Canada, FISHERIES AND MARINE SERVICE

DATA RECORD NO. 17

PROGRESS REPORT ON STUDIES OF THE SURVIVAL AND GROWTH OF LARVAL HERRING IN LARGE BAGS SUSPENDED IN DEPARTURE BAY, BRITISH COLUMBIA, CANADA

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NOVEMBER 1976

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INTRODUCTION

Despite a large number of field and experimental studies on the feeding of fish larvae, it has not yet been established whether year-to-year changes in the feeding conditions for larval herring may account for a major part of the observed fluctuations in subsequent recruitment (see "Symposium on the Early Life History of Fish," Oban, 1973). It is generally accepted that the relative size of a year-class is established during or at the end of the larval phase. The mortality during this phase may depend on the food supply both directly due to starvation if food is scarce, and indirectly, as the availability of food determines the time needed to grow through a succession of decreasing predatory fields.

Direct observations on growth and mortality of larval herring at known food supplies have been made in the laboratory but quantitative results obtained under laboratory conditions are known to be biased to some extent. Their validity has to be checked by field observations. Attempts have been made to assess the feeding conditions of herring larvae at sea; however, such results have not been definitive and are difficult to compare with experimental results because of the different methods involved. An alternative approach seemed to be needed. One promising approach involved using large floating bags in which survival and growth of larval herring could be monitored at controlled levels of natural food supplies and under environmental conditions as natural as possible.

For a program of this kind, the Pacific Biological Station at Nanaimo appeared to be especially well suited. Extensive spawning of herring in the vicinity, easy access to the spawning beds, the availability of herring eggs over a period of almost 2 months and excellent laboratory facilities combined

to provide favourable conditions for this work. Arrangements were therefore made to conduct such a study at Nanaimo through the Canada-West Germany Scientific Exchange Program.

Work was started at Nanaimo at the beginning of February 1976, and was integrated with the Herring Program of the Pacific Biological Station. Four bags and auxillary gear were shipped over from Germany by air freight, while another four bags, made out of reinforced plastic material, were sent off by ship together with other auxillary gear that would not be needed until after the experiments were under way (mid-March).

In preparing the experiments, four main items had to be attended to:

1) designing and constructing floating frames in which the bags were to be suspended,
2) establishing the methods for regular collection of food plankton to be used in both outdoor and indoor experiments,
3) becoming acquainted with the in situ conditions that were to be expected for the herring larvae in this area (Departure Bay),
4) adjusting the methods developed in Germany to make most effective use of the local situation and facilities.

The last item involved discussions with, and practical help from, many employees at the Station. Laboratory space and equipment was generously made available by the Salmon Enhancement Program. Continuous invaluable support was provided by Dr. D. Alderdice and F. Velsen.

Items 2 and 3 were mainly discussed with biologists of the Fisheries Ecology Section at the Station. Latest unpublished data were made available by Dr. R. LeBrasseur and Messrs. J. Fulton and O. Kennedy on the seasonal development of the plankton in Departure Bay, including data on small-scale variations in the concentration of plankton organisms and frequency distributions of concentration and maximum values. This information was needed in order to plan

the food sampling for the bag experiments and to interpret the results of our experiments. Besides these data, various types of plankton sampling gear were made available by this Section. A device for accumulating plankton in desired size fractions during the night was especially useful in collecting the required food supply throughout the term of the experiments.

As to item (1), the floating frames used to suspend the bags at Kiel (Germany) were not shipped to Canada because of the high costs involved and the possibility that they might not have been suitable for conditions at Nanaimo. Financing was made available by the Herring Program to design and build wooden frames at the Nanaimo Station. A Herring technician (Jack Robinson) was fully involved in this and associated tasks for about 2.5 months. When the ship freight from Germany was delayed for about a month, the Herring Program also provided for the construction of a second set of four bags. After successfully testing the float construction and the way of suspending the bags, the floats for the first four bags were moored near the Station wharf in mid-March.

METHODS

Field sampling of herring larvae and feeding experiments in the laboratory were carried out concurrently with the outdoor bag experiments.

Field sampling

Herring larvae were caught from the wharf of the Station mostly at night. They were attracted by a light bulb placed near the water surface. After allowing time for accumulation of the larvae, a sample was taken in a very gentle manner using a 10 ℓ bucket, trying to avoid any major disturbance of the aggregation of larvae. In the laboratory the larvae were narcotized and length measurements were made immediately, before shrinkage could have taken

effect. Dry weights were provided for most of these specimens by a Herring Technician (Susan Kerr). Some larvae were preserved in formalin solution and measured repeatedly after definite time periods in order to assess the shrinkage due to fixation.

Observations on the gut contents were made in connection with length measurements and, in some cases, larvae were preserved for more comprehensive analysis of gut contents. These data were intended to provide a standard for comparison with larvae from bag experiments of increases in length and weight, condition factors and food intake.

Laboratory experiments

In order to obtain some information on digestion rate, herring larvae caught at dusk in the very gentle manner mentioned above, were kept alive individually in small buckets (about 200 mℓ) in the lab and were examined repeatedly for their gut content. In addition, feeding experiments were carried out with a number of sea-caught larvae kept in black circular tanks containing slightly less than 10 ℓ of sea water. The temperature was maintained at *in situ* levels by a cooling bath of running sea water. Stagnation of the water within the tanks was prevented by slight aeration. A major part of the water was frequently siphoned out and renewed. Part of the wild plankton sampled for the outdoor experiments was used as food. Subsamples were taken from the tanks after definite time periods in order to monitor the decrease in the amount of food and possible changes in its composition due to the feeding activity of the herring larvae.

These studies are designed to give information on feeding rate and food selection when natural food supplies are offered under laboratory conditions

and to provide reference data for results from the bag experiments and field sampling.

Outdoor bag experiments

Large floating bags moored in a main area of larval development were employed to: (a) provide enlarged aquaria for the herring larvae, (b) achieve environmental conditions as natural as possible, and (c) permit monitoring of the growth and mortality of a specific group of herring larvae and of changes in their food supply. The bags were made out of strong polyester sailing cloth and had a capacity of about 6 m^3. An upper cylindrical part 2 m in diameter and 1.20 m in length was followed by a conical part that narrowed to 0.1 m on a length of 2.30 (1.80) m. The tip of the cone was closed while the cylindrical part was open. Three aluminum rings supported the bags which were suspended in a floating frame. The cylindrical part projected about 0.5 m over the surface in order to prevent any overflow of water masses due to wave action. The wall material was permeable for water but not for plankton.

After the initial filling of the bags with surrounding sea water, the desired plankton concentration was achieved by adding an appropriate amount of plankton caught with a net of 44 μ mesh size. The plankton supply in the bags was monitored at intervals by sampling the whole water column at once by means of a long tube and at three different depths using a water bottle. Plankton from outside the bags was accumulated during the night by light attraction and pumped into a net of 44 μ mesh size. These plankters were filtered through a 200 μ mesh net and the resulting food organisms were apportioned to the bags according to monitored changes in the food supply for the larvae.

The supply of herring larvae for these experiments was obtained by three different methods: (1) Algae and seaweeds carrying naturally spawned eggs were collected and kept in a tank with running sea water until shortly before hatching. The desired number of well developed eggs was then removed and transferred into the bags. (2) and (3) Eggs were artificially spawned and fertilized on glass plates. They were incubated in the laboratory at a temperature chosen according to the desired hatching time. Before hatching, the number of well developed eggs was counted and/or photos were taken for a later check of the numbers. After some time of adaptation to in situ temperatures, the glass plates were either suspended in the bags (Method 3) or the larvae were hatched in the laboratory and then transferred into the bags (Method 2). Growth and mortality of the larvae were checked by occasionally sampling live larvae for length and weight measurements and by regularly siphoning all dead larvae out of the narrow bottom part of the bags.

First experiment

The main emphasis of the first experiment, started in the last week of March, was to test the equipment and methods and to acquire experience for the second, main, experiment in which all eight bags were to be employed. At the same time the routine designed for the program was carried out as regularly as possible with the limited personnel available. Because of heavy commitments by Station personnel to other projects during the spawning season, no assistance was available for this aspect of the program except from my wife. She undertook the task of analyzing both the composition of the plankton samples from the bags and the concentration of organisms by size group. These analyses, carried out routinely, were the basis for maintaining the differences in food density between

bags. The required food supplies were provided by regular collections of plankton during the night (supplemented on occasion by collections made during the day). Absolute food densities showed marked changes during the experiment. Nevertheless, differences between bags could be maintained for an extended time period at least on an ordinal scale.

Naturally spawned herring eggs had been collected before mid-March and, after a developmental time of about 2 weeks in a large tank, about 5000 eggs were counted into each of the bags.

The detritus was collected daily from the bottom of each bag. Dead larvae were immediately sorted out from the rest of the detritus and counted in order to follow the decline in their number in each bag. Mortality turned out to be fairly high. Although a larval mortality is known to be high in nature, some additional mortality may have been introduced by enclosing the fish in plastic bags. A more thorough evaluation of the data and examination of the larvae themselves may yield more definite clues with regard to such mortality.

During this first experiment, work on the development of the herring larvae at sea was designed to fit in with another larval program carried out by Dr. H. Rosenthal. He also supported us in preparing the main experiment by artificial fertilization of herring eggs. In addition, the following two problems were tackled in cooperation: (a) the shrinkage of larvae due to fixation and (b) the digestion rate observed of sea-caught larvae. Since the method involved in solving the latter problem was rather time-consuming, the data obtained on this subject were rather limited. The former problem was more comprehensively dealt with. Some measurements have still to be made before the data can be assessed.

Second experiment

The main experiment was started in late April when only a small portion of the larvae from the first experiment was still alive in the bags. This time, artificially fertilized herring eggs had been developed in the laboratory. In a first series the newly hatched larvae were transferred into the four long-established bags, whereas in a second series glass plates with eggs were suspended shortly before hatching into four newly constructed bags which had been moored beside the other shortly before. Artificially fertilized eggs were used rather than natural spawn in order to produce a more simultaneous hatching at a more exactly predictable date. Moreover, it was easier to introduce roughly the same number of larvae into each of the four bags. A quick estimate of the number of well developed eggs was made shortly before hatching, and photos were taken for a more exact count later. Eggs which did not hatch were counted.

The main emphasis in this second bag experiment was to monitor the growth and feeding of the surviving larvae under known natural food supplies of different concentration. This involved the same food-control routine as in the first experiment, now with eight bags, and regular sampling and analyzing of live larvae out of the bags. Technical assistance was provided by the Herring Group for the weight measurements. Sampling was again carried out on both plankton and detritus to obtain information on the distribution of food within the bags and the number of dead larvae per day. These samples have still to be analyzed and all data so far available have still to be evaluated.

Methods were further improved during this main experiment. The procedure for removing dead material from the bottom of the bags was simplified to avoid catching live larvae along with the detritus. Another modification was the introduction of a continuous supply of air bubbles to provide for vertical mixing within the bag.

Third experiment

The third experiment was started towards the end of May. At that time the amount of well-developed eggs from artificial fertilization was rather limited. Consequently, only four bags were populated with herring larvae this time. Different numbers of larvae were introduced into each bag which now had similar food densities. Generally, the same program was carried out as in the second experiment. The other four bags were used to test the degree of similarity in temporal changes of the plankton supply between bags with comparable starting conditions. By pumping water from one bag into another and back again, the water masses of two respective bags were thoroughly mixed. Identical plankton masses were occasionally added and samples were taken out of the bags to follow the changes occurring with time.

The third bag experiment was accompanied by some grazing experiments with sea-caught larvae in the laboratory. However, lack of time and personnel prevented a comprehensive series of trials. These experiments were mainly aimed at assessing the method under the specific favourable conditions at the Biological Station. The field sampling of herring larvae, started by Dr. H. Rosenthal during the first bag experiment, was continued through to the end of this experiment. Thus some comparisons of growth under natural and experimental conditions should be possible.

The third experiment was finished early in July. As many as possible of the surviving herring larvae were caught alive and processed through the usual procedures before the bags were emptied entirely through a net of 300$_{\mu}$ mesh size. All retained material was preserved. After taking the

bags out of the water, cleaning and storage of all gear was arranged by the Herring staff in such a way as to minimize the preparations required for any continuation of the experiments.

RESULTS AND COMMENTS

Studies on the biology of larval herring using large floating bags were carried out by way of a compromise between two somewhat contradictory demands. On the one hand, comprehensive tests of methods were desirable in order to find out the best way of using this new approach. On the other hand, the objective of obtaining several comparable time series of data on survival and growth of herring larva required making as few changes in the methods as possible. What has been achieved by the studies in the spring of 1976 cannot be more than a start in both these directions, though it appears to be a promising one. Valuable experience has been gained in handling procedures, so that adequate methods are now at hand. Regular control of the food supply was achieved for the whole period. Though absolute densities varied greatly, sufficient differences between bags were maintained. The recapture of dead larvae appears to have been fairly complete. In the first experiment, where samples were processed immediately, the number of larvae transferred into the bags compared well with the total number of larvae recaptured. In the second and third experiments, a regular check of length and weight increments of larvae was carried out in connection with information on the gut content.

Further improvements are required in the techniques involved, especially for taking representative samples of live larvae out of the bags. The colour of the bags needs to be changed from white to some darker colour. Also the testing of different shapes of bags appears desirable as crowding in the tip of the cone at the bottom of the bag may have caused some mortality in the youngest larvae.

Records of the data accumulated during this study are on file at both the Pacific Biological Station, Nanaimo, British Columbia, Canada, and the Institut für Meerskunde an der Universität, Kiel. No evaluation of these data is possible at this stage as a large number of samples has still to be analysed. Results of this study will not be ready for publication before 1978. However, a first assessment of data can be expected within about 1 year. By then it will be possible to identify any special problems and gaps which remain within the information so far obtained and to plan any additional experiments that appear desirable in 1978.