

# Artificial Propagation of Cod

*Some recent results of the liberation of larvae*

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The sea-fish hatchery at Flødevigen was founded in 1882 by Capt. G. M. Dannevig. At that time the cod had become less abundant on the Skagerak coast of Norway, and captain Dannevig's idea was to increase the local stock of cod by liberating large quantities of larvae in the fjords and between the skerries. From the very beginning the opinions differed considerably as to the utility of such a programme. The experiences of the fishermen indicated that the recruitment to the stock was increased by the liberation of larvae, and so did the results of direct experiments by K. Dahl and G. M. Dannevig (1906). It was impossible, however, to arrive at a definite conclusion without a far more thorough knowledge of the biology of the cod than was then available.

Alf Dannevig, who was given charge of the station in 1911, started an extensive research programme in order to study the biological and hydrographical factors involved. Simultaneously the hatchery was kept going in order to obtain more experience. Large scale experiments on the usefulness of larvae liberation were postponed for many years, however, and systematical experiments were not started before 1950. In this paper the problem of artificial propagation of cod will be discussed on the basis of the experimental evidence now at hand and in light of our present knowledge of the cod in these waters.

The methods developed by G. M. Dannevig (1910) for hatching cod eggs on a large scale have proved to be very efficient and have been used unaltered up to the present time. Mature fish for the hatchery are collected during the months of January and February. Both the male and female fish are kept together in a special spawning pond. Provided a suitable temperature, the cod will spawn here as under natural conditions and the fertilized eggs will accumulate at the surface. The wastewater from the pond is drained from the bottom so that the eggs will not be lost.

The eggs are generally collected once a day. When doing so, the water outlet from the bottom of the pond is closed and the surface water passed out through a large filter of silk gauze that retains the eggs. From the collector the eggs are subsequently transferred to special hatching apparatus.

The sea water used in the hatchery is always filtered through large sand filters. This filtration was originally introduced in order to remove the plankton that might cause clogging of the silk gauze used in the hatching boxes and subsequent overflow and loss of eggs. Several later observations indicate, however, that the filtration is also of importance for other reasons. Thus we evidently eliminate to a great extent the microorganisms that may cause diseases and mortality to the eggs and larvae. Of no less importance is the fact that the excess gases in supersaturated water are liberated when the water passes through the sand. Several experiments have shown that it is often difficult to maintain fish larvae in water supersaturated with oxygen (Alf Dannevig and Gunnar Dannevig (1950)).

At favourable temperatures of 4 to 5°C the eggs will hatch after approximately three weeks, and the total mortality up to that time is generally less than 10 %. At lower temperatures, however, the mortality may be somewhat greater as a consequence of the prolonged incubation period.

The larvae are liberated at an age 3 or 4 days, before the yolk sac is absorbed. It has proved impossible to rear cod larvae on a large scale in ordinary aquaria. When fed on *Artemia*, they may thrive well for a few weeks until the gas gland begins to function. Then the swimbladder becomes strongly distended with gas and the larvae float to the surface and succumb. The fatal effect seems to be due to the fact that the larvae are kept at too low a pressure when the gas gland begins to function. Direct experiments have demonstrated that the larvae seem to prefer a higher hydrostatic pressure and in nature they are most abundant at depths between 10 and 30 meters.

Originally the fry were liberated directly at the surface. Now we take into account that the hydrostatic pressure is presumably an important factor and liberate the larvae at a depth of about 8 meters. This is performed by means of a large rubber hose with a weight at one end and used as a siphon. The larvae are generally transported onboard our own research vessel which is then equipped with special tanks for that purpose. Provided the sea is not too rough, the larvae may be transported for 12–15 hours without significant mortality.

The type of cod occurring along the southern coast of Norway does not undertake any long migrations, even in the spawning season.

Tagging experiments have clearly demonstrated that there is little or no exchange between the stocks of different fjords, or between the fjords and the adjacent waters outside.

Another fact is that there is generally no influx of pelagic eggs or larvae into the fjords from other districts. The recruitment to the populations here is mainly dependent on the local spawning. Thus the cod population along the southern coast of Norway is split up into a number of local and quite independent stocks.

The cod in these waters is heavily exploited by fishing and few fish survive to become sexually mature. It is most likely, therefore, that the recruitment is limited by the number of spawners. It is realized that in many species there are no clear indications of a pronounced relationship between the abundance of spawners and the numbers of subsequent recruits. It has to be kept in mind, however, that the presence of extremely large fluctuations in recruit numbers from quite other causes will tend to obscure such a relationship. It is logical to assume that under identical conditions the number of recruits will vary linearly with the numbers of eggs spawned. This must hold good as long as the rate of natural mortality during the earliest stages is not affected by the density of the population considered.

Extensive investigations in the coastal waters have demonstrated that the number of cod eggs is greatly reduced during development and that the number of pelagic fry is exceedingly low compared to the number of eggs in early stages. A very large percentage of the eggs is evidently being destroyed in nature. In the hatchery at Flødevigen, however, there is only a slight mortality on the eggs and about 90 % of them will hatch. The number of larvae produced by each spawner is therefore greatly increased when the eggs are maintained in a hatchery. If the recruitment to a local stock is limited by the number of spawners and the production of larvae, there is at least a chance that it may pay to take the spawners to a hatchery. In this connection it is certainly also of importance that the whole production of larvae at Flødevigen represents a net contribution to the fjords were they are liberated. The fish used for the hatchery are always purchased on the open market and thus given an opportunity to reproduce themselves before being killed.

The fact that we are dealing with local and heavily exploited stocks of cod certainly affords favourable conditions for artificial propagation. The most efficient method for studying the usefulness of artificial hatching would be to tag or mark the larvae in such a way that they could be recognized as older fish. Lacking tagging methods

suitable for such a purpose, Rollefson (1940) made an attempt to study the problem by producing larvae of a bastard (*Pleuronectes platessa* ♀ × *Pl. flesus* ♂) and liberating these larvae in a small fjord. Some months later the ratio of bastards to plaice in the littoral region was ascertained by sampling the flatfish population with a seine. The results were as follows:

Year	Bastards liberated	Percentage of bastards
1935	2 millions	1,5
1936	13 »	30,0
1937	7 »	0,5
1938	10 »	96,0
1939	7 »	40,0

In some years the bastards evidently had a very high survival rate. It was shown with rearing experiments, however, that the plaice and bastard larvae did not thrive well together in the same pond, and that the rate of survival was higher for the bastards than for the plaice. For that reason, the bastards could not be used to study the usefulness of liberating plaice larvae, as was the actual problem in this case.

At Flødevigen we have carried out since 1950 a special research programme in order to study the usefulness of artificial propagation of cod. Our plan has been to liberate 100–150 million larvae in the Oslofjord every second year and then try to ascertain whether these liberations are of consequence to the abundance of young fish. Such investigations will, of course, require many years to give conclusive results as the effect of the liberations may be more or less obscured by great natural fluctuations in the strength of the year-classes. We have, however, no better way of elucidating and eventually solving the problem.

The liberation of larvae has hitherto been accomplished according to plan, with the exception of one year in which the hatchery operations were impeded by exceptionally cold water. The fry have always been well scattered on both sides of the fjord inwards to Drøbak, whereas no larvae have been liberated in the innermost and heavily polluted part of the fjord.

The strength of the year-classes has been evaluated on the basis of the abundance of the 0-group and I-group fish in the littoral region during the autumn. At that time of the year the youngest age-group has attained a size of about 10 cm or more and is then most abundant in the littoral region. Here the 0-group cod may

easily be caught by a shore seine of suitable construction. Simultaneously we get samples also of the I-group, even though this age group has largely migrated into deeper water. The catch from each haul is counted and grouped according to age and the various age groups are treated separately.

The codling population has each year been sampled at 35 fixed localities distributed on both sides of the fjord inwards to Drøbak. Every precaution has been taken to ensure that the material from the various years is really comparable with regard to the numbers of fish caught. The seine used has been of the same size and construction each year and the hauls are always taken at the same time of the year. Also of importance is the fact that the seine has always been worked by the same crew.

In the following discussion the mean number of fish per haul is used as a measure of the abundance of the various yearclasses. As the 0-group and I-group fish are being treated separately, we get two independent measures of each year-class. The catches of the former are presumably the most representative as much of the I-group cod has left the littoral region.

No attempts have been made to evaluate the relative strengths of the various year-classes on the basis of the age composition within catches of older fish. Such a procedure is, in fact, rather difficult when concerned with populations that are heavily exploited by fishing.

The mean number of fish per haul of the different year-classes is shown in Figure 1. Considering the 0-group first, one sees that there are large fluctuations from year to year irrespective of whether fry have been liberated or not. The survival rate of the larvae liberated will, of course, depend on the environmental conditions in quite the same way as for the larvae originating from the local spawning. It is seen, however, that larvae have been liberated in each of the three years that yielded the most numerous catches, viz. 1955, 1957 and 1961. Another fact is that none of the years in which larvae were liberated has yielded substantially smaller catches than the best of the intervening years. Thus the 0-group cod have on the whole been most abundant in those years in which larvae were liberated.

The I-group cod are far less abundant in the littoral region than the 0-group and the catches are correspondingly smaller. It is evident, however, that all of the four year-classes that yielded the largest catches of this age-group originated from years in which larvae were liberated. Only two years when larvae were liberated have shown smaller catches than the best of the other years.

The material now at hand indicates, therefore, that the liberation

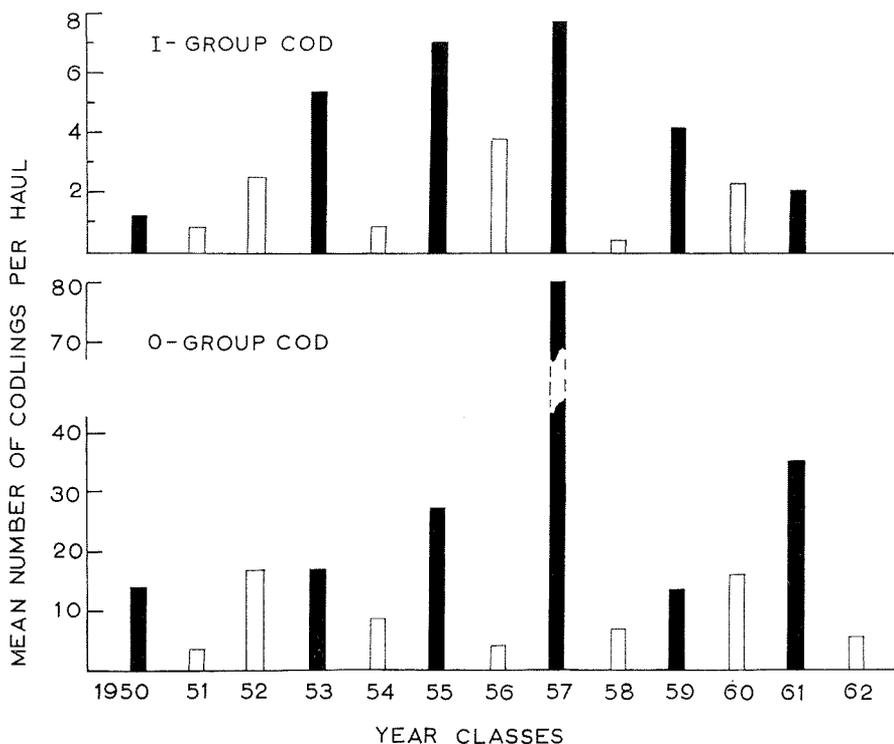


Fig. 1. Mean number of O-group and I-group cod per haul from the year-classes 1950 to 1962. Black columns: Year-classes with larvae liberated. Open columns: Year-classes with no liberation of larvae.

of larvae has had a noticeable effect on the abundance of young cod in the Oslofjord district. These results are in close agreement with the experiences of the fishermen who maintain that the liberation of larvae has been of great consequence. The fishermen have, in fact, good possibilities for evaluating the abundance of the different year-classes as they exploit the cod from its second year of life.

These preliminary results from the Oslofjord indicate that the artificial propagation of cod may prove profitable when concerned with local stocks that are heavily exploited by fishing. The investigations in this fjord will be continued in order to get more experimental evidence for judging the usefulness of this programme. Plans are also being developed for carrying out a similar research programme in other districts.

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