 also more than 400 were put in after the population from 1892 had been caught in the spring of the same year. . . .

. . . .

The purpose of my first investigations was to find the different stages of the larvae in the park, and for this purpose a dip-net was used. We succeeded in finding a lot of young, but we could never get larvae other than those of the first stage. The same investigations were carried on for two years, but always with the same result. We also tried to catch young on the bottom, but without result. In 1893 we tried to catch the one year old bottom stagers from 1892, but we did not succeed. The experiments in the park were then stopped. However, also in the following year, lobsters with external eggs were put in there.

When I started my experiments again in 1897 in the same place, I caught some small sized lobsters, which in all probability had grown up in the park. Similar things have happened later. It must therefore be considered as proved that some young lobsters really grew up in the park. But at all events their number has been very small in comparison with the quantity of hatched brood, and it is no proof as to the practical use of hatching and rearing of lobsters in a closed park.

With regard to the question where the brood disappears, I have no doubt that the greater part of the young already in the first stage is led by the current out through smaller openings in the walls. Otherwise we would have caught lobsters in later stages during our experiments in the following years. I think that these experiments have proved that rearing of lobster in parks, at least when they are built according to the principle used in the Kvitingsø park, is impossible. The purpose of such a rearing is to protect the brood from the dangers of a different kind to which they are exposed in nature, but one of the conditions for the rearing is of course that the young really go through the development in the park.

. . . .

On account of the experiences made in the above mentioned park, we cannot take into consideration rearing in closed basins if our purpose is to increase the lobster population by rearing of the larvae to the bottom stage. But such basins are excellent when it comes to make investigations concerning the adult lobsters' biology. In this respect the park at Kvitingsø has been of great help to me and without it I would not have been able to solve several important questions.

. . . .

For several years I have made my rearing experiments by means of boxes which float near the surface of the sea. As this method has given better results, I shall give a more detailed description of the same, although the percentage of reared individuals has not been satisfactory here either.

The material used for the rearing boxes must be strong and cheap. This is specially important with regard to the net of which the sides and the bottom of the boxes are made. At the beginning I used net made of horse hair, but this was too expensive. Lately I have used a certain kind of thread-net, so-called iron-thread-net, with as large meshes as possible. This is cheap -- and very strong, stronger than the horse hair net. -----It is also easy to keep clean.

The wooden part of the box consists of a somewhat wide frame on the top; below and on the sides of quite narrow wooden boards. I refer to the enclosed picture of such a box (fig. 1). The size is as follows:

Entire height of the box	90	cm.	
Breadth of the box	75	"	On all sides
Height of wooden frame on top	20	"	
" " " " bottom	10	"	
" " net	60	"	
Breadth of net	65	"	

The wooden frame at the botton can be made 5-10 cm. wide.

On one side of the upper wooden frame two pieces of canvas thread (twine)are fastened, by means of which the box is tied to a rope, which will be mentioned below. At the bottom a piece of canvas thread is fastened in two diametrically opposed corners; on this piece of canvas thread one hangs a stone of adequate size, so that the box will keep the balance in the water.

By means of the two canvas threads fastened to the upper wooden frame, the box is tied to a rope,which is fastened in both ends, and which lies right near the surface of the water. The rope is most conveniently fastened to rocks on both sides of a bay. In choosing a place, one has to make sure that the water is salt enough, i.e., no rivers must run out there, etc. - - - Of course several boxes might be tied along the same rope.

With regard to the material used for the boxes, it is necessary that the meshes of the net are as wide as possible. My experiments have shown that this fact is of greater importance than one should think. If the meshes are narrow, the supply of fresh sea water will be less, and this has a very harmful effect on the development of the brood, as the mortality increases considerably. Good circulation of fresh sea water is one of the main conditions for making the lobster young thrive.

No cover should be used on top of the box. At least 10 cm. of the upper wooden frame should always be above the water. Neither should metal netting be used in the boxes. Wire netting rusts easily, even if galvanized, and thereby the water in the boxes is polluted; also it is easily broken under such conditions, and thereby the young can escape. According to my experience, brass netting is the worst thing to use. This is simply poison for the brood (the copper of the brass is poison for most animals); probably one would not be able to rear a single young lobster in floating boxes if brass netting should be used.

In short, if we should use the above method of rearing young lobsters in floating boxes, the following must be observed:

The rearing boxes must consist of as little wood and as much net as possible; the net should be a thread-net (best is the so-called iron-thread-net), and this must have as wide meshes as possible in order to get the best possible water-circulation. The places of the boxes must have sufficient salt water on the surface, scarcely below 25 o/oo.

These boxes cannot be used as rearing-boxes for loosened spawn. I have made some experiments in this respect, but I succeeded in hatching only a very little number of brood. The movement, which is one of the main conditions for hatching of lobster-spawn, is not sufficient in these boxes. Better results are obtained if the loosened spawn is hatched in smaller boxes which are placed in a spot where there are waves. But still the result will not be quite satisfactory.

Therefore to procure the brood necessary for rearing there is only one possibility, i.e., to keep the mother-lobster in special boxes, where they hatch their spawn. The young must then be transferred to the rearing-boxes.

. . . .

The mother lobsters, which are kept together in the hatching boxes, ought to have spawn in approximately the same stage of development, so that the spawn can be hatched simultaneously.

. . . .

In each rearing-box of the above mentioned dimensions, there is place for about 8000 young, but there ought not to be any more. I have already mentioned that also in these boxes only a very small percentage can be reared beyond the larval stages (in most cases scarcely more than 5-7%). These floating boxes will therefore not be of any practical importance for rearing lobsters to the bottom stage. However, they might with advantage be used for a "partial" rearing; the larva is then only kept for about a week or up to the time when it changes shell for the first time, i.e., enters the second stage. Certainly, the instinct to hide is not developed until it reaches the 4th, or better, the 5th stage. But the lobster swims less in the second stage; therefore some of the dangers which threaten the swimming larvae are eliminated, and consequently there is reason to believe that a relatively higher percentage of the brood will reach the bottom stage if they are put out in the second stage instead of immediately after the hatching.

. . . .

We have now mentioned two methods of rearing. From an economical viewpoint, none of these are quite satisfactory. . . . .However, I have mentioned and described the last method in detail in spite of the fact that this rearing in floating boxes cannot produce a sufficiently high percentage of bottom-stagers; the reason is that this method, because it is so simple and cheap, can be practiced by any fisherman or any other interested person almost everywhere on the coast where there is a protected bay and sufficient salt water. Only because this method is so simple and so cheap can I recommend it to a certain degree, beside the method which I am now going to describe.

This third rearing method was first used at Wickford experiment station in Rhode Island, U.S.A. I shall not here give the historical development of the question in America, i.e., a survey of the many experiments with rearing of lobster which have been made, as none of the used methods, with exception of this last one, has been effective. The method was invented by Dr. A. D. Mead (Brown University, Providence, R.I.). In 1900 Dr. Mead discovered that a constant movement of the water in the boxes where the lobster-larvae were reared, had a good effect on their development, as the percentage which reached the 4th stage, was considerably higher than if the young were reared in boxes without such movement. At the beginning the water was put into movement by means of an oar. This experiment gave good results, and in 1901 an apparatus was built in which the water in the rearing boxes was put into movement by means of a propeller, which again was driven by a motor. The apparatus was gradually improved, and as far as one can judge from the descriptions, it had already attained its present form in 1903. From the year mentioned there is a description of the apparatus by Mead and Williams, and in 1906, E. W. Barnes gave a full description with several pictures of the same. Besides referring to these descriptions, I shall here give a description of the apparatus used by me; this is built after the same principle as the American; they differ, however, somewhat in a few respects.

The whole apparatus used for the rearing boxes or rather the rearing bags is exclusively made of square planks (4 x 4 or 4 x 5 inches), which are put together by means of screws, and which easily can be taken apart and stored. The size of the apparatus depends, of course, on the number of rearing bags and on the power of the motor or steam engine. As my purpose was to try the apparatus under our conditions, which differ very much from the American, our apparatus was made much smaller than the American. The whole apparatus is only 28 feet 3 inches long and 13 feet wide and has a capacity of four rearing bags, which are about 5 feet wide on all sides and 4 feet deep. It is, of course rather difficult to describe the apparatus in detail, but by means of the pictures given, I hope the reader will be able to understand its main features. With regard to the size of the different parts of the apparatus, I refer to pl. IX; with regard to the construction as a whole, I refer to pl. IV-IX.

. . . .

(The next pages give a very detailed description of the apparatus.)

. . . .

(p. 121) With regard to the rearing bags I want to emphasize that the construction of these differ essentially from the American ones. According to my experience as to the great importance of a sufficient water supply, I have followed another principle in the construction which differs from that of the American scientists. As the pictures and the descriptions of the last mentioned bags show, these consist mainly of canvas cloth with relatively small openings, which are covered by a fine-meshed copper-net. There are only three openings, i.e., one in the bottom and two on the sides; two sides are made exclusively of canvas cloth.

I have not tried these bags in connection with the American method on our coast, but the experience I have made during many years of rearing experiments in floating boxes, shows that the result would be less satisfactory. I have already mentioned that the poorer the water supply, the poorer the result of the rearing, and there is no reason to believe that these conditions would be any different even if there is movement in the boxes. Especially I want to draw the attention to the fact that brass (copper) netting is very unfortunate. . . . . .In spite of this, in my opinion, unfortunate construction of the bags, relatively good results have been obtained in America with this method. The reason is probably partly that the brood needs a relatively short time for its development in the higher temperature over there, partly because good hygienic conditions are created by the movement in the boxes. I am, however, of the opinion, that the principle: best possible water supply, is just as important as the principle: movement in the boxes, if the rearing should give good results, at least as far as our coast is concerned. I think therefore, that the bags should be made as open as possible; neither must copper or metal netting be used to cover the openings.

With regard to the apparatus and how it works I still have to give the following details:

. . . .

(The following pages give a detailed description)

. . . .

The experiments I made during the summer 1908 at Kvitingsø with the apparatus described above, had the following development and results:

In one of the bags (which we may call E), there were put in some brood, which for the greater part were not new-hatched, but were taken from a box where some mother lobsters were kept for hatching of their eggs. Some of the young lobsters which were put in were already in the 2d stage. I do not know the exact number of the young lobsters which were put in, but they were probably between 4000 and 5000 in number.

In this bag the motion was very irregular; especially during the first days the propellers did not work because of engine trouble. The larvae were put in on July 20; on August 8, those which were left, i.e., 400, were taken out; almost all were in the 4th stage. These started already to attach themselves to the sides of the bag and to give up their swimming "way of life." In this bag, then, about 8-10% was reared to the 4th stage. - I beg to remark that at the time when the motion in this bag became the same as in the other bags, the loss of brood was already so large, that we could tell with certainty that the result would show a very small percentage. It is however interesting that, in spite of this fact, the result was better than those attained by my experiments with floating boxes.

In another bag (F) about 5000 young lobsters were put in between July 21 and 24. These had been hatched the same day and were taken from a box where a mother lobster was kept for hatching. At the beginning there was no motion here either. The first 24 hours the motor did not work, and also later it worked very irregularly; it had to be stopped for a whole night several times and also for several hours on different occasions. When we know about the bad results from the experiments in the floating boxes, it is easy to understand that the same thing would happen in these apparatus as soon as they were exposed to the same conditions, i.e., without any motion. When the experiment was finished on August 8, 1500 young lobsters were taken out; about half of these were in the 4th stage. The other half were in the 3d stage. . . . . and we might therefore assume that a total of 1000 young lobsters would have reached the 4th stage. Accordingly, in this rearing bag the number of young lobsters which reached the 4th stage would be about 20%.

In the third bag (G) about 10,000 young lobsters in the first stage were put in. These were newly-hatched and were put in between July 24 and 29. Also in this bag the motion was irregular at the beginning, so that the first 800 young lobsters spent some time without motion in the water. Later on the motion became more regular, although not quite satisfactory. On August 8 there were at least 4,000 young lobsters left in this bag; however, of these only about 500 were in the 4th stage, the rest partly in 3d, partly in 2d stage. To evaluate the final result, which only can be an estimation, I have to remark that as long as the propellers worked steadily, there was little loss in the bag; but if the propellers stopped for some time, especially during the night, the loss was considerable. I therefore suppose, that of the 4000 young lobsters, about 3000 or about 30% would have reached the 4th stage by one week after the experiment was stopped, if the development had proceeded just as quickly as in the other bags.

In the 4th rearing-bag (H) I wished to try the method also for hatching the lobster eggs which had been loosened from some mother lobsters. As we could have expected, this was easily done. I did not make any calculations as to how many percent were hatched; it was however, - by means of direct examinations of the quality of the eggs and of the contents of the bag - possible to find out that the hatching was completely successful for this method. All spawn remained fresh and was put into quick circulation by the current. Here I found none of the hatched, but "undeveloped" brood which were found in such a large quantity in the floating boxes, where the loosened spawn develops without any motion.

I let the hatched larvae stay in the bag H without giving them any food. They had to live on what food they could find in the bag, i.e., partly by cannibalism, partly on the eggs which had not yet been hatched. I saw that they ate much of the last mentioned food. It was interesting to find that all the larvae in this bag were generally bigger and stronger than in the other bags, where the young only got food from time to time. It seems, therefore, that we can produce stronger larvae by keeping food available at all hours.

During the time we made the rearing experiments, the temperature of the water was rather high and steady. (The foot-note p. 125 gives the tempratures in the rearing bags during the time July 13 to August 8.) Partly this fact, partly the better hygienic conditions, created by the motion, probably caused a quicker development than I have observed in my earlier experiments. It seemed that the 4th stage was reached generally a week earlier than by my preceding experiments, where I mentioned that the time necessary for reaching the 4th stage was 28-29 days (p. 58). Further experiments and measurements of the temperature will give more certain information as to this question.

In spite of the fact that these first rearing experiments cannot be regarded as proof that rearing to the bottom stage can be made successfully on our coast under all conditions, they might be considered rather promising; they positively indicate progress, so that we might hope that they will be profitable, both practically and economically, also for our country, when the relatively unimportant technical difficulties have been removed. The method was first introduced at Wickford, R.I., where it is now used on a large scale; however, they did not reach any better results there during the first years, than we attained last summer at Kvitingsø. (A report by Dr. Mead for 1902 shows that the results at Wickford varied from 16 to 50% - the last figure, however, refers only to one single case, but later the results have become better all the time, as far as we can see from the reports (Barnes, p. 123).

The relatively high percentage attained at Kvitingsø with this method, even under unsatisfactory technical conditions, indicates that we might expect better results under completely satisfactory technical conditions. I have therefore based my judgment as to the effectiveness of the different methods on these assumptions, which I think I am justified in making after the many years I have studied the questions in connection with rearing of lobster.

(p. 126)

Corrivault, G. Wilfrid and Jean-Louis Tremblay
1946 Travail de recherche sur le homard Homarus americanus. Rapp. Gen. Stat. Biol. St.-Laurent 1943-1944-1945 (1946), App. no. 1, pp. 35-73, illus.

(p. 61)

Observations on the larvae in captivity:

In response to the desire manifested by the authorities of the provincial Ministry of Fisheries, the biological station has undertaken experiments to bring to a focus the methods or techniques concerning the rearing of lobster larvae. To this end, a building has been constructed in 1944. A reservoir with a capacity of 6000 gallons, 15 feet from the ground, supplies with sea water four rearing tanks situated on the ground floor of the establishment.

The rearing basins:

The rearing basins are of a different type than those which are used by the rearing establishments situated on the Atlantic Coasts, in the states of Maine and Rhode Island: they are rectangular concrete basins, measuring six feet by three feet, divided in the middle part by a partition. Two water entries, one on the surface and the other at the bottom creates a one to two miles per hour current, according to the water supply.

A few thousand larvae have been placed in two tanks in the course of last season. Despite the fact that the experiment has not been crowned with the desired success, we have nevertheless been able to inquire into the efficacy of the rearing basins. A water current of one to two miles per hour is as efficacious as a mechanical agitation to prevent the agglomeration of larvae and cannibalism in the rearing tanks. Moreover, their shape facilitates the rapid gathering of the larvae by means of a net whose contour fits the shape of the tanks' interior section. The use of the net simplifies the work of collecting the larvae and their transport to another basin for cleaning.

Circulation of sea water in the rearing establishment:

The piping of water into the establishment was finished only at the beginning of last season. The irregularity of supply to the sea water reservoir, (which was) caused by an energy defect in the motor necessary for pumping, and the difficulty in maintaining an optimum temperature of the water has compromised the success of that first experiment. A change in the water heating system is evident; the installation of an automatically regulated oil heating system will assure the maintenance of a constant temperature.

Feeding:

An adequate nourishment is, with the agitation and the optimum temperature, an important factor for the success of such rearing. The young larvae have been fed very regularly with a mixture of equal parts of beef liver and *Mytilus* muscle. This concentration was diluted with sea water before being served to the larvae.

Corrivault, G. Wilfrid and Jean-Louis Tremblay
1948a Station Biologique du Saint-Laurent recherches sur le homard (*Homarus americanus* Milne Edwards). Rapport préliminaire année 1946. Rapp. Gén. Stat. Biol. St.-Laurent 1946 (1948), App. no. 1, pp. 15-43, illus.

Work on the Lobster for the year 1946:

The work on the lobster during the summer season of 1946 has concentrated on the following problems:

1. Rearing the lobster larvae to the 4th stage.
2. Biological observations made in the course of experimental fishing at Grand-Rivière.
3. Analysis of the lobster populations of three sections of the Bay of Chaleur.

Several researchers have devoted all their time to assure the good conduct of these problems. These are:

André Gagnon, student in the Department of Biology, Quebec.
Lucien Morisset, student in the Department of Biology, Quebec.
Reine d' Anjou, student in dietetics at Montreal University.
Gaston Dompierre, student in Quebec Theology. (July 5 to Aug. 8).
G. W. Corrivault, Biology Department, Quebec.

The rearing establishment has necessitated a continual observation. This result has been obtained, thanks to the formation of teams of two investigators who, after a watch of eight hours of work, were relieved by one other team. The authorities of the Biological Station may congratulate themselves for the generous cooperation and the spirit of duty of each of the collaborators who have been appointed for the lobster work.

First Part

Rearing of larval lobsters:

The fulfillment of the plan for the rearing of larval lobsters has obliged Laval University to make considerable expenditures during the years 1944 and 1945 for the construction and fitting out of the rearing establishment. It is only at the beginning of the 1946 season that the final details of the equipping have been completed.

Days of operation:

The rearing establishment has been put in operation the 1st of July with the arrival of the first larvae and has functioned without interruption during 65 days, viz., up to the 3d of September.

Water temperature of the rearing basins:

The previous labors have demonstrated that the water temperature of the rearing basins was an important factor. The ideal temperature is from 18.0° to 19.0° C. (65.0° F.) In the course of nine weeks of operation, thanks to a rigorous supervision of the heating and pumping systems, the mean deviation of the rearing tanks has been maintained between 18.1° and 19.6° C. and this despite the important deviations of the temperature of the sea water pumped to supply the reservoir.

The average variation of the temperature (minimum and maximum) between the water of the sea and that of the rearing tanks is reported in Table I for successive weekly periods.

In Table II are grouped, for the periods of a week of operation, the average temperatures of the pumped sea water and the sea water in the rearing tanks; in the third column, the difference between the two values represents the average heating necessary to bring the pumped water to the temperature advocated for rearing.

If one calculates the average for the 65 days during which the establishment has been in operation, one gets 6.74°, and by a simple calculation one arrives at the following result: for heating the quantity of 36,000 gallons of water used daily, one must furnish about 10,600,000 calories per day.

Rearing tanks:

The rearing of larval lobsters has been carried on in two types of tanks, namely four oval concrete tanks and two wooden tanks of the type in usage at Boothbay Harbor, Maine.

In Plate I, an early photograph shows the four oval basins, previously described in the 1945 report of the Biological Station; the second photograph shows one of the basins in operation with larvae.

The Boothbay Harbor type of tank is a wooden box 18" x 18" x 18" in which the water enters through the bottom and flows away in an over-flow situated in the upper part. These tanks are able to manage the rearing of 3,000 larvae while the oval tanks illustrated in Plate I are able to take 15,000 to 25,000 larvae. The economic factor concerned in such a rearing establishment is the daily consumption of water. We have found four times in the course of a season the output of water of the different types of rearing basins. Here are the average results of our observations:

Tank, Boothbay Harbor type:	93 gallons per hour
Tank, oval	332 " " "

The six rearing tanks in operation consume 1,514 gallons an hour; that is, 36,336 gallons per 24 hours of operation.

Larvae hatched and employed in rearing:

In the course of the season, 177,490 larvae from the hatching troughs have been taken care of for the purpose of rearing. These larvae came from 55 females confined in the troughs especially constructed to collect rapidly the young larvae after their hatching. In Plate II, one sees a photograph showing one of these troughs without its covers and one other showing it in operation; that is to say, with its covers. Note that during the hatching the females are kept in darkness.

The hatching period is extended for seven weeks, namely from the 1st of July to the 19th of August. The height of the hatching has occurred during the second week of July; indeed during that week alone, 39 per cent of the larvae hatched. In Table III one can see the number of larvae hatched and used for rearing.

This prolonged hatching period has permitted the distribution of the rearing into 11 groups, 8 groups in the oval tanks and 3 groups in the type of tank in use in Boothbay Harbor.

Plate I - Rearing tanks

A) The tanks in operation with the exception of No. 3. Note in the background at the right the two bolting cloth nets used for counting; these nets carry checker-work to facilitate the work. The arrangement in batteries of the two tanks permits the utilization of a common drain.

B) A rearing tank in operation, close view. Note the larvae and also the over-flow.

Plate II - Batteries of two rearing troughs supplied by a single source of water.

A) Upper trough uncovered to show the partitions and corresponding outlets. Note at the nearest end the rectangular receptacle for collecting the larvae.

B) Trough in operation with its cover in order to keep the females in darkness. The water enters at the remote end of the upper trough and flows in the center up to the receiving collector with mesh bottom and from there into the lower trough which is shown in a reverse sense.

Table IV gives the allotment of the groups of larvae used in rearing. The analysis of this Table shows that the groups of basins of the type in use at Boothbay Harbor are more homogeneous with regard to the age of the individuals than those of the oval tanks. In the latter, the first larvae are already some days old at the arrival of the latest. We have ascertained that the recently hatched larvae are voracious during the first days and devoured their older congeners, weakened by the physiological modifications which accompany or precede the moulting.

The homogeneity of the groups of larvae is an essential factor to assure a good percentage survival to the 4th stage. This fact shows itself clearly in Table V in which we have set up the comparison of the survival in the oval tanks and in those of the "Boothbay Harbor" type.

To conduct the homogeneous rearing in the oval tanks, it is important to have some hundreds of egg-bearing females in an enclosure in order to gather in 24 hours the quantity of young larvae necessary to form a homogeneous group filling up a tank.

Tables VI, VII, VIII, IX, X show the detailed results of our observations for each rearing group in the oval tanks. In the case where two broods having attained approximately to the same stage were united together, the results figure in the same Table. The data for the observations in "Boothbay Harbor" type basins are shown in Tables XI, XII, XIII.

The important facts which are revealed with the study of these Tables are the following:

1) The percentage of survival, either in the oval tanks or in the "Boothbay Harbor" type tanks, is much greater among the later groups than among the earlier. It goes without saying that the personnel, in gradually familiarizing themselves with the numerous secrets of this delicate rearing, has improved either the methods of feeding or those of the acclimatization of the larvae. Moreover, we are of the opinion that the later reckonings of young larvae have been more judicious than the earlier in that sense that the weakened individuals with little life have been eliminated at the time of the early census that had not been made for the first groups.

2) Each group of larvae used in rearing must be homogeneous, that is to say, that this group ought to be composed of individuals of the same age. This statement shows itself naturally in comparing the survival results for the groups of the two types of tanks.

3) The conducting of a rearing of many thousands of larvae in one tank may appear hazardous; if an accident occurs, it involves the death of many thousands of larvae. Moreover if the smaller groups appear to remedy this eventuality, on the contrary, they multiply the surveillance and the chances of accidents.

Larvae reaching the fourth stage:

Of the 177,276 young larvae used in rearing, 8,168 have reached the 4th stage. The average percentage survival to the third shedding in the course of the season is 4.61%. This percentage is 4.3% for the rearing conducted in the oval tanks and 14.1% in the "Boothbay Harbor" type tanks. This average yield is inferior to that of the Boothbay Harbor Station. At the time of a visit in June, 1946 to that Station, one informed us that the average survival to the 4th stage was estimated at 20 or 25%. It is a question of a rough evaluation not admitting deduction. The yield of 23.2% in the group 9 compares to that of Boothbay Harbor. The results of this rearing are shown in Table XIII and in Table XV are reported the average yields obtained for each group of larvae used in rearing.

The majority of the larvae reaching the 4th stage have been liberated in the sea, generally opposite Cape Rouge at Grand Rivière, and at depths of 1 to 3 fathoms. In advance of their liberation, the individuals were gradually acclimated to the temperature of the sea water. The larvae have been liberated in clear weather and calm sea. Immediately after their liberation, the larvae directed themselves towards the bottom; they disappeared from the surface of the sea after about ten minutes.

Feeding:

The larvae of each rearing group have been nourished with a beef liver puree; some times we have served a puree of the muscles of the soft-shelled clam in place of beef liver. This puree of beef liver was prepared by passing the frozen liver through a meat grinder. This nourishment is used in similar establishments because it is relatively cheap and it is easy to obtain all the time. The feeding of the larvae at the Biological Station has necessitated the purchase of 170 kgs. (340 livres) of beef liver. The food was dispensed at the rate of one teaspoon of puree diluted in 200 cc. of sea water per 3000 larvae every two hours.

We have often observed that excess food, which stayed sometime on the bottom of the rearing tanks, was harmful. The larvae agglutinated themselves occasionally with the waste food and died. This act occurs especially in the oval basins where the water circulation differs from that of the other tanks. Concerning the toxicity of the liver particles remaining some hours with the larvae, (we) mention the following experiment: larvae placed individually in 250 cc. beakers died if the particles of beef liver remained in the beaker more than two or three hours; on the contrary, larvae of the same age, receiving no food, stayed alive well during several days and the same were able to survive if, after this fasting, they were fed again.

The too prolonged stay of the excess food in the tank is woeful for the survival of the larvae. This misfortune that occurs some times in the oval tanks may be well due to the reasons: too slow elimination of the excess food; circulation favoring the agglutination of the excess food; insufficient supply of water. These three reasons more or less related to each other may be easily corrected.

Moulting:

At temperatures of 18.0° C. the larvae make their first shedding about the 5th day; their second moulting about the 10th day and the third at the 14th day.

Experiments on the 4th stage larvae:

During the first fortnight of the month of September, 71 larvae in the 4th stage have been isolated individually in 250 cc. beakers. This experiment was for the purpose of obtaining information on the intermoult period between the 4th and 5th stage. They have had the water changed twice a day and fed only once a day. After the 10th day of observation, one recovered:

15	surviving in the 4th stage	21.1%
26	dead " " " "	36.6
26	" during the fourth molt	36.6
4	in the 5th stage, well and good	5.6

Moreover, we have tried the mammalian hormones in view of observing their influence on the moulting of the lobster larvae. The products used are thyroxin, antuitrin and pituitrin. The experiments made on some tens of individuals seem to demonstrate that these hormones are without effect on the shedding of the lobster larvae.

TABLE I

Average deviation between the temperature of the sea water and that of the rearing tanks.

	Temperature of Sea Water			Temperature of Tanks		
Week	Min.	Max.	Max. Dev.	Min.	Max.	Max.Dev.

TABLE II

	Weekly Temperature		Elevation of the Temperature
Week	Of the Tank	Of the Sea Water	

TABLE III

Yield of lobster larvae from 55 females

Week	No. larvae	Percentage

TABLE IV

Grouping of larvae used in rearing

Groups in oval basins

No.	Dates of collection of larvae for rearing	Duration of Collection	No. of larvae

Groups in "Boothbay Harbor" type tanks

TABLE V

Results of rearing in oval tanks and in Boothbay Harbor type tanks

Rearing in oval tanks

No. of Group	No. of larvae	Diff. in age between 1st and last day	Per cent survived to 10th day	Survived to 15th day	Remarks	Per cent to 4th stage

Reared in "Boothbay Harbor" type tanks

TABLE VI

Rearing in circular basin

Group 1			Group 2		
Date	Quantity	Per cent	Date	Quantity	Per cent

Percentage Survival

Group 1			Group 2		
Age	Quantity	Per cent	Age	Quantity	Per Cent

Groups 1 & 2 fused

Age	Quantity	Per cent Survival

4th stage larvae liberated in sea

TABLE VII

Rearing in oval basin

Group III			Group IV		
Date	Quantity	Per cent	Date	Quantity	Per cent

Percentage survival

Group III			Group IV		
Age	Quantity	Per cent	Age	Quantity	Per cent

Groups 3 and 4 fused

Age	Quantity	Per cent Survival

Larvae liberated in sea

Date	Quantity

TABLE VIII

Rearing in oval tank

	Group VII	
Date	Quantity	Per cent

Percentage Survived

Age	Quantity	Per cent

Larvae liberated in sea

Date	Quantity

TABLE IX

Rearing in oval tank

	Group VIII			Group X	
Date	Quantity	Per cent	Date	Quantity	Per cent

Percentage Survival

	Group VIII			Group X	
Age	Quantity	Per cent	Age	Quantity	Per cent

Larvae liberated in sea

Date	Quantity

TABLE X

Rearing in oval tank

	Group VI	
Date	Quantity	Per cent

Percentage Survival

Age	Quantity	Per cent

4th Stage Larvae

Date	Quantity

TABLE XI

Rearing in "Boothbay Harbor" type tank

Group V		
Date	Quantity	Per cent

Percentage Survival		
Age	Quantity	Per cent

Remarks: The 18th day, these larvae have died after a stoppage of the water circulation; 7.9% had reached the 3d and 4th stages.

TABLE XII

Rearing in "Boothbay Harbor" type tank

Group VI		
Date	Quantity	Per cent

Percentage Survival		
Age	Quantity	Per cent

Larvae liberated in sea	
Date	Quantity

TABLE XIII

Rearing in "Boothbay Harbor" type tank

Group IX		
Date	Quantity	Per cent

Percentage Survival		
Age	Quantity	Per cent

Larvae liberated in sea	
Date	Quantity

Remarks:

Larvae to 2d stage	Age
" " 3d "	"
" " 4th "	"

TABLE XIV

Larvae reaching the 4th stage

Group	Quantity	Larvae to 4th stage	
		No.	Per cent

GRAND TOTAL:

Corrivault, G. Wilfrid and Jean-Louis Tremblay
1948b Contribution à la biologie du homard (<u>Homarus americanus</u> Milne-Edwards) dans la Baie-des-Chaleurs et le golfe Saint-Laurent. Contrib. Stat. Biol. St.-Laurent No. 19, 222 pp. illus.

(p. 37)

C. <u>The rearing establishments and natural spawnings</u>

At the beginning of the century, two events marked the history of the Canadian lobster fisheries: they were the hatching establishments and the fitting-up of natural spawning. These events were the logical and practical consequences of the recommendations of the commission in 1898.

6. <u>Natural spawning</u>

The first natural hatchery which had been organized was, according to the annals of the period, to restore the lobster fisheries. It was established at Fourchu, Cape Breton Island, in 1903. This natural hatchery encircled by a stone wall, had a surface of 63,700 square feet, viz. 380 by 167 feet and it was subdivided into many small pools. Small openings from one to two inches diameter, which allowed a free circulation of sea water, were made in the wall. It goes without saying that such an enclosure has not entirely the characteristics of a natural hatchery; it was rather a large pool where one was able to make observations on the biology of the lobster. In the beginning 50,000 egg-bearing females were purchased of fishermen and placed in the pool. Before putting them back in the enclosure, numerous observations were made on each specimen: for instance, one measured the length, then estimated the degree of maturity of the eggs carried by each female. One was able thus to pick up the following facts: 1st, 2 per cent of the berried females measured $7\frac{1}{2}$ inches (19 cms.); 2d, 73 per cent from 8 to $10\frac{1}{2}$ inches (20.3 to 26.9 cms.); 3d, 25 per cent more than $10\frac{1}{2}$ inches (26.9 cms.); 4th, the degree of maturity of the eggs was very variable from one female to another, etc. Yet the Fourchu experiment did not give the expected results because as early as the following springtime one realized that a great number of specimens thus shut in had died in the course of the winter season. The experiment was continued for some years with relative success. It was in 1905 that the lagoons of the Magdalen Islands had been made sanctuaries where all fishing was forbidden, to determine the value of natural hatcheries. The fishermen still spare these natural hatcheries as the regions where the berried females remain during the hatching of the eggs. Only the seals are allowed--doesn't it seem--depredations in this shelter.

It should be desirable to make a study of the relative efficacity of the Magdalen Island lagoons as natural hatcheries; such a study should complete the work done by Templeman (1935) on lobster migrations in the waters adjacent to those lagoons.

It seems however, according to the population studies that we have made in that region in 1945, that the protection of lobsters in the lagunes may have had a successful effect.

In the Bay of Chaleur, no locality has been recognized as a natural hatchery; at any rate, the annals make no mention of it. The Fourchu experiment and that of the Magdalen Islands lagoons are the only attempts which may have directly aspired to improve the natural restocking. The artificial restocking attempts have had more importance; and the hatcheries are the largest enterprises tried in Canada to restore the lobster fisheries.

7. Lobster rearing stations

The artificial restoration of the fisheries by rearing establishments was not a new idea. Indeed Richard Nettle, who ought to be considered as the founder of fish culture in Canada, had put into successful operation in 1857 the first Canadian salmon fish cultural station in a modest installation situated at Quebec at the corner of Saint-Jean and Saint-Ursule streets. At the end of the last century, there already existed in Canada fourteen fish culture stations under the technical direction of S. Wilmot.

One is able to suppose that the wholly new initiative to repopulate the lobster fishing grounds by artificial methods may have stirred up a great deal of enthusiasm among the leaders of the period. It is in 1891 that the first lobster hatchery opened at Bay View in Nova Scotia. The under minister of Marine and Fisheries informed his minister in the following words:

> "This new undertaking of lobster culture by artificial methods of restocking has been inaugurated in Canada in the course of the last year and is the first public work of its importance in Canada or in the neighboring republic of the United States."

Such a hatchery was already in operation for a year at Newfoundland.

The Bay View installation included a building of 45 by 35 feet with a 20 horsepower steam engine, double-action pumps, reservoir, etc. The eggs, after having been scraped from the abdomen of the females were incubated in glass jars in which circulation assured the aeration and agitation of the water. Each day, the canning factories were visited for collecting the eggs, which were transported to the hatchery for incubation. It goes without saying that the canners and fishermen looked upon the innovation with good will.

From 1903 to 1912, in Canada, there were in operation fifteen hatcheries which were distributed as follows:

Nova Scotia	8
New Brunswick	3
Prince Edward Island	2
Quebec	2

In the province of Quebec, these stations were situated at Port Daniel, Bonaventure County, and at Havre-aux-Maisons, Magdalen Islands; they were put into operation in 1910. But a first attempt to incubate the lobster eggs had been made already in 1900 at Gaspé. In fact, thanks to the assistance of Rodolphe Lemieux, then county deputy, Gaspé had been able to provide for a fish cultural establishment which had to serve at that time for the rearing of salmon and lobster. However, the incubation of lobster eggs was there checked completely because of the low salinity of the water used in that hatchery.

After some years of experiment, the efficacity of this method of restocking was placed in doubt, and, in order to verify the output, it was decided to attempt to restock an old fishing ground formerly known as rich, but abandoned at that time because of its depletion. It is thus that during five years the harbor of Bedford, in Nova Scotia, was planted annually with eight million larvae. The experiment not having been encouraging, the director of fish-culture of Canada decided to suspend the work of the hatcheries. In 1919, these had all been closed.

The opinion of Professor Knight on the efficacity of these hatcheries has been preponderant and here is that which he thought in 1916:

> "The hatcheries have not given satisfaction as means of enriching our waters depleted of lobsters. The female is able to hatch a much greater percentage of eggs than any artificial incubator."

Dannevig, Alf
1916 Beretning om forsøkarbeiderne ved statens hummer-station ved Korshavn sommeren 1916. Aarsberetning ved. Norges Fiskerier for 1916, h. 1, pp. 221-233.

Report on the experiments at the State's lobster rearing station at Korshavn, the summer 1916.

The rearing station at Korshavn was founded by Assistant of Fisheries Sund in 1913 and was managed by him for the first two years. However, as I started to work for the government and as Mr. Sund wanted to be free from the responsibility for the lobster station in order to work on other things, the Director of Fisheries recommended that I should take over the management.

On telegraphic request of June 21 this year from the Director of Fisheries, I went to Korshavn on June 24 in order to inspect the rearing station and get it ready for work.

Due to the war no work had been done at the rearing station since the summer of 1914, and we found it necessary to have a good deal of repair works and improvements done, although we had to limit these as much as possible because of the small budget.

. . . .
(The following paragraphs concern repair works, etc.)
. . . .

On July 7 and July 10, a total of 247 spawn lobsters (114.7 kilograms) was purchased from the lobster store-houses at Ulvesund and Korshavn. However, as the lobsters developed slowly this year, we obtained no young until July 21, at which date the work was started.

The spawn lobsters which were ready for hatching were kept in rearing boxes in which the propeller was rotating only for a short time every day in order to renew the water; the lobsters with relatively undeveloped spawn were kept in the usual lobster boxes and were transferred to the hatching boxes as the development proceeded, while the lobsters which then had finished their hatching were sold again.

From the 247 spawn lobsters we got a little more than 33,000 young, a very poor result. If we count on an average of only 5,000 eggs on each lobster, we should have obtained 1,235,000 young, i.e., 40 times more than we really got. As Sund gives a similar result for 1913, we take it that the hatching in the boxes is very deficient; Sund supposed the cause to be a little worm, Histriobdella, but since this worm was not to be found this year, there must be another cause for the loss. In my opinion, the adult lobster itself is to blame; it eats the eggs off its companions, and as shown by Sund, it also eats its own young. Sund made a few experiments in order to prevent these calamities, but without success. It is therefore natural for me in my future work to go back to the method used by my father, i.e., to hatch eggs which are taken off the lobsters. Already in 1885 he hatched thousands of lobster young with a loss of about 50 per cent; in 1892, the loss was only five per cent of brood from 30 spawn lobsters (i.e. 150,000 to 200,000?). This method also has the advantage in that we do not have the work and risk of having so many lobsters to take care of. In this respect it will be a great advantage to have the rearing station at Fl/devigen where we can use the hatching equipment, - but of course my father's method might also be modified in such a way that it could be used also at a floating station.

From the enclosed tables you will see that the development of the hatching essentially follows the changes in temperature, however in such a way that the maximum of number of young per day decreases a few days after maximum in temperature,- which is in accordance with what we might expect.

The rearing apparatus were started July 21 and were in work up to August 21 - only with the interruptions caused by the motor; the auxiliary motor was unfit for use. At the beginning the engine stopped very often, but later on it worked regularly for about a week at a time between each cleaning; according to the journal, the motor stopped 12 times, averaging three hours at a time; in addition there were a similar number of short interruptions which were not entered into the journal.

Such stops and cleanings of the engine at all hours are very unfortunate, both directly for the rearing apparatus and especially because we have to give all our attention to the motor to keep it going. The rearing work suffers greatly because of this; it would be a very great advantage if the motor could be electrically driven.

I tried to carry on the rearing experiments in such a way that they would give some information about the conditions under which the young would thrive best, but because of the short time and because of the difficulties with the motor, not all the experiments could be quite completed; they will be repeated next year. For the experiments we partly used the rearing boxes as they had been used by Sund, partly with different changes - a few of which appeared to be favorable. However, as the rearing boxes are so large that they cannot be kept under accurate control, I had some quite small sample boxes made (40 x 45 x 75 centimeters). These were made of frames on which was nailed perforated celluloid of the same kind which was used for the "windows" of the boxes. These were hung in straps on the vessel, in such a way that the upper fourth (1/4) was above the water. At first it was necessary to find out what was the most appropriate food for the young, and also in which way the young should be fed.

Experiments were made with:

A) Finely crushed crabs (every 3d hour)
B) Minced shrimp
C) No food, only algae, grown with different bryozoans, hydroids, etc, were put into the boxes

B and C were started at the same time; A two days earlier (see the tables).

A) gave about 17 per cent in the 4th stage
B) " " 12 " " " " " "
C) " " 0 " " (they all died after two days)

The experiments from August 10 to August 21 give the following results when we take into consideration the time between each feeding (with minced crabs).

D) fed every 12th hour, gives 12 per cent
E) " " 6th " " 12 " "
F) " " 3d " " 48 " "

However, when the experiment was completed, the young had not all reached the 4th stage.

From time to time experiments were also made with finely ground fish, but as this polluted the water, we stopped the experiments. Besides, what will be seen from the above mentioned experiment, i.e. that a frequent feeding with crabs seems to give the best results, I have also made the discovery that the crab (both entrails, the "support for the feet" and the claws) ought to be crushed very finely and be screened for the young in the boxes. One thereby obtains a fine distribution of the food; also, that which is not used will gradually be carried away by the stream of water out of the boxes, so that it will not pollute the water for the young; but it necessitates a plentiful and frequent feeding; when we had the largest number of boxes working (i.e., 8), we used three crabs at a time every 3d hour. Further, I think it is important to feed the young already in the hatching boxes; however, I have made no experiments in this respect.

With regard to the current in the rearing boxes, which is also of great importance for good results, I have also made different experiments - which cannot be given in table form.

In the rearing boxes the water gets a rotating movement, and in spite of the rise of the propeller wings, the suction from the bottom windows is very small; the even rotation will further cause a dead-point in the water near the propeller axis, where both the dead and the living young will gather - and often be lumped together at the bottom.

To prevent these difficulties I have experimentally placed inclined deals (about 40 x 75 centimeters) in the box, and placed them in such a way that they both direct the water upwards and disturb the formation of eddies and dead points. One of the frames was fastened to the bottom on a 20 degree angle, the other one at the surface, on the opposite side of the propeller shaft. The current was in this way turned into a screw-like motion; at the same time the renewal of water was improved because the suction from the bottom windows increased.

In the course of the experiments it appeared that the best results were always obtained in boxes with these current regulators; however I do not want to give any figures as other things also might have played a part.

Professor Appellöf has in his earlier works strongly emphasized the danger in using brass mesh for the windows, or in any way let the copper compounds come close to the rearing boxes, as the brood was very sensitive to these compounds. As, however, copper paint excellently prevents all parasites, there were made experiments with three rearing boxes: the inside was given a coat of copper paint - and one of the boxes was also given a window of brass mesh.

The result was that the boxes with copper paint gave just as good results as those, which were only painted, and the box with the brass mesh gave even the best result of them all.

After the engine had been stopped for a longer time, there was a considerable death rate in a box, which had just been painted with copper paint, but it is hard to decide whether the death rate was due to the copper, to the lack of water circulation, or both.

There is hardly any reason for not using copper paint where this is desirable; I know that in Sweden exclusively copper paint is used for the rearing boxes.

From Flødevigen I have experienced the harmful effect of grease on the cod young. I therefore made an experiment to find out how the lobster young would react if there should be any lubrication oil or petroleum from the machine-(barge) in the water of the rearing boxes.

In box G (see table) I added a little lubrication oil mixed with petroleum every day - only so much that it gave a visible film on the water. After five days - when the experiment had to be stopped, there were 30 young lobsters left of 50; in the control box without oil, however, 37. There was no time for further experiments, but the above results indicate that we ought to be aware of this. If we do not show the utmost care it is impossible to prevent grease from coming into the boxes, at least as long as we have to use petroleum engines.

With regard to the influence of the temperature on the brood, it is very difficult to make experiments in this respect with the present location of the rearing station. In order to get the right understanding of the conditions we have to make investigations concerning the mortality of the different stages as the temperature of the sea water changes. I have not been able to make as accurate investigations as could be desired, but as far as I can understand the first stages are especially very sensitive to low temperature - or to a drop in temperature. This problem can, however, be relatively easily solved at Fl/devigen, as the temperature in the rearing basin to a certain extent might be regulated. If it should be proved that the temperature plays an important part, so that the death rate decreases at a higher temperature, then we could move the whole rearing work to the basin.

The cannibalism of the lobster young has for a long time been regarded as the most serious impediment for an economical rearing work. I do not agree here; it certainly plays a part, but I do not think it an essential cause of death. This year, at least, I have only by exception seen that one young lobster really killed another - even if they were of different sizes. Experiment No. 4 shows this very clearly: when the brood had entered the 3d or 4th stage, 300 newly hatched brood were put in, and of these 75 were still alive (in 2d and 3d stages) after 11 days, i.e. the result was not worse than those of the other experiments.

In addition, in 1914 I examined 50 dead young lobsters from the rearing apparatus at Korshavn; of these 10 were badly hurt, 17 partly hurt while 23 were without visible injury; (the examination was made by means of microscope).

When only a fraction of the dead young was hurt in such a way that we might suppose the injury to be the cause of death, and at the same time the injury might have taken place after the young had died of another cause, - then the cannibalism is only of relatively little importance. Of the 50 young lobsters examined there was only one (2d stage) which had remains of young in the ventricle; the other ventricles were usually empty, or partly filled with an amorphous undefinable content. The brood had been fed with hard boiled eggs.

Before I finish the report on the work of this summer, I also have to mention the storm on August 3. In spite of the fact that the rearing station is located in a well protected creek, the spray flew over the station for several hours; several "windows" were smashed into the boxes, and the sea went completely over the rearing boxes. A number of the moorings were broken, and the men were so busy in trying to keep the station in place that there was no time to care for the young. The storm was followed by a violent decrease in temperature - down to 11.5° C. (maybe lower); only gradually it increased to a normal summer temperature again.

It is hard to say to what extent the young were injured, but at all events the damage was considerable; this was shown only too clearly when we counted the young during the next few days.

(Results of experiments follow:)

No. 1 Without circulation, fed with crabs twice daily

July 12-15	Put in (48 - 50 - 30 - 6)	134 young
15	Counted, cleaned	47
	Transferred to box No. 3, same conditions	
21	All dead	

No. 1b No circulation July 17-21, fed with crabs twice daily

July 17-21	Put in (63 - 129 - 84)	276 young
21	Counted	68
25	"	12
	which were transferred to experiment box	
	Four reached 4th stage	

No. 3 Engine working, fed with crabs eight times per 24 hours, Regulator

July 21-22	Put in (275 ÷ 275)	550 young
26	Counted	365
28	All apparently 3d stage	
29	Counted 3d stage	287
31	4th stage seen	
Aug. 1	Took out (4ths)	20
2	"	44
3	"	29
4	"	16
5	"	5
6	"	5
7	"	7
8	"	4
9	"	1
12	"	1
	Total 132 bottom stage young	

No. 2 The box given coat of copper paint, propeller raised, from now on always fed as in No. 3

July 23-24	Put in (471 + 800)	1271 young
28	Counted (mostly 2d stage)	441
Aug. 5	"	48
18	Box empty, all dead	

No. 4 Copper paint, with regulator

July	25-26	Put in (1717 - 2300)	4017 young
	30	Counted	690

Note: Hole in net, many young recently dead. Poisoned by copper paint, because of engine - stop?

Aug.	7	Counted	104
		Thereof put out in 4th stage	7
Aug.	8	Put out	9
	9	"	8
	10	"	10
		In newly-hatched brood	
	11	Put out	17
	13	"	16
	14	"	4
	15	"	2
	19	"	3
		Counted (2d stage)	90
	21	Put out (3ds)	50
		" (2ds)	25

Total: 76 bottom stagers

No. 1c Without current-regulator

July	27-28	Put in (2550 - 3950)	6500 young
Aug.	1	Counted	112
	5	"	3
		Experiment finished	

No. 6 With regulator

July	29-31	Put in (3840 - 2150)	5990 young
Aug.	4	Counted (2ds)	620
	8	" (3ds)	200
	14	Put out in 4th stage	6
	15	" "	5
	16	" "	8
	17	" "	24
	18	" "	32
	19	" "	7
	21	" "	8

Total: 90 bottom stagers plus 15 3ds.

No. 5 With regulator

July 31) Aug. 1)	Put in (2500 - 1375)	3875 young
4	Counted (1st and 2ds)	1180
9	"	350
17	" (3ds and 4ths)	101
	Thereof put out in 4th stage	4
18	Put out	3
19	"	21
21	"	19

Total: 47 bottom stagers and 50 3ds.

No. 8

Aug. 2-4	Put in (2650 - 800 - 700)	4150 young
7	All lost; hole in net, probably caused by high sea August 3.	

No. 7

Aug. 5-6	Put in (900 - 700)	1600 young
10	Counted	630
17	" (3ds)	172
21	Put out 11 in 4th stage and 100 in 3d stage	

No. 1d With current-regulator, no cleaning

Aug. 7-8	Put in (1050 - 600)	1650 young
21	Put out 10 in 3d stage	

No. 8b Copper paint, regulator

Aug. 9	In	425 young	
10	"	460	
12	"	300	
13	"	500	
14	"	341	
			2026 young
19	Counted		1250
21	Put out 900 in 3d stage and 200 in 2d stage		

No. 3b Regulator

Aug.	15	In	263 young
	16	"	110
	17	"	125
	18	"	35
	19	"	62
			585 young
	21	Put out 450 in 2ds and 1st stages and 50 in 3d stage	

Experiment box A

July 18 In 60 young
Fed somewhat irregularly with crabs until work started July 21. From then on every 3d hour.

19 Counted at 11 a.m.: 52 numbers, no dead
" 6:30 p.m.: 45 living, 5 dead 2 missing. No injury seen on 4 of dead, the 5th may be injured.

	20	9:30 a.m.	29	living,	no dead
	21	10:00	29	"	
	22	11:00	27	"	2d stage
	23	10:00	24	"	2 dead of which 1 injured
	24	10:00	22	"	2 dead " 1 "
	25	10:00	19	"	thereof 5 in 3d
	26	10:00	18	"	1 dead, injured
	27	10:00	16	"	2 dead, thereof 1 injured
	28	10:00	13	"	3 dead
	29	10:00	12	"	thereof 3 in 4th stage
	30				
	31	10:00	10	"	2 dead (4th stage)
Aug.	1	10:00	9	"	
	2	10:00	9	"	
	9	10:00	6	"	
	11	10:00	6	"	
	12	10:00	5	"	
	14	10:00	3	"	in 5th and 2 in 4th
	15	10:00	5	"	"
	16-19	10:00	Counted 5 living in 5th stage		

Experiment box B

Fed with minced shrimp every 3d hour (Always counted around 10:00 a.m.)

July	20	In	50	young	
	21	"	42	living,	1 dead and (7 missing)
	22	"	40	"	
	23	"	27	"	1 dead, not injured, and (12 missing)
	24	"	26	"	1 dead, injured
	25	"	21	"	
	26	"	18	"	1 dead. Note: found a small hole in box
	27	"	15	"	
	28	"	10	"	5 dead
	29	"	8	"	
	30				
	31	"	6	"	2 dead
Aug.	1	"	6	"	
	2	"	3	"	whereof 2 in 4th and 3 dead in 4th
	5	"	2	"	put out in 4th

Experiment box C

No food given. In the box some sea-weed (Fucus, heavily over-grown with hydroids and bryozoans)

July	20	10:00 a.m.	In	50 young
	21	"		20 living & 10 dead whereof 2 injured & 20 missing
	22	"		None living, 6 dead, partly devoured. Some amphipods found in the box; they might have destroyed some of the young. The young reacted quickly if they came near the hydroids (Clava); they withdrew then immediately, apparently burnt by the stinging cells.

Experiment boxes

	D Fed 7:30 a.m. & 7:30 p.m.	E Fed 7:30 a.m. 1:30 a.m. & p.m.	F Fed every 3d hour
Aug. 10	50	50	50
11	48	42 plus 2	41
12	37	33	44
14	37	29	40
15	35	26	40
16	32	21	36
17	31	18	35
18	29	16	32
19	20	15	31
21	6	6	24

	Experiment box G with oil	Experiment box H without oil
Aug. 16	50 young	50 young
17	50	50
18	47	48
19	42	45
20	-	-
21	30	37

Dannevig, Alf
1918 Arendals fiskeriselskap, Beretning for Fl⌀devigens utklaekningsanstalt 1 July 1917 - 30 June 1918 Aarsberetning ved. Norges Fiskerier for 1918 hefte 1, pp. 202-203

Report for Fl⌀devigen hatchery, July 1, 1917 - June 30, 1918

After the moving of the rearing station to a little bay at Fl⌀devigen, renewed experiments according to Mead's system were made during the summer 1917.

The result was just as bad as those of the preceding years, and as the weather during the hatching period was very unfavorable with violent showers, thunder and storm, the experiments, which I had started in order to find out the cause of the high death rate of the lobster young were ruined.

Besides, it appeared that the rearing station needed repairs to a large extent; the celluloid of the windows of the rearing boxes had, for instance, become so brittle that it could not stand the movement of the water, which was caused by the rotation of the propeller.

Instead of repairing the rearing station and continuing with this, I obtained the authorities' permission to stop further experiments after Mead's system, and to dispose of that part of the material which could not be used later on.

At the same time I recommended that we should start experiments at the hatchery in order to investigate the problem on a small scale before we start working on a larger scale.

The hatching of cod has also been stopped this year, as I could not get any gasoline for the motor boat.

During the revenue year I have been busy with preparation of different scientific material.

The report on fish eggs and young collected by Dr. Hjort on his trip to Lofoten 1913 has been finished and is to be printed in Report on Norwegian Marine and Fishery Investigations. Also the material which I collected in the spring 1917 has been partly prepared. As such a work is very exhausting if it is done with accuracy, it takes more time than could be desired before the results can be printed; I hope, however, to get it finished the coming fall.

Fløddevigen, July 13, 1918

Alf Dannevig.

Dannevig, Alf

1919 Fløddevigens utklaekningsanstalt. Aarsberetning for terminen 1.juli 1918 - 30 juni 1919. Aarsberetning ved. Norges Fiskerier 1919, hefte 1, pp. 255-257.

Fløddevigen hatchery annual report for period July 1 to June 30, 1919

Note: This article was not translated completely. A summary follows:

Mead's method of artificial rearing was abandoned.

The hatching of lobster eggs was improved by putting the egg lobsters into cod hatching boxes instead of removing eggs from lobsters and circulating them until they hatched. The newly hatched larvae were led to the mesh net by the water current. From 56 egg-bearing females, a total of 28,000 young hatched, or about 500 per lobster. Although they hatched successfully, the lateness of the season and transportation may have caused the small number of eggs present on the females.

Attempts were made to rear the lobsters in carboys and aquaria, but were unsuccessful. It was believed that the current was too strong at shedding time.

Dannevig, Alf
1920 Fl⌀devigens utklaekningsanstalt. Beretning for terminen 1 juli 1919 - 30 juni 1920. Aarsberetning ved. Norges Fiskerier 1920, hefte 1, pp. 50-61, illus.

Fl⌀devigen hatchery, Report for period July 1, 1919 to June 30, 1920.

Note: This article was not translated completely. A summary of the principal points follows:

The causes of the mortality were found:

1. Must remove dead larvae and food remains

2. Must have adequate current to prevent cannibalism

A galvanized iron rearing apparatus was built. It had a double bottom with the upper bottom of perforated celluloid. Current came in through the bottom and up through the celluloid, then out through windows in the upper part. Later hose was placed in the top to give a rotary motion. Some times the apparatus was successful; some times it was a failure. It was difficult to clean the celluloid perforations.

Cannibalism was prevented by the water current and the fine food. Minced mussels were especially good.

Twenty-four egg-bearing female lobsters yielded 6,700 young. This number was satisfactory because of the late season and many eggs had already hatched.

About 400 fourth stagers were put out and some released in earlier stages.

Dannevig, Alf
1921 Fl∅devigens utklackningsanstalt. Aarsberetning ved. Norges Fiskerier, for 1921, hefte 1, pp. 105-108

Fl∅devigen hatchery

Lobster

The work with the rearing of lobster was started July 14 with 53 spawn lobsters and was finished August 11. The experiments were made in order to try some new rearing apparatus of galvanized iron similar to those which were used during the summer 1919 (see Report for 1919/20). The experiments were better than those of the preceding years, but they were not completed; there were still improvements to be made. These have now been finished - and the experiments will be repeated this season in the changed apparatus.

During the season there were gathered in all about 24,000 young, a result which must be regarded as satisfactory, as a great deal of the lobster eggs had been hatched already before the mother lobsters were put into the apparatus.

The hatching proceeded without accidents of any kind.

The greater part of the young was used for different experiments, of which several failed completely; 486 were liberated in the 4th stage and a few thousand in the first.

The tagging experiments, mentioned in my earlier reports, were continued - and with considerable success. A good number of the tagged lobsters are recaught, and they give us a sound basis for our knowledge of the growth and the migrations of the lobster. I have given preliminary reports on these investigations in Norsk Fiskeritidende for 1919, p. 47; 1920, p. 80, and also in the report which will probably appear in the July-August number of this year. When the experiments have been finished, we intend to gather the results in a special report.

It seems that the lobster is extraordinarily stationary, at least in the locality where the experiments have been made (Fl∅devigen).

The results will also be of importance for the problem of raising the minimum size; in planning the experiments I have taken this problem into consideration.

These investigations will be continued, but in order to get as general results as possible, we shall experiment in another locality, i.e. one of the outer shoals.

Dannevig, Alf
1922 Fl∅devigens utklaekningsanstalt. Aarsberetning ved. Norges Fiskerier 1922, hefte 1, pp. 84-87

Fl∅devigen hatchery

Note: This article was not translated completely. A summary follows:

In 1921 with an early spring and warm water, lobster hatching started July 1st. A total of 48 egg-bearing females yielded 19,770 larvae between July 1 and 24. 12,200 larvae were used in six experiments and 5,780 were put into the sea. 1,790 larvae were also put into tanks after first six experiments concluded.

Experiments were carried on in two iron containers and one wooden box with four rearing compartments. The results differed somewhat in the various containers.

From 12,200 there were 2,988 fourth stage lobsters planted. This was an average survival of 25 per cent.

The last experiment (using 1790 larvae) gave 360 third stages which were released.

Dannevig, Alf
1923 Fl∅devigens utklaekningsanstalt. Aarsberetning ved. Norges Fiskerier 1923, hefte 1, pp. 169-171

Fl∅devigen hatchery

Note: This article was not translated completely. A summary follows:

A total of 101 egg-bearing females were bought in an attempt to find the best methods; part of the females were put in iron containers, part in old wooden boxes, and part in new wooden boxes. The last was the best. A total of 37,000 young were hatched; 5500 were planted because of the lack of space. The rest was used for experiments. A few experiments failed completely.

A little more than 4,000 were reared to the 4th stage. These experiments were encouraging. It was necessary to get more money to improve the equipment.

Dannevig, Alf
1924 Fl/devigens utklaekningsanstalt. Aarsberetning ved. Norges Fiskerier for 1924, h. 1, pp. 173-195, illus.

Fl/devigen hatchery

Rearing of lobster young

For the fiscal year 1923-24 a sum of 2,000 kroner was granted for new rearing apparatus; as I already previously had planned the building of these, I finished them by the middle of July when the work started. Originally I had counted on five new apparatus, but by increasing them somewhat in size and because some changes were made, they became more expensive than calculated, so that I could not get more than three. These were built according to the same principle as the apparatus which had been used with success the preceding year (model 1922), but with different changes in order to get some new experience.

On July 9, a total of 255 lobsters was purchased from Lager/ya at Lillesand; they were immediately placed in the hatching boxes where the spawn lobster lives in a small room in order to hatch its eggs. By the steady water current the young are led down in strainer boxes from which they are taken out every morning and transferred to the rearing boxes.

On July 16, the rearing work was started; up to that time the young had stayed in the strainer boxes. At the beginning we had, however, great difficulties to fight; the supply of water was not satisfactory and by the time I could get the necessary material from Oslo to change the water hose, a great deal of young had been lost.

On July 27 the water hoses were changed and from now on they worked without accidents. The result is seen from the following data:

Apparatus No. 1

Of the three new apparatus No. 1, which was an exact copy of the one used the preceding year, gave good results in accordance with the results in 1922. The first experiment suffered a good deal from the mentioned fault in the water supply.

Experiment 1.

July 16 to 22:	In	abt. 15,000 brood
Aug. 4 to 18:	Released	1,202 4th stage
Aug. 18	Transferred to apparatus 4	84 3d "

Experiment 6.

Aug.	6-7:	In	about 8,000 young
"	24-31:	Released	2,043 4th stage
"	31:		31 3d "

Apparatus No. 2

This was an exact copy of No. 1 as to dimensions and circulation of water, but here a bottom net of metal was used. The first experiment suffered much from the mentioned fault in the water supply.

Experiment 2.

July 22 to 27:	In	6,000 young
	High death rate	
	No young in 4th stage	

Experiment 5.

Aug. 4 to 6:	In	6,000 young
	High death rate	
Aug. 22 to 26	Released	197 4th stage

Apparatus No. 3

The circulation of water was somewhat changed, so also the dimensions of the boxes.

Experiment 3.

July 28 to Aug. 1:	In	15,450 young
Aug. 13 to 20:	Released	5,268 in 4th stage
Aug. 20:	The rest transferred:	
	755 brood to apparatus 1c & 1d	
	of which released Aug. 20	
	to 31	492 in 4th stage
	and	13 in 3d "

Experiment 7.

Aug. 7 to 11:	In	about 12,000 young
" 24 to 31:	Released	4,757 in 4th stage
" 31:		200 in 3d "

Experiment 8

Aug. 20:	Transferred from apparatus 4.	about 8,000 young
Aug. 21 to 29:	In	2,350
		10,350
Aug. 29 to 31:	Released	450 in 4th stage
Aug. 31:		4,000 3ds or 2ds

Apparatus No. 4.

Same apparatus as used in 1922.

Experiment 4.

Aug.	2 to 4	In	about 8,000 young
"	18	In from experiment 1	84 3ds
"	20 to 31	Released	2,471 4ths
"	31		11 3ds

Experiment 8.

Aug.	12 to 20	In	8,000 young
"	20	Transferred to apparatus 3.	

You will see from the tables that the different methods gave very different results. Apparatus 1 and 4, which were alike, gave also the same results - and similar to preceding years.

Apparatus 2 failed completely - while apparatus 3 in two finished experiments showed itself superior, as this brought forth a little more than 35 per cent of the young to the bottom stage, e.g. about five young lobsters per cubic decimeter cubic capacity.

According to the experiments made, the apparatus 1 and 2 have been changed as far as possible in accordance with apparatus 3 (model 1923).

At this time I do not wish to give any detailed description of apparatus and methods. With regard to the work, we had some difficulties in procuring adequate food for the young; it was practically impossible to obtain crabs, and at last they had to be ordered from Lillesand.

The lobster young was released in the following places: (see table p. 176, at the bottom). (Total: 16,875 4ths; 4,255 3ds or 2ds.)

Dannevig, Alf
1926a Flødevigens utklaekningsanstalt. Aarsberetning ved. Norges Fiskerier for 1925, h. 1, pp. 129-136, illus.

Flødevigen hatchery

<u>Rearing of lobster young</u>

During the season 1924-25 we used the same apparatus which were used last year for the rearing work; two of these, No. 1 and 2, were however, partly changed according to the experiments made.

On July 10 a total of 307 spawn lobsters was purchased from the storehouses at Agerøen, and these were immediately placed in the rearing boxes. Because of the low sea temperature, the lobster hatched slowly; not until July 20 did the young reach a number of 500 per day; on August 16, the daily number of young was again below this figure.

There were gathered about 83,000 young of which about 3,000 were released in the sea immediately due to lack of space; the rest was used for the rearing experiments. Of these 13,086 were reared to the 4th stage, 50 were kept for further rearing, 20 were preserved, while the rest was liberated at or near Flødevigen.

When the work stopped, the rest of the lobsters in 2d and 3d stages, 2243, were released in the sea, also at Flødevigen.

Because of the relatively large number of spawn lobsters, and in order to save water, two individuals were placed in each hatching box; this did not prove profitable, however, as the spawn fell off the lobster; there was a considerable quantity of dead spawn in the boxes.

With regard to the result of the year's work, this is not as good as earlier; the number of reared lobsters is less than that of preceding years; the reason is that we could not obtain crabs for food for the young; I did not get the first shipment of crabs from Kristiansand until August 16. Up to that time I had to try another kind of food - mostly we had to use mussels. I knew from earlier experiments that they were not ideal food, but nothing else could be obtained. The result was therefore not very good until we got crabs; then things went better again.

The development of the different experiments will be seen from the following survey:

Experiment:	In:	Brood:	Out:	4th stagers:

(See Table p. 130)

You will see that the later experiments in which a crab diet was used, have given a much better result than the earlier, in which mussels were especially used for food. That mussels are not very well fitted for food, is probably due to the physical nature of the meats. They will not keep floating in the water as long as the crab food does.

Of the 50 4th stagers, which were retained in the rearing apparatus, 11 individuals were still alive in the fall; of these eight passed the winter in the aquarium, and now, at the beginning of August, - 11 months old - are of the following sizes: 28, 32, 33, 33, 37, 43, 46, 47 millimeters.

Dannevig, Alf
1926b Beretning for Fløddevigens utklaekningsanstalt for 1925/1926. Aarsberetning ved. Norges Fiskerier for 1926; h. 1, pp. 163-194 illus.

Report for Flødevigen hatchery for 1925/1926

Rearing of lobsters

The rearing of lobsters started July 2; on that day 133 spawn lobsters were purchased from Aakerøy; they were put into the hatching boxes the same day. From July 3 to August 12 there were gathered in all about 120,000 young

Thereof released in sea directly due to lack of space	"	41,000	"
Left for rearing	"	79,000	"
Thereof reared to 4th stage	"	8,020	"
Released in earlier stages	"	522	"

As you will see the result is a little more than 10 per cent reared - or an average a little less than earlier years.

The cause was the total lack of crabs; all the time we had to use mussels for food (when we except some dozens of sand crabs and some eggs). Mostly we used the quite small mussels which grow on points and rocks; these were generally fatter than the large mussels, and they were also more easily ground in the food mill.

From previous years I know that mussels are not ideal for food, but as we could not get crabs in the district Arendal - Flekkefjord during the rearing season, I had to use what could be obtained in sufficient quantity and at a reasonable price. There were used about 120 liters per 24 hours of "bremskjell" (edge mussels).

As you will remember the previous experiments were conducted with crabs as food, but later on, as the crab has practically disappeared, the objective of the experiments has been to find other adequate food.

Probably the crab will again be found at islets and points in Sørlandet (southern part of the country) - but it is necessary to know what we should use for food when the crab is lacking; therefore the experiments have to be carried out even if the present results are bad.

The lobster young were released in the following places between July 21 and August 12:

Flødevigen	5,744
Terneholmen - Smaaskjaer	724
Stølsviken	598
Havsøen	894
Put into App. 1 for further rearing	60
	8,020

The newly hatched young lobsters, about 41,000, were all released in Flødevigen.

The temperature in the rearing apparatus varied between 15.1° and 18.7° C. - the lobsters hatched early and the water was relatively warm. Of the young reared in the aquarium, three lobsters are now alive; they are 87, 50 and 39 millimeters long (July 29). These are now two years old. The difference in size is remarkable, as they have lived under the same conditions all the time. It is interesting to note that the largest young lobster now very seldom tries to hide - contrary to what usually takes place. Is the reason that it has now reached such a size that it leaves its hidden life and starts crawling about? And is this in accordance with conditions in nature?

Also some young lobsters from 1925 were reared; of these are two alive, 51 and 45 millimeters long. (July 29, 1926.)

Dannevig, Alf
1928a Beretning om Flødevigens utklekningsanstalt for 1926/1927. Aarsberetning ved. Norges Fiskerier 1927, nr. 1, pp. 150-156 illus.

Report on Flødevigen hatchery for 1926-27

<u>Rearing of lobsters</u>

On June 30, 1926 a total of 205 spawn lobsters was purchased from the storage at Agerøen, but on account of some investigations made on the same trip, these were not brought until July 5. In the meantime, the lobsters had been exposed to unfavorable conditions - some were dead and only 155 were placed in the hatching boxes.

From these were gathered July 6 - August 9 . .	76,521 young
Thereof let out in the sea due to lack of space	12,720
Left for rearing	63,801
Thereof reared to 4th stage	1,215
Released in other stages, approximately . . .	10,338

This bad result was due to the same conditions mentioned in earlier reports. Lack of crabs for food - together with a growing infection of the lobster young by a few tenths of a millimeter long "suctorie". One single young lobster could have a hundred or more of these individuals.

According to a preliminary determination, made by conservator Dons in Trondheim, it is a "suctorie", Ephelota gemmipara, which very frequently is to be found in the sea. This is a highly organized one-celled animal.

Whether the "suctorie" is the real cause of the mortality is, however, not certain. There is a possibility that the mortality is due to bacteria which developed on account of pollution in the salt water reservoir and that the same pollution was the cause of the development of the suctorians.

When this is written, August 1927, it appears that both the infection as well as the mortality of the young lobsters stopped when the basin had been thoroughly cleaned. It was also empty during a cold period last fall.

By thoroughly going through certain lobster material we see that it has also appeared in earlier years, but in a small number. It also occurs in small quantity this season but without doing any harm.

In the absence of sea crabs, mussels and sand crabs were used for food. This is supposed to be a sufficiently nutritive food, but because this can be served only in a ground (crushed) condition, so much inedible stuff goes with it that it pollutes the water. Also the meats are somewhat heavy, they are apt to sink. Understanding this, we had to find a method to clean the water in the rearing apparatus for food remains. That which sank to the bottom was sucked up with a siphon or washed out when the apparatus were cleaned; (the young are transferred to a clean box every day or every second day). There were more difficulties with the floating particles. An earlier accident with the supply of water gave me, however, a usable idea.

The centrifugal pump draws some air when there is a leakage in the storerooms; this air is whipped into the water by the quickly rotating wheel and the water in the suction pipe therefore sparkles like the carbonic acid in soda water. On one occasion the water from the pump-hose was led directly into the rearing apparatus with the result that both the brood and the food immediately rose to the surface. The air bubbles attached themselves to all floating particles, including the lobster young.

Now, by leading an adequate quantity of "sparkling" water from the pump-hose to the hose of the apparatus, I succeeded in getting to the surface all small particles, which could be skimmed off, while the young lobsters were not affected at all. In this way all the rearing apparatus might be cleaned in the course of a quarter of an hour for all floating particles - including old food and the shells which have been thrown off.

The experience gained as to the importance of keeping the salt water reservoir clean, and the method worked out for cleaning of the apparatus are so valuable for the future work that they more than compensate for the small profit of one single year of experiments.

In connection with the described mass occurrence of a "suctorie" it may be mentioned that in the Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, Vol. 72, Jena 1914, there is an article by professor dr. Reiner Müller about "Fischsterben bei gleichzeitiger Vorticellenwucherung auf den Daphnien des Gewässers".

In September 1913 a mortality of fish occurred in a 6 hectares large and 2.5 meters deep basin in Kiel. "Sting"-herring and some eels died. An investigation of the dead fish gave no information about the cause of the death. At the same time a lot of small crawfish appeared in the water, and these were quite over-grown with "vorticeller" (parasites?), up to 1000 on one individual. These "vorticeller" are very similar to the "suctories". The "vorticeller" were not to be found on the dead fish - and the only explanation one could give was that all the "vorticeller" had used the oxygen so that the fish was stifled.

It is, however, impossible that the lack of oxygen should be the cause of the death of the lobster.

Dannevig, Alf
1928b Hummeropdretningen 1927. Aarsberetning ved. Norges Fiskerier 1927 (1928), nr. 1, pp. 156-159

The rearing of lobsters 1927

In the later years the results of the rearing of lobsters have not been as good as one could wish, and as mentioned before, I have had reason to believe that this is due to lack of adequate food. The earlier successful experiments were all made with crabs - but it has been impossible to procure these for several years.

When the rearing experiments started July 7 this year it was therefore necessary to try other and different food, and fortunately already the first experiment was successful. It appeared that fresh ox liver was eaten with great appetite; it had the adequate consistency and was easily distributed in the water without sinking. Fresh ox liver could be bought all the time, and if kept in the refrigerator it stayed fresh for more days.

The results of the experiments will be seen from the following survey; I remark that for experiment 1 only the yolks of hard boiled eggs were used. Those young in early stages were released from the experiments 8-12; this is due to the fact that the resources for the rearing of the lobster were then exhausted.

Experiment I (Apparatus I)

July 8-11:	In	2,640	young
" 16:	Finished, let out	375	" chiefly 2d stage
	Preserved (?) 20		

Experiment 2 (Apparatus I)

July 12:	In	3,080	young
July 21-Aug.1	Released	76	" in 4th stage
	Transferred to experiment 3	790	" in 3d "

Experiment 3 (Apparatus 2)

July 13	In	3,180	young
Aug. 1	Counted	1,104	" chiefly 3ds
	From exp. 2 and 3 let out		
July 31-Aug. 6		1,784	4ths = 28%
Aug. 6	Transferred to exp. 4	111	3ds

Experiment 4 (Apparatus 2)

July 14-15	In	8,000	young
Aug. 6	In from exp. 3	111	3ds
" 1-7	Let out	2,833	4ths = 35%
" 7	Transferred to exp. 5	133	3ds

Experiment 5 (Apparatus 3)

July 16-17	In	11,350	young
Aug. 7	In from exp. 4	133	3ds
" 9	" " " 6	275	3ds
		3,936	4ths = 35%
" 12	Transferred from exp. 8	97	3ds

Experiment 6 (Apparatus 1)

July 18-19	In	10,850	young
Aug. 5-9	Let out	3,470	4ths = 32%

Experiment 7 (Apparatus 4)

July 19-25	In	58,750	young
Aug. 3	The stock let out in the sea, the apparatus must be stopped	25,000	2ds

Experiment 8 (Apparatus 4)

Aug. 6 Transferred the stock from app. 1 and app. 3, gathered

Aug. 1-6	In	29,950	young
" 12	In from exp. 5	97	3ds
" 15-22	Let out	8,660	4ths = 29%
" 22	Let out	457	3ds
	Preserved	100	3ds

Experiment 9 (Apparatus 1)

Aug. 7-8	In	6,150	young
" 20-22	Let out	692	4ths
" 22	Let out	2,463	3ds
	Preserved	100	2ds

Experiment 10 (Apparatus 1)

Aug. 9	In	5,400	young
" 22	Let out	2,725	2ds and 3ds

Experiment 11 (Apparatus 3)

Aug. 10-12	In	9,700	young
" 22	Let out	2,717	2ds

Experiment 12 (Apparatus 2)

Aug. 13-16	In	5,405	young
" 22	Let out	3,161	1st and 2ds
	Preserved	100	1sts

For experiment 1 only the yolks of hard boiled eggs were used. It was generally eaten by the young; the microscope showed that the ventricle was full, but no contents could be seen in the intestines. The young died; the experiment had to be abandoned.

For the other experiments ox liver, which had been kept in the refrigerator, was used. The experiments 2-6 in our old wooden apparatus gave a profit of between 28-35 per cent. In one of the experiments we tried to give the young lobsters too coarse food - they ate too much - but not many died.

Experiment 7 in our new cement apparatus was bad; it appeared that the sea water dissolved the cement so that the sand was standing out and had an effect like a sandpaper on the young. It became very worn, especially the rostral spine was exposed. The young were for a time transferred to apparatus 3, the cement box was cleaned and polished (with "shellac"-solution). The young were taken back again and now appeared to thrive better. As it had already suffered a good deal, however, all of them were liberated in the sea August 3. The apparatus was cleaned and polished with cellulose polish. A new experiment was started August 6, as the young lobsters were already gathered in the other apparatus. The apparatus now functioned excellently; 29 per cent were released in the 4th stage by the time the work had to be discontinued.

With regard to the capacity of the apparatus it might be mentioned that apparatus 1 and apparatus 2 each have two rooms with an effective cubic capacity of . . . . 500 cu.decimeters
Apparatus 3 also two rooms . . . . 1,000 " "
Apparatus 4, one effective room at . . . . 3,350 " "

You will see that the experiments have given between two and seven young lobsters in the bottom stage per liter cubic capacity - a result which must be regarded satisfactory.

The troublesome infector from last year's experiments appeared also this year; but in a normal number and without having the least harmful effect on the young. The water reservoir had been cleaned the preceding winter, and had also been empty during a period of frost.

The temperature conditions were favorable at the beginning of the season, about 16-17 degrees (C.), but sank during the days July 25-27 below 14 degrees; at such a temperature the development proceeds very slowly. Later on it increased again and stayed generally between 16 and 18 degrees C.

The total result of the work of the summer is as follows:

Purchased, in all	160 spawn lobsters	
Gathered from these	178,705 young	
Let out due to lack of space	24,150 "	
	154,555 "	
Preserved as newly hatched	100 "	
Left for rearing	154,455 "	
Thereof released	21,290 "	4th stage
Kept and for further rearing	90 "	" "
Liberated in other stages	36,898 "	
Preserved in other stages	320 "	

In consideration of the results here mentioned and of the experience gained while the work lasted, I think it desirable to increase both the working time, and later the rearing station.

An increase in working time will help us determine how much young we can get from the spawn lobster and how much we can rear in each apparatus. An increase in the number of apparatus will economize the work and give us an account of the cost of the reared young. I shall probably set forth propositions relative to this matter when I have seen the results of a prolonged working time.

Dannevig, Alf
1928c Hummerkultur. Naturen, 52de aargang, nr. 10, Oktober; pp. 289-305, illus.
(Translated by Arden Nilsen, Whitefield, Maine)
Lobster culture

Lobstering has been known here in this land since the age of sagas, but there were hardly any rules for maintenance and handling before the Hollanders began buying up the lobsters around the year 1600. That was the first time that the Northmen learned to set a price on lobsters as an item of merchandise and export - later they, here in this land, learned in a steady rising degree to value it in its chief importance. Oslo especially is a great consumer of lobster.

When lobster fishing began here about 300 years ago, there were plenty to take. The stock was so great that natural conditions allowed (this unlimited harvest) and since fishing the first hundred years was carried on only with pinchers, tines about two or three fathoms long, thus it was only the shallow regions along the shore that were fished. Meanwhile the stock here diminished and then nets were introduced, also because of the Hollanders' (demand).

Wherever the fishing had been carried on more intensively the catch diminished, and in 1737, country judge Lemi Lister suggested a bill for the protection of lobsters at the time the lobster sheds its shell and hatches its eggs and also forbade the catching of lobsters under 9 - 10 inches in length. He stood alone, meanwhile, with his proposal.

During the war in the beginning of the preceding century all the exporting of lobsters stopped and the stock was allowed to increase (accidentally - because war stopped commerce). So when the fishing again took place, they got fine catches - fishing became a paying proposition, and was carried on more intensely for a number of years. While the lobster fishing in the 1700's was carried on especially between Lindesnes and Karmøen it now stretches farther East and North, but for all that they take the catch to the full quantity (all there is).

In 1830, Member of Parliament Leis Lundegard from the district of Lister and Mandel advanced the proposal for a protective law for lobsters. This (proposal) led to the making of a Royal suggestion for a law on the catching of lobsters whereby it should be forbidden to catch or handle lobsters under eight inches in length. The Royal suggestion fell through in the lower and upper houses.

Meanwhile an English company, which at that time bought lobsters, eliminated their buying season in the summer months (of course with regards to quality) - and there in that district the stock remained good. In another district, on the contrary, where they fished all summer the lobster fishing was ruined.

This led to the first protective law for lobsters being set down, and it was put in force in 1839. This law protected the lobster from July 15 until the end of September. This law seems to have had a favorable result and now the fishermen desired more protection. This suggestion meets opposition meanwhile, and time after time was defeated by the legislators - but finally the committee on foods gives in - to comply with the wishes of the great majority, not because they themselves believe in it.

After the law of June 17, 1879, the small lobsters also are protected and the old summertime protective law is still in force. Thus came about the essential support for our present lobster lawmaking. I think that I can say that few laws in our land have been so completely understood by the fishing population as this one; fishermen generally have been advised of the great value of the law.

A rational regulating of the catch, such as a law like this entails, must be said to be the first step towards putting our lobster stock under cultivation.

The question arises now: Shall we be in accord with this? Has the protection - that is to say the regulation of the catch - come so far that it can be said to utilize the lobster stock wholly scientifically? I don't think it is the case; it would be phenomenal if we had already reached a perfect arrangement. We can without fear easily go a few steps further according to the experiences we have had that have enabled us to reach this (present) goal; to bring the lobsters' yield up to the maximum limit that the natural conditions promise.

The question is how far can one go in the way of restrictions? Earlier the opinion was that the important thing was that it was first and foremost necessary to add to the stock by restrictions, in that their first contention was that a greater stock gave a greater yield than a small one. This opinion has, as a matter of course, its full right - still one must be observing if his conclusions are to hold true; that the yield really becomes larger; it doesn't benefit as a matter of course to maintain a big stock with the aid of restrictions that will hinder the (overall) benefit of the stock.

When one discusses the question and what can be done to bring the lobsters' yield as high as possible, there are different questions that then come up. The following points will perhaps have an essential meaning.

1. Quantity of the stock under this - prolongation and start.

2. Lobsterfishermen's Economy.

How great is the lobster stock along our coast? This question can be answered fairly with the aid of marking experiments. If they planted 100 marked lobsters and caught back 50 of them in the run of the first year, then one must figure also that of the natural stock the same size as the marked ones only 50 per cent are taken.

Marking experiments on the Skagerak coast show that out of 1199 marked lobsters, 543 were caught in the run of the first year - consequently a good 45 per cent. This is the result in the localities where they carry on normal fishing. One must meanwhile also assume that lobsters are spread out over large areas where they do not fish, where the stock isn't centralized enough. We assume that the stock here - for the reason of the wide area, is as great as where they are fished intensively, so we come to the conclusion that about 25 per cent of the stock is caught up each year.

This condition that one generally doesn't harvest more than 1/4 of the stock is strong security against the depletion of it (the stock); there is a great natural reserve.

If we employ the statistical count of the lobster catch then there is fished yearly well over a million fish; that is, of the stock in that part of the coast where the lobster fishing is carried on, according to More, you can estimate up to around 5,000,000 adult fish. This sort of calculation cannot be used with any exactness, but it at least gives us an idea of the greatness of the material with which one has to work.

When one thinks about the long stretch of coast then this (quantity) isn't great. But one must remember that the lobsters are confined to the comparatively shallow sections of their own coastal waters, especially to depths of less than 20 fathoms.

If he is asked whether this stretch of coast can support a greater stock - then one can refer to lobster fishing's halcyon days - then a couple of boys could take lobsters to the value of a couple of dollars (specie) with their pinchers along the shore in the run of a forenoon. The price at that time (first half of the 18th century) was two shillings apiece. Then there can be no doubt that our coast can house a greater stock.

How can this be brought about? First and foremost by fishing less - we have an excellent example of that in the beginning of the previous century, the restriction brought about by war-time conditions made it so that the stock increased enormously. Meanwhile fishermen reluctantly accept this plan; it demands too much (of them). And yet I think that, without any difficulty whatever, we can gain something with this plan. The thing is that the really profitable lobster fishing is carried on only about one month's time each year, for the remainder (of the year) there is just a little casual fishing here and there.

It is a question whether these occasional catches cannot limit the profit on the stock - and also (a question) whether there should be a closed time at the time of year when fishing is the least active. On the Skagerak coast this would be in mid-winter, for example from the 1st of December throughout April. Such a restriction for fishermen as a whole would be no inconvenience - but the lobsters which are saved will become a gain to the stock.

A more limited restriction is the protection of the smaller lobster - and eventually the seed lobster. If the minimum measure for the lobster is raised so much that it not only guards the immature lobster, but also a lot of the individuals able to propagate, this will mean an increase of the reserve of adult lobsters - so that the size of the catch shouldn't suffer more than one or two years by carrying out the raising (of the minimum measure). There are namely no signs that the lobster will in any manner disappear - it doesn't wander away, nor is it harvested in any other manner than by men. Marking experiments show that in the passing of a couple of years one will recover the greatest portion of the marked ones; there is no possibility of any great percentage of loss.

How high can the minimum measure be raised without doing any harm?

It is clear that there must be a limit that cannot be passed. Here is where the lobster fishermen's economy enters in. It is clearly shown that it doesn't pay to fish the lobsters until they are big enough to be of food value - also it doesn't pay to protect them until they are so big that they are no longer first class quality.

Bearing in mind that the lobsters' food costs nothing, and that by the marking experiments it is shown that no migrations take place, and that the overwhelming levy on the adult lobster stock is collected by man, then one must come to the conclusion that it is most economical to fish the lobster at the size that brings the most per individual. Meanwhile this holds true only so long as the lobster maintains an even growth - it won't pay to allow the lobster to go on for a number of years to gain the growth that a younger one will reach in a year - unless the increase is illimitable for food.

The worth of the lobster per kilogram is the greatest at a weight of 4-6 hectograms per individual - one can then at once take for granted that lobsters under this weight are worth less both per individual and per kilogram. This is also grounds for making a minimum measure which will assure a weight of 4 hectograms - that is 23-24 cm.

Marking experiments show that male lobsters between 22-26 cm. gain around 1.3 hectograms per year - females, however, about .6 hg. These data show that the minimum size can be raised without fear to 23-24 cm. About half will be caught again within a year with a gain in weight of about 1 hectogram, also prime quality. Those caught later will be slightly larger than the finest size, but here their gain in growth will surely outweigh their decreased quality. It would be only exceptionally that they would gain a size that would mean a markdown in price (over 1 kilogram).

Without directly increasing the yield of the stock by greater weight, the raising of the minimum measure will work indirectly in that the size between the present minimum measure 21 cm. and 23 to 24 cm. amounts to the important part of the spawning stock. If you spare this part for propagation, an overwhelming good will come of it.

Restrictions on seed lobsters stand in a little different light. Since the greater part of the seed lobsters are first quality, one makes considerable sacrifice in preserving the stock by this restriction. The right for (taking) such a step is this - that a lobster's value in reproducing its kind becomes greater the closer it approaches the hatching time - it has avoided all peril and has made use of the greater part of its increase in nourishment for the development of the eggs.

It is clear that a restriction on lobsters that are ready to spawn will mean both a direct and indirect gain to the stock. It is true enough that catching lobsters ready to spawn is unimportant (in number) with regards to other lobsters. Lobsters spawn as a rule only every other year, but the stock of seed lobsters in the ocean surely is also small, yet restrictions established will for all that have great meaning in comparison.

A wider development of thought about the restrictions on seed lobsters is the protection of the eggs and the hatched out young - now not against persecution by man but against all the perils that arise in nature. This leads us over to lobster culture in a sense, to the hatching and rearing.

In spite of (the fact) that the lobster fishery's yearly yield is not as great by far as the (yield of) most of our edible species of fish, the lobster is still counted as a very valuable animal.

This is on account of the aforementioned restrictions - or regulating of the catch whereby it is possible for the fisherman to harvest the stock in a very short time - less than a month. Next the lobster fisheries are unfailing (perennial) - that is, something the fishermen can depend on. That is the reason that the interest in preserving the stock and advancement has been so great, and has among other things, led to a lot of investigations concerning the hatching and rearing of the lobster young.

Similar experiments have been carried out in this land surely as far back as 60 years in the previous century.

It was soon seen that there was no trouble to get lobsters to hatch their eggs in captivity; you could find the newly-hatched young in an ordinary lobster trap. In 1883 it was also my father's good fortune to hatch out the eggs after they had been freed from the mother lobster. But to get the young to grow up - there was the difficulty. Part of the young ate each other; others died of disease.

I shall not go into all the experiments, here, that have been carried on - if they have not succeeded most of them have certainly been contributory in clarifying the difficulties and have made possible the way forward. It isn't the positive results alone that have worth - but also the negative.

It is no trouble to get the lobsters' eggs hatched, one can let the lobster hatch its own eggs in captivity, a thing which is done every year where the lobster is held on hand in the summer months, or one can heave the lobster into the sea where it can hatch in freedom. If it is just the hatching of the lobster eggs you wish, surely the last method is both the best and the cheapest even if the State paid full price for the lobster. It is not in a person's ability to do it better than the lobster itself. It carries the eggs under its tail for nearly a year, here they are taken care of, they get fresh sea water and here they are held free from filth. In that respect the lobster stands high over our usual edible fish - these lay their eggs before they are fertilized and leave them to nature's caprice. But also the number of eggs spawned among the salt-water fish is 100 times as great (or around that figure) as among the lobsters.

It is well enough to let the lobster lay its eggs in the lobster pound (or trap) but the net profit is very little (more). It is easy, in the first place, for lobsters in the close quarters of the pound to lose their eggs. In the second place the lobsters have the inclination to eat their own young. This has among other things been recorded by advisor Sund in his work on lobster-raising at Korshavn.

It will be clear from what has been brought forth that if one shall be able to help the stock by preserving the many germs of life, then the preservation must take aim at the larval stage. We must begin where the mother animal quits.

It will be known that the lobster goes through a larval-development. When it comes out of the egg it looks more like a shrimp than a lobster. The characteristic feature is that at this stage appendages on the body-feet serve as tools for swimming, and at this stage also they are able to swim around freely in the water. After the passage of a few days the young lobster shifts its shell, stretches itself out, grows, and gets a new shell. It has then come up to its second larval stage. At the same time that it shifts its shell it undergoes a metamorphosis, the tail feet begin to grow forth and the claws become larger. The swimming feet however are now insignificant. This development is continued further until we come over to the 3d stage, swimming feet are further reduced, the claws become comparatively large and heavy, and the tail-fan now begins to develop.

When they reach the 4th stage the larval development is over - the young lobster now has taken on the adult lobster's appearance.

During the larval development and also for the first two days after it has come to the 4th stage, the lobster can swim to and fro up in the water for a short while at a time. In general, one must say that the lobster larvae are superior in adjusting themselves and they live on and between the stones and seaweed on the ocean's bottom.

That the lobster for a short time in its existence has the ability to float has a great meaning in nature's plan of expansion - otherwise the lobster is more stationary. That it has the ability also to swim around after the larval development is passed is also very fortunate, since the lobster-young are better equipped to search out favorable living conditions. In the space of a day or two it hunts another of its kind on the sea bottom - it lives by preference in the bottom, in that it digs itself into the sand and hides itself under stone and shell. As it is greatly cannibalistic, another extraordinarily large advantage is that the young can disperse itself. When the lobster is to be raised (by man) through a longer period over the larval stage one must have one youngster in each compartment. If you have more than one in the same compartment the end result will be exactly the same. In no time there will be only one left.

We shall now see how the lobster young are raised at Flødevigen.

In the last of June or the first of July they brought in seed lobsters from the large pounds at Lillesand. There they buy only lobsters with eggs that are far advanced in development; one can see the young in the egg.

The seed lobsters are transported to Fløddevigen under observation with the customary precautionary measures and are placed there in the hatching boxes, one in each room (compartment). If one tried to put two in each room the result would be worse than if you had only one. The lobster's quarrelsome disposition keeps it always on the war-path.

These hatching boxes are the same as are used in cod hatching illustration - see fig. 7-8

Here the lobster also hatches the eggs, the youngsters float up to the surface and are drawn down by the current into boxes provided with a silk net in the bottom to hold back the youngsters. There is meaning in the young being hurriedly separated from the mother animal - otherwise they would be eaten up.

From these silk netted boxes the young are taken up with a small landing-net, as long as one works experimentally it is then important to control the results. If one goes over to mass-raising then you cannot practice - one must then use a more time-saving method - even if isn't so exact.

To reach more favorable results in the raising there are three things one must be sure of:

1. Fresh running water
2. Cleanliness
3. Adequate food.

Minus even one of these things the following will quickly show itself.

If you do not know the reason for this increase in the death-rate, then an examination of the dead young will as a rule give the answer. A lot of cannibalism is blamed as a rule on unfavorable food - or else too little. Too much food will be shown by a greatly stretched ventricle - little digestible food difficult to digest, for example cooked egg yolk, will not go from the ventricle into the intestine. It will cause constipation. Wear and tear on the young (chiefly on the rostrum and legs) means there was too strong a stream or the apparatus wasn't smooth enough. If the young are infested with bacteria and protozoa, then that is a sign that it (apparatus) lacks cleanliness, etc.

The rearing apparatus' construction appears in fig. 9. The principle is that water is led into the box in different places as though one brought forth a weak rotary stream with a horizontal axis. This is of essential importance for the young that gather near the stream's axis will sink down into the flowing water. Rotating the water around a vertical axis, therefore - as in the American rearing apparatus - will form a death-trap at the base of the axis where the young will swirl around in a whirlpool and be destroyed.

The overflow of the box goes over the edge through strainers of perforated celluloid; these must be made just so big and the outlets are placed so that the youngsters will not be pressed against the flat surface of the strainers.

With the spreading out of the water that takes place when you employ more inlets and outlets it is possible to make use of a lot of water without making the stream embarrassingly strong. This rich change of water has a meaning for the prosperous development of the young - and makes it easier of course to clean it (apparatus). Excrement, bits of food, and the moulted shells of the lobster young naturally contaminate the water greatly. A part of this will follow the water-stream out, another part will stick to the strainers' sides in front of the outlets where it can easily be dislodged with a brush. A third part will keep rotating a shorter or longer time in the water along with the lobster larvae and becomes a steady fountain (breeding ground) for all kinds of wretchedness. That part is removed by means of very fine air bubbles that come in by the water entrance, these air-bubbles fasten themselves on to all minute particles and bring them up like a scum to the surface where they are easily removed. This method is extraordinarily effective and of great meaning but - if one introduces too much air then the young ones will rise, too.

Every other day the young ones are automatically forced through a large opening into a reservoir while the rearing pools are scrubbed and washed down. Then they are automatically sent back again. The food question has long been very difficult. First the food must be to the lobster young's taste; it must be nourishing and digestible, it must have a consistence so that it can be administered and it must at all times be fresh and enough to go around. The inner parts of the crab are very good, but when the crabs disappeared from the Skagerak coast a couple of years ago one had to hunt some other sources of supply. An experiment with ox liver (it was used before for salmon and brook trout young) gave very good results. It is finely ground, mixed with sea water, and strained into the rearing apparatus, about five grams per 1000 lobster young every two hours throughout the 24. The youngest of the young get their food through a fine screen - the older ones through a coarse one.

In addition to these things the water's temperature and salinity of course play a big part. Salt water of reduced salinity is poisonous to lobsters - both young and old. A low temperature will arrest the development - a high one will speed it up - but if we attain the 20°'s, then there is danger. With the usual summer temperature the larval development takes about three weeks.

The results of the rearing (work) in later years have become increasingly better - and what's more, if there have been any mortality or mishaps the reasons have been found and could be corrected. And when the methods now are proved out in detail, I think the questions about large scale rearing of lobster young are cleared up. It is possible to get the young to live and the work and the cost of it will not be too frightening - if the rearing is based on a large scale.

The results of the rearings in the summer of 1927 was a profit of from 28-35 per cent young in the 4th stage in the experiment that was carried through by this method. About 22,000 lobsters in the 4th stage were planted. In 1928, 50,187 young were raised to the 4th stage = 34 per cent of the young used.

So far have we now come, but we still have to find out how to transplant the lobster young so the work can be of advantage to a large stretch of coast - and find the best places where the young can be released.

The last question will be a hard one to clear up - and also the things that go with it: possibilities for showing a gain in the stock. It takes practically five to seven years before a young lobster becomes "measurable" and shows itself in the statistics, and then, too, a single year's class in all probability will not show itself in a uniformly-sized group. On account of this long time (5-7 years) the variation in growth will be very large. We have no direct means for deciding on a lobster's age.

If one could only look ahead (for it becomes hard to follow the youngsters further) and point out what influences the hatching out has on the stock, then one could not (must not) let these questions drop out of sight. But at the same time one must remember that if he wants to share in nature's household, then he must not work with trifles. Nature, herself, works in large numbers.

ILLUSTRATIONS

FIG. 1. Percentage of marked lobsters recaught in each age group
· count = count of marked lobsters
(- -) = female
(---) = male
FIG. 2. Lobsters' weight in proportion to size
FIG. 3. Lobsters' increase in length and weight per year for different sizes.
FIG. 4. A lobster's growth in freedom at Fl⌀devigen (Possibly incorrect 1919-20 - cm.)
FIG. 5. Three shells of a lobster held in captivity.

Dannevig, Alf

1929a Beretning om virksomheten ved Fl/devigens utklekningsanstalt for 1927-1928. Aarsberetning ved. Norges Fiskerier 1928, nr. 1, pp. 118-123, illus.

Report on the work of Fl/devigen hatchery for 1927-1928

Rearing of lobster young

The experiments with the rearing of lobster young, which took place during the revenue year, are described in Norges Fiskerier, 1927, No. 1, and in Report on Norwegian Fishery and Marine Investigations, Vol. III, No. 9. The results of the experiments were generally satisfactory, the apparatus functioned well, and the new experiments with different food for the brood led to solution of this question. Ox liver proved very satisfactory; it can be supplied in sufficient quantity, it is easy to handle, and the young thrive on a liver diet.

During the season about 24,000 newly hatched lobster young were liberated due to lack of space, and about 21,300 were released in the bottom stage.

Dannevig, Alf

1929b Hummeropdretning sommeren 1928. Aarsberetning ved. Norges Fiskerier 1928, nr. 1, pp. 124-128, illus.

Rearing of lobster during the summer 1928

On June 28 a total of 200 spawn lobsters were purchased from a storehouse at Agerøen. The lobsters were placed in the hatching boxes the same day, but the hatching proceeded slowly. We did not get young enough to begin collecting until July 10; up to that day the newly hatched young were released into the sea.

On July 13 the night watch started and therefore also the ordinary work.

As in the preceding season we have used ox liver and crabs, the latter proves to be the best, as it prevents the cannibalism better than the ox liver. The supply of crabs has been sufficient during the last half of the season, but the price has been high, so that a crab diet is rather expensive.

The apparatus have functioned well; the large rearing apparatus of concrete is, however, rather difficult to work with, and when we again are going to buy new apparatus, we shall go back to the somewhat smaller wooden boxes - but somewhat larger than the present wooden boxes.

The cement apparatus was this year given a coat of black varnish; this seemed to be good, as the young did not show much wear and tear. But at the end of the season also the black varnish started to come off just like the other painting which had been used before. The difficulty in getting the right painting to take away the roughness of the cement is one of the reasons why we are going back to wooden apparatus.

As far as the place has allowed it, we have this year kept the young for several days after they reached the 4th stage, so that they can recover after the moulting and cease the pelagic period at the beginning of this stage. The duration of this decidedly pelagic period varies; this question will be further investigated.

This year there has been observed on the spawn lobster some "red spawn" - dead eggs; the worm Histriobdella, mentioned by adviser Sund, was also generally to be found.

The suctorie Ephelota gemmipara, which troubled us very much two years ago, was very scarce.

The sea temperature was very low - a lower average temperature for July has never been observed by the Torungen lighthouse near by; observations were started here in 1874. The low temperature delays the hatching of the eggs and prolongs the rearing period.

The water's salinity has been relatively high.

The newly hatched young, which could not be used for rearing, have been released in Haavesanden at Tromøen; the reared young lobsters were released outside of Hisøen.

A summary of the year's work shows that the results are far better than those of preceding years.

200 spawn lobsters are used for rearing:

July 2 - August 24 gathered in all	222,629	young
Released in the sea immediately because of lack of space	74,030	"
Left for rearing	148,599	"
Thereof reared to 4th stage	50,187	" 34 per cent
Liberated in the sea in other stages, especially 3d	6,826	

Exp. 1, (App. 1)

7/10-11	In	5,790	young
7/27	Out	1,561	3d stage to exp. 2

Exp. 2, (App. 1)

7/12-13	In	5,360	young
7/27	Transferred from exp. 1	1,561	3ds from exp. 1
7/30-8/5	Released	2,688	4ths = 24% for exp. 1 and 2
8/5	Transferred to exp. 3	801	3ds to exp. 3

Exp. 3 (App. 2)

7/13-15	In	6,375	young
8/5	Transferred from exp 2	801	3ds from exp. 2
7/31-8/6	Released	2,900	4ths = 45%
8/6	Transferred to exp. 4	1,032	3ds to exp. 4

Exp. 4 (App. 2)

7/16-17	In	6,750	young
8/6	Transferred from exp. 4	1,032	3ds from exp.4
8/2-7	Released	3,030	4ths = 45%
8/7	Transferred to exp. 5	1,300	3ds to exp. 5

Exp. 5 (App. 3)

7/17-19	In	19,900	young
8/7	Transferred from exp. 4	1,300	3ds from exp. 4
8/4-8	Released	7,150	4ths = 36%
8/8	Transferred to exp. 6	1,057	3ds to exp. 6

Exp. 6 (App. 4)

[Exp. 6 on 8/9 transferred to App. 3]

7/20-25	In	60,470	young
8/8	Transferred from exp. 5	1,057	3ds
8/6-14	Released	21,005	4ths = about 34%
8/14	Transferred to exp. 7	487	3ds to exp. 7

Exp. 7 (App. 1)

7/27	In	5,500	young
8/14	Transferred from exp. 6	487	3ds
8/13-17	Released	2,380	4ths = about 43%
8/18	Let out the rest	186	3ds

Exp. 8 (App.1)

8/5-6	In	5,100	young
8/20-23	Released	2,449	4ths = about 48%
8/23	Transferred to exp. 9	336	3ds to exp. 9

Exp. 9 (App.2)

8/6	In	6,000	young
8/23	Transferred from exp. 8	336	3ds
8/21-25	Released	3,165	4ths = about 53%
8/25	Released	225	3ds

Exp.10 (App.2)

8/7-8	In	8,600	young
8/22-25	Released	3,820	4ths = about 44%
8/25	Released	890	3ds

Exp.11 (App.4)
[On 8/15 Exp. 11 transferred from App. 4 to App.3]

8/9-24	In	18,754	young
8/24-25	Released	1,600	4ths
8/25	Released	5,525	1st, 2d and 3ds

Dannevig, Alf
1930 Beretning om virksomheten ved Flødevigens utklekningsanstalt for terminen 1928-1929. Aarsberetning ved. Norges Fiskerier 1929, nr. 1, pp. 103-107

Report on the work at Flødevigen hatchery 1928-1929

Rearing of lobsters

On June 28 a total of 200 spawn lobsters were purchased from Agerøen, but they did not start to hatch enough so that the rearing could begin, until July 10. The temperature of the sea water was relatively low at that time.

A specific report is included in Norges Fiskerier for 1928. A summary shows the results. (See Dannevig 1929b)

As you will see the result of the rearing was very satisfactory.

The temperature of the sea water was constantly low, but it appeared that this had no especial harmful effect on the rearing attempts in themselves. But the development proceeded slowly, so that we did not have time to treat such great quantities as would have been possible under other circumstances.

Dannevig, Alf
1932 Beretning om virksomheten ved Fløidevigens utklekningsanstalt for terminen 1929-1930. Aarsberetning ved. Norges Fiskerier 1930, nr. 1, pp. 101-119, illus.

Report of the work at Flødevigen hatchery for the period 1929-1930

1. Rearing of lobster

On July 6 a total of 185 spawn lobsters was purchased from Aakerøy. They weighed together 97 kilograms of an average of 0.53 each. The details with regard to the gathering of newly hatched young, collection of young in the bottom-stage, together with the temperature and the degree of salinity of the sea water, will be seen from the Table in the back of the report. (p. 118) The usual working with the night watch started July 19. A summary shows the following:

Gathered July 9 - August 28	abt.	232,169 young
Liberated in the sea due to lack of space	"	76,525
Left for rearing	"	155,644
Reared to 4th stage	"	46,200
Liberated in other stages, especially 3d		1,144

This gives about 30 per cent in the 4th stage - a result a little smaller than the preceding year which gave about 34 per cent.

The different experiments developed as follows:

Experiment I (Apparatus I)

July 9-13	In	11,060	young
" 22-30	Released	2,308	in 4th stage, e.g. about 21 per cent
" 30	Transferred to Exp. 2	302	in 3d stage

Experiment 2 (Apparatus I)

July 14-15	In	11,208	young
" 30	Transferred from Exp. I	302	in 3d stage
" 29-Aug. 1	Let out	5,540	in 4th stage, e.g. about 49 per cent
Aug. 1	Transferred to Exp. 3	600	in 3d stage

Experiment 3 (Apparatus 2)

July 16-17	In	10,800 young
Aug. 1	Transferred from Exp. 1	600 3d stages
July 29-Aug. 1	Let out	3,935 4th stages = about 36%
Aug. 3	Transferred to Exp. 4	415 3ds

Experiment 4 (Apparatus 2)

July 17-18	In	8,230 young
Aug. 3	Transferred from Exp. 3	415 3ds
Aug. 1-4	Let out	3,900 4th stages = about 48%
Aug. 4	Transferred to Exp. 5	308 3ds

Experiment 5 (Apparatus 3)

July 18-19	In	18,350 young
Aug. 4	Transferred from Exp. 4	308 3ds
Aug. 1-7	Let out	5,708 4ths = abt. 31%
Aug. 7	Let out	568 3ds

Experiment 6 (Apparatus 4)

July 19-22	In	60,010 young
Aug. 5-16	Let out	15,328 4ths = about 26%
Aug. 16	Let out	51 3ds

Experiment 7 (Apparatus 1)

Aug. 1-2	In	10,710 young
Aug. 19-23	Let out	3,010 4ths = abt. 29%
Aug. 23	Transferred to Exp. 8	244 3ds

Experiment 8 (Apparatus 1)

Aug. 2-4	In	7,285 young
Aug. 23	Transferred from Exp. 7	244 3ds
Aug. 20-26	Let out	3,660 4ths = abt. 50%
Aug. 26	Transferred to Exp. 9	186 3ds

Experiment 9 (Apparatus 2)

Aug. 5-28	In	10,919 young
	Transferred from Exp. 8	186 3ds
Aug. 21-31	Let out	2,811 4ths = abt. 26%
Aug. 31	Let out	525 1st, 2d & 3ds

When we except the first experiment which was conducted under partly unfavorable conditions due to lacking care at night, etc., the rearing percentage varies between about 26 and 50 per cent. Apparatus IV with its large number of about 60 thousand brood always gives a worse result than the others. This apparatus is somewhat too large and is made of concrete which proves to be unfortunate - at least the way it is made now. The temperature conditions were generally favorable, but the great decrease in temperature from 17.7 degrees (C.) on July 20 to 13.8 degrees (C.) on July 25 was followed by some mortality in the rearing apparatus. The young lobsters which had just moulted, have probably had difficulties in getting new shells at the low temperature.

Crabs and ox liver are used for food.

The newly hatched young lobsters are released inside Merdø and between Gjesøen and Haave; the reared ones are liberated on the coast between Havsøen and Jerkholmen, and a part at Store Torungen, e.g. in the immediate neighborhood of the rearing station.

Dannevig, Alf
1933a Beretning fra Flødevigens utklekningsanstalt for terminen 1930-1931. Aarsberetning ved. Norges Fiskerier 1931 (1933), nr. 1, pp. 105-110, illus.

Report from Flødevigen hatchery for the period 1930/1931

1. Lobster

My concern with the rearing of lobster started in 1916 when I took over the management of the apparatus at Korshavn in Vest-Agder, which was built after the American pattern by counselor O. Sund.

Neither Sund's nor my own efforts led to the goal, and since that time also the Americans have abandoned their own method.

In 1918 we started small experiments at Flødevigen; these were gradually extended so far as the results made them possible.

The results of the last years' work are as follows:

Year	Fry gathered	Reared to 4th	Per cent in 4th
1924	83,320	13,086	16.7
1925	120,213	8,020	10.3
1926	76,521	1,215	1.9
1927	178,705	21,380	13.8
1928	222,629	50,187	33.8
1929	232,169	46,200	29.7

The percentage in the 4th stage is calculated on the basis of the number of young lobsters used in the experiments. A part of the newly hatched brood had to be liberated in the sea because of the lack of space.

As you will see, the number of newly hatched young lobsters has increased all the time; there are no difficulties in getting a sufficient quantity of young. When we except 1926, when the whole work was discontinued because of an infection in our salt water basin, the number of young in the "bottom" stage has also increased considerably during the last years. The profit has generally been good in some of the apparatus since 1924, but on the other hand additional attempts at improvement have failed. These more or less unsuccessful experiments have, of course, reduced the percentage of the profit.

When the new building takes place, the apparatus will be made in accordance with the best experimental apparatus, only somewhat larger.

The available number of young in the "bottom" stage has been about 50,000 the last two years; this number could not be much increased with the present experimental apparatus. The latter had finished its task; now we have to go one step further and try to increase the supply of lobsters in the sea; but for this purpose a larger apparatus was required, which would be capable of producing considerably more young. In anticipation of a grant for a new apparatus, the rearing of lobsters was therefore suspended during the summer 1930.

The marking experiments mentioned in earlier reports have been continued on a small scale, chiefly for the purpose of studying specific questions concerning the biology of the lobster. Similar to earlier years statistics have been gathered concerning the catch of certain lobster fishermen in the district Mandal-Kragerö. This first-hand statistical information will probably be of great importance for the study of the variations of the lobster fishery. It ought to be extended to the entire lobster district.

Dannevig, Alf
1933b   Fl∅devigens utklekningsanstalt 1882-1932. Aarsberetning ved. Norges Fiskerier, 1932 (1933), nr. 4, 41 p. illus.

(Translated by Arden Nilsen, Whitefield, Me.)

Fl∅devigen hatchery 1882-1932

V Lobsters pp. 31-36

Already in the construction of the yearly report for 1884, we find the successful experiment in question, with regards to the hatching of separated lobster spawn. This is so much more worth remarkable because at that time they thought that the external eggs of the lobster had a physiological connection with the mother animal and could not be separated from her without arresting their development.

One opinion, which Professor G. O. Sars gave expression to: "You may well try Dannevig ('s advice), but I do not think it will work."

In 1885, they managed to hatch many thousand young lobsters in this manner and they were fortunate also in raising a lot of them through the larval stage; certain ones were kept until they were 56 days old and their habits recorded.

They had a great deal of trouble raising them on account of cannibalism; one youngster ate the other right along.

For the remaining, they established a systematic experiment to find the best living conditions. In that way it was revealed that crabs were better than whiting for feeding.

The apparatus is described, and it (also, in addition) gives a guide for those who would like to hatch out the young lobsters and raise them. What has been said here (in the report of 1881) will benefit men to notice to this very day.

It was especially the question of hatching that interested my father - he thought that the eggs laid in the spring should be taken from the lobster before it was exported. When the young had been hatched and returned to the ocean that showed a distinct advantage over exporting with lobster and eggs together.

Economic difficulties, however, hindered the continuation of the work in great measure until 1892, when the hatching and rearing was resumed in the new (political) set-up.

The work continues in order to find the best living conditions for the lobster young; it establishes, for one thing, which salinity is best,--and what influence the temperature has on their development. The work proceeds very well, but may well be entirely suspended since Fl⌀devigen has no authorization to do it. The work with lobster culture is apportioned to Stavanger under the leadership of Dr. Appell⌀f, of the Bergen museum.

In 1914, the present director of Fl⌀devigen received a request from the Director of Fisheries, to take over the lobster culture here in this country. At this time it is the rearing that is important. After a great many unsuccessful experiences with an apparatus after the American pattern, it (American apparatus) had to be abandoned. Instead they continued with difficult laboratory experiments to find out the best living conditions and the best methods. After an infinity of experiments, more or less unsuccessful, the problem was cleared up, little by little. The difficulties were:- to furnish quickly adequate circulation of seawater without injuring the young; to get the apparatus cleaned; and to furnish the proper food.

In 1922, they established a workable method. The main idea was that the stream (of sea water) was introduced into the apparatus in such a way that the water rotated around a horizontal axis. In this manner the young which gathered in the center in the calm area (doldrums) little by little would sink into the rotating stream of water. With the American apparatus the stream rotated around a vertical axis, with the result that the young gathered at the bottom, near the axis, where it was easy for them to be injured. The cleaning of the apparatus goes on now practically automatically and is more effective. It was ill luck that showed us the way. During the experiments at one time it was found that the sea water became very warm in the reservoir. To correct this,we sent the water directly into the apparatus where the pump leads in. On account of the strong suction in the pump, the water bubbled fast in the intake, almost like a seltzer (effervesced)--the result was that all the small air bubbles fastened themselves on to the young lobsters. They then floated up to the surface, and in the lapse of just a few minutes the youngsters died. So far it was indeed a tragic outcome but they got the idea for an automatic cleansing of the water. Now, also, they put effervescing water into the apparatus, but the air bubbles are so small that they only take minute particles to the surface, and the lobster young are left in peace. All the impurities and broken food gather on the surface and can be skimmed off.

The above procedure long dodged the difficulties. It showed that crab was good food, immediately;- then crabs disappeared from the shores of Skagerak. New experiments had to be tried, and so they found that beef liver was a workable substitute, so now we have two means of supplying food for the young. Since they eat every other hour it takes a lot to feed them.

The latest experiment has shown that we can raise about every third young lobster through the development of the larvae to the bottom stage. In case the expenses are reasonable it must be considered to be a fully satisfactory method. In this experimental apparatus we have managed to bring forth nearly 50,000 young to the bottom stage in one season.

In the present year there was built a new apparatus intended to double (increase) production five times.

The great question now is whether one can show the results of releasing them into the water,-(whether there's an increase in lobster stock). It will be a comparatively long job for it takes about five years for the young to show up in the lobster nets, and before that time (until then) one has no survey over how numerous the lobster young are in the sea. And it takes about seven years before they are grown and counted in the statistics.

As the years go by there is brought forth a good deal of investigation concerning the full grown lobster, with the distinct aim to study its wanderings. This question has a great practical purpose, namely, when it is necessary to establish a suitable minimum measure.

People are not like this at all:--that they are willing to spare the small lobsters which they think will drift away and next year be caught in another district! These investigations, carried out, show, just like the earlier findings of Dr. Malm (?) and Professor Appellöf, that the lobster is remarkably stationary, the majority of them are fished up where they were liberated in the ocean.

Among a lot of fishermen there is the opinion that the lobster is a "migrating fish" which comes in from the ocean in large schools. In any other way they can not explain how they can continue fishing lobster in the same grounds, every single year: - they fish each year as long as they think there is a single lobster to be taken.

The thing is (in the meantime) however, that just a few of the lobsters creep into the nets, especially those which have just shed their shells, and lobsters with old shells creep into the nets especially when the temperature rises strongly in the spring,-- that's when they are hungry. As long as the water is cold the lobster needs a minimum of food.

This conduct:--that all lobsters do not as willingly creep into the nets results in a condition that there is always stock left behind, even if men fish ever so intensely. If this were not the case, the lobster fishery wouldn't have held out as well as it has.

To study these questions, they worked at lobster fishing every month the whole year through, in one big salt water basin where beforehand we had slipped in a lot of full grown lobsters. In spite of knowing there were lobsters there,--we didn't catch a single one the whole winter through. As soon as the water became warm, we got a lot right after they had shed their shells,--all through the summer. Simultaneous experiments in nature (under natural conditions) showed the same results.

Illustrations:

p. 32 -	Fig.	15	Rearing apparatus, model 1923
p. 33 -	"	16	Lobster young in the first four stages. In the 4th stage the young go down to the bottom
p. 34 -	"	17	Lobster with eggs (attached externally)
p. 34 -	"	18	Lobster young about seven months old, length 36 mm.
p. 35 -	"	19	Interior of the new construction for lobster raising. The floor surface in the rearing room is 19x17 meters.
p. 36 -	"	20	Chart of lobster fishing in the basin.

Hummerns Fishlachet = fishability of lobsters [ha! do you know what I mean? it was the extent that they allow themselves to be caught]

The number of lobsters per catch of 10 nets (on the average) in breeding basin.

○ Fish uncaught
▮ number with new shells
☰ " without new shells
--- the average temperature in the basin per week

Dannevig, Alf
1934 Beretning for Flødevigens utklekningsanstalt for terminen 1931/1932. Aarsberetning ved. Norges Fiskerier 1932 - nr. 1, pp. 96-98

Report for Flødevigen hatchery for 1931/1932

Lobster

In anticipation of the new apparatus, for which means had been granted by the Storting (Parliament), there was no hatching of lobsters during the summer 1931. In the course of the year the building has been finished and the new apparatus installed. The building is 21.18 x 7.68 meters, on one floor. It is built of timber raised on end with inside and outside plates (planks). The roof is made of corrugated plates. The floor is entirely made of cement.

Besides three old hatching boxes with a total of six effective apparatus, two new ones have been installed, each with 10 apparatus. Twenty-six apparatus are now at our disposal for the rearing of lobsters. The new ones are considerably larger than the old ones, so that the capacity of the whole station is about five times greater.

The apparatus are placed in a large room in the southern part of the building. In the northern end there is an engine room where a new pump and motor have been installed. The motor is of 17.6 kilowatt and the pump gives about 270 tons of water per hour with pressure and lifting capacity of about 11 meters. We also have the old pump which gives about 60 tons per hour. A room near the engine is set aside for refrigerator for the lobster food.

Statistics are still being gathered concerning the catch of some lobster fishermen. This is preparatory work for later investigations as to the utility of releasing lobster spawn in different localities. The statistics gathered also give good information in other respects - and as soon as the economic conditions make it possible, we should gather similar material for the entire lobster district.

Dannevig, Alf
1936a Beretning for Flødevigens utklekningsanstalt 1 juli 1932 - 30 juni 1933. Aarsberetning ved. Norges Fiskeries 1933 (1936) nr. 1, pp. 58-60.

Report for Flødevigen hatchery July 1, 1932 - June 30, 1933

Rearing of lobsters

During the spring of 1932 we finished our new rearing apparatus for lobsters and the experiments started in the month of July. The supply of ovigerous lobsters was very scarce; by July 2 we had only 215 lobsters in spite of our inquiries at all lobster store houses between Farsund and Aakerøy. The lobsters had very little spawn that year. On August 2 we got 25 more lobsters with a few eggs ready for hatching. The eggs are easily scratched off the lobster when it is kept in confinement.

Between July 13 and August 15 about 70,000 young lobsters were gathered. Of this quantity about 20,500 were reared to the "bottom" stage. These were liberated near the hatchery.

Because of the lack of help the newly hatched young were not fully counted, so that the total percentage of reared lobsters cannot be given, but some control experiments gave between 21 and 31 per cent in the "bottom" stage.

The new hatchery (apparatus) functioned very satisfactorily.

Dannevig, Alf
1936b Hummer og Hummerkultur. Fiskeridirektoratets Skrifter, Serie Havundersøkelser (Rept. Norwegian Fishery and Marine Investigations) vol. 4, no. 12, 60 p., illus.

Lobster and lobster culture
Chapter "Previous Investigations", p. 19, at the bottom

In the late eighties my father performed considerable work to solve the questions concerning the hatching and rearing of lobster young. (G.M.Dannevig: Report on the Work at the Hatchery for Sea-water Fish, Arendal 1885. And Annual Report for 1892 for the Arendal's and Vicinity's Branch of the Association for Promotion of the Norwegian Fisheries). In 1883 he succeeded in hatching spawn which he had taken from the mother lobster - and he proved in this way that there is no physiological connection between the eggs and the mother. During his work with the rearing of the young he made clear by means of experiments some of the necessities of the young lobsters if they shall thrive. He showed for instance how a low degree of salinity kills the young, how heavily the development depends upon the temperature, which food was best for the lobster larvae and so forth. He also succeeded in rearing the lobster larvae to the bottom stage, but on account of the cannibalism of the young lobsters, the rearing could not be conducted on a larger scale.

In 1893 the lobster work in this country was taken over by Dr. Appelløf. He made many observations concerning the biology of the lobster. He studied the growth of the lobster and introduced a new tagging system in order to study the migrations of the lobster. Further he introduced an American method for the rearing of the brood. (Appelløf 1909).

On the basis of Appelløf's investigations there was decided in 1912 to start rearing of lobster young. This work was taken over by Assistant of Fisheries, Oscar Sund, who established a floating rearing station for lobster young at Korshavn in Vest-Agder. This was built according to an American system, the same which was tried by Appelløf. Sund worked with this apparatus in 1913 and 1914. See O. Sund: Report on the Building of the State's Rearing Station for Lobster and on the Work 1913, in AARSBERETNING BED KOMMENDE NORGES FISKERIER, No. 2, 1914, and The State's Rearing Station for Lobster in AARSBERETNING VEDKOMMENDE NORGES FISKERIER, No. 2, 1915. The results of the experiments fell short of the expectations.

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. . . .

When the metamorphosis of the young lobster ends with the transition to the 4th stage, it also changes its appearance. A young lobster in the 4th stage is easily recognized among a swarm of lobsters in earlier stages, because it has then acquired the elegant lobster shape. While the young lobsters earlier have been somewhat bent with the claws hanging down, the body is now straightened out completely and the claws are stretched forward.

At the beginning the newly hatched young lobsters swim around in the water - in an aimless fashion. They are eagerly searching for food and grasp all floating particles. If they do not find anything suitable, they eat each other. After a few days they become somewhat heavier and are apt to gather at the bottom of the aquarium. But after having changed their shells - which normally takes place after four or six days with us - they once more swim easily around in the water. The same thing is repeated after the two next changings of shells.

Also in the 4th stage they are good swimmers at the beginning in spite of the fact that they have lost their swimming setae; they now swim by means of well developed pleopods. In the course of a few days they get heavier again and start attching themselves to the walls and the bottom of the aquarium. While the earlier stages seem to thrive in a relatively brisk turbulence, which reminds of the sucking motion of the waves between the rocks out in the sea, the 4th stage lobsters prefer a very slow current; they bury themselves under stones or shells. This step of the development is therefore called the bottom stage.

The time required for development up to the 4th stage is - as shown by my father - dependent upon the temperature of the sea water. At a normal summer temperature on the Skagerak coast - about 16-18 degrees C. and otherwise favorable conditions, the development takes about 14 days.

From now on the young lobsters lead a hidden life; they practically do not appear in the aquarium in daylight. This tendency to live a hidden life is the reason why we do not know these stages from nature. When we liberate lobsters in the bottom stage into the shoal regions, it is remarkable how quickly they hide between algae and rocks.

The young lobsters live this hidden life both in the aquarium and in nature until they reach a length of about seven centimeters. When they have reached this size, they more often "go for a walk," esp. in twilight, and when they are about 10 cm. long, the fishermen catch them with their tools, esp. the hoop nets.

I have found out that it is best to study the lobster in nature during the dark, quiet August nights. During the day it is hard to find the lobster because it is hidden, but during the night, especially in the summer time, it might be found in large numbers in shallow water by means of a good light. Lately I have used an electric lantern which I have lowered into the sea. When the light first falls on the lobster, it keeps quiet and is not disturbed, so that one might easily make observations. If the light gets too sharp, it usually starts to move, and generally toward the place where it hides. In this way one might find these caves only by rowing after the lobster. One might also find the caves directly, as the bottom outside is kept clean from algae, etc. Very often we see part of the claws or the antennae sticking out.

I have also had an opportunity to see how the lobsters build their houses. Partly they dig them out like caves; partly they gather small stones for material. But as a rule they live in crevices or under big rocks. The lobster's tendency to live in caves continues all its life, as far as I can understand.

. . . .

Ibid, chapter "Food", p. 25

We do not know what kind of food the youngest lobsters eat in nature, but in confinement they thrive excellently on different foods. I have the impression that the young lobsters during the first period seize everything of adequate size; if it is not food, they let the thing go again. They eat living crustacea with great appetite, and preferably their own brothers and sisters. These cannibalistic tendencies continue all their lives. The young lobsters thrive excellently on crabs and ox liver.

. . . .

As mentioned before the appetite of the lobster is small when the water is cold. The need for food and the appetite increase with the temperature. Another factor which decides the appetite is the shedding of the shells. In this period the lobster lives on its own resources. The body absorbs water and gets thin. I have not analyzed these conditions, but by weighing the lobster immediately before and after the change of shells, we found out that the soft lobster is about 100 per cent heavier than the soft parts before the change. I can mention one example from our experiments. The weight is put down in grams.

No.	Sex	Weight 9-25-34	Changed	Weight of Shell	Weight of soft parts before-after change of shell		Weight 10-26-34	Weight 2-18-35
14	Female	335	15/10	120	215	390	390	423
15	"	410	16/10	160	250	480	470	500
16	"	285	10/10	90	195	340	340	362
29	Male	320	10/10	100	220	430	440	460
Total		1350		470	880	1640	1640	1745

Ibid, chapter "Growth" (p. 27), transl. p. 28.

. . . .
. . . .

The growth of the young lobsters we know only from reared individuals; and one has to be careful in transferring these results to conditions in nature; however, the main trends should be obtained by carefully conducted experiments. The young lobsters at Fl⁄devigen reach a length of about 30 mm. in the first growing period and about 60 mm. in the second; some individuals are much longer and some much shorter than the figures mentioned. At Port Erin - the biological station on the Isle of Man - an experiment was recently made by which 72 out of 99 young lobsters were brought up to an age of 11 months at the same time. The growth is about the same as with us, perhaps somewhat larger. In this experiment it appeared that the moulting was practically limited to the time when the temperature was above 10 degrees C. (W. C. Smith: A Lobster Rearing Experiment contributing some Addition to Knowledge of the Early Life History of Homarus Vulgaris).

. . . .

Ibid, chapter "Lobster Culture", p. 41.

With regard to the question whether it is necessary - or desirable - to protect or increase the lobster population, there are many things to take into consideration. First and foremost is whether the lobster is our own - or whether we have to share it with other nations. Whether the population is dense enough along our coast or whether this can house more lobsters. And whether we have the adequate means to regulate the population. The possibilities of sale are usually relatively good for the lobster, - we do not have to fear over-production.

The question whether the lobster is ours - or whether we have to share it with other nations - is clear in this case; the lobster, large and small, which is to be found along the Norwegian coast, belongs to us. We might even say that each district has its own population.

The second question, whether our coast has an adequate population or whether it reasonably can house more lobsters under such conditions that they thrive and grow, can only be answered at a rough estimate. It is obvious that the density of lobster must have been much larger about 100 years ago than it is now. A larger human population, more tools, good vessels with motors have certainly multiplied the intensity of the fishery - while the profit has not been multiplied even if we include the extra-ordinarily large catch of lobster during the last years. Even if it is impossible to give quite dependable figures with regard to the lobster population at an earlier time and now, there is no doubt that the population earlier was much denser along our coast and that it could be much denser than it is now. This might be said even if we count on the relatively dense population we have had the last few years. We have both space and food enough.

We must not depend too much upon the increase during the last few years. We may always get such rich years, even if the population is small. A single lobster hatches so many young that it is possible for only a few spawn lobsters to produce young enough for a large population, if more young lobsters than normally grow up. But this happens very seldom. The normal condition, is and must be, that of the thousands of eggs which a female lobster hatches, only a few reach puberty; and it is the steady, annual profit which carries the economy of the lobster fishery. This profit will be affected if the population of hatching lobsters is kept low.

With the present population we have reason to believe that the average annual increase in number of lobsters will depend on - and will be approximately proportional to - the supply of brood. If we shall increase the lobster population, we must increase the supply of brood.

We can obtain an increase in the number of spawning lobsters by protection of the egg-bearing lobster or by raising the minimum measurements.

The first method is easily understood - and is approved of by the fishermen. It is, however, difficult to carry out. The egg-bearing lobster is very valuable and to throw this out will cause a heavy economic loss; also the law might easily be evaded by scraping the spawn off the lobster.

By raising the minimum measurements we save both the male and the female young lobsters. The present minimum length is 21 centimeters, and as we know that the female lobsters normally are not capable of propagation until they have reached a size of 22-24 cm., it is obvious that we would get considerably more spawning lobsters by raising the minimum measurement - especially as our measurements show that the largest quantity of the catch consists of just the smallest individuals. We would get a larger population of spawning lobsters, and also the lobster would obtain a higher weight per individual - and thereby increase in value.

Table 2 shows the distribution (per 1000) in proportion to the size.

Length in cm.	Jomfruland		
	Number	Weight Kilogr. %	etc. (see Table, p.42)

The question is whether the higher weight and the larger number of spawning lobster will compensate for the loss which the fishermen would suffer by throwing back lobsters with an increased minimum measurement of, for instance, 1 cm. Our tagging experiments show that within a year we recatch about 44 per cent in number. This corresponds to about 60 per cent in weight. But after a while we recatch part of the lobsters which we did not recatch the first year and so on. An example will illustrate this condition, but first we shall find out how many lobsters of the catch are between 21 and 22 cm. - and what weight percentage these have of the whole catch.

If we increase the minimum measurement we have to throw out 28 per cent of the number, e.g. 21 per cent of the weight in the waters around Jomfruland. At Arendal the figures are respectively

34 and 27 per cent, and in Halse and Harkmark 33 and 26 per cent. This will be the reduction which the fishermen will have to take the first season after the increase in the minimum measurement. Likewise the second year, but this year he will recatch 44 per cent in number - or 60 per cent in weight of what he threw out the preceding year. The third year he must again throw out lobsters between 21 and 22 cm., but now he will recatch 44 per cent of the number he threw out the preceding year plus part of what he threw out the first year, and this part has now grown considerably.

By means of tagging and measuring the growth we are in this way able to figure out how a fisherman's catch will be affected by an increase of the minimum measurement to 22 cm.

Table 3 shows a fisherman's catch before and 1 to 3 years after the increase of the minimum measurement from 21 to 22 cm. The figures are based on an annual catch of 1000 lobsters prior to the increase.

	Jomfruland		
	Number	Weight in Kilogram	etc
Present catch with min. measurement 21 cm......			
First year with min. measurement 22 cm......			
Second year etc.			

(See Table, p. 43)

Table 4 is a revision of Table 3. This shows directly the loss in weight which a fisherman will suffer by an increase in the minimum measurement from 21 to 22 cm. with a presupposed annual catch of 1000 lobsters before the increase.

(See Table at the bottom of p. 43)

You will see from Tables 3 and 4 that the loss will be considerable, especially the first year when it will vary between 21 and 27 per cent in weight.

The fishermen will get a full catch already in the third year. I wish to state that these calculations are totally based on the average results which we have obtained year after year. It is no rough estimate.

If we look at Table 1 b, p. 56, concerning the percentage of the recatch of the tagged lobster, we see that the sizes between 21 and 22 are just the ones mostly exposed to catching; here we can count on an annual recatch of 60 per cent instead of 44 per cent which we have used for the calculations. Our calculations are therefore completely on the safe side.

In order to demonstrate directly how much the fishermen recatch of the lobster they have thrown out, two experiments were made at Hidra in Vest-Agder in 1926 and 1927. Some tagged lobsters between 21-22 and between 22-23 cm. were liberated. The recatch as to number and weight is seen from Table 5. As we must expect, the results were somewhat different. In the first case we recaught less - in the second case much more than we let out. Because the tags disappear after a while, the figures given are minimum figures.

These direct experiments confirm the calculations; a few years after the increase in the minimum measurement, we shall have obtained an increase of the lobster population - including the number of spawning lobsters. And this without permanent expense for the fishermen.

On the other hand it is obvious that we cannot go on increasing the minimum measurement with one centimeter after another. Thereby we should certainly obtain a larger population, but too many of these would then belong to less valuable sizes; the natural death rate would become higher and the individual increase less. All this tells against a high minimum measurement. It is necessary to find the happy medium. All the material we have points at 21 cm. as too low a minimum; we should be able to increase it to 22 cm. without any risk what-so-ever.

Chapter The Annual Protection, p. 46

The purpose of the annual protection (closed season) which we have had since 1879, is to prevent fishing of lobsters which have just moulted, as these are of poor quality and less capable of living in confinement. It also prevents an extended fishing of the spawning lobster.

The obligatory protection period in the early summer will increase the number of spawning female lobsters, a prolongation in the fall will improve the quality in the districts which start the fishery in September and partly in October. Besides, a considerable prolongation of the protection period will affect neither the profit of the fishery nor the population. The lobster fishery proper takes about a month in each district. Whether the annual protection period is one or six months is of no consequence for the result of the catch.

Besides protecting the lobster during the time it is of poor quality, the annual protection is, in my opinion, of the greatest importance as a regulating factor. It regulates the fishery so that this will last only for a short time - but will be relatively profitable.

Besides increasing the number of brood by protecting the female lobsters, we can also obtain an increase in the lobster population by improving the possibilities of development for the eggs and the young.

The mother lobster carries the eggs during the whole development period - and there is no reason to believe that any hatching technique can produce more eggs for hatching than the mother can do herself - note, as long as it is permitted to live in freedom. But if the spawn lobster with eggs ready for hatching is sold for consumption - or for export - then it is of course an advantage for the population if the eggs are taken off the lobster, hatched, and the brood let free. In this country this "saving-work", as we might call it, has previously been practised by my father. He was the first to know that loosened eggs might be hatched successfully and he also designed apparatus for this purpose. But this work was discontinued. This work of his was not approved of by the authorities. His idea was taken up in Canada and New Foundland. The eggs of the lobsters, which were used in the canneries, were scraped off and hatched. However, the technique used there has been very inefficient. According to Mackay (1929) the result from 27½ million eggs at one station was only 100,000 three days old brood. Obviously enough, after such a result the work had to be stopped. It is not enough to carry on hatching only theoretically.

In this connection it might be of interest to mention that a large quantity of the spawn lobsters hatch their eggs in floating cars in the lobster storehouses. These are located in Vestlandet and in the western part of the Skagerak coast. Provided that the cars are so open that the young can get out in the sea quickly, the young will immediately be living under natural conditions.

Because some food remains fall out of the cars when the lobsters get their food, usually some small fish gather underneath, and the young which are released are therefore exposed to some decimation. These storehouses are no great source for the renewal of the population. Because of the density of the lobsters in the boxes is very high, they lose their external eggs, and the young which are not let out of the boxes are eaten by the grown up animals or by each other.

With reference to what is mentioned here we take it that hatching of loosened spawn is only justified as an action to save the doomed eggs. It would be just as good to let the spawn lobsters out in the sea again and let them hatch their eggs themselves. Which of these alternatives should be preferred is a matter of expense.

Chapter Rearing, p. 48

The purpose of the rearing is to care for the young during the entire larval-development, and to do this better than even nature herself. The reasoning is that the lobster's three youngest stages must be exposed to particularly great dangers in nature as they are pelagic to a large extent; they might easily be destroyed by the numerous swarms of fish which swim along the coast. However, when the lobster has reached the 4th stage of development, it gives up its free life after a few days. It becomes a real bottom animal with an outstanding ability to hide.

The significance of caring for the young lobsters during this critical period has been pointed out by authorities for ages; for instance Professor Ossian Sars has, as mentioned before, spoken for this work already in his thesis The postembryonic development of the lobster.

Much work has been done in different countries in order to find good methods for such a rearing. In 1883 my father succeeded in rearing some brood, but the method was not so successful that it could be used on a larger scale. Success was, however, obtained at Fl⌀devigen in 1923. It is now possible to rear the young lobsters to the bottom stage on such a large scale that there are possibilities of conducting the work economically. The technique is shortly as follows: (See Alf Dannevig: The Rearing of Lobster Larvae at Fl⌀devigen.)

In the early summer a few hundred egg-bearing lobsters are bought from the lobster storehouses. The lobsters are brought to the rearing station and placed in the hatching boxes. They have one room each. They get food according to their appetite, and fresh sea water is constantly streaming through the boxes. When the sea water reaches summer temperature, the lobsters start hatching their eggs. The current of water immediately carries the larvae away from the mother and down into some strainer boxes. They are taken up every morning and transferred to the rearing apparatus. These consist of square wooden boxes 1.28 x 1.45 meters and 0.96 meters deep. These boxes are built coherently in two series, 10 boxes in each row. We also have some older apparatus. In these boxes the larvae spend the next 3 to 4 weeks. They are fed every second hour, day and night, with finely ground, absolutely fresh ox liver; (the liver is kept in the refrigerator until it is given to the larvae). If the larvae are not fed regularly, they eat each other. Another thing which also prevents cannibalism is a relatively strong current. If there is not sufficient current in the aquarium, the larvae will gather together on the bottom and destroy each other as best they can. The circulation is brought about by the water which streams in. This is led in at the side of the aquarium near the bottom and causes the water to circulate around a horizontal axis. A great difficulty is the pollution of the water. Even if the water is constantly renewed, many food remains, shells after the shedding, excrements, etc., will be gathered. In order to remove these things, small air bubbles are forced into the hose leading to the apparatus. This happens twice per 24 hours. These air bubbles attach themselves to all polluting particles and cause the latter to rise to the surface. They are simply removed by means of a fine dip net. Also all the strainers for the outlets must be kept constantly clean.

In each of these aquaria it is possible to rear about 5,000 larvae to the bottom stage at a time; the percentage is dependent upon the number of larvae in the box, - the denser population, the smaller percentage. One might count on a profit of 20 to 40 per cent. The temperature and the degree of salinity of the sea water are of great importance. At Flødevigen we always take the sea water from a depth of four meters; this has always proved salt enough. As is known, the degree of saltness increases as we go deeper. On the other hand it appears that the temperature might fall so much that the development of the larvae is hampered and the death rate increases. This is due to the fact that the larvae which are in the process of changing shells, are hindered in their production of shell by the low temperature. We can avoid this difficulty by using a large water reservoir - but this is rather expensive.

When the larvae have reached the bottom stage they are very easy to recognize on account of their long claws which are stretched forward. They are then picked up, counted and transferred to clean aquaria where there is a very weak current. During the first time the larvae swim quickly around near the surface, but after having been fed for some days, they start settling down on the bottom and the sides of the aquarium. Now they are ready to be liberated in the sea.

The transportation is partly made in the same tubs, which are used for transportation of cod young; these are square wooden boxes 0.73 x 0.80 meters and 0.56 meters deep, in which is installed a somewhat smaller inner box with walls of wax cloth in order to protect against the rolling of the vessel, and with a fine screening mesh (cloth) in the bottom which makes the renewal of the water possible during the transportation. On longer trips, however, the transportation must take place in especially designed tubs with constantly circulating water - in accordance with the principle used in the rearing station. We have made two successful experiments with transportation as far as to the Oslofjord.

In this way the technical problems both as to the rearing and the transportation have been solved. The question is now to find out how economical the rearing might be done. This depends upon whether one has means for full production so that the possibilities of the rearing station can be fully utilized. The development shows the right tendency - we can now count on about five øre production expenses per individual in the bottom stage. There is reason to believe that it will be possible to reduce the expenses to a fraction of the figure mentioned. But we cannot expect it to happen in the near future. We need time and money to carry on the experiments.

At this time I do not want to make any predictions as to which results we might be able to obtain in the rearing of lobster. I would rather tell about our attempts at getting information about these things.

In the immediate neighborhood of the rearing station we release varying quantities of young without any definite purpose. We must simply have a place to liberate the young which we do not use for our experiments. But more and more we now chose certain isolated districts where the brood is released according to a definite purpose. In these places we get accurate information about the catch of the lobster fishery from year to year, partly together with measurement of both the regular and the small sized lobster. In this way we will gradually obtain some accurate information about these difficult problems. For the time being we must content ourselves by working further on the theoretical basis of the justification of the rearing, which I have mentioned before. Some people point out that it is impossible to know anything about the advantage of hatching and rearing. Here I do not agree; the more information we get, the closer we get to the solution of these difficult problems. By intensive work we shall certainly reach our aim.

Dannevig, Alf.
1937a Beretning for Flødevigens utklekningsanstalt 1 July 1933 - 30 June 1934. Aarsberetn. ved. Norges Fiskerier 1935 (1937), nr. 1, pp. 66-75, illus.

Report from Flødevigen hatchery from July 1, 1933 to June 30, 1934

Hatching work. Rearing of lobster.

On account of the high temperature of the sea water in the early summer of 1933 the lobsters hatched their eggs about a month earlier than normal. In spite of the fact that we were on the market to buy spawn lobsters at least 14 days earlier than usual, it was therefore impossible to buy a sufficient quantity of spawn lobsters.

We started the rearing on June 29 with a supply of 139 spawn lobsters (56 kilograms) of which only a very few had a normal amount of external eggs. The rearing therefore lasted only for a very short time in order to procure young for some experiments with our new apparatus for transportation of young lobsters. This is placed aft on the motor cutter (vessel), but in such a way that it might be easily removed when we do not need it.

The transportation apparatus consists of a wooden box with a cubic capacity of about 1.6 cu. meters divided into four rooms. These are comparatively long in the fore and aft direction of the cutter, but narrow in the other direction. This is to prevent too much agitation when the vessel rolls.

The necessary sea water is delivered from a centrifugal pump connected with the engine of the cutter. This is led into the transportation basin according to the same system which we have in the rearing apparatus. Besides supplying the young lobsters with fresh water it also provides the right motion in the boxes.

It appeared that the apparatus functioned excellently in the preliminary experiments while the vessel was lying at the pier;- there was no opportunity for a larger transportation because we lacked the sufficient number of young lobsters. Further, experiments were made by letting the young lobsters out by means of a rubber hose. This was used as a siphon and was so long that it was lowered to the bottom and dragged after the vessel. In this way the young lobsters went from the transportation tank directly down to the bottom. By experiment it was proved that the young lobsters were not injured by this method of release.

On July 22, 1933, about 2,500 young lobsters were in this way let out at Gjesösanden (Tromöy county).

Dannevig, Alf
1937 b Beretning fra Fløvigens utklekningsanstalt 1 juli 1934 til 30 juni 1935. Aarsberetning ved. Norges Fiskeries 1935, nr. 1, pp. 75-79.

Report on Fløvigen hatchery, July 1, 1934 to June 30, 1935

Hatching work. Rearing of lobsters.

Purchase of spawn lobsters started on June 9 and terminated on July 7. The supply was scarce and we did not get the number we wanted. A total of 307 spawn lobsters were purchased from which were gathered 248,790 young; 244,624 of these were used for rearing; 50,777, i.e. 20.8 per cent were reared to the 4th and 5th stages. Some were released in earlier stages.

To gather a sufficient number of brood for the planned transportations to the Oslofjord, some of the 4th stagers were kept in the aquaria so long that they changed shells once more and so entered the 5th stage. Two shipments of young lobsters were sent to the Oslofjord, i.e. on August 10 and 24. The first shipment was 17,000 young lobsters in the 4th and the 5th stage. The second time 7,500 in 4th and 5th stage plus 2,500 young in earlier stages were sent.

The transportation was without any mortality both times and the young lobsters were liberated at Gaasungene in good condition. The shipment to the Oslofjord was made on request of the "Association for Promotion of the Fishery in the Oslofjord inside of Drøbak." This association now tries to follow the development of lobster in this place.

On a trip westwards with the motorboat on August 13, about 2,700 4th stagers were brought to Dolfsvaagen at Randesund.

About 6,800 were released in Søndeledfjord, and 12,200 young lobsters were liberated in the waters at Arendal.

Dannevig, Alf
1939a Beretning for Flødevigens utkelkningsanstalt 1935-36 Aarsberetning ved. Norg. Fisk. 1936 (1939) nr. 1, pp. 76-79, illus.

Report from Flødevigen hatchery July 1, 1935 - June 30, 1936

Hatching work. Rearing of lobsters

The supply of spawn lobsters was very scarce. We had in due time tried to secure the necessary quantity, but it appeared that the lobster exporter in question could not nearly provide us with the necessary number in spite of the fact that we paid a very good price for the selected spawn lobsters. There might be several reasons why it was so hard to get a sufficient number of egg-bearing lobsters. One of the main causes was probably that the lobster eggs developed unusually early this year. We started to purchase by June 1 and obtained the first young in the middle of the month. On July 4 we had to stop the purchasing after having obtained only 163 spawn lobsters. The greater part of the eggs was then hatched.

The greatest difficulty we have to fight is to get a sufficient number of spawn lobsters which still have the main part of their eggs.

About 136,200 young lobsters were gathered, of which about 134,300 were used for rearing. Of these a little more than 26,300 were reared to the 4th and 5th stage - e.g. about 19.5 per cent. A few were released in earlier stages when the work stopped.

The young lobsters were this year distributed on three districts:

July 31:	I and at Framvaren near Farsund	about	7,500
Aug. 13:	At Skogsøy in Halse and Harkmark	"	10,500
" 26:	At Torungene	"	7,650

A few died in the transition period between the 4th and the 5th stage.

The transportation was very successful. The weather conditions were favorable and the water sufficiently saline. On account of the salinity of the water it is much easier to transport the young lobsters westward instead of eastward.

The first young lobsters which were hatched, about 1,900, were released in the oyster basin from June 18 to 21. On June 29 a young lobster in the 2d stage was caught. Also on July 2 a young lobster was noticed. On July 7 I noticed three young lobsters in the 4th stage swimming quickly around near the surface. They had a pronounced dark, somewhat bluish color and looked very strong. They attacked different things floating near the surface or a few centimeters below it. On July 8 three more young lobsters were seen. They were swimming near the surface with a peculiarly steady course and with a speed of about 10 meters per minute. On July 10 a lobster in the 4th stage was seen again, but then no more were noticed until the basin was emptied May 12-14, 1936. At that time 11 lobsters were found. The length was 6 to 8 centimeters. Nine of the young lobsters moulted in the course of one week. Three were released in the oyster basin again. The number of lobster caught again in the oyster basin must, however, not be considered as the correct number of lobsters which were there. It is very hard to find them in the mud which gathers on the bottom.

Dannevig, Alf.
1939b Beretning for Flødevigens utklekningsanstalt 1936-37 Aarsberetning ved. Norges Fiskerier 1937 (1939) nr. 1, pp. 70-75, illus.

Report from Flødevigen hatchery from July 1, 1936 to June 30, 1937

Rearing of lobster young

In the spring of 1936 we had, like many preceding years, difficulties in getting a sufficient number of lobsters with good eggs. In the fall it is not hard to get lobsters with large amounts of new external eggs, but as the spring and early summer pass by and the eggs develop, they increase in size and fall off easily. This happens especially to the lobsters in confinement. When we are informed by the lobster buyers that they have a relative large quantity of spawn lobsters in stock in the spring, and we go there to pick them out, it usually appears that the lobsters have lost a great deal of the spawn. If the water is warm, this may happen because the spawn has been hatched comparatively early, but at all events the hatching does not take place until the midsummer time.

In 1936 we started purchasing by May 28 and continued until July 8; we had then got a total number of 649 spawn lobsters with eggs ready for hatching. But the amount of eggs was very small on each lobster. In the hatching boxes where each lobster is by itself in a small room with sufficient renewal of the water, the lobsters have no opportunity to fight and to scratch the spawn off each other. Yet the amount of spawn still decreases. This may be due to the fact that the spawn is infected with a parasite, a "suctorie", Ephelota gemipara, which can barely be seen with the naked eye. If a great number of these develop, the eggs die, and the lobster scratches off the dead eggs, or they loosen by themselves. This parasite is to be found everywhere in the beach region. I have found it on newly caught lobsters, on beach crabs and on clams (mussels). But I have never noticed that it plays any part as a destroying factor in nature. I dare not say anything certain about this, however, but in the hatchery, where we notice it all the time during the summer, it has on certain occasions appeared in such great quantities that it has been an impediment to our work with the lobster hatching.

That it appears to be so numerous here, was hard for me to understand at first. But the first time I noticed this heavy development during the summer 1926, it appeared that we had a source of infection in the salt water reservoir from which the water was led to the lobster apparatus. When this source of infection, namely a colony of clams, had been removed and the reservoir had been scrubbed and washed, conditions improved. After that time we have not used the salt water reservoir for any experiment which could possibly contaminate the water, but still we had a new heavy development of the parasite during the summer 1936. The salt water basin was once more emptied and scrubbed and conditions improved somewhat. But the essential part of the young which were hatched early in the season, died on account of the infection. When we remember that during the rearing of the lobster 300 cubic meters of water per hour pass through our salt water reservoir, which is capable of about 2,000 cu. mtrs of water, then it is hard to understand that an infection from the sides and the bottom of the reservoir, which is overgrown with common salt water animals and seaweed, could be the cause of a mass development of parasites. It is also a big question whether this same parasite is the essential cause why the lobster loses its spawn in the lobster storerooms. The conditions there are very favorable for the development.

This parasite, which attaches itself to all possible solid things, feeds on the nutritive substances which follow the current of water, and the name parasite is therefore not quite correct. But it still has some harmful influence on the eggs or the larvae, although I cannot say how. In the following table I have summed up the number of young that we have obtained from the spawn lobsters. You will see that there are a few hundred per individual, while we should expect several thousands according to the number of spawn on a well egged lobster.

Number of brood per spawn lobster for the years 1920-1936:

Year	No. of Young	Year	No. of Young
1920	457	1928	1110
1921	412	1929	1253
1922	371	1932	260
1923	435	1933	151
1924	262	1934	811
1925	900	1935	835
1926	490	1936	164
1927	1110		

The question as to the reason why the lobster loses the external spawn, which is almost ready for hatching, is of rather great importance in judging what might be gained by a protection of the spawn lobster by storing it until the beginning of the closed season. The net profit by this procedure will undoubtedly be very small. Conditions are different in regard to protecting the spawn lobster in such a way that it is immediately released in the sea. As far as I can understand, the spawn lobster in this way keeps its eggs to a much larger extent than it does if it is kept in confinement. The question is also of great importance for the rearing work. We have to try to get more eggs from each lobster.

The rearing of lobsters started on June 17, but had to be discontinued in the middle of July in order to get the reservoir cleaned. Up to this time about 50,000 young lobsters had been gathered. Of these about 21,000 were liberated in the sea on July 17. Between July 18 and August 25, about 56,000 young lobsters were gathered. Of these a little more than 10,000 were released in the 4th and 5th stage, while the rest, about 2,000, were liberated in earlier stages. The rearing work proceeded normally. The best apparatus produced 37 per cent in the 4th stage. The reared lobster young were released at Kragerö.

Dannevig, Alf
1940 Beretning for Fl⌀devigens utklekningsanstalt 1937-38 Aarsberetning ved. Norges Fiskerier 1938 (1940) nr. 1 a, pp. 3-6, illus.

Report from Fl⌀devigen hatchery from July 1, 1937 to June 30, 1938

Rearing of lobsters

The purchase of spawn lobster started on June 7, 1937, and was finished on July 3. We had then bought a little more than 700 lobsters. The supply was, contrary to earlier years, very large, so that we could have obtained much more than we could use.

From June 25 to August 21 we got about	600,000	young
Of these the following were liberated at once due to lack of space	75,000	"
Left for further rearing, about	525,000	"
Of these, reared to 4th stage	62,500	"
Reared to 3d stage	4,000	"

You will see that the supply of young was quite good, but as we obtained the essential part of the hatching in the course of six days, between July 25 and 31, the hatchery was overloaded with young and the net result of the rearing was therefore not as great as it could have been. If we had had some more hatching boxes, the results would have been much larger.

This year there was a great number of spawn lobsters in Sörlandet (southern part of the country), and there was comparatively many eggs on the lobsters. We got about 1,000 young lobsters from each spawn lobster this year, a result which we regard as quite good. But also this year we had a good deal of the earlier mentioned parasite Ephelota; however, this was not so numerous that it had any harmful effect on the hatching work. The young lobsters were let out in the Kragerö district.

Dannevig, Gunder M.
1885 Beretning over Virksomheden ved. Udklaekningsanstalten for Saltvandsfisk, Arendals Bogtrykkeri 1885, 43 p.,illus.

Note: This article was not translated completely. A summary follows:

Work in hatching lobsters was begun in 1883. It was continued in 1884. Too high temperature led to poor results. In 1885, hatching was successful. Also some lobsters were reared. One of the big causes of death was cannibalism.

Dannevig does not believe that rearing has practical importance, for the expense is too great. He believes that the lobster eggs should be hatched and the young released when eight days old.

A description of the various stages, 1 - 5, is given and also instructions for hatching the eggs and rearing the young. The main requisites for successful lobster propagation are:

1. A continuous supply of fresh salt water.
2. One must secure mother lobsters in advance of the hatching time.
3. One must remove the eggs carefully from the seed lobsters with a spoon.
4. Feed the young every hour.
5. Give protection in the 5th stage (after 5th shedding).

Date	Living young	Dead				% Loss 24 hours	Water		Remarks
		Total	No. Injury	Tail eaten off	Head eaten off		Spec Grav	Temp R	

Dannevig, Gunder M.
1892 Aarsberetning fra Arendals og Omegns Filial af "Selskafet for de norske Fiskeriers Fremme". Aarsberetn. 1891 (1892) Selskabet for de norske Fiskeriers Fremme, pp. 1-7

Note: This article was not translated in its entirety. A summary follows:

Made one experiment in lobster rearing. It was a complete failure because of the unfortunate natural conditions. In July the temperature of the sea was 18°-20° C. The specific gravity was 0.014 which killed the lobster young.

Dannevig, Gunder M.
1893. Aarsberetning fra Arendals og Omègns Filial af "Selskabet for de norske Fiskeriers Fremme." Aarsberetning 1892 Selskabet for de norske Fiskeries Fremme, pp. 1-15, illus.

Note: This report has not been translated completely. It is concerned almost entirely with the hatching of lobster eggs and mentions the success attained in 1883.

Dannevig, Gunder M.
1911 Om mindstemaal og utklaekning av hummer. Aarsberetning ved. Norges Fiskerier for 1911, 2d hefte, pp. 313-331, illus.

Concerning minimum size and rearing of lobster

After the discussion of Dr. Appelløf's bill by the interested corporations and official representatives, I hereby present the lobster case for renewed discussion and beg to make some remarks.

First I would like to express my great admiration for the work which Dr. Appelløf has made in order to procure a sound basis for the knowledge of the lobster's life history. This work is of the greatest importance, also because Dr. Appelløf has been the only one who has devoted himself to a thorough investigation of the lobster in Norway. Before I start speaking of the proposition on a new law for the lobster fishery, I find it desirable to sum up shortly the main points of the conclusions about the lobster's natural history, on which Dr. Appelløf has based his bill and proposition that the state grant money for hatching.

The lobster carries the spawn under the tail for about a year, after which time the spawn is hatched. The young now swims around for 3-4 weeks and during this time it casts the skin three times. After the 3d change of shell, although not yet an inch long, it has acquired the body shape of the adult lobster and lives at the bottom. But how the young lobster arranges its life at the bottom and what it feeds on, is still a big question, because it has been almost impossible to catch young lobsters smaller than 15 centimeters long in spite of great efforts. However, this fact as well as observations made of lobster reared in confinement, show that the young lobster is even more afraid of light and more cautious than the adult lobster.

On the West coast the power of propagation begins when the lobster is 24-25 centimeters long; on the East coast already when it is 22-23 cm. long; in some cases we have even seen lobsters of 21 cm. with external eggs.

As to the lobster's migrations, our knowledge is only based on Dr. Appelløf's investigations as far as Norway is concerned; but all the facts we have indicate that the lobster is a stationary animal, as it is proved that it lives for years on the same shoal or at the same rock. Like all articulated (jointed) animals the lobster grows in another way than fish and mammals; the growth shows only every time the animal changes shell, at which time it suddenly increases in size. Dr. Appelløf has found that the lobster usually grows about $1\frac{1}{2}$ centimeters each time it changes shell. During the first five years it changes shell several times each year; later only once a year at the most. Through rearing experiments and measurements of the lobster before and after changes of shell it has been proved that the lobster on the West coast reaches the legal size when it is about nine years old; power of reproduction is reached when it is about 11 years old.

The encroachment of the fishery on the lobster population is very extensive. On the West coast, where the question has been most thoroughly studied, it appears that about one-fourth of the caught number are animals which had not reached the minimum size the preceding year. On the East coast this fact seems to be still more pronounced; although only few investigations have been made here, it seems that half of the numbers caught are 21-22 centimeters long, i.e. they had not reached the minimum size the year before. This is also proved by the fact that of 100 lobsters, which were tagged and put out at Kvitingsø, 40 individuals were recaught the following year and further 34 during the next four years.

The great encroachment of the fishery on the lobster population is best shown by the fact that 70 per cent of the caught animals have not yet reached the average size at which they are capable of propagation.

From what is mentioned above you will see that the knowledge of the lobster's conditions of life has been much extended by Dr. Appellöf's work. However, it is limited thereby that the lobster population and the fishery might be said to have been thoroughly studied only as far as the West coast is concerned.

. . . .
. . . .

Professor Appellöf's propositions for increasing the lobster population consist mainly of the following:

a) Gradual increase of the minimum size to 25 cm. in the course of nine years in order to obtain
   1) that all individuals get the opportunity of propagation at least once during their lifetime,
   2) a more valuable catch, as a lobster of 25 cm. weighs about twice as much as a lobster of 21 cm.
b) The same protection-period for the whole country
c) Further work with rearing of lobster to the bottom stage
d) Further arrangements to sharpen the control with the law.

The case was preliminarily discussed in the Council of Fisheries of last year; decision was put off in order to give the interested communities, corporations and authorities an opportunity to express their opinions. The different statements have now been gathered when we except those from Bergen and Søndre Bergenshus' county and sheriff.

The following Table gives a survey of the opinions as to items a) and b) in the proposition:

(See Table, p. 315)

. . . .

. . . .

(p. 317)

After having given the essential points in the material gathered, I should like to give my own opinion, and shall deal with the different items separately:

1. Increase of the minimum size

. . . . . .

2. Protection period.

. . . . . .

3. Artificial rearing of lobster. (Dannevig encourages the idea of artificial rearing of lobster. pp. 318-320 is a discussion as to who should be the manager, which method should be used, how many rearing stations should be built, choice of location, etc.)

. . . .

Subbilag 1. (Sub-enclosure 1). (p. 324)

To Arendal Fishery Association.

Relative to the letter from the Director of Fisheries, dated June 30 this year, concerning proposition for a new lobster law, I beg to make the following remarks:

If Professor Appelløf's theory, which is based on the official fishery statistics, and which maintains that the lobster population along our coast is rapidly increasing, were right, I would not recommend an extended protection. However, as mentioned in the Vestlandske Tidende of March 13 this year - a copy follows enclosed, the statistics are generally so full of big mistakes that it cannot be taken into consideration at all; thereby also the estimate and comments of the professor concerning the condition of the lobster-population become null and void.

For the same reason the statements given by the different county councils, fishery associations, etc., are without any value, because they are based on false assumptions, i.e., that the lobster population increases, while the fact in all probability is that it everywhere decreases, and in some places even has disappeared.

There is no reason why I should repeat what I said in Vestlandske Tidende concerning the statistics, but I shall only remark that the mistake consists of counting the same lobster stocks twice, first in the district where they were caught, and then in the town from which they were exported.

. . . .

. . . .

(p. 327)

Mr. Appelløf has, pp. 138-142, made very detailed calculations in order to show that a rearing to the 4th stage is much more profitable than a mass hatching and putting out of the newly hatched brood. He calculates:

1. Large scale hatching without rearing:

1 bag 5x5x3 ft. has a capacity of . .	1 million spawn
1 " 10x10x3 ft. " " " " . .	2 " "
20 such bags will make	1 hatchery
5 hatcheries would have a capacity of	200 million spawn
Hatched	90 per cent
i.e. newly hatched brood.	180 million young
Of 1000 brood there will grow up to a length of 8 inches	1 lobster
180 million brood will give	180 thousand lobsters
Expenses in working five hatcheries	9,000 kroners

These are Appelløf's calculations. His calculations are, however, wrong.

When a bag of 5 x 5 x 3 feet has a capacity of one million spawn, another bag of 10 x 10 x 3 feet will have a capacity of four million (not two million as given by Appelløf). The five hatcheries will therefore give 400 million spawn and hatch 360 million brood, which again will represent 360,000 lobsters which can be used for food, i.e. which are eight inches long.

2. Hatching and rearing:

The five hatcheries mentioned above will, for the same amount, 9,000 kroner deliver 750,000 brood in the 4th stage, i.e. about 1 inch long.

I cannot agree as to Professor Appelløf's theory that 750,000 young in the 4th stage are much more valuable than 360 million brood in the first stage, when these represent 360,000 grown-up lobsters. It takes seven years for the 750,000 to reach such a size that they can be used for food.

Neither do I agree with him when he, on p. 142, warns against hatching of lobster on a large scale. Even if his own wrong calculations are used as a basis, it would be excellent business for the state.

At a cost of kr. 9,000 we can get 180,000 lobsters, which can be used for food after the seven years which the lobster needs for its development. If the price of these lobsters is 1.00 kr. a piece, the annual profit would be about 300 per cent. If we correct Mr. Appellöf's calculations, the profit will be twice as big; every year we should have an income six times greater than the cost.

On pp. 140-141 Mr. Appellöf gives a calculation as to how much Flødevigen - compared to the apparatus recommended by him - can produce and what it would cost.

Here he makes new mistakes, which ought to be pointed out. He says for instance that my apparatus are 5 x 5 inches square and 4 inches high. Thereby he gives the impression that their cubic capacity is 5 x 5 x 4 = 100 cu. inches. This is quite wrong. The bottom is, as mentioned, 5 x 5 inches, but as the walls slant considerably, the upper edge of the apparatus is 12 x 12 inches, and the breadth in the middle is $8\frac{1}{2}$ x $8\frac{1}{2}$ x 9 = 650 cu. inches; this makes quite a difference.

Concerning the expenses in Flødevigen the professor finds that no calculations are necessary "as we know that the building-expenses as well as the working-expenses are many times higher at such a stationary hatchery, than they are at a temporary one of Mead's type." This is not so certain. Let us first look at the building-expenses:

. . . .
. . . .

(p. 330)

As it seems that also we are going to start hatching of lobster, a short survey of the history of this case might be of interest.

From the middle of the last century we have worked with hatching and rearing of lobster in this country, up to 1880 mainly in Stavanger.

One used the method of putting lobsters with outside spawn into boxes which were placed in the sea. The brood was partly hatched, but disappeared.

From 1880 on the Association for Promotion of Norwegian Fisheries continued the experiments up to 1891, but without any particular success.

Already in 1883 I got the idea that, if lobster-hatching should ever be carried out on a large scale, we had to get away from the method used up to this time, i.e. to keep the mother lobster in confinement while the eggs were hatched. Instead the spawn should be loosened from the mother lobster and hatched just like other fish spawn. The experiments were successful and already in 1885 it was proved that it was possible to hatch the loosened spawn and to rear the brood to the bottom stage.

The Fishery Association in Bergen acknowledged this fact in its letter of Oct. 7, 1891 to the government, but maintained that the method was too expensive and that they therefore had to draw the attention to the earlier experiments of the association. "These experiments have failed, but we do not have to give them up as hopeless." For continuation of these experiments by a zoologist, the association recommended to give an amount of kr. 2,000 to the Stavanger Branch; this was granted by the Storting.

And thereby Flødevigen dropped out as far as lobster-hatching is concerned.

In foreign countries the following has been done:

In 1885 I got several inquiries from the United States Fishery Association concerning rearing of lobster. I gave the information they wanted, and hatching of loosened lobster spawn was started immediately over there.

The work, which partly has given excellent results, has increased steadily. In 1909-1910, 163 million young lobsters were put out.

In 1889 I got a similar inquiry from the Canadian government concerning the method used by me in the hatching of lobster. Based on the information given, an excellent hatchery was built near Piktou (Pictou) in 1891.

Later four similar hatcheries have been built. In 1908, 501 million young lobsters were put out; three new hatcheries are now being built, so the result must have been satisfactory.

In 1888 the Newfoundland's Fishery Association adopted my method of hatching loosened spawn on an immense scale.

I have no information as to the results.

Scientific investigations have been continued in Norway. The results are to be found in Dr. Appelløf's book, which I have criticized above.

Flodevigen, Sept. 8, 1911 G.M.Dannevig

Ehrenbaum, E.
1903 Neuere Untersuchungen über den Hummer. Mitt. Dtsch. Seefischerei Ver., Bd. 19, no. 5, pp. 146-159, illus.

(Partial translation)

(p. 146)

Recent investigations on the lobster

Already in the 1899 annual set of "Mittheilungen" (p. 99), the Norwegian scientist, Dr. Appelløf, reported on the investigations which he has carried on for a series of years in the commission of the Selskab for de norske Fiskeriers fremme in Hvidingsø, near Stavanger, and which has the lobster as its subject. These studies have been continued since that time; and since their results have experienced an interesting supplement by means of some recent observations made at Helgoland, so, on account of this relationship, shall be described here shortly.

The Norwegian Captain Dannevig was, as is known, one of the first who succeeded in a primitive hatchery established for sea fish at Flødevigen, near Arendal, to incubate lobster eggs artificially and to hatch them.

Since then this artificial incubation is conducted on a large scale in Norway, the United States of America, in Canada and especially Newfoundland, and with very good success. In the bays of Newfoundland in many years 500 million and more newly-born young lobsters are put in the water.

But the newly-born lobsters--no matter whether they come into the world under natural conditions or in hatching boxes--are, as is known, exposed in huge numbers to danger, since they live in the first weeks of their lives, not as the grown lobster on the bottom, but in surface water layers and since they in this time fall victims to their numerous pursuers, owing to their bright colors and awkwardness. It is therefore of the greatest importance to bring the young lobsters under the protection of rearing over this critical period of their lives and one is troubled for ample time to study closely the young stages of the lobster in reference to their living conditions and needs in order to smooth the course of artificial rearing. From this aspect Appelløf's researches on the rearing of young lobsters are of especial interest to attain the fixed goal, although it must be conceded that one is still far distant from it, since too small a percentage of the larvae born in captivity succeed in living from the first young stage to the beginning of residence on the bottom.

The young lobsters are born at a body size of eight mm. or somewhat less and indeed they strip off at once as they leave the egg a delicate larval skin which envelopes all segments and their appendages so that they, with the first moult, enter the first larval stage. The age which this stage attains, that is, the interval of time which passes until the next or second molt, depends to a great degree upon the temperature. Already Dannevig has made observations concerning that. He found for a greater number of larvae that these had in nine days:

No moulting with water of 8-10 degrees C.
One shedding finished with water of 12 degrees C.
Second moult begun with water of 14 degrees C.
Second moulting finished with water of 16 to 22 degrees C.

Appellöf observed in his research an age of five days as the shortest time for the first larval stage, mostly, however, six to seven and sometimes also eight to nine days. For our research in the Helgoland aquarium, the first larval stage was completed in four to five days in July and August.

From the second moult, which most still pass rather smoothly, the second stage larvae then passes, distinguished from the first by means of the newly appeared swimming appendages on the ventral surface of the tail (second to fifth pair of abdominal feet). [see illustration on page 149] This stage is seven to twelve, mostly nine to ten days old according to Appellöf; according to our observations in Helgoland, on the other hand, not older than the first stage, namely also only three to five days.

The now following third moult which leads to the third stage requires again a heavy sacrifice in captivity as a rule. These are not able to free either the claws or the tail from the old shell and perish in spite of these efforts. Appellöf's research to discover the basis for it, has only shown so much that it is necessary above all things for the health of the larvae to keep their containers entirely free from collections of filth and to provide for a constant inflow of clear and pure water. However, indeed in spite of the use of the very greatest precautionary measures, Appellöf raised from 1500 second stage larvae, not more than 400 individuals in the third stage. The 3d stage is distinguished from the earlier stages by the appearance of the sixth pair of abdominal appendages, which takes part in the formation of the fan-shaped caudal fin. The length of this stage amounts to 12 to 14 mm. and will be, according to Appellöf's data with which our observations agree, about 10 days old.

The now following fourth moult which leads to the fourth stage requires again a heavy sacrifice. There, Appellöf saw 300 individuals perish from 400 larvae. The young lobsters are now at the end of their planktonic life and have a substantially changed appearance. First of all, the outer swimming appendages (exopodites) of the five pairs of walking feet, which enable the larvae to swim about freely in the water in a particular manner hitherto, have vanished in a single residue (cast off shell). On the other hand, the filamentous elongated antennae of the body have become visible. The body length is about 16 mm. Directly after the fourth moult the young lobsters still swim about for a short time, about two to three days, then however they seek the bottom and hide themselves as well as possible under stones which they only seldom leave in order to make some short swimming movements. The fourth stage is according to Appellöf 23 to 28 days old; in Helgoland we observed, in perhaps a dozen cases, that it was 17 days (25.8 to 11.9), in somewhat later season however (it was) also 25 days old.

Accordingly it followed from these observations on the speed with which the first sheddings followed themselves that the planktonic life of the larvae lasted at least 19 to 22 days -- thus around three weeks -- and at most four to five weeks. Since this period which is by far the most dangerous in the life of the lobster, in which the greatest reduction of stock occurs, so it is of great importance that it most quickly terminates; and for this, as one sees it, a high as possible water temperature is necessary. It is therefore not without meaning that at Helgoland where the average temperature of the sea water reaches its maximum in the second half of August (at 16.8 degrees C.) most of the lobsters are born in August and complete their planktonic stages during this month.

Moreover, it deserves to be emphasized that the greatest obstacle to the successful rearing of young lobsters is not the often unpleasant result of the shedding process but instead the cannibalistic tendency of the larvae to eat up each other reciprocally. All attempts to check this tendency have been futile. For if one offers the larvae also copious quantities of finely ground crab flesh, then to be sure they eat of it, but do not yet cease their habit of assailing their comrades. Not merely older larvae are dangerous to the younger, but also equal-aged ones fall upon each other and know to find with skill the susceptible place--the connection between carapace and tail! Appellöf observed that 20 to 30 fourth stage lobsters destroyed daily 50 to 80 first stage larvae and left hardly three to four of them remaining. Especially the fourth stage turned out to be particularly predaceous. The animals, usually for the first time, use the claws in this stage for attack while they used only the mouth parts in the earlier stages. The English scientist Cunningham expressed the opinion that the lobster larvae take principally no living food, neither in the free state nor in captivity, and that in the latter case it may be a certain sign that the larvae may be healthy no longer, if they become concerned with each other. Appellöf, to whom we must agree according to our experience, contested this quite decidedly. He has often seen that one larva swam about with another one half consumed, but still living; now they attack each other from the front, now from the rear, now diagonally; and also occasionally, if the attacked (ones) are successful in freeing themselves, then they are however mostly but so damaged that they subsequently perish. It may be observed that with the rearing in glass vessels the victims of cannibalism are less numerous than in the generally used wooden breeding troughs, but the real reason was not to be determined and other means for the restricting of this fatal cannibalism can also not be indicated.

There is not the slightest doubt that in natural conditions amounts of larvae hardly worth mentioning are destroyed, for here the principal reason for it is lacking: the thick crowding that is not allowed to hinder them with artificial rearing. In free nature such crowding must surely therefore be avoided since they soon attract enemies in great number and a thorough destruction of the swarms of larvae would be caused. Accumulations of such a kind are also prevented in nature in this way that not ever the offspring of a single female go into the water at the same time, since the hatching of a brood takes place so gradually that it usually occupies a full week. One also sees that the artificial rearing here finds itself at a disadvantage in relation to nature which they never will be able to compensate; just the enormous expanse which nature has at its disposal for the distribution of the larvae offers them the most essential expedient for the protection of the young lobster from all kinds of dangers. It is also not very likely that artificial lobster rearing will bring it to results worth mentioning as long as they, as it now happens, must content themselves therewith to put out directly into the open waters the newly-born larvae. It must be aspired to, on the contrary, to hold the larvae in safety until after the end of the fourth moult and then to put them out. If indeed many larvae until then have fallen victims to cannibalism and the perils of shedding, then it still has a much superior value when 1000 fourth stage larvae are put out than one million new-born. However here lies just the difficulty? It requires so large and numerous receptacles to keep thousands of lobsters living to the fourth stage that this appears hardly feasible in a hatchery and one must probably experiment (?) in a pool. Here however one meets new obstacles, as Appelløf's researches show, since there the animals withdraw themselves from control. Appelløf had the greatest difficulties in the lobster pound which was used by him for research, 1/ in which numerous

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1/ The lobster pound at Hvidingsø used by Appelløf in his research included five larger and smaller plots of land surrounded by water which are connected together by a wall. In the wall, two openings, covered with brass wire netting, are situated facing each other so that the current runs straight through the basin. Moreover, the water again flows back and forth through smaller, not controllable, perforations in the wall. The greatest depth of this basin amounts to two fathoms; the bottom is partly rock bottom with rich vegetation, part sand bottom with growths of eelgrass.

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young lobsters had been born, to find these (young lobsters) with nets. The first attempts aiming at that with gauze nets resulted entirely negatively; then it appeared that one could well catch lobster larvae in the twilight or the night, particularly in still water, however these were all in the first stage; and where particularly the older larvae dwelled, if they were present at all, could not be determined although they were also fished for in the depths. Unfortunately, the possibility must be reckoned with that the lobster larvae had escaped from the park into the neighboring open water which could not be absolutely prevented. On the other hand, it demonstrated that some small gadoids (coalfish and pollack), which entered the pound from the outside and had been caught in it, had eaten the lobster larvae almost without exception. It is therefore possible that the young larvae from the second stage on keep themselves in hiding not on the bottom to be sure, but yet in the neighborhood of it where of course they are hunted up by their pursuers, but are not available to the gauze nets. However it remains remarkable that Appellöf was not able to get ahold of the older lobster larvae although he succeeded in enticing and catching other and similar animals which also live in hiding with the help of sink nets and small traps especially constructed for this purpose which were baited and set on the bottom.

Also in Helgoland we have had the experience that the lobster larvae of the first stage were caught no doubt oftener--although also not frequently--in the season from mid-June to mid-September, older stages on the other hand not at all as well; only once the capture of a 13 mm. long third stage larvae was noted, on September 7. Therefore it proves also as impractical to determine according to Hensen's proposal, the size of the Helgoland lobster population by means of quantitative captures of larvae with the aid of vertical fishing plankton nets.

It is also clear that our knowledge of the juvenile history of the lobster still shows very many gaps. One has also never succeeded in capturing in the free state the first bottom stages of the lobster. However it is explained sufficiently from the minuteness and great versatility of these animals and from their preference for hiding under stones which are hardly accessible and which they unwillingly leave. One knows meanwhile their appearance and the rapidity of their growth from the rearing experiments.

(p. 152)

Gompel, M. and R. Legendre
1927 Effets de la temperature, de la salure et du pH sur les larves de homards. C. R. Soc. Biol., t. 47, pp. 1058-1060

Effects of temperature, salinity and pH on the larvae of lobsters

We have begun this summer, at the marine laboratory of the College of France at Concarneau, a series of researches relative to the effects of variations of many external environmental factors on the littoral animals.

One of these studies is carried out on the lobster larvae just after hatching.

One knows that the adult lobsters live on the bottom and that the females carry their eggs under the abdomen for nearly a year before they hatch. They draw closer to the shore at the moment of spawning which happens especially in July and August, at the time of the maximum surface water temperature. The hatching occurs in the evening (Fabre-Domergue and Biétrix) and the young larvae disperse, making for the upper layers where they swim actively during almost a month, up to after the fourth moult. Various authors (Herrick, Mead, Hadley, Havinga) have noted that the speed of development is greatly reduced when the temperature is lowered: for example, for the American lobster the first stage, which may last from one to five days at Woods Hole at 21 degrees, may be prolonged up to 25 days at Rhode Island in a water temperature of 15.5 degrees.

We have sought the limits of temperature, salinity and pH which are able to support the larvae of stages one and two caught with a fine net at the surface of a reservoir for lobsters.

The environments for the various temperatures are easily obtained by means of the constant temperature block of Cardot, Laugier and Legendre (C. R. de la Soc. de Biol., 1924, t. XCI, p. 331). Some larvae, happening to be caught, are introduced into a series of ten tubes, each containing 20 c.c. of sea water, placed in the block with constant temperatures graduated from 22 to 40 degrees.

The waters of various salinities are prepared by mixing sea water of 1025 density either with fresh water or with sea water concentrated up to 1060 by evaporation. One pours 50 c.c. of each mixture into a series of small crystallizing dishes where the densities graduate regularly from 1000 to 1060, and one introduces some larvae into each vessel.

The different pHs, from five to nine, are realized by the mixing of sea water (pH 8.2) and the same (sea water, that is) put into equilibrium with a nil tension of CO^2 (pH = 9) or with the same (sea water, that is) saturated with CO^2 (pH = 5), according to the technique indicated by one of us (Legendre. La concentration en ions hydrogène de l'eau de mer. Paris, 1925, p. 239).

Action of the temperature. --- The larvae, taken from water at 17 degrees, died in a few minutes at a temperature above 30 degrees. They resisted for a longer time between 30 and 26 degrees, but ended by dying. They live indefinitely in sea water below 24.5 to 25 degrees.

Action of salinity. --- In the brackish waters, the larvae coming from water at 1025 do not appear troubled until the density 1020. They die rapidly at densities lower than 1015. The limit of dilution that they are able to stand is in the neighborhood of 1017.5

In super saline waters the larvae stand a density of 1033. At 1042, they become immobile, but the same, after 20 minutes of immersion, resume their activities when one replaces them in normal water. At 1051, almost all die in less than 20 minutes; at 1060, all die in a few instants.

Action of pH. --- The larvae tolerate very well water brought to pH 9 by prolonged paddling with air deprived of CO^2; they bear equally well waters acidified by CO^2 to pH 6.4; about this point only they show temporary troubles: fall to botton, immobilized, from which they recover completely afterwards. At pH 6.2, they die in ten minutes; at pH 5.6 in four minutes; at pH 5.2 in one minute.

These experiments show that the lobster larvae, a little time after hatching, are sensitive to elevations of temperature and to decreases of salinity, insensitive to variations of pH which they may encounter in the marine environments where they develop.

The limits that we have determined appear to us to agree remarkably with the geographic extension of the species. One knows that the european lobster is found the length of the east coast of the Atlantic, from Norway to the Mediterranean. It extends to the north Tromsoe at 69 or 70 degrees north latitude but it is very rare, if not unknown at Iceland. One finds it in the North Sea but it does not penetrate into the Baltic. It becomes less frequent in the Mediterranean where it disappears from the Adriatic and from Tunis. The american species, very akin, is known from Labrador to Virginia where the surface water reaches just, in summer at the time of spawning, a maximum temperature of 24.4 degrees. It seems therefore that the geographic distribution of the larvae is limited in the north by temperatures too low for the normal development of the larvae; to the south, by a maximum temperature of 24 or 25 degrees on the surface near the coasts; in the interior seas, by the brackishness, whenever the density is lowered below 1020 or 1017.

Gagnon, A. and Jean-Louis Tremblay
1948 Station biologique du Saint-Laurent élevage des larves de homard. Année 1947. Rapp. Stat. Biol. St.-Laurent 1947 (1948). App. no. 3, pp. 49-54, illus.

In the course of the 1947 summer the biological station offered to repeat the larval lobster rearing as the preceding year. In fact, at the beginning of the 1946 season the work of fitting-up the rearing establishment was completed and allowed the carrying on of artificial lobster rearing. The method in fact has given good results and in 1947 the same method must be applied on a much greater scale, that is to say, to raise a number of larvae twice as great.

Purchase of berried females

The few twenty lobster traps of the biological station were not able to furnish required number of berried females for the purpose of rearing, we have had to purchase from the outside. Also, thanks to the cooperation of the fisheries inspectors, Mr. A.-J. Ahier of Anse-aux-Gascons and Mr. J.-A. Bourget of Anse-du-Cap, we have met the principal fishermen of the neighboring regions. These persons are bound to take care of, in traps prepared for that purpose, the captured egg-bearing females. At a set hour, we go to fetch them and bring them to Grande-Rivière. We have taken all the necessary precautions to take care of the females and the eggs in good condition while transporting them. And we have endeavored to reduce to a minimum the time that these females must pass out of water. For transportation in the truck, the females are placed in large pans and covered with seaweed. Upon return to the station, they are placed in the tank.

The 10th of July we have in captivity more than 200 female seed-lobsters; we have then discontinued the purchasing. However, at that date, more than 50 per cent of the egg-bearing females that were offered us bore a recent spawning. As for the others, they had already liberated many larvae.

Hatching boxes and rearing basins

The carrying on of rearing with a greater number of females necessitated a more spacious arrangement. Also, we have added two batteries of two rearing boxes to those of the last year, which is described in the report of 1946. Concerning the rearing basins, let us say from the first that a single type has been used in 1947, viz. the oval cement tank such as described in the report for the year 1945. The rearing establishment numbers at this time eight of these tanks. The four basins of recent construction keep the form of those already in operation in 1946, but the water inlets there have been shifted, they are situated in the upper two-thirds of the basin, and one at each end. This modification assures a better circulation and prevents at the same time the agglutination of the larvae, reducing by so much the cannibalism among them.

Water consumption and temperature

Each of the rearing basins consumes about 405 gallons of sea water an hour. This sea water is first warmed which has for its aim to accelerate the growth of young larvae. The thermographic recording shows us that our equipment of control of heat has functioned well; in fact, the temperature has been maintained at 19° C (66° F) close to (varying) 0.5°.

Cleansing of the rearing tanks and the hatching boxes

The temperature factor is very important but there is another thing that we have not neglected, it is cleanliness. Each day we have made in the rearing basins the preliminary cleansings consisting in the elimination of foreign bodies which settled there either on the bottom and walls or on the metal screening of the overflow. A more thorough clearing was made then at the change of one group of larvae from one box to another. In the hatching boxes, one was not able to clean also regularly in consequence of the presence of berried females. It may seem indeed that the too frequent manipulation of these lobsters hurts the eggs. Yet in the course of the hatching period we have three times performed the cleaning of each compartment. We have also benefitted in examining the berried females one by one and eliminating those whose larvae were released. The following Table indicates the number of females that we had at the beginning of rearing, the weekly mortality rate, as well as the number of females eliminated at each of the inventories. These last data also gives us information on the speed with which the larvae are liberated.

TABLE I

Berried females kept in captivity for rearing

Week	Inventory		Mortality	No. of females
	Date	No. females eliminated		
July 14	--	----	----	204
" 15-19	--	----	8	196
" 20-26	26	30	11	155
" 27-) Aug. 2)	--	----	9	146
" 3-9	6	99	----	47
" 10-16	--	----	----	47

Lobster culture working days

It is July 6 at 5.30 in the afternoon that we have observed the first larvae in the collector. It was only a precursory sign of their coming arrival for, during the week which followed, their number hardly exceeded 100; therefore we have bothered with them in the collectors. On July 12, the hatching began in earnest. The rearing station was then put into operation and it had to function without interruption up to August 15. This has been rendered possible thanks to the formation of three crews of two assistants who worked eight hour shifts.

Larvae hatched and employed in rearing

In the course of four and a half weeks of operation, we have gathered 96,062 larvae distributed into six groups, according to the date of their hatching.

TABLE 2

Grouping of the larvae used for rearing

Group	Date	Number of larvae
1	July 14-16	15,742
2	" 17-25	36,544
3	" 23-31	28,685
4	Aug. 1-4	9,273
5	" 5-8	3,396
6	" 8-13	2,422
	Total	96,062

One sees, according to the Table that the groups do not always include the same number of larvae and that the time of collection has not been the same for all the groups. It should have been preferable that the groups might be very homogeneous; but it has been impossible for us to fulfill this condition, being given the exceptional slowness of hatching (see curve, page 53).

It is to be noted that groups 1 and 2 have been lost as a result of a perforation, barely visible, of the metal screening of the basin holding those groups. Finally, only groups 3, 4, 5 and 6 have been conducted to a good end, therefore we shall consider only the latter ones

TABLE 3
Larvae released in the sea

Group	No. larvae hatched	No. larvae liberated	Stage
3	28,685	36	4
4	9,273	233	4
5	3,396	613	3
6	2,422	1,826	1 and 2

Liberation of the larvae

The 2,708 larvae which formed groups 3, 4, 5 and 6 have been liberated in the sea August 15, in front of Cap-Rouge, Grande Rivère in the same region where the biological station places its traps. Before their liberation, we have acclimated these larvae to the temperature of the sea water, then several degrees lower than that of our rearing basins. If we have terminated the rearing so abruptly, it is that at this date that hatching was ended and it should have been very costly to keep the rearing station in operation during the time that it should have taken the last larvae to reach the fourth stage.

Moulting

We have attentively observed the growth of the larvae in the rearing basins, particularly during their sheddings. Knowing to which group each larva belonged, we were able some days later to fix its age. It is thus that we have found that there must be eight days for the larva to pass from stage one to stage two, five days from stage two to stage three, and six days from stage three to stage four, viz. in all nineteen days. But that period will in reality be slightly shorter, as for zero time have we considered no exact date, but a period of two to three days. Thus the larvae of the first group had hatched between July 14 and 16 and we have considered all of them as hatched the 14th.

Feeding the larvae in captivity

We have fed the larvae with a beef liver soup, prepared by grinding the frozen liver. This liver was first passed through a meat grinder and then through a mixer (Waring blender) after which it had the appearance of a real emulsion. Every two hours one gave to each of the groups about 50 grams of this emulsion.

During the four and a half weeks of operation we have fed 261 livres (130.5 kilograms) of liver.

Probable causes of failure

Rearing conducted on a larger scale has presented new difficulties. The first cause of failure showed in the hatching. Transportation and manipulation, although fulfilled in the best possible conditions, seems to have caused the heavy mortality recorded among the females and particularly among the eggs. In the first place, we have credited to the existence of different environmental conditions; however we have discovered the deviation of temperature and salinity so minute in proportion to that of the reservoir water, that we do not believe that we ought to take it into account.

Observation may give us further information on the causes of failure. In particular, we have noticed that the majority of the egg bearing females did not aerate their eggs in the proper manner. This has been confirmed by the presence in the collectors of a great number of dead eggs.

Finally, we have observed that the young larvae were less vigorous than those of the preceding year. This fact had been observed in 1945, and one attributed it to "the exceptional duration of hatching" (up to August 15). In 1947 the hatching period is also prolonged to August 15. Must we see in that a relation with the strong fluctuations of temperature that we have recorded in the course of the season; that is strongly plausible. Finally, there is reason to charge the possible toxicity with the paint freshly put on the interior of the hatching boxes.

Géraud and De Kérillis
1895 Le laboratoire maritime de Dildo. Bull. des Peches Maritimes, Rev. Maritime et Coloniale, tome 76, Juillet, Paris, pp. 157-174, illus.

The Dildo Marine Laboratory

(p. 170)

We have also been able to see, and in all their details, the truly floating incubators, invented by Neilsen himself, which permitted the coastal industries to replace whenever they wish, by increasing the number of incubators in proportion to the lobsters destroyed on the spot in such great numbers by the intensive fisheries each year and by the waste which results from preparing the canned (lobsters) for export.

This incubator is composed of a white wood tank, oblong, of 1 m. 25 long by 0 m 30 wide and about 0 m 20 deep. The bottom is curved. The tank is equipped externally on a large part of each lateral face with two ailerons, not absolutely horizontal, but slightly curved spirally; they are also white wood. A line, fixed to the bottom of the outside, and attached at the other end to a heavy rock, permits the apparatus to be maintained easily in a specific coastal region. A vulcanized rubber tube makes communication from the sea water to that of the tank. In the angles the uprights are opened from top to bottom by a narrow pipe which assures the air circulation.

A metallic screen (galvanized iron) of fine mesh, is stretched horizontally for a few centimeters above the bottom. It supports the eggs, which, deposited there after fertilization, are going to hatch into the desired lobsters. On one of the small sides of the tank at the left extremity, a rectangular port is also formed by a fine metal screen of the same nature as the other.

The incubator is closed by a cover, like a coffin, and all is painted black on the exterior.

The water temperature of the tank is that of the sea water. The lobster eggs need darkness. The apparatus therefore places the egg under the usual conditions of its ordinary life; two rope handles, placed on each extremity, permit the removal and the balancing of the tank.

Thus furnished with all the gear, the incubator is worth three dollars. Six hundred exist in actual activity; it is few. There are in all the country 50 stations where they appear. It is an apparatus easy to make, little cost; we have just seen, very ingenious. It replaces advantageously the former metal tanks. It is wished for the posterity of the fishery that the use is spread more and more.

M. Neilsen recognizes that the fishermen show a certain eagerness to take advantage of this apparatus, whereas on the contrary they resist the use of applied science to the cod research, probably on account of the much greater expense.

Havinga, B.
1921 Rapport over de kreeftenvisscherij in Zeeland en de Kunstmatige kreeftenteelt. Mededeelingen en Verslagen van de Visscherijinspectie, no. 30, 51 p., illus.

Report on the Zeeland lobster fishery and artificial lobster rearing

(Translation by Louise Pinard Dekker in 1949)

Chapter III

The Artificial Propagation of Lobsters

In the preceding chapter we have seen that the young lobsters, just emerged from the eggs, differ widely from the adult ones in manner of living. They do not live on the bottom but in higher water strata, do engage in active swim movements but let themselves be swept along by even weakly streaming water. They are typical plankton organisms. In ordinary aquaria it is impossible to keep them alive.

It is plain that the dangers which threaten these larvae are exceptionally great.

In the first place must be listed the danger of destruction by all sorts of fish which are often found in large schools in the Ooster Schelde, like herring, anchovies, Belone acus and Mugil chelo. The young of the last named, which I kept in my aquaria many times, devoured in no time all the larvae which were put in the water. Other animals besides fish doubtless hunt down the practically helpless, noticeable larvae. Repeatedly specimens of Pleurobrachia pileus were thrown into the propagation tanks through the action of waves. More than once I found that they had swallowed larvae, which could be seen through their transparent bodies, often entirely undigested. Since this animal was numerous in 1919 it is very well possible that many larvae were destroyed this way also in open water. In addition the current must be a source of danger to the larvae as they are transported to areas where living conditions are unfavorable to them. Thus it is no wonder that of the numerous larvae but a small percentage manage to grow into a marketable lobster. Based upon his studies Herrick found that in all probability from every 30,000, and certainly from every 10,000 newly born larvae not more than two attained market size. Meek even concluded for the English lobster that only one in 38,000 reached that point. 1/

1/ In this connection attention is again called to the fresh-water crayfish which periodically lays 100 to 250 eggs. Their young are however, as to development, to be compared with sea-lobster in the fourth stage and, during the first days, continue to find protection under the abdomen of the mother. If one may fairly compare the biological values of the sea and fresh-water crayfish, then about 200 young of the last named would be equal to about 20,000 larvae of the first-named variety.

Once the larvae cease their planktonic manner of living and move to the bottom of the water the dangers become much less. The change takes place during the beginning of the fourth stage, after they are from 11 to 20 days old, depending upon circumstances.

This change does not take place suddenly, larvae in the fourth stage may swim around often even as high as possible along the surface. In the rearing tanks too they move about continually but the circumstances there cannot be compared with those in nature especially in the absence of all protective cover. When one transplants these young, fourth stage, lobsters from the tanks to the aquarium where the bottom is covered with stones and weeds it is not long until they reach the bottom and work themselves under the weeds. After a day or two they are so well hidden that it becomes a rarity to see one walking about in the daytime.

I take this initial swimming about to be in the nature of orientation, a natural instinct which can be very useful when the larvae, during the transposition to the bottom stage, have landed in terrain which offers unfavorable living conditions. If the change were sudden and the young lobsters could not swim during a considerable period at the beginning of the fourth stage, a great number of them would succumb on bottom formations unfit for them.

This swimming around is not so much a searching for prey since one may often observe the young swimming while clinging to a morsel of food. Generally food is not gripped with the claws which are held straight forward.

It will be clear from the preceding that free swimming larvae are exposed to the greatest dangers and that this period is the most critical in their development. It would therefore be most desirable if one could keep the larvae in suitable nurseries during these 10 or 12 days and to free them at the end of the planktonic period.

This has always been the goal which the numerous students engaged in the artificial lobster propagation have set for themselves.

It has been previously pointed out (in Chapter I) that the production of lobsters in Zeeland has steadily increased during later years, in most countries however, where the lobster has for a long time been the object of intensive fishing one has been seriously concerned with the decline shown in this branch of the industry. Measures toward the protection of seed and small lobsters did not prove to be sufficient to halt the decline and one was forced to explore other, possibly more successful means toward this end. Therefore attempts have been made over a long period of time in Norway and North America to grow lobsters from eggs. As already mentioned the number of eggs is very large, 20,000 or more in the case of a lobster of medium size. It soon became apparent that it was not at all difficult to hatch eggs which had been scraped off the mother animals. In 1891, 2000 kronen were appropriated in Norway for the construction of a plant toward this purpose and in 1892 this plant was in use. Some of these little islands so numerous on the Norwegian coast near Kvitingsö were connected by means of walls so that a closed basin was created. In a few places in these walls openings were left and screened off to allow for changing the water but these openings were later closed when it was proven that sufficient change took place through existing holes elsewhere.

In 1892, 450 and in 1893, 400 lobsters were placed in this basin. Of the first 450 only 130 were later captured since the walls were not tight and the balance of the animals escaped. With a plankton net larvae were taken, never however in the bottom stage. The method then was not useful in practice and crates were made 90 cm. high and 65 cm. wide of which the walls were to a great extent screened. These crates, lashed together, were permitted to float in the sea and of the 8000 larvae which comprised the capacity of each crate 5 to 7 per cent were secured in the fourth stage of development. Although this method as well proved to be useless in practice since the percentage was too low it was however the first successful attempt to bring a somewhat important number of young lobsters past the larvae stage.

Some specimen 2.5 cm. in length had already been artificially propagated by Saville Kent in 1883.

Most attempts were successful in hatching the eggs but soon a great mortality would ensue and not a single one remains. However, just the hatching of the eggs leads no farther since in nature this is also done quite readily, the larvae emerging not simultaneously but at short intervals. The result is consequently that the larvae do not occur in dense masses as is the case when great numbers are released after hatching artificially. This massing of larvae naturally leads to the attraction of animals of prey particularly fish.

This method of hatching eggs and releasing the young larvae has been practised widely in Canada and the United States. Results, in the form of increased supply, did however not materialize; in fact, the supply diminished steadily. Cooperation from the side of the fishermen also left much to be desired and as a result this method is being abandoned more and more.

In Zeeland also numerous fishermen and dealers interested themselves in attempts to aid larvae in passing the larvae stage. In oyster beds particularly repeated experiments were made. Results however were without exception unfavorable which is not surprising in view of the fact that for a long time men of science also did not succeed in surmounting the many difficulties. The question was not so much the hatching of the eggs as the raising of the larvae.

Of later years Mr. Belderbos, keeper of a lobster hatchery in Bergen-op-Zoom, has been occupied in a small way with the experimental propagation of lobsters. A rubber hose entering at the side and bottom of a tube served to change the water and at the same time created a whirling motion, excess water being permitted to flow over the edge of the tube. According to his reports results were quite good. The experiments were however not repeated in 1919 and 1920 so that I have not been able to observe the method personally.

The honor of having found a method of use for practical purposes belongs to Dr. A. A. Mead of Providence, Rhode Island. He also had to overcome many difficulties during the first years and he says: "In the case of all fishes which we have attempted to rear, the problem is easier than in the case of lobster."

In 1901 a plant was built in Wickford, Rhode Island to test the system invented by Dr. Mead. This system is nothing else than the application of the principle that the water in which the larvae are to grow is to be not only changed regularly but must also be kept in fairly strong motion so that:

1. The larvae do not sink and pile up at the bottom.
2. The food in the water remains suspended.
3. The larvae, because of the movement of the water, cannot attack each other, so that cannibalism is minimized.

For a detailed description I refer to Mead's articles 1/ and

1/ State of Rhode Island and Providence Plantations. Report of the Comm. of Inland Fisheries 1901 - 1910

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others. Chiefly the arrangement is however as follows: Alongside a raft on which a machine shop is located are other rafts constructed of skeletons of timbers. Within these latter rafts, whose buoyancy is considerably increased by means of a number of pontoons or barrels, are suspended large wooden cases of a surface of 3 x 3 meters and a depth of 1.3 m. In these cases, submerged except for the rims, the larvae must be reared. Changing of water is taken care of by windows of copper screen of a mesh so fine that the larvae cannot pass. Each case is provided with a vertical shaft to which two blades are attached and which turns at a velocity of about nine revolutions per minute. Motive power is provided from the central raft and the operation is continuous around the clock.

This assembly gave, over succeeding years, proof of great practical usefulness. It reached a point where annually several hundreds of thousands, yes, in 1920 even more than one million larvae were raised past the larvae stage.

The method soon was copied and in Norway Dr. Appelløf built a pilot unit at a cost of only $290. - with which he succeeded in bringing 20 to 30 per cent of the larvae into the fourth stage. The fact that his percentage was lower than Mead's at Wickford is perhaps explained by the longer period required for larvae to attain that stage in the colder water of Norway. In 1912 the Norwegian Parliament allotted 6200 Kronen towards an improved apparatus. This was completed in 1913 and was an exact copy of the one at Wickford. The results however were exceptionally bad and only about 1000 larvae were obtained. The next year showed no increase, the number of lobster larvae to reach "bottom" stage was but 1600. Much difficulty was also experienced in the hatching of eggs. Blame for these poor results were placed chiefly on the appearance of a parasitic worm, Histriobdella 1/ ; which attaches

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1/ Meant here is Histriobdella homari, a worm like parasite of the lobster, which lives mostly on the eggs. Mr. A. Dannevig assured me later verbally that this was probably not the reason.

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itself to all parts of the lobster as well as to the larvae. In the course of the years following no improvement in the results was made. The apparatus was constructed and during the first years also managed by Sund, later by A. Dannevig, the manager of the well known seafish station at Flödevigen. After the season of 1918 the plant was disassembled for lack of results. 2/

2/ In the annual report of Norwegian fisheries, 1919 - 1920, appears a notice by Dannevig to the effect that the experiments halted after 1918 were resumed with changed methods and on a smaller scale. In this case a cylinder was used with a double bottom. The upper one consisting of perforated celluloid. A stream of water was entered at the bottom, passed through the celluloid and out of the cylinder through a screen at the top. To create a whirling stream a hose was inserted and made to eject water alongside the wall but the stream coming up through the celluloid bottom prevented the forming of a whirl in the middle of the cylinder. The result was that six per cent of the larvae could be grown to the fourth stage while a number of younger larvae were provided for planting or for experiments. In the event this method should be continued it should be watched and if finally the results became favorable a decision shall have to be made as to whether the American or the Norwegian system offers most chances for successful propagations.

Conditions were about as described when in 1918 the Fisheries inspection service moved to tackle the problem. The good showing made in America with an apparatus which was the result of lengthy experiments made it seem desirable to commence in 1919 with an assembly based on the same principles. Because of the then great expense and scarcity of required materials and the proportionately slim funds allotted we were forced to limit ourselves carefully during construction and managed to bring our plant to completion by housing everything on one raft and by building only two rearing tanks.

Construction and arrangement are best understood by a study of figures 6, 7 and 8 showing section, elevation and plan of the original assembly. In the center, (plot plan) one sees the machine shop in which the motors are housed as well as a number of pulleys for the purpose of speed adjustment. The shaft which extends from the shop normally turns at about 25 RPM while the motors are of from 400 to 700. The shop also contains a table which may support aquarium basins for the service of which a pump is provided with a capacity of 1000 liters per hour.

The horizontal shaft has at either end a conical gear which in turn engages another conical gear with three times as many teeth and which is fastened to a vertical shaft supported and steadied by a tripod. At its free end this last-named shaft carries two paddles pointing in opposite directions, each 1.25 meter long and tapering in width from 0.25 m. to 0.15 m. The sideway pitch of each paddle is adjustable.

The ratio of 1:3 between the conical gears allows for a speed of about 8 RPM for the vertical shaft and thus for the paddles. The disturbance of the water is further influenced by changing the pitch of the aforementioned paddles.

In figure seven these paddles may be seen through the water in the tank. The tanks have a capacity of about 3.5 x 3.5 x 1.2 cubic meters and the sides extend some 10 cm. above the water surface. This however proved to be insufficient because of wave action which was common at our site so that later the tank walls were built up another 15 cm. higher. Outside water must obviously not be permitted to enter the tanks over the side since weeds, fish and other marine animals are also apt to intrude.

The walls of the tanks were made of wood impregnated with carbolineum (creosote?) and tarred. The seams between timbers and boards were not calked, a neglect which led to difficulties since upon cleaning the tanks the seams proved to be hiding places for all manner of lobster-like animals like crabs, Gammarus, Mysidon, etc., which were hard to dislodge. Although the food of these animals will no doubt have consisted mostly of refuse it is not impossible that they did absorb lobster larvae also. Considering the great number present the damage they did was perhaps not unimpressive.

To provide a change of water in the tanks, openings were cut in each of two sidewalls and in the bottom. These openings, one of 100 x 20 cm. in each sidewall and two of 50 x 50 cm. in the floor were covered with copper screening of a 1.6 mm. mesh fastened on the inside with a narrow wooden framing.

For the purpose of hoisting the tanks for cleaning and repairing a removable tripod and tackle were provided. However a different arrangement later proved to be more efficient.

Acquiring the motor in 1919 was very difficult. The supply of light gasoline motors suitable for our purpose was practically exhausted and prices very high. Finally it was decided to buy a 1½ hp vertical motor (Premier) while an Evinrude outboard motor was converted to a stationary type as a reserve engine.

The great drawback of both motors was that they operated through ignition provided by a battery. Various circumstances, chiefly necessary recharging but also moisture contributed to long and annoying interruptions.

To keep the raft afloat 28 barrels were placed between the timbers on both sides and four additional ones under the floor of the shop. At least every other day these barrels would have to be inspected and, if necessary, emptied by pumping.

In general the timbers used for framing were of generous dimensions, a provision which later proved to be useful. The timbers running lengthwise were 11 x 15½ cm. as were the main braces while those upon which the shop stood measured 11 x 20 cm. The walls of the tanks were of 22 mm. boards. Furthermore, a number of cross timbers were placed over the tanks for reinforcing purposes but these were easily removable in the event the tanks were to be hoisted from the water. The driveshaft above each tank could be disconnected by means of a clamp connection. The entire assembly was built at Tholen and, when completed, towed to the site of operations.

In 1920 various changes were made and additional tanks installed to give added opportunity for experimenting. Originally the scheme was to construct eight much smaller tanks alongside the two existing ones. Funds were however insufficient and we finally had to limit ourselves to the construction of four new tanks. Inside dimensions of these were 1.4 x 1.36 x 0.9 m. and they were attached to the side of the raft (see figure 8). The reasons for building these small tanks were economy, easier handling and the fact that it took much less time to stock them with the required number of larvae. The latter item is of great advantage in that a few seed-lobsters can in one day produce for one tank enough larvae all of the same age. Thus cannibalism was reduced and it was also possible to see at one time into all corners of a small tank, an advantage the large tanks did not have. Construction was somewhat different from that of the large tanks. For one, the screened openings in the bottom were omitted since they not only became clogged very easily but an eventual break in the screens might have escaped detection. On the other hand, larger windows were cut into the sidewalls, namely windows 0.6 m. wide by 0.5 m. high in the walls running lengthwise and 0.3 m. by 0.5 m. in the other walls. The screens were mounted on slides inside of the tanks while on the outside solid wooden shutters were similarly mounted which made it possible to remove the wire screens for cleaning after closing the apertures by means of the wooden shutters. This same arrangement was later applied to the large tanks. The stirring device remained the same with the exception that instead of supporting the shaft in a tripod the end was placed in an iron socket on the bottom. Motive power was also transmitted through conical gears and to prevent rainwater from washing grease off the gears and into the tanks the gears were covered with tin housings.

In figure 8 the left most one has been removed. The supports for the horizontal driveshaft were placed high enough to give clearance for the tanks when hoisted for cleaning.

It was not easy to find a suitable location. Several requirements had to be kept in mind:

1. The water must be reasonably clean and so no source of dirty nor fresh water must be nearby.

2. The site must not be subject to heavy wave movement.
3. There must be no important marine traffic because of danger of collision, disturbance and condensation-water.
4. The distance to centers of the lobster industry must not be too great with a view to the acquisition of seed-lobsters and the planting of young lobsters.
5. The current must not be too strong.
6. The distance to rapid transit and a fairly large community must not be too great in the event motor repair or replacement is required.

A site satisfying all these requirements is not to be found in the waters of Zeeland, particularly a combination of 1 and 2.

Most suitable seemed a location in the Zandkreek not far from the Ooster Scheldt, in the so-called Katsche Gaatje.

The conditions enumerated under 1, 3, 4 and 5 were met entirely here, the one under 2 only partly, but that under 6 not at all.

As to wave action, this could be fairly severe although we have had no heavy storms. At times it was bad enough however to cause seasickness among members of the personnel who were not immune to that discomfort. Rather severe damage to the installation occurred only once but the risk seemed too great to choose this particular site as a permanent one.

Towing the raft from Tholen to the Zandkreek gave some difficulties since the face of the tanks offered strong resistance to the water causing the front end of the raft to pitch downward. Hoisting the tanks halfway and a reduction in speed overcame this however.

At the conclusion of the tests the installation was returned to Tholen in August, partly disassembled and stored.

In 1920 a new site was chosen, an oyster bed inside the dike near the harbor entrance to Bergen-op-Zoom. This turned out to be a great improvement. Most important was no doubt that the temperature here was in general higher than in outside water.

The absolutely quiet and safe anchorage as well as the nearness of a town and the bacteriological institute there were of great advantage.

For keeping the mother lobsters use was made of lobster pots. The upper and lower walls of these were made of wood while the sidewalls consisted of so called "accordion" screen, the dimensions were 1 m. x 1 m. x 0.3 m. in depth. In practice they proved to have one disadvantage. Although the screen had been tarred before use it was seriously affected by corrosion before the end of the season until finally the holes became so large that a number of lobsters escaped. As to their main purpose, namely keeping alive the mother lobsters, these containers left nothing to be desired. During the two or three months the lobsters were kept not a single fatality occurred which could have been prevented by a different construction of the pens.

The rusting of screens will be prevented by substituting heavier material, as for instance perforated steel plate and more frequent tarring as is done in the case of oyster screens.

It was my plan initially to let the eggs hatch in a lobster pot floating in the propagation tank in the manner described by Dr. Mead. I abandoned this idea however because:

1. One lacks control over the number of larvae present in a tank. The American experiments, which provided for numerous tanks of which one could be especially equipped for hatching, were not thus handicapped. In that case the larvae may be scooped up and counted out into the propagation tanks. When, as with us, one disposes of only two tanks this method cannot be applied.

2. In Norway very poor results were had with this way of hatching and, according to Sund and Dannevig, who were very emphatic in their opinion, not a small part of the difficulty was in the getting of a useful number of larvae. They were inclined to blame this on the probability that the larvae, borne on the water current, and passing the mother lobster, were eaten by the latter.

I then attempted to construct a system which would overcome both of these objections. In principle it amounted to the expectation that a water current passing the mother-lobsters would carry away the hatched larvae and deposit them in a separate tank. In a large, rectangular tank divided into five sections by means of chicken wire screens, the ripe mother lobsters were placed. The pump installation brought water into this tank, however not directly but through a gutter placed along the side over the entire length. At both ends of this gutter water could flow out through openings in front of which gauze of silk with a 3/4 mm. mesh prevented dirt and undesirable animal life from entering.

The water thus flowing into the tank at the ends would course past the mother lobsters, take up the newly born larvae and continue through three wide rubber tubes located near the middle and designed to overflow into an adjacent tank. Out of this tank the larvae could then be fished with a net and counted out into the propagating tanks. Aside from that the installation would run itself.

I went out from the supposition that five ripe seed lobsters would be able within a short time to produce enough larvae to stock a tank but this expectation was not fulfilled. In the first place, it is impossible to tell whether the eggs are entirely ripe and ready to start hatching and furthermore five lobsters cannot produce from 10 to 20 thousand eggs in one or two days. Yes, even when two lobsters were placed in each section the daily hatch amounted to only a few hundred. Although aside from that the system operated with complete satisfaction I had to abandon it because the capacity was too small. To increase this capacity by adding another tank of mother lobsters would have overtaxed the buoyancy of the raft.

I then returned to the previous American method, placed the available mother lobsters in one or two ordinary lobster pots and floated these in the corners of the propagating tanks. Also in the season of 1920 the ripe seed lobsters were usually placed in one of the large propagating tanks and the larvae fished out and planted in the smaller ones.

When in 1919 I had the disposal of only two tanks it was a long time before these were stocked with larvae. The slow hatching of eggs was also contributed to by the very low temperature of the water during the most important part of the season. The reason that the number of larvae coming from one seed lobster is often small is probably due to the circumstance that in caring for these potential mothers so many eggs, just the ripest, which are easiest to dislodge, are lost. The seed lobsters are mostly kept in captivity from the end of May and must be handled daily to check on the bands around the claws and to inspect the process of ripening of the eggs. During these inspections and before one has a good hold on them, the lobsters are apt to violently thrash their tails about causing the dislodgement of a number of eggs.

All this could be avoided to a great extent by procuring from the fishermen the ripe seed-lobsters whenever one were momentarily in need of them. By allowing the larvae to hatch in the propagating tanks themselves it is of course not possible to make certain of the number of larvae present. This has to be estimated and for this purpose I constructed a small, circular wire frame of a diameter of 20 cm. over which wide mesh silk gauze was tightly stretched. This I permitted to sink to the bottom of the tank after which I would raise it at a fair rate of speed. The larvae contained in the column of water of which the little silken net was the base would then settle on the net and could be counted without trouble. From this figure it was possible by simple computation to approximate the number of larvae in the tank. The method is not very exact, the filtration coefficient has not been taken into account and the larvae are not equally distributed in the water. This however was to some extent compensated for by repeating the count over various locations within the tank. For comparing the daily numbers of larvae present this method was entirely useful.

Attempts were made to work without interruption but in this we did not always succeed and usually it was the motors which caused the delay. The Evinrude, used as an auxiliary in 1919 had to be utilized repeatedly but finally was not equal to the strain. In 1920 a stationary marine motor was used in reserve but this also was unsuitable. As a result the stirring device was frequently stopped sometimes even for 24 hours at a time and these stoppages were invariably the cause of great losses.

The care of the motors, feeding of larvae, keeping the raft clean, etc., took two men who relieved each other every half day. When the base of operations was located at Zandkreek in 1919 quarters for the personnel were established in a houseboat anchored near the raft. In Bergen-op-Zoom it was possible to live ashore at a considerable saving in cost of maintenance.

For the purpose of planting the young lobsters in the Ooster Scheldt repeated use was made of the "Albatros", a boat put at our disposal by the Chairman of the Direction of Fisheries for the waters of Zeeland.

Chapter IV

Rearing the larvae. The results

Experiments in 1919 were commenced on June 4. In 1920 they could be started on June 9. It was on the 4th of June in 1919 that for the first time considerable numbers of larvae were obtained, namely 130 specimens, and already on the 20th of June the first larvae in the fourth stage of development were observed. Sixteen days then were required for the development from the 1st to the 4th stage. This result was encouraging, especially since the motors often failed and once were out of commission for 48 hours. The mean temperature during this time was 17.7° C. (In the afternoon), often a temperature of 18° to 19° occurred, on but three days falling to 15°. The first stage had lasted five to six days; the second, four to five; and the 3d, five days. That the first stage was relatively long is explained by the fact that the temperature was then low. On the 23d of June the majority of the larvae had progressed into the 4th stage.

This experiment was suddenly halted by the breaking of the framing on the copper screen due to inferiority of this wartime material. The young lobsters escaped and could not be counted, an estimate of their numbers was approximately 200.

Soon after the end of this experiment, (the second rearing tank could not be used because of the shortage of available larvae) a long drawn out period of bad weather commenced and the temperature of the water fell to 13°. Under such circumstances growth is retarded considerably and it took eight days to reach the second stage while not less than seven days passed before the first larvae in the third stage were noted. Not a single one of the 6000 larvae with which the experiment started, reached the fourth stage altho there were specimens among them of 20 days of age. After this cold period the weather improved, the course of the test started on 14 July is to be found in Table V. The estimating of quantities was done as previously described and on 21 July the seed lobsters were removed from the rearing tanks.

TABLE V

Date	Number of larvae	Percentage of larvae in the various stages in relation to the total present I	II	III	IV	
2 Aug.	3300	68	32			first in IV stage
5 "	1300		100			IV are present, but few are caught with the net

The 4th stage was, as shown, reached in 19 to 20 days. The figures of the total numbers reveal that a rather regular decrease exists, disregarding the errors in observation. Only toward the end the numbers decreased much faster percentage-wise. This occurs generally when the larvae are at the end of the 3d stage and entering into the 4th. In 1920 this also took place without exception and caused great damage.

The reason for this is unknown to me. In the station at Rhode Island something similar seems to have happened in 1920 but mortality there was definitely halted by transferring the larvae to other, newly cleaned tanks at the critical moment. According to the manager at Rhode Island the reason is to be found in lack of sanitation.

The time required for passing through each stage was quite varied in the various experiments during 1919. For easier comparison I present in Table VI the results of three tests

TABLE VI

Duration of the different larval stages and the average temperature during three tests in 1919

Stage I		II		III		Stages I thru III	
Days	Temp.	Days	Temp	Days	Temp.	Days	Temp.

*Did not reach the 4th stage

The figure showing the average temperature is only partly correct since it often happens that at one moment larvae in various stages are simultaneously present. The averages are therefore taken on days during which the preponderance of larvae present were in the applicable stage. Also the figures show the highest daily temperature taken between 2 and 3 p.m.

The Table shows clearly the relation between the temperature and the number of days required to pass through one stage. There must however be other influences which determine these durations. The nature and quantity of food as well as cleanliness are undoubtedly factors of equal importance. This appeared convincingly from the last test taken in 1920 during the cold and wet August days. The average daily temperature was then 16.8°, still some specimens arrived in the 4th stage within 12 days while in all 27 per cent of the larvae reached that point. At that time it was however possible to keep the water in the rearing tanks as well as the tanks themselves very clean. In 1919 it was just this circumstance which offered the greatest difficulties.

The results of test in 1920 are best shown in the form of a Table (VII).

I have arranged the tests in three groups, the first were made in June, the second in July and the last in the beginning of August. The percentages are considerably higher than in 1919 and increase steadily in the three succeeding groups.

TABLE VII
Results of the 1920 experiments

Tank number	Quantity of larvae at start	Duration of stages I	II	III	Per Cent of larvae planted	Temp.
III	345	4-5	4-5	4	11.6	20°8
			-etc.-			

The figures which show the duration of each stage are to be regarded as minima. They refer always to the first appearance of a new stage. There are however many late comers even though the larvae are of the same age. In all cases the first larvae in the 4th stage were noted in 11 - 12 days, usually the young were not planted until after the passing of about 16 days but even then there invariably were some present in the 3d stage.

The seed lobsters got rid of their eggs very early in 1920 so that even in the beginning of August it was impossible to obtain sufficient larvae. An attempt was still made to continue testing by importing seed lobsters from Scotland, the Chairman of the Fishery Board of Scotland lending his cooperation toward this end. Transportation was completely successful, the entire shipment of 23 lobsters was alive upon receipt. The eggs however were in widely different stages of ripeness and many would not hatch until the season of 1921. It proved impossible to collect sufficient larvae to restock our rearing tanks.

One of the most important reasons why so small a percentage of larvae attained the 4th stage during the tests in June was the fact that the tanks had been painted with creosote also on the inside. The water thus was poisoned and this lasted throughout the first series of tests. When tanks III, IV and V were empty, the first and last named were painted with varnish over the creosote. As a result the percentages in III and V increased considerably while IV remained very low. Since other circumstances during the tests were equal for all three tanks, the original supposition of creosote poisoning during the first series was sufficiently proven.

By far the best results were achieved during the last test when fully 27 per cent of the larvae reached the 4th stage. This favorable showing was of importance especially because from almost the beginning to the end of the period bad weather and low temperatures prevailed. The average temperature had been almost 2° lower than during July and 4° lower than in June yet the 4th stage was attained in 12 - 13 days which tends to prove that a 4° drop in temperature does not lengthen the larvae period by more than one day.

I believe however that growth will be greatly retarded if the temperature should fall to 15° or lower as was the case regularly in July 1919.

Where several tests failed completely in 1919, in 1920 the 4th stage was not reached in only one case and that as a result of contamination of the water in the tank.

The time also, within which the 4th stage was reached, was invariably shorter in 1920 than in 1919, i.e. 11 - 13 days as against 15 - 19. In 1919 at a temperature of 17°7, it took 15 days while in 1920, when the temperature was lower, only 12 days elapsed before this stage was attained.

From the above it will be clear that the optimum living requirements of the larvae are being approached more and more.

Of all the larvae placed in the rearing tanks, 4.2 per cent could be released into open water as young lobsters of the 4th stage. Undoubtedly this percentage is already a good deal higher than that which would have been established under natural conditions.

Taking into consideration only the small tanks (and these only could be given the necessary care and will therefore be used preferentially in the future) the average percentage is already much higher, namely 8.3 per cent.

But a very small part of the hatching larvae can be used, once the tanks are stocked, which must be done in one day, the larvae emerging afterwards must be released. These are however not necessarily lost, they may continue to develop naturally.

The tests have taught us that it is always possible to bring larvae into the desired 4th stage. The problem now is to discover the circumstances under which the percentage can be raised to the highest point. Details of the method employed as well as the installation used will have to be improved upon. Already in 1920 many errors and shortcomings were corrected.

In 1919, when only the two large tanks were available, it proved impossible to stock these within a short time with sufficient quantities of larvae. During the first days not more than 100 - 250 larvae would usually hatch. The seed lobsters in store amounted to about 100. Even at the height of the season not more than 1500 larvae hatched out daily. Since the tanks could easily hold 10,000 larvae the seed lobsters had to be kept in the tanks from 7 to 10 days to get a fair supply so that the larvae present differed from 7 to 10 days in age. The older larvae were usually in the second stage by the time the youngest ones emerged from the eggs. It will be plain that the simultaneous presence of stronger and weaker larvae considerably increased cannibalism. The worst was that the cause of these losses could not be avoided, this could only have been done by the acquisition of 800 or more seed lobsters, an impossibility as far as we were concerned.

To overcome this during the succeeding year it was decided in 1920 to construct tanks of only 1/8 of the previous volume. As a consequence the difficulty was indeed eliminated.

Additional unfavorable factors in 1919 were the inclement weather and the low temperature in July, the most important period of the season. Growth was thereby greatly retarded as was moulting and a spread of external parasites appeared which would have been best counteracted by a rapid succession of moultings whereby they would have been removed.

Since, in our climate, the frequency of cold summers must be taken into account, that drawback also was in so far as possible, met by moving the entire installation to an inland oyster bed at Bergen-op-Zoom. The temperature of the water is influenced more quickly here by the temperature of the air but although the heat of the sun is sooner noticeable in the temperature of this water it also cools off faster and becomes colder than open water. In general however the advantage was with this enclosed oyster bed.

A great difficulty was also encountered in the keeping clean of the water in the tanks as well as the walls and screens. The latter, particularly those in the bottom became fouled and grew shut to some extent so that changing of the water was obstructed. This was the reason why in the new tanks bottom-screens were eliminated and that instead all four sides were supplied with relatively large windows which furthermore were removable for cleaning without interfering with the functioning of the tanks. Eventual weak places in the screens are then also easier to notice before their breaking may lead to catastrophic consequences. In 1919 it happened repeatedly that holes appeared in the screens or that they became dislodged by the rusting out of iron nails which, in contact with the copper, eroded promptly. After that, copper nails were used. It is no wonder that with all these handicaps the number of young lobsters resulting was not large. As has already been stated, the greatest mortality now occurs when the larvae are well along and begin to pass into the 4th stage. I have not been able to find a single hint which could lead to the cause for this fact. During the ensuing season this will be the main issue upon which concentration will be focused.

In 1919 much trouble was experienced from fungi and diatoms living on the larvae. The last named were easily and promptly disposed of by shutting out the light from the tanks by covering them with canvas; as can be seen in fig. 8. At the time however it was impossible to properly rid ourselves of the fungi. Whether to regard them as parasites or whether they used the larvae only as a base to grow on I have not been able to determine. In the event the latter is the case the only disadvantage of their presence would be the interference they imposed upon the moving about of the larvae and the attendant handicap to their breathing and feeding. If the hypha are densely placed, food particles and infusoria collect between the threads so that the larvae are surrounded by an impure layer deficient in oxygen.

The speed at which this covering took place was remarkable. In one or two days a fur visible to the naked eye would form.

Upon moulting the larvae would of course be suddenly free of this growth. A speedy succession of moultings was therefore of great advantage and the 1919 promptness of moulting left much to be desired.

In 1920 no difficulty was had in this respect probably because we managed to keep the water in the tanks much cleaner. By using the canvas covering from the beginning to the end diatoms also did not give any noticeable trouble. The cleanliness of the water is chiefly determined by the quantity (perhaps also somewhat by the type) of food given and by the rate of water change.

As regards the needed quantity of food I did not have the least information and by lack of data on this score one is apt to give too much for fear that the larvae will suffer and not grow fast enough. Establishing the right amount is the result of experience. Too little is of course wrong, too much will soon bring on a dirtying of the water and the forming of thread like, yellowish masses which would grow to enormous proportions in remarkably short periods. These consist of the threads of fungi, diatoms and bacteria charged with infusoria and food particles.

There being but little known of the food which larvae normally take in nature, feeding under artificial conditions has been exclusively with animal-food such as meat, liver, fish, even hard boiled egg, jelly-fish and meat of crustaceans, all in finely ground condition. It has been impossible to determine however whether a preference existed for any of these or whether a noticeably faster growth resulted.

During my experiments I generally used finely ground crab (Carcinus moenas) these were in their entirety ground in a meat grinder to a mushlike consistency, placed in a strainer and sifted out into the water so that only the finer particles would leave and the courser ones, mostly remains of shells, stay in the strainer.

Every two hours, a quantity of about 25 cubic cm. of this pap would be released in each small tank, later these quantities were reduced. One must realize that a great part of this food consisted of shell and that a certain proportion would soon exit from the tank through the screens of which the mesh was much wider than that of the strainer. Ground fish, as for instance young herring, also gave good results. As the larvae grew, the food was generally changed to a more solid variety as ground oysters or ground fish of more solid meat. Another measure which materially aided in changing the water was the introduction of the larger windows and the opportunity to clean these oftener.

I have tried to determine how often complete changes of water in the tanks took place. To that end I dissolved in one tank with a volume of 1.4 cubic meters one gram of potassium permanganate. With the wooden slides over the windows this was first thoroughly stirred into the water after which the wooden slides were removed. Beforehand a number of solutions had been prepared ranging from 1 : 1000,000 to 1 : 20,000,000 and placed in glass tubes to equal heights.

With these we compared the samples periodically taken from the tank. At 8.02 p.m. when the slides were removed the first sample was taken and this and subsequent samples ran as follows:

time:		Concentration 1 in:
8:02		between 1 and 2 million, closer to one million which agrees with the computed concentration of 1 : 1.4 million
8:10		4.000,000
	etc.	
8:40		color still visible
8:50		" " "
9:00		color entirely invisible

After 35 or 40 minutes the refreshment of the water was so strong that the solution had been weakened more than 20 times and one may safely say that after one hour the water was completely changed.

Attempts were also made to determine whether the oxygen content of the tanks was also sufficient. Especially in still, warm nights, when plants also absorb much more oxygen than they expel, it seemed not improbable that there would be a shortage. To ascertain this I used the titration method after Winkler, according to the modification, given by the Codex Alimentarius for testing water. This modification seems however to be unreliable for testing sea water which agrees with my own observations. Thus it would have no value to publish the figures obtained although I could determine, from the typical and similar analyses made, that there can be no question of a lack of oxygen even at night and that the proportion within and outside of the rearing tanks was practically the same.

In 1919 much trouble was caused by crustaceans which in an undetermined manner but probably as eggs or young larvae had entered the tanks. Thus we found shrimps, varieties of Schizopods as for example Praunus sp., Amphipods (Gammarus sp.) young specimens of ordinary shore-crabs etc. Also young fish (herring, harder, little grondel) were regularly to be found.

The crustaceans continually increased in numbers, they were difficult to dislodge during cleaning operations since they would then enter in cracks and seams and could not be reached. These seams were tarred shut in 1920 so that this handicap was also overcome.

Many larvae are lost by cannibalism, especially when they become a little older and various ages are present among them. To circumvent this, the small tanks were constructed. It is possible to supply those with larvae in one day by means of a small number of seed lobsters and since the larvae emerge almost exclusively in the evening the difference in age is only an hour or two. Yet this does not solve the question because at the first moulting already it becomes clear that they do not all moult at the same rate; between the advent of the first 2d stage (larva) and the passing of the last 1st stage (larva) two or three days generally elapse; during succeeding moultings this difference becomes greater still and, after the 4th stage begins to appear, one must still wait a few days before releasing can start since even after six days there still remain some in the 3d stage. Thus, even if no age difference exists there are differences in development and practically always one may find larvae of more than one stage in a rearing tank. Repeatedly therefore one will see larvae swimming around with a captured colleague or one finds the remains of half eaten larvae, front ends generally since even a young lobster is able to appreciate the best parts.

To take direct measures against this is impossible, probably the rate of development of the various specimens will become more equal as we succeed in improving the living conditions of the larvae.

In closing I want to point out the brilliant results obtained of late years in Wickford, Rhode Island. In about 1900 a start was made there with the practical development of scientific experiments. In that year 3425 larvae were grown to the 4th stage, this number mounted regularly until in 1910 the number was 511,274. According to information received personally the million mark was exceeded for the first time in 1920. Sixty tanks are in use there of approximately the dimensions of our oldest, large model. The results of the yearly planting of such great numbers of young lobsters made themselves felt. Catches had diminished, as elsewhere, with frightening speed, but after releasing larvae in the 4th stage on a large scale, they started to increase. In 1904 the catch was only 376,994 lbs. or 45 lbs. per pot. Such a small catch has not been repeated since 1904; in 1913 the catch mounted to 1,210,094 lbs. and in 1919 to 1,634,271 lbs. or 78 lbs. per pot.

These figures speak for themselves but a still surer proof of the great value of artificial propagation is that the fishermen of Rhode Island cooperated intensely with the station at Wickford.

With these results before us I believe that we may in full confidence continue in the direction we have taken.

Harlingen, February 1921

Advisor of Fisheries
B. Havinga

Havinga, B.
1929 Krebse und Weichtiere. In Handbuch der Seefischerei Nordeuropas, Stuttgart, Band 3, Heft 2, 147 p., illus.

Crustacea and mollusca

(p. 29)

Lobster

The larval habits of life. The lobster larvae have, as many plankton organisms, considerably strong self locomotion; they use this however not for the attainment of a definite objective, but are activated by other stimuli as light, temperature, water, currents, etc. The locomotion method is the same in all three larval stages; a similar rowing motion by means of the swimming limbs of the thoracic feet and the last maxilliped appendages, which are beset with long feathery hairs. Besides, the larva can, as the grown lobster, make quick backwardly directed motion through quick snaps of the rear of the body. The rear of the body of the 2d and 3d stages plays a minor roll for swimming. The forward motion is merely slow, that to the rear considerably rapid, but not to compare with the velocity which many other crustacea attain. For every pursuer, the larvae are easy prey; one can catch them easily with the hand; a fear instinct has not developed. The young 4th stage lobsters have an entirely other locomotion; they can swim and walk. They hold the body extended straight for swimming, also the claws are situated in a straight line with the body so they row themselves forward with the rear body feet. If they then come in contact with any object by means of the outstretched claws, then they strike back quickly.

The position and orientation of the larvae in the water. The larvae of the first three stages swim with bent bodies, the head bends by a sloping angle downwards and the cephalothorax forms with the rear of the body an angle of about 90 degrees. This position they however not always maintain, occasionally they turn themselves around head foremost. They have no definite direction when they are irritated. The circulation of the larvae in the water is caused probably for the great part by the stimulation of light, especially if they are held in pools. Information on their behavior in the open is missing entirely. Directly after the larvae are born, they seek the surface of the water and begin their planktonic life. In a dark fish tank it is very easy to attract together all the larvae to a small place through a single falling light ray. Towards the end of the second and third stages this positive phototaxis is much less present, or it is even negative. One can often observe that the larvae seek the shade. Hadley has described very fully for the American lobster the influence of light stimuli on the behavior of the larvae.

Yet towards the current direction the larvae are very sensitive; they face the head to it when the current is not much too strong.

The larvae lack an organ of equilibrium or in any case it is only imperfectly developed. They orient themselves in space by the light and the eyes: they turn the back to the place which has the most light, normally the sky. Let one however allow a light to fall into a pool only from beneath, then one sees that the larvae, almost without exception, turn themselves immediately and swim quietly farther with the abdomen towards the top until the light again falls normally from above. The claws occasionally become stretched upwards, a proof that they hang down not passive and loose in spite of the swimming animal, but become actively stretched downwardly. The young lobsters of the fourth stage react equally quickly as the larvae.

Although the lobster larvae are planktonic organisms, which must occur very generally in many places, yet they are caught only seldom with surface nets; most frequently of the larvae first and fourth stage were still caught. The larvae in nature very probably keep themselves often in the deeper water layers. Much about their life history lies still in darkness. So it is inexplicable that in distinct small districts (Helgoland, Osterschelde) not all the lobster larvae during the two or three weeks of their larval life are carried on far from the dwelling place of their parents by the ebbing and flowing currents whose resultant can yet never be exactly zero. One has perhaps thought that the egg-bearing females, travel (off) against this current resultant, in order to compensate the spread of the larvae in a down-current direction (Meek 107); such upward migrations however do not occur generally.

When the young lobsters have reached the fourth stage, they immediately seek the bottom of the sea. Generally, however not at once, indeed they ascend even more frequently from the bottom and swim again on the surface for some time. Fast rules are not to be given and great individual differences occur. The transition from a planktonic to a bottom animal is therefore a slow one, which is of very great importance for the discovery of a suitable dwelling place. If they have settled down on a mud bottom, which is not suitable for them, they can entrust themselves anew to the current and seek another place. Such a thorough examination of the botton can become continued throughout more days. At the end of the fourth stage and in the later life however, the young lobsters no more voluntarily abandon the sea bottom.

Food. The swimming larvae can catch only floating food. Especially copepods and diatoms, occasionally also algae, were indicated in connection with the larvae caught in the sea. In connection with rearing experiments only animal food is used. The larvae are very rapacious, animals as large as they themselves and even their own species are attacked and overwhelmed. Hours at a time the larvae can swim around with a large piece of prey, which they hold fast with all the thoracic feet, while the branched swimming feet are yet employed for swimming. Pieces of prey must approach very near, in order to be seen; for the searching of food however, taste and olfactory organs also play a roll, since the larvae react also toward dissolved food.

Growth rate. Concerning the growth of the lobster and the age connected with it, we are acquainted only very imperfectly. At most, we know more of the young developing stages, for only very little may be said of the age of a large lobster. This gap in our knowledge results chiefly therefore that no periodically growing organ occurs which gives rise to annual rings -- as on the scales and otoliths of fish: on the contrary, all hard parts are thrown off at each shedding. The molting makes it also impossible to brand the lobster with marks which last for a long time. Add moreover to this that the living conditions in the various regions cause great differences in the growth rate. The temperature plays a very great roll for development; we will see what relationship exists for the larvae between the growth rate and the temperature, where the same is exactly known; very probably, a similar relationship also exists for the large individuals. The following description is restricted chiefly to an average as it occurs in the southern part of the North Sea. When the larvae hatch from the egg, they at once pass through a molting in which the larval skin strips off. They enter thereby the first larval stage and are about 8.7 mm. long, while the carapace has a length of 4.2 mm. 1/ For the

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1/ The relationship between the length of the whole animal and the carapace (inclusive of the frontal process) is the same for the larvae as for the adults--namely 2.2 - 2.1. Although the length of the carapace is much easier and more exact to measure than the whole length, as a rule only the last is given, since it is the commonly used one.

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most, the first shedding (the molting at birth is usually not included) follows in three or four days and the second stage is reached with a length of 11 mm.; the length increment is therefore

25 per cent, which is considerably more than for the old animals, where the increment amounts to 15 per cent, in order to become later yet less. The duration of the second stage amounts to four days. The third stage is considerably greater and more strongly built than the preceding, its length is 13.5 mm. and, after five days, it changes into the fourth stage in which the larval life is ended.

The duration of the various larval stages is, to a high degree, dependent on the temperature of the water; in rearing experiments for which continuous nourishment is present in sufficient amounts, it is almost the only factor which determines the length of this period. In Table 5 is clearly evident the relationship which exists between these both in rearing experiments. The numbers in this Table are borrowed from Dutch rearing experiments, but however are in agreement with those of other investigators. Peculiar are the individual differences in growth of the larvae which were exposed in a container to exactly similar circumstances; when, for example, the quickest growing individual had completed the larval stage after 12 days, the bulk came after 13, while also on the 14th day, the last had yet not all moulted.

Table 5. Duration of the first development stages of the lobsters at various temperatures, in days.

	Duration of the developmental stages			Duration of stages
	I	II	III	I to III
Temperature				
14	4(5)	6	7(8)	18
15	4	5(6)	6(7)	16
16	4(3)	5(4)	6	14(13)
17	3(4)	4(5)	5(6)	13(14)
18	3(4)	4(5)	5	13(12)(11)
19	3	4	5(4)	11(12)(10)
20	3(2)	4	4(5)	10(9)
21	2(3)	4(3)	4(5)	10(9)
22	2(3)	3	4(5)	9
23	2	3(2)	4(5)	9
24 - 27	2	2(3)	4(3)	9(8)(7)

The young lobsters in the fourth stage, after the end of the larval period, are usually 15-16 mm. long and 13 days old; since they are born in the middle of July, they have reached this stage in August. After 15 days they enter the 5th stage and have then a length of 17 mm. A striking difference exists in the color of the growing lobsters, it is now--and indeed still in the following stages--blue-green with dead white flecks; at what time this color changes into that of the adults, is not known to me. The duration of the 5th stage is put at about 20 days. Having then reached the 6th stage, it has a length of 19 mm.; again after approximately 20 days it changes into the 7th stage with a length of 22 mm. In this stage the first abdominal appendages appear, in the 8th stage these have developed so far that they make possible the differentiation of the sexes. According to Jorgensen, the first abdominal appendages appear still later and indeed approximately in the 10th stage. Lobsters born late in the year enter winter-rest already in this stage, the earlier born reach yet the 10th, or 11th stage with a length of 35 or 42 mm. respectively. All numbers mentioned here are taken from aquarium experiments which are almost wholly without confirmation by observations in the wild. Small lobsters of less than 80 mm. length almost never come to sight; that however many young ones spend the winter at a length of 40 mm. results from the fact that some small lobsters which were caught in winter, had approximately this length. In the winter, growth stands still. In their second summer--to understand during summer is the time of growth--the lobsters moult approximately ive times and are, at the beginning of the second winter, in the 13th to 15th stage and have a length of from 65-80 mm. When they have shed yet once in the spring and have attained a length of 90 mm., they are already captured in the lobster fishing apparatus. In the 3d summer they mou' two or three times and are, at the beginning of the 3d winter in the 16th to 18th stage at a length of 10-12 cm. In the 4th summer two moults probably follow, in the 5th perhaps also still, in many cases however only one more; in the 4th and 5th winter the length is 16 and 22 cm. If they have reached these last sizes, they then shed not oftener than once in a year. Directly after the following moulting, the females can have reached sexual maturity and become mated; in the following summer, they then for the first time extrude eggs. The females do not shed in the 7th summer, but not again until the 8th; moulting and egg-laying then alternate with each other every summer still farther. The males still however continue every year in doing so, each summer to shed once and maintain thus an advantage in growth over the females. The above mentioned numbers are for the most part taken from a work of Ehrenbaum (47) who succeeded in observing in an aquarium for three years a lobster raised from the egg and collecting thereby all the castoff shells.

The accounts of the growth of the older animals depend principally upon marking experiments (Dannevig 37, 37a) and direct observations of the shedding of caught lobsters. All figures are however only to be interpreted as approximate values, which become influenced by many factors. For the first year it is of importance in what time the larvae are born; early born ones experience in the first year four or five stages more than later born ones. Also not each stage is characterized by a definite length. In reference to the artificially reared 4th stages it is noteworthy that the difference of growth can become evident up to 30 per cent, also, for the larger animals, one can observe that the length increase for each shedding expressed in percentage, has varied much; it can lie between 7 and 20 per cent. Also herewith the temperature appears to be of importance: Dannevig (37) mentions that in the neighborhood of Flødevigen, 28 marked lobsters from 21-22 cm. long showed an increase of 11.6 per cent with an average temperature of 8.48 degrees; in another year, lobsters of 20-21 cm. had increased in length about 7.3 per cent at a temperature of 7.52 degrees. Lobsters of the same age are hence not always equally large and the equally large are not equally old. It is therefore impossible, even in limited regions, to establish the boundaries of the year classes through measurements.

How old are the lobsters which weigh more than a kilogram heavy and are more than a half meter long, let us not distinctly say with accuracy. One supposes that they shed once a year at a length of 22-30 cm. and from 30 cm. every two years; and increase in length everytime 10 percent and later 7 per cent (for old individuals the percentage increase in length at each moulting will always be less) so one arrives at an age of 24 years.

The males grow not only more rapidly than the females in that they shed each year, but they also become larger. The very large individuals are therefore always males; Herrick (70) reported on a lobster of 50 cm. length and 11 kg, while maximum for the American lobster is indicated at a length of 60 cm. and a weight of 15 kg.

I have tried to gather together the various observations on the growth and to combine them for a growth curve.

There is a rather simple method to determine the weight of a lobster from its length. The weight (in grams) is namely $.03 \times L^3$; L is the length of the lobster in centimeters (measured from the point of the rostrum to the end of the telson, whose hairs are included). In Table 27 the relationship is graphically displayed. When, however, the lobster becomes sexually mature, the weight of the males increased more strongly than is indicated from the above formula while the weight of the females remains in good accord with the formula. The variation by the males is probably explained therewith that their claws increase proportionately greater in weight with increasing length. My analysis concerns Dutch lobsters about two months after shedding. For animals with very old shells the weight comes out somewhat higher.

Utilization

Lobster stock, protection and artificial rearing. In many lobster districts the statistics exhibit a regular decline of the catch; some pertain to those, in Europe as well as in America, which earlier were reckoned for the most productive. And yet it is possible--apart from economic obstacles--to keep the stock at least stationary or to lead it up to the attainment of a biological optimum. I could estimate that in the Dutch lobster districts about 80 per cent of the males and 60 to 70 per cent of the females of 23 cm. and more were caught yearly. These figures do not however prevent the lobster population from increasing annually still around about 6 per cent. Principally there are two methods for the maintenance of the stock: First, one can require so far as possible, through legal size regulations, the natural course of fecundation, birth and growth, and second, one can improve the natural progress through artificial rearing. The last method is, at the present time, not yet practically worked out satisfactorily, to give a positive result. The first however suffices to regulate the fishery at a desired elevation. This happy condition is a sequence of the fact that first, the lobster is a very stationary animal; second, aside from humans, neither foes nor parasites in considerable numbers endanger it; third, sexual maturity occurs at a size that renders possible, on economic grounds, the protection until the attainment of this size; fourth, the fishery does not coincide with the spawning time. In regard to this matter, the following protective measures should exist as far as possible: first, a minimum size that protects the lobsters as long as they have at least once contributed to propagation; this size will in the various districts alternate between about 23 and 26 cms. or what is better and more easily determined, 11-12 cm. from the frontal process to the posterior margin of the carapace; 1/

1/ A maximum regulation and a maximum entrance opening of the fishing apparatus also has become proposed, in order to spare the large individuals and especially the large females which, with increasing age, always produce more eggs. Economic difficulties will however mostly prevent the installation of this regulation.

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second, sparing of the egg-bearing females; the police control on this is not so difficult as is often claimed since it is quite laborious to remove the eggs down to the last one, because accordingly the presence also of a single egg can be placed under penalty this measure becomes supplied or substituted through a closed time for the females; third, a closed time in summer, since the eggs are then ripe and easily great numbers are lost by the catching and releasing of the females; also the stock in this time can become reduced because of more females than otherwise--when the egg bearers are protected because, for many, the eggs already have slipped off and the new oviposition has not yet followed. There is thus a time in which few females carry eggs and so lack protection. During this summer closed time also most of the lobsters shed and would form because of it an inferior product for the market. The length of this closed time or of closed times in general should become so chosen that at least a balance between capture and growth remains regulated and is preserved.

These regulations render it possible principally to preserve the lobster stock at a definite level; not rarely however economic conditions appear to stand in the way of their performance, then however an always continuing decrease in the catch is the unavoidable result.

Artificial rearing. We know that the fertile eggs are glued fast to the hind trunk of the mother until they become ripe and that they, during all this time, are protected excellently from all possible dangers and enemies. As soon as the larvae are hatched out however, they do without this protection on the part of the mother and are exposed to many dangers during their planktonic life. A very great percentage run into destruction in this period, the most critical period in the life of the lobster. Considering the near related crayfish lacks this dangerous planktonic period, consequently this needs for the maintenance of its species about 100 eggs, while the lobster in the same time produces about 20,000 eggs; the newly born crayfish has about the same value as 200 lobster larvae for the maintenance of the species.

The artificial hatching of the eggs has no purpose; in this regard the natural situation is not to be bettered. American plantings of millions of newly born lobster larvae have consequently also not led to results. Only when the egg-bearing females are not protected legally, has it a purpose to allow the eggs to hatch artificially since they else would be abandoned to destruction.

A rational artificial rearing must occupy itself with the young lobsters during their planktonic life; they must be reared until attaining the bottom stage and can then become quietly released to nature. Since the ripe lobster eggs are readily obtained in more satisfactory numbers and the planktonic life lasts only a short time, principal obstacles do not stand in the way. So much the greater are the practical (ones) which are the reasons that until yet today no good method for the artificial rearing of the European lobster which guarantees success exists, although it has not lacked research to bring the problem to solution (G. M. Dannevig, Appellöf, Sund, A. Dannevig). The greatest obstacles are the helplessness of the larvae and, apparently in contradiction with that, their cannibalistic tendencies, since they are crowded together in a small space in the rearing tanks.

A broader difficulty is that the larvae and the food must be kept floating by the motion of the water, that however no direct current is allowed to be present since then the weak larvae become carried along and pressed against the walls. The merit is due A. D. Mead (103, further literature Herrick, 70) for having removed these difficulties for the American lobster.

He employed incubator sacks hanging in the water and later wooden incubator sacks with windows of brass gauze for the exchange of the water; in these the water was kept in constant rotating motion by means of a two bladed propellor; the establishment is housed on a float. The results which were already reached in the first years induced many fishery authorities to adopt this method, but everywhere it is again given up, or as in Holland, has become modified severely. The European lobster is raised artificially today only in Norway and Holland, aside from laboratory experiments. The Dutch apparatus is, as the American, housed on a float which carries the brood boxes hanging in the water. While however the American boxes were built originally of sail cloth and later of wood, and had a 10 x 10 feet flat bottom and a depth of four feet, the Dutch are made from perforated celluloid or aluminum plates and have a volume of only 1.5 x 1.5 x 0.9 cubic meters. Through the small box's perforated walls and the surface, which is greater in proportion to the volume, the pure water has an easy entry which is of great importance for the good vitality of the larvae. In all boxes a propellor driven slowly by a motor rotates (eight revolutions per minute). The larvae are obtained in a very simple manner, since by putting a female bearing ripe eggs in the middle of a box, one can, on the following morning, fish out and put in another box the hatched out larvae which seek at once the surface. They must now be fed heavily, for which various animal matter can be employed: mussels, fish eggs (salted cod eggs, for example), fish and crabs (for example, shore crabs). The food must be ground very finely, mixed with water and be turned out in great quantities, since otherwise the cannibalism of the larvae causes a great loss. The large quantities of organic matter which by far can not all be again provoked by the perfusion, produces a heavy browth of bacteria, infusorians, diatoms, etc. on the larvae and on the walls. It is not easy here to find a correct middle way; feeding with small living animals (for example, copepods) is without doubt the best.

After the American methods had been abandoned in Norway after five years of unsuccessful experimentation, Dannevig (36) there tested thoroughly a new method. Also with it the motion of the water rotates, but it is produced by a stream of water opening at a tangent to the bottom of the side wall. The whirling-up water motion caused in this manner keeps the larvae and the food floating and at the same time makes possible a renewal of the water.

The efficiency for the methods adhered to today is not always essentially less than for artificial fish rearing. If one places about 2,000 newly born larvae per cubic meter in the brood boxes, thus the average yield for the Dutch experiments is not much higher than 25 per cent, the maximum is 65 per cent. The losses for the first stage are very low, at the end of the second and third they however become very great, for mostly entirely unknown reasons; here the great gap which yet exists in our knowledge of the life history of the larvae avenges itself well. In addition, during the shedding which leads to the fourth stage many larvae perish. Are they however so far developed since they are to be held without trouble in the tanks or in aquaria with standing water. The setting out of the young into the free water ensues very easily by siphoning water with the young to a transport barrel by means of a wide rubber hose which can open to the sea bottom and thus forward the young directly there. Railroad transport of the young in the usual fish transport containers is very well possible; in these 50 young lobsters per liter can pass through an eight hour rail journey without great loss.

It is impossible to control what becomes in nature of the released young lobsters. Only the catch statistics in the districts in which, five or six years previously, releases occurred can, in the progress of the fishery, yield a hint or evidence that the plantings have had results. For the European lobster, such data do not yet exist: from America, however, reports come that in the environment of Rhode Island, where Mead's apparatus works, the catch has strongly increased, while previously a regular decline was ascertained. Meanwhile it is not declared whether both of the rearing methods existing today will be also of advantage for the lobster stock on our coasts; just as little which method is best. That employed in Holland places a high demand on hydrographic conditions; the water ought to be quiet and clear and have a definite force of tidal flow, the method is however very cheap; the Norwegian (method) on the other hand is to be used everywhere where clear water is at one's disposal. A high water temperature is always of great importance since with it the larvae grow much more rapidly, and in general the progress is better since they moult in short intervals and will lose the many growing organisms which will cast off with the old skin.

Moquin-Tandon and J.L.Soubeiran
1865 Establissements de pisciculture de Concarneau et de Port-de-Bouc. Bull. Soc. Imp. Zool. Acclim., 2e sér., t. 2, pp. 533-545, illus.

(p. 539)

For the young lobsters hatched during the year in the enclosures (viviers), we have data for the different sheddings extant at that time in the pools.

Lobster	Length (cent.)	Weight (grams)

The ease with which the young lobsters in the pools of Concarneau multiply and develop is one sure guarantee that on our coasts one should easily find suitable localities for creating similar enclosures where one should be able to obtain myriads of young which should be allowed the freedom of the sea only when they should be enough advanced in age to resist for the most part the causes of destruction which menace them incessantly. From what we have seen since our first visit to Concarneau (July 1865), that is to say, the pools literally black with small lobsters hatched in the enclosures and what we know of the way that a great number of species of fish have in producing immense quantities of fry in special regions the length of our coasts, we have hopes that one should be able to regenerate the fishery on certain of our rivers; by nursery reservoirs, one should attain the creation of an abundant supply of food. That which exists already at Concarneau and Arcachon proves the excellence of M. Coste's idea to prepare a protective area for the innumerable hosts of the young of edible species in order to draw there the elements of a perpetual harvest and demonstrate the easy realization of the views of the learned professor.

Raveret-Wattel
1890 L'aquiculture marine en Norvège. Rev. Sci. Nat. Appl., t. 37, pp. 147-156, 246-257

(p. 151)

In regard to lobsters, we were only able to succeed in obtaining the hatching of the eggs. Before the first moulting, that is to say, in the space of some days, the young crustaceans perished in succession; we were not able to save a single one.

In 1885, we concerned ourselves only with the cod and the lobster. Thanks to the experience acquired in the previous year, the operations were carried on better and this time we succeeded in rearing completely the young lobsters; we were able to bring them up to the fifth period, that is to say, beyond the fourth stage period where, shedding the larval form and ceasing to float in currents on the surface of the water as they do at first, they make for the bottom in order to lead an adult existence.

Roché, Georges
1898 La culture des mers en Europe. Bibliothèque Scientifique Internationale, Paris, 1898, 328 p., illus.

The culture of the sea in Europe

It appears to me interesting to compare the observations of Ehrenbaum with those which have been made at the laboratory of Concarneau in 1865 by O. Moquin-Tandon and J.-L. Soubeiran.

"For the young lobsters hatched during the year in the enclosures (viviers)," say these naturalists, "we have data for the different sheddings extant at that time in the pools:

Lobster stages	Length	Weight	
4th	17 mm.	0 gr	101
8th	50	3	00
9th	60	5	00
10th	65	6	25
11th	75	10	50
12th	90	17	00
13th	100	19	50
14th	117	37	00

"The ease with which the young lobsters in the pools of Concarneau multiply and develop is one sure guarantee that on our coasts one should easily find suitable localities for creating similar enclosures where one should be able to obtain myriads of young which should be allowed the freedom of the sea only when they should be enough advanced in age to resist for the most part the causes of destruction which menace them incessantly. From what we have seen since our first visit to Concarneau (July 1865), that is to say, the pools literally black with small lobsters hatched in the enclosures and what we know of the way that a great number of species of fish have in producing immense quantities of fry the length of our coasts in special regions, we have hopes that one should be able to rejuvenate the fishery on certain of our rivers; by nursery reservoirs, one should attain the creation of an abundant source of food."

According to Captain Dannevig, "shortly after hatching from the eggs, the young lobsters whose shape is very different from that of the adults, measure about nine millimeters long. They are considered very promptly as the Mysis form. They are extremely voracious and seek to devour each other, principally during the first days which follow hatching. One is able to feed them with the flesh of crushed crab.

"At about eight days, after the second moult, they reach 12 millimeters in length and after the sixteenth day, when the third moult is effected, they are about 15 millimeters.

"At the age of four or five weeks, they undergo a fourth moult in which they lose their swimming organs, that is to say, the double appendages of the limbs, and they enter into what Sars calls their fifth period. From swimmers, they become walkers until the end of their existence.

"A new shedding occurs before the ninth week. The measure then (is) 21 millimeters in length and from three to four millimeters in width in the greatest part of the body. Of grayish green color, of very lively behavior, endowed with an insatiable appetite, these young crustaceans appear very robust."

Growth of the body takes place, furthermore, under the following conditions:

A lobster which	(20 cm.	3)		(25 cm	4)	It	(5 cm	1)
measures	(25	4)	measures	(30	5)	has	(5	1)
before the	(26	7)	after	(32	4)	grown	(5	7)
shedding	(26	7)		(30	5)		(3	8)

Contrary to that which has been announced by many authors, by Sars among others, it seems unmistakeable that the same animal is incapable to give eggs each year. Fullarton, as Ehrenbaum, shows also that the annual period of egg-laying is not spread out the entire year, but that it is rather exactly included between mid-July and mid-September.

Fullarton estimates that, for the same animal, the egg laying, on the European coasts, occurs every other year. Ehrenbaum, on the contrary, thinks that this egg laying is effected every fourth year. The latter author arrived at this conclusion by finding the percentage of egg females contained in the enclosures of the Heligoland fish dealers. The proportion of reproductive females which he had thus counted is from 23 to 25.4 per hundred. But, as Allen (E. S. Allen, Journ. Mar. Biol. Assoc., IV, No. 1, 1895) justly remarks: "It is not improbable that a berried female may enter more irregularly into a lobster trap than another one which should not be encumbered with eggs, particularly if the trap contains already other lobsters among which non-berried females happen to occur. In case also any maternal instinct in some degree should not exist among this species, an egg-bearing female is placed in state of physical inferiority for struggling with the other animals. Is it not therefore impossible that it be less bold to enter in the restrained space with other lobsters."

In 1879, Mr. S. H. Ditten, court pharmacist at Christiania, in a report entitled "For the Protection and the Reproduction of the Lobster and Oysters," proposed to collect egg-bearing female lobsters in a large floating enclosure and to hold them there until all the larvae coming from their brood might attain liberty naturally.

It was again in Norway that in 1885, Captain Dannevig was to hatch for the first time the young larval lobsters, by artificial means in an aquatic establishment. It was by using his incubators that he attained this result.

It is indisputable that the artificial method of hatching is more economical than that which has recourse to the segregation of egged females. Besides, under the ordinary conditions where the marine fisheries are carried on, it is practically impossible to reckon that the fishermen return to the sea berried females which shall be caught by their gear. However, they are bound, at Newfoundland and Canada, by demand from industry to furnish to the fish culturists the eggs which are carried under the berried female's abdomen.

In the United States attempts have also been made on the artificial propagation of the lobster. We are not acquainted in a fashion nearly complete with the results obtained by the U.S. Fish. Commission, but on the other hand we have very precise data on the works of the same species carried on by the Newfoundland and Canadian governments.

Originally, at Newfoundland, artificial lobster propagation used methods analogous to those of fish culture, properly speaking. The lobster eggs, rubbed from the berried females which were captured by the fishermen were placed in jars where a current of pure water circulated continuously. But, since 1893, this method has ceased to be employed by Dr. Nielsen. All the developing eggs rubbed off from the females are actually placed in a special incubator, invented by this scientist, and which, floating at the surface of the waters in the chosen localities, permit a considerable number of fry to develop.

Nielsen's floating incubator is composed of a box of white wood, oblong, 1 meter 25 long, 0 m 30 across and 0 m 20 deep. The bottom is curved. The box is provided with, on the outside, on each lateral face, two fins, not absolutely horizontal, but slightly curved like a propellor; they are also of white wood. In yielding to the sea caught by the incubators, the ailerons facilitate, by means of the waves, the manner in which they are rocked in a continual fashion. A cord, fixed to the bottom of the exterior, and tied on the other end to a heavy rock, permits the apparatus to be easily maintained in the region determined for the coast. A rubber vulcanized tube of 0 m 23 long allow the sea water to communicate with the interior of the box. In the corners the uprights are traveled over from top to bottom by a narrow canal which assures air circulation.

"A metal cloth (galvanized steel), fine meshed, is stretched horizontally a few centimeters above the bottom. It holds the eggs which deposited there, after fertilization, are going to give birth to the lobsters. In one of the small sides of the box, at the extreme left, a rectangular light is hung with a fine metal cloth.

"The incubator is closed by a cover, like a coffin, and all is painted black.

"The temperature of the water (in) the tank is that of sea water. The lobster eggs need darkness. The apparatus consequently places the eggs in the normal condition of their ordinary life. Two handles of rope placed at each end allow the removal of the tank. Thus equipped with all the rigging the incubator is worth $3.00. There (are) in existence actually 600 in full activity; it is few. There are in the whole country 50 stations where they appear. It is an apparatus easy to construct, cost a little and as we have come to see it very ingenious. (1)" (1) Géraud et Kerillis.

The very active industry of lobster canning destroyed every year in New Foundland and Canada a considerable quantity of berried females.

Thanks to the use of the floating incubator numbers of eggs were collected, more with the aid of the superintendant of fisheries of New Foundland than with the directors of lobstering themselves and were able to be brought up to the hatching stage.

It should not be necessary to believe, however, that the operations rendered with the use of the floating incubator do not require any precaution. It is necessary that the latter be placed in the regions where the water is as pure as possible and that they (waters) be as approximately brisk and the eggs should be absolutely healthy. It is also necessary that the apparatus be kept rigidly clean and that they be visited frequently to disentangle the eggs of the slimy particles which are able to pollute them. Finally, it is necessary to remove from the incubators the embryoes (eggs?) which die in the course of development. Without these precautions, it is to be feared that the pores such as the micropyle of the vitelline membrane will be obstructed by the elements in the course of development and that the stopping of oxygenation may involve the development of the embryo.

The following Table (p. 156) gives us in a complete manner the progress of operations effected at Dildo Island for the artificial propagation of the American lobster (H. *americanus*.)

In Canada, they continue, at the Bay View establishment, to use the incubation method used at first at Dildo and which was made to develop fecund eggs in MacDonald jars. It is reported in the accounts contained in the 28th Annual Report of the Canadian Fisheries Department that the owners of the lobster factories appreciated already the influence of the release of fry effected thru the efforts of the lobster station at Bay View.

The director of that station, at the time of the lobster fishery, visits the coastal factories aboard a small steamer fitted out for this service. He brings back from the factories the eggs removed from under the tail of the berried females which have been captured by the fishermen. These eggs, placed aboard a boat in jars where a water current circulates, are carried to the Bay View establishment. There, they are finally "managed" and induced to hatch. The following Table (p. 158) permits us to follow the operations of the year 1895 and to judge the results which are given.

Of the 168,200,000 fecund eggs, collected by the efforts of the Bay View establishment. 165,000,000 were induced to hatch and transplanted to Canadian waters.

In Scotland the Fishery Board has instituted, under the direction of Dr. J. H. Fullarton, attempts on artificial lobster propagation. There, however, in place of using the incubation methods used in Newfoundland or in Canada, in place of making use of floating incubators, Dannevig's incubators, or the American jars, they have simply kept the berried females in an enclosure similar to the crustacean reservoirs of our French coasts. They are also kept in floating tanks such as those which are still used at Quiberon, Belle-Island, Camarat, le Conquet, Lampaul, Quessant, l'Aberwrach and at many other points of our shore.

These experiments were made at Brodrick Bay on the west coast of Scotland where the lobster fishery is particularly active. There are allowed to not only study completely the larval development of the European lobster, but also to follow the larval evolution during the four weeks after their hatching. Speaking of that, it is necessary to report that Dannevig has hatched in his apparatus, in 1892, the eggs of European lobster and that he has been able to keep them living for two months after the hatching of the larvae.

M. Dannevig does not think it would be advantageous to limit oneself to hatching the eggs in order to set the young immediately at liberty. He also made reservations on the possibility of raising the young in captivity because of their pugnacious disposition..... But he thinks that in keeping the young until the age of six weeks, there was a real advantage to perform this rearing; because, if the loss is relatively great in the apparatus, it is again greater under the natural conditions. (1) (Raveret-Wattel, 1890)

The Scotch method of propagation should not, properly speaking, be considered as artificial. In any case, according to J. H. Fullarton, more than 700,000 young lobsters have been produced in 1895, in the tanks at Brodrick Bay.

Under these conditions, the tanks for crustaceans, which are widespread on our Brittany coasts should not fail to exercise a successful influence on lobster production on our coasts.

The fishery for the large crustaceans, lobster and langoustes, is especially developed among us, as it shows on the attached graph on the Brittany localities. There, the seamen who devote their attention to the capture of these animals sell their catch to the dealers who save a part in enclosures in order to regulate the sale for trips to the interior.

In 1895 these enclosures have given use to the commercial movement summarized in the above Table; I ought to say certainly that, besides the animals bought from our fishermen and taken on our French coasts, the keepers of the reservoirs for crustaceans in Brittany keep also in them the langoustes and lobsters which they send for from the Spanish and Portugese shores in the tank-boats (well boats).

If we shall believe the fishermen, also the Bay of Quiberon showed only small numbers of lobsters for long years. Now since the dealers have installed wooden floating tanks in the port of Port-Maria de Quiberon, it should appear that one may encounter the young lobsters in the shallow waters frequently.

This assertion cannot surprise us very much, being given that which we know of the development of this animal. It is not doubted, in effect, that if the females are kept under good conditions, their larvae cannot fail to hatch and disperse themselves in the waters which border on their hatching points.

In France, the experiments have been held at Croisic, in 1890, to apply to langoustes and lobsters the Newfoundland artificial propagation methods in floating incubators.

These experiments gave no results, that is to say, that the eggs placed in incubation are dead and gave birth consequently to not a larva. Without prejudging the utility that it might have to apply to our waters the methods of propagation used in America, we are certainly able to say that the attempts of development made in France have not been over-whelmed by any of the precautions which are indispensable in order to assure the hatching of eggs.

One cannot therefore say that these processes are not susceptible to be a success in our regions. We ought to admit rather among ourselves, as everywhere else, it is important that experiments of this kind should be watched over with care and conducted by agents sufficiently acquainted with the delicate operations that the development of marine animals renders necessary.

Sund, Oscar

1914 Beretning om anlaeg av statens hummeravlsstation og driften i 1913. Aarsberetning ved. Norge Fiskerier for 1914, 4 de hefte, pp. 525-532, illus.

Report on planning of the state's lobster rearing station and the work in 1913

The rearing station was planned already in the spring 1911, when I examined different localities along the southern part of the coast, which could be used for this purpose, as for instance Varholmsundet and a few other places at Risør, Portør at Kragerø, Aalo at Ny Hellesund and a few other places in the vicinity together with Korshavn at Lindesnes and Hvidingsø, where Dr. Appelløf's rearing station had been. After having compared all these places on the basis of all known conditions which are or might be of importance - such as location in relation to the sea and rivers, depth, bottom conditions, supply of mature lobsters, it seemed to me that Korshavn on the whole offered the best conditions.

When the Storting (Parliament) in the spring 1912 had granted the money for the rearing station, 6,200 kroner, I went to Korshavn on August 1 the same year and gave contracts for the building of the rearing boxes and the machine barge to people in this place or in the vicinity.

In May 1913, the rafts which keep the boxes in their place and carry the propellers and their shafts, were built and the whole hatchery was mounted and made ready for work by the middle of June.

Description of the Hatchery

The hatchery was built essentially after the pattern of the one described by Dr. Mead at Rhode Island. On each side of a barge there is a wooden frame, 54 feet long and 26 feet wide, supported by 15 tarred barrels. The frames are bolted together of 4 x 5 inch timber, and in each frame (or raft) there is space for 12 rearing boxes.

The rearing boxes are made of one inch planed and grooved planks, painted with coal tar on the outside, with white zinc on the inside. The length and the breadth of the box are eight feet, its depth four feet. At the bottom, near two opposite corners, there are two windows 2 x 1 foot, covered with frames, on which is stretched a fine net of "isengarn" (i.e. a kind of cotton cloth with 1-1½ millimeters meshes). At the height of one foot there are two similar windows or hatches on two sides of the box. The box is made of six parts which are put together by means of brass screws. In the middle of the bottom of the box there is a cast iron socket, which serves as support for the propeller shaft. The propeller has two blades, each about $3\frac{1}{2}$ feet long; it is placed six inches from the bottom of the box and makes about nine revolutions per minute. Both things will be somewhat changed in 1914, partly to give the engine more resistance, partly to increase the circulation.

The length of the machine barge is 40 feet, the breadth 12 and the depth below deck three feet. The place below the deck is divided into four rooms by means of three water-tight bulkheads, so that a possible leakage would not be able to cause any considerable tilting. There are two motors, an older Alfa and a new Dan, respectively $1\frac{1}{2}$ and 2 indicated horsepowers (in reality, 2 and 3 horsepowers).

One motor serves as an auxiliary to the other; this is a good precaution; thereby we can work without stopping day and night the whole summer through, with exception of a few hours' interruption.

. . . .
. . . .

(p. 528)

The Hatching

(410 spawn-lobsters, weighing 201 kilograms had been bought.)

It was very surprising that the hatching proceeded so slowly. The first young lobsters were observed on June 24, but we did not reach a number of 2,000 until 14 days later. At the same time we observed that the brood was infested with a kind of worm, which I do not know, and which has not been mentioned by Dr. Appellöf either. However, it has been described and studied in England, and the author in question (Cresswell Shearer) thinks that it has no harmful effect on the brood. But the possibility is there, as the worm occurred in an unusually large number, at least five for each grain of spawn.

The cause of the poor results might be another kind of damage brought upon the eggs. A good deal of the eggs appeared to be scarlet red and dead, which according to fishermen's statements occurs very seodom. Foreman Evertsen had observed this phenomena before in the experiments at Hvittingsø, however, not on such a large scale.

The large numbers of the little worm and the red spawn were no peculiarities for Korshavn in 1913. During a visit at Hvittingsø in August we examined Bjelland's spawn lobsters. The worm

(Histriobdella homari) was found on all individuals, and on several lobsters were also found red eggs in smaller or larger number. It is possible that the death of the spawn is caused by some kind of fungi or bacteria. Next year we shall make specific experiments "if the red spawn should occur again."

When the young had been hatched in the hatching boxes, they were taken up and transferred to new boxes in order to keep the different stages separate.

We should have expected a couple of millions of young from the 400 spawn lobsters, but the hatching proceeded very slowly and all the time we found a great deal of unhatched red spawn in the boxes. The total hatch of living young was 58,700, i.e. only 1/40 of the number of eggs on the lobsters.

The Development of the Young

The development of the larvae proceeded more quickly than stated by Dr. Appelløf at Hvittingsø. In 1913 he found that it took about 26 to 29 days for the young to pass through the first three stages; in 1908 he found that the third shedding of shells occurred about one week earlier, i.e. after 19 to 22 days, probably because of the higher temperature of the last mentioned year; during the time he made his experiments the temperature was between 14 and 17 degrees C., average 15.9 degrees.

Some of the experiments at Korshavn did not even take that much time, which will be seen from the following Table:

Time:	Duration of 3 first stages (days):	Temperature Highest	Lowest	Average	4th Stage Number	%
18/7 - 9/8	16 - 21	18°.0	12°.5	15°.5	25	1.2
27/7 - 20/8	18 - 25	18°.0	13°.0	16°.0	68	0.5
29/7 - 23/8	18 - 26	18°.0	13°.0	16°.1	117	1.3
1/8 - 24/8	18 - 24	18°.0	13°.0	16°.2	434	9.0
9/8 - 26/8	12 - 17	18°.0	14°.5	16°.8	211	8.1 + ?

On figure two the time which elapsed from the beginning of the experiments up to observation of the first young lobster in the 4th stage, has been marked as horizontal lines at the top of the diagram. You will see at once that the development proceeded more quickly during periods with steadier and higher temperature.

The Results

From an economic point of view the result of the summer's work was very poor: instead of the expected 200,000 to 300,000 young in the 4th stage we got only 1,000. On the other hand we had a good deal of valuable, although partly bitter, experience.

It is quite clear that high temperature is of the greatest importance; in spite of all the disappointments of last year, we hope for a better result in 1914, because we have now chosen a new place, Øinekilen, which combines the salt water of the south coast with the highest possible temperature. The temperature might be higher many places farther east on the coast, but it is not desirable to have the rearing moved to places where people are reluctant to store fully developed lobsters for a longer time.

Also I want to emphasize the importance of training an interested and capable personnel and of getting a best possible apparatus.

The temperature

The Norwegian Metereological Institute has kindly given us a copy of observations concerning sea water temperatures for the last three years from the two nearest points east and west of Korshavn. This report helps to evaluate the result of the hatching at Korshavn in 1913 by stating two important factors:

1. The temperature at Korshavn in comparison with other places.

2. The temperature in 1913 in comparison with the two preceding years.

On the diagrams (2 to 4) the temperature has been given graphically. You will see that the temperature in Korshavn in 1913 was just as high as in the other two places, the temperature curves of which are given on the same diagram. You will also notice the great variation in the surface temperature; this seems to be peculiar to the year 1913. During the two preceding years the sea water temperature was steadier as well as higher in the places where observations were made, and this was probably the case also at Korshavn.

In order to avoid the unfavorable temperature conditions we moved the whole rearing station from Havnesundet to Øinekilen on August 9; here the water was considerably warmer and not exposed to such great variations in temperature. The result was that some young which were hatched that same day completed the development in much shorter time than the other young which were kept for a while in the colder water at Havnesundet.

It was considered rather unsafe to move the apparatus into Øinekilen, as Dr. Appellöf strongly emphasizes the importance of fresh, flowing water. But as the results at Havnesundet were very poor, we had nothing to lose; the apparatus was moved and the result proves that Øinekilen is a much better place. Of course the renewal of water goes much slower here than in a sound where the current goes right through. However, the mouth of Øinekilen is both deep and wide, so the renewal of water is quite good. The fact that young and fully developed lobsters were kept there for three weeks proves that the water is healthful. That the results at Øinekilen were not too good either, is probably due to the fact that not much spawn was left at the time when we moved. Most of the eggs had fallen off or had been spoiled already before that time.

The only rearing experiment made at Øinekilen from which we may draw any conclusions, showed a better result than any of the other experiments. After 17 days 8.1 per cent (211 individuals) of the brood had reached the 4th stage; still there were left 404 strong young lobsters in the 3d stage; most of these would probably have changed shells shortly after August 26. The percentage of young in the 4th stage would thereby have been about 24. This corresponds to the best results which hitherto have been reached on this side of the Atlantic.

Experiments have been made for years at Wickford, Rhode Island, where the temperature conditions are most favorable, i.e. 18½ to 22 degrees. The latest reports we have (1908) show that here a result of 40 per cent was reached in only <u>one single case</u>.

Sund, Oscar
1915 Statens hummeravlsstation, Korshavn. Aarsberetning ved. Norges Fiskerier for 1915, hefte 2, pp. 176-181.

The state's lobster rearing station, Korshavn

The work started on July 7 and lasted until August 23.

The experiments were not successful this year either, in spite of the fact that the temperature, which was supposed to have a bad influence in 1913, was much better. During the working period the noon temperature was always above 16 degrees and only a few days below 18 degrees C. So the temperature left nothing to (be) desired.

The engines of the station (two petroleum motors) were constantly working in the water. Only the night between 12th and 13th of July was there a stop of a few hours, in addition to four stops which lasted for less than an hour.

At the end of the 1913 season we got sun shades of tar paper for the boxes. Thereby we practically prevented growth of algae.

It was hard to get sufficient circulation in the water because the "windows" of gauze were over-grown and were hard to clean. This difficulty was overcome by using windows of perforated celluloid.

The brood was fed regularly several times day and night. Mostly we used hard boiled and minced eggs for food, which the young ate with great appetite. Besides we used minced, raw mussels, two different kinds of shrimp (crushed), finely ground boiled meat and finely ground raw fish. All this food was eaten by the young with appetite, but we found out that eggs were most practical, as they made the control of the consumption in the boxes easier, so that we could prevent pollution. The difficulties in connection with artificial rearing of lobster are very great, and very much greater in a large hatchery than in a small experimental hatchery.

Experiments were also made with living food, i.e. small crustacea which was caught in the sea by means of a dip net. But the young lobsters did not try to get hold of them.

The first difficulty is to get a sufficient number of spawning lobsters. They had to be purchased at a very high price, as the lobster dealers found out that the average quality of their stock decreased when the egg-bearing lobsters were taken out. As the protection period starts before the work at the station begins, all the spawn lobsters which we intend to use, have to be brought in beforehand and stored; this leads to loss of eggs as well as of lobsters.

The next difficulty is to make the lobster hatch. In 1913, we used a method which was recommended in the report on the work at the American rearing station at Rhode Island. This consisted in putting about 20 spawn lobsters into a rearing box with a propeller. However, the method did not prove satisfactory, because the lobsters lumped together in the corners of the box and ate the spawn off each other. In 1914, therefore, boxes with separate rooms for each lobster were designed. These boxes were at first kept floating near the surface, but it appeared that the lobster in one way or another got hold of the newly hatched larvae and ate them. Probably the young were drawn in under the carapace with the respiratory water, which is released near the front of the carapace, where any solid particles are caught by the feather-shaped sides of the maxillipeds and are eaten. Several times we stated that lobsters in the above described position had young in the stomach; the brood was in all stages of dismemberment; (the chewing is performed in the stomach, which is equipped with tools for crushing of food). The boxes were therefore placed on the bottom, so that the lobster could not catch the young, which are kept floating by the rotating propeller.

Still we got very few young. Spoiled eggs soon appeared under the rear part of the lobster's body. Such eggs are easily noticed because of their scarlet color. Only during the first part of the season did we get some young from the spawn lobster which had been bought near the station. After three weeks all the eggs were already spoiled if we except the small part which had been hatched. The last half of the season we got some young from three spawn lobsters, which had been bought in Haugesund.

The cause of the poor results is probably the large number of parasitic worms (Histriobdella) which were also mentioned in the preceding report. This parasite is not to be found in America; it is very probable that the good results obtained over there are due to the fact that they do not have to fight this parasite. Every single lobster which we got in Korshavn, was infested with thousands of these small worms, which did not limit their activity to the eggs and the egg bearing lobsters; they were also observed on the young where they were creeping around on the gills, the legs and everywhere. We do not know in what way they harm the eggs and the young, but we suppose we might blame this worm at least for part of the difference when we compare the results of the experiments made on this side of the Atlantic with those obtained in America. The Swedish experiments in Bohuslen in 1913 did not give any good results either; according to the papers the result was 5,000 brood in the 4th stage. At Hvidingsøy only small quantities of brood were reared; here the result was about 1,600 in the 4th stage. At Hvidingsø the supply of newly hatched brood was unlimited; here we had Bjelland's entire stock of lobster (about 20,000,i.e. at least 1,500 spawn lobsters) at our disposal.

In comparing our results with those obtained at the very well-known rearing station, which is managed by Dr. Mead, Rhode Island, U.S.A., we have to take into consideration that good results were obtained over there only after many years' experiments. Especially we emphasize that the above mentioned parasitic worm which ruins all our experiments, is not to be found in American waters.

We have to grant that the problem of rearing of lobster brood is still in its experimental stage in Europe.

Below is a short survey of the rearing experiments made in 1914:

Experiment 1.

July 8: In 400 brood
10: In 1800 "
11: In 1010 "
10: In 500 " (?)
14: Of 12 individuals, 11 had reached stage 2.
18: Almost all had reached stage 3.
20: First young lobster in 4th stage observed
21: Four more in the bottom stage observed
27: Five young lobsters in the bottom stage were taken up; up to this time there were in all, 10.

Now no more young were left; the rest had either died or disappeared. The reason why such small quantities of larvae were put in (and even in the course of four days), was that the supply of young was very scarce, although we had almost 300 spawn lobsters which should produce larvae.

Experiment 2.

July 19:	Put in 1,000 young	
20:	" " 1,400 "	
21:	" " 2,500 "	
22:	" " 2,450 " , up to this time, a total 7,350	
22:	Most are in 2d stage, some few already in 3d stage.	
27:	" " " 3d "	
27:	Ten young lobsters in bottom stage taken up	
28:	Twelve " " " " " " "	
29:		
	etc. (see Table pp. 178-179)	

. . . .

. . . .

August 14: Four young lobsters in the bottom stage taken up. The box is now empty. Total result 256 in the bottom (4th) stage, or 3.61 per cent.

These were eventually liberated on the beach at the outlet of the Øinekilen, where the bottom is covered with stones and seaweed. The young lobsters immediately seek the bottom. As you will see, there is quite a variation in the duration of the development; in this experiment there was a difference of 19 days between the first and the last young lobster in the bottom stage. This variation is a great difficulty which will cause a lot of work if we, some time in the future, should succeed in rearing young lobsters by the thousands, - which is our intention. In order to use the apparatus properly, we should then have to sort out brood of the different stages all the time, and then put a large number of individuals of the same stage together into other boxes, in order to keep the boxes full and to prevent having young of different stages in one and the same box. The older ones will injure the younger ones. However, not even young in the same stage spare each other; a young lobster occupied in eating one of its companions might be seen any time.

Experiment 3.

July 23:	Put in 2,300 young
24:	" " 600 "
29:	Five young lobsters taken up
	etc. (see p. 179)

. . . .

August 7: The box is empty. Taken up, total 55, i.e. 1.9 per cent.

Experiment 4.

July 25: Put in 600 brood.
26: The number has decreased considerably.
28: Only a few are still alive.

Experiment 5.

Aug. 3: Put in 780 brood
4: " " 1980 "
5: " " 2050 " Now total 4810
7: Looked at 20. Most of them had eggs in stomach. Four individuals had entered stage 2.
8: All taken up. 2040 were alive, of these 17 per cent in stage 1, 82 per cent in stage 2 and 1 per cent in stage 3. More than 800 were found dead. All which were alive, were moved to another box.
13: All taken up. Only 705 left, of these 97 per cent in stage 2, two per cent in stage 3 and one only in stage 4. A little slot had been formed in a joint of the box, through which some younger brood may have escaped. The 705 which were left, were therefore moved to another box.
17: The rest were counted. Only 185 were left, most of them in stage 3. Moved to another box.
20: All taken up; total 63, whereof 26 in stage 2, 36 in stage 3 and one in stage 4.

Experiment 6.

Aug. 6: Put in 4,700 brood
7: " " 2,400 " Now total 7,100
10: About half the number entered stage 2.
11: The brood taken up and placed in a new box. There were now left about 2,660 alive, most of them in stage 2. A lot of dead ones were found among these.
15: Brood counted: 723 left. These were put into another box after having been fed with eggs and minced shrimp.
19: All taken up; total 189 whereof 169 in stage 2, 19 in stage 3 and one in the bottom stage. All, except the last-mentioned, put into a new box.
20: Put in 63 from another box, whereof 35 in stage 3 and 28 in stage 2.
22: All taken up when the work was stopped. A total of 116 were alive, whereof four in stage 4, about 80 in stage 3, and about 30 in stage 2. There were many dead ones in this as well as in the other boxes. Of 40 dead young lobsters, there were 33 in stage 2, six in stage 3 and one in stage 4. So the number of young ones was relatively larger among the dead than among the living.

Experiment 7.

Aug. 8: Put in 2,300 brood
9: " " 2,100 "
10: " " 1,350 " Now total 5,750 newly hatched brood.
13: Taken up and counted: only 895 left, which were moved to another box. Part of the loss may be due to waves breaking into the box.
17: Counted: 326 left (in stages 2 and 3). Moved to new box.
21: All taken up; only 53 left, almost all in stage 3. The high death rate was probably partly caused by a big jelly-fish which had come under one of the bottom windows during the night between Aug. 20 and 21. The long nettle threads of the jelly-fish had been drawn into the box by the current; here they were now floating in large quantities. Some years such accidents might happen very frequently. In 1914 there were only few jelly-fishes in the sea near Torshavn.

Experiment 8.

Aug. 11: Put in 1,150 brood
12: " " 500 "
13: " " 500 "
14: " " 200 " Now total 2,350. At 7 o'clock in the evening they were all counted. 1,442 were then left. All egg particles which could be seen, were removed, and the young were fed with very finely minced eggs, which most of them ate with great appetite. The young were moved to another box.
18: All taken up. 359 left, all in stage 2. There were also 40 dead individuals. Moved to new box.
21: Counted. 254 left, whereof 40 per cent in stage 3 and 60 per cent in stage 2. Fed with eggs.
22: Experiment was stopped. Only 121 left, thereof 30 in stage 3. A similar number of dead ones.

Tremblay, Jean-Louis
1946 Rapport de la station biologique du Saint-Laurent pour l'année 1945. Rapp. Gén. Stat. Biol. St.-Laurent 1943-1944-1945 (1946). pp. 19-34, illus.

(p. 26)

The few larvae held in captivity in the rearing tanks did not pass through the first molt, the water temperature not being favorable and the food not sufficiently sought after.

Finally certain physiological works on the shedding of larvae should be conducted on an equal footing with the planned rearing work.

Tremblay, Jean-Louis
1948a Rapport de la station biologique du Saint-Laurent Université Laval pour l'année 1946. Rap. Gén. Stat. Biol. St.-Laurent 1946 (1948), pp. 3-13, illus.

(p. 10)

The rearing of lobster larvae to the fourth stage for the purpose of restocking was able to be begun in 1946, after having been postponed for two consecutive years because of the difficulties in ordering apparatus. The system advocated for this rearing differs at many points from that in use at Boothbay Harbor, Maine. This system which has given proof of its ability necessitates however some modifications in order to compare it, with regard to yield, to the Boothbay Harbor system. These modifications are very small and are able to be furnished without involving considerable trouble. Under conditions rather unfavorable for this rearing begun in 1946, the cost of each larva raised to the fourth stage and ready to be liberated in the sea is 26 cents. We hope to be able to reduce the cost at something less only by furnishing the necessary modifications for the rearing system and by profiting from the experience acquired with the handling and feeding of the larvae.

Tremblay, Jean-Louis
1948b Rapport de la station biologique du Saint-Laurent Université Laval pour l'année 1947. Rapp. Stat. Biol. St.-Laurent 1947 (1948), pp. 1-12, illus.

(p. 8)

Lobster rearing

In 1947, it was understood that the lobster larvae rearing experiments should be continued but on a larger scale, so that the effect of artificial restocking might be more appreciable. To this end, it was necessary to assemble a greater number of berried females than the preceding year. That is why, in 1947, the station has purchased all the berried females captured by the fishermen from Grande-Rivière to Newport inclusively. These females have been transported in a truck from the region of their capture to the station; but many among them, almost the majority, have arrived in very sickly condition at the station's fish tanks. It is important to point out that also in case the females appear in good condition, their eggs have been mostly somewhat affected.

One of the first consequences of transportation has been the decimation of females in captivity. In fact, after a few days of captivity, one recorded a very high mortality, viz., 13 per cent. This state of things is repeated for the larvae among which the percentage survival at hatching has been very feeble. In fact, according to probabilities, the 204 berried females held in captivity should release several hundred thousands of larvae; and actually, 96,062 larvae only have emerged from the hatching apparatus, which may agree well with the facts mentioned above concerning the weak state of the berried females on their arrival at the fish tanks. A fresh layer of paint on the hatching boxes seems also to have been unlucky for the larvae and also possibly for the females also; but this unfavorable factor cannot explain by itself, it seems to us, the failure of hatching.

In the best rearing conditions realized to date, one knows that the survival rate up to the fourth stage is about 25 per cent, that means that of the 96,000 larvae collected in the hatchery one was able to expect that about 24,000 might be raised to the fourth stage for liberation in the sea. But, of this number of larvae, the majority were, at hatching, in a precarious state of vitality; and furthermore in the course of the rearing period, an electricity failure has forced us to restrict the circulation in the rearing boxes, and we have in 48 hours recorded a mortality of 30,000 larvae.

At the end of the rearing period, we have liberated in the sea a few less than 3,000 larvae of stages 1, 2, 3 and 4. This almost complete check of rearing operations represents for us a year of delay in this experiment, but otherwise it makes evident the influence of certain factors conditioning the success of rearing, and we believe to be able to control these factors with more mastery in consequence of such a check.

Vaillant, Leon
1880 Rapport sur les poissons, crustacés et mollusques. Exposition Universells Internationale de 1878, Groupe 8, classe 84, pp. 1-29.

Report on fish, crustaceans and mollusks

(p. 5)

Crustaceans - The lobsters and langoustes (crawfish) are the only ones of these animals who seem to be able to become the object of practical rearing, the low price of the different species of crabs which are consumed does not hardly permit the hope that they may be able to defray the expenditure of a less important cultivation; as for the shrimps, their small size, the quantity of water and nourishment which is necessary may also be obstacles to their rearing.

The adult crustaceans offer great difficulties for the preservation of their living state. Their feeding is very active; they require, therefore, abundant nourishment to maintain themselves in good condition; they should, to tell the truth, obtain it themselves; these animals are not particular in the choice of food, but their water should be frequently renewed. If all these conditions, especially the latter, are not fulfilled, these animals may become thin and, their shells covered with mud and marine vegetation, they lose all their marketable value. Also, usually, one ought to hold only a small number of these animals at a time and for the shortest period possible, a serious disadvantage for the fisherman who is not able to choose the time favorable for the sale. However, M. Halna of Fretay has succeeded in overcoming these difficulties and in a reservoir, of which a relief model has been shown, he has been able to keep with a volume of water about 4,800 cubic meters up to 30,000 crustaceans at a time and not have a mortality of more than 1.5 to 2 per cent. The langoustes have been able to be held captive for six months without losing any of their qualities. This result has been brought about by a cleverly ingenious system of partitions and sluice gates, which dividing the reservoir, permit at each tide the establishment in the latter of violent currents and various directions according to the needs.

With regard to the artificial reproduction of crustaceans, for those which we have, the langoustes whose larvae of so bizarre form live in the high seas, aquiculture appears impractical a priori; for lobsters, which are not in the same position, a model of the reservoir has been well shown in the Norwegian section by the Society of Stavanger, which should concern itself, according to its title, with the artificial reproduction of the lobster, but it has not been possible for us to obtain satisfactory information on the use of this apparatus and the results obtained.

According to a notice published since by M. H. S. Ditton, pharmacist of the Christiania office (De la protection et la reproduction du homard et des huîtres, 1879) the system should consist of taking the female lobsters which have their eggs developed, placing them in a car moored in a region suitably chosen and maintained by floats at a certain depth below the water level. In putting the animals back again during the appropriate season, as soon as their eggs hatch, one obtains in these tanks a great number of embryos which are maintained for some time by means of proper feeding. But, reaching a certain point of development, they plunge to the bottom of the car, leaving by holes prepared at a certain point and going to sea. This method, as one sees it, demands certain work without assuring the owner reimbursement for his troubles, since the young escape his surveillance once outside the car, but should only be recommended from a viewpoint of public usefulness, if the experiments are favorable to it.

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