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MASS-PRODUCTION OF COD FRY IN A POND IN WESTERN NORWAY, WITH ADDITIONAL FEEDING POST-METAMORPHOSIS

by

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ABSTRACT

Two million yolk-sac cod larvae were released to a dammed pond in late March. One month later more than half a million metamorphosed. As the natural food supply was declining due to grazing by the rapidly growing cod fry, 10 automatic feeders were installed in the pond in mid-May. These fed the fry a small pellet containing 30% krill meal. The pellet was rapidly accepted by the fry, and in a laboratory experiment with cod fry from the pond, growth was comparable to that from a diet of natural zooplankton. From mid-June, the pellet was the dominant diet for the cod fry, with calanoid and harpacticoid copepods a minor supplement. The cod population declined during summer due to cannibalism and predation from birds. No outbursts of disease were observed, and infestation with parasites (nematodes) was less than 20%.

About 40 000 cod fry were transferred from the pond to other facilities for specific experiments. Most of the cod fry surviving to October will be tagged and released in the Austevoll region to initiate a case study on culture-based fishery on cod.

INTRODUCTION

The first successful rearing experiment reported with cod larvae was carried out in 1886, in a large basin at Flødevigen Biological Station[+]. Since 1975, these basin experiments have been repeated with similar success. Since 1980 they have been continued in a more natural environment: a dammed pond. The results obtained in 1980 and 1981 have been reported to ICES (Øiestad and Kvenseth 1981). In 1982, when 9000 0-group cod were collected from the pond, further progress was made in finding methods for rearing cod. This year a somewhat different larval release strategy was chosen.

MATERIALS AND METHODS

The pond experiment was carried out at the Institute of Marine Research, Marine Aquaculture Station Austevoll, south of Bergen. The pond with a volume of 60 000 m^3, has been shut off from the open sea with dams since 1980. Rotenone treatment was carried out in October 1982 to prevent sand-eel from spawning in the pond. Treatment was repeated in February 1983. Sea water was pumped into the pond from 40 m depth at a rate of 3 m^3/min until 20 March. Then 1.2 million 5-day-old cod larvae were transferred from the hatchery to the pond (Table 1). Ten days later another 0.7 million cod larvae were transferred to the pond. Larvae were transferred every 10 days until 30 April and the total number transferred was than about 2.5 million.

Survival and growth of the cod larvae were monitored two to three times a week, including one weekly midnight sample. Zooplankton and hydrography were monitored weekly. After larvae metamorphosis , automatic feeders were installed in the pond, the electric pump was started again (at 3 m^3/min), and the dam was partly replaced with a metalic screen that permitted zooplankton to enter the pond with the tide.

From mid-May, the cod fry were fed a dry pellet consisting of 30% krill-meal, 60% sprat meal, and 10% binder, vitamins etc.

[+]Rognerud (1887)

The krill component was reduced during the summer to 10%. For more details, see Braaten et al. (1983). Infestation by endoparasites was monitored weekly by squeezing the viscera of ten cod fry between two glass plates, so that live nemotodes were easily observed. From late July, 200 cod fry were kept in a net cage in the pond to faciliate detection of disease outbreaks in the pond. Cod larvae were captured by net hauls at six distinct depths, until a size of 20 mm. Post-metamorphosed cod (12 mm) were not captured representative. Cod fry were captured with a variety of devices.

About 40 000 cod fry were transferred alive for the following specific experiments:

- the economic of cod farming, from reared cod fry to market size
- development of a vaccination against vibriosis
- development of a feed pellet specifically for cod, from 0-group cod to market size
- cod farming in arctic water (Båtsfjord, Finnmark coast)
- protein syntesis in cod (RNA/DNA-relation)
- laboratory testing of the pellet used in the pond
- factors causing cannibalism among cod fry.

RESULTS

Hydrography

The temperature at 4 m depth (maximum depth 5.5 m) increased from 6.9 on 22 March to 14.0°C in late June (Fig. 1). In the summer it fluctuated near 14.0°C. The oxygen saturation at 4 m depth was above 100% until 30 June. During summer a minimum value of 82% saturation was measured 19 July (Fig. 1). The salinity at 4 m depth was about 32°/oo for the whole period.

Zooplankton

The zooplankton collected with the net hauls (350 µm) was dominated by Calanus finmarchicus in April and May. From late

April the population declined rapidly. It was negligible during summer. Harpacticoid copepods increased slowly in April (Fig. 2). Juvenile stages of decapodes increased to a high level during April (Fig. 2).

Among the hydromedusae, Rathkea octopunctata dominated in numbers, with Sarsia sp. and Tiaropsis sp. dominating in biomass. Overall maximum density observed was about 200/m^3 in mid-April (Fig. 2). All species declined in late April and virtually disappeared in May.

Rotifers and nauplii of calanoid copepods occurred at low densities in the pump samples (40 µm), (Fig. 3).

Cod larvae

The first and second populations of cod larvae released metamorphosed 35 days posthatching (20 April and 30 April, Fig. 4). About 50% and 30% respectively reached this stage (Fig. 5). The three next populations survived only for a fortnight (third population) or a few days (Fig. 5).

During the first two to three weeks, the diet was dominated by nauplii and rotifers, with a gradual change to copepodites and copepods. During day time the larvae had a lower gut filling and feeding incidence than during dusk and dawn. Most cod larvae were at 3 and 4 m depth day and night. With increasing age, however, they had a shallower distribution.

Cod fry

The food supply in the pond declined dramatically in mid-May, when more than a half million cod fry were grazing in the pond. For a period, the main food supply came with the inflowing tidal water through the screen. Most of the cod fry were then stemming the current in a large school, grazing on the incoming zooplankton and paying only minor attention to the food from the automatic feeders. During June, an increasing fraction of

the diet came from the feeders (Fig. 6). In July only a small fraction of cod fry were stemming the current for food.

The most likely explanation for the decline in the second group in early May was cannibalism from the first group. Cannibalism continued during the summer. It was also observed among cod fry transferred to the laboratory. The cod fry in the pond were also preyed upon by birds, mainly terns. Parasite infestation averaged 20% and did not increase during the summer. The only endoparasite observed was nematodes with a mean of 1.5 nematodes per infested fish. No outbreak of disease was observed among the cod fry in the net cage in the pond.

The dry pellet used as food in the pond was tested on 800 cod fry in the laboratory for two weeks. The growth was comparable to that of a control group fed on natural zooplankton.

	WET WEIGHT PER FRY (in gram)			
	Initial	Final	Increase	In %
Test group 1	0.99	1.49	0.50	51
Test group 2	0.93	1.40	0.47	51
Contr. group 1	0.97	1.78	0.81	83
Contr. group 2	1.02	1.91	0.89	88

At the end of July 1700 kg dry pellets had been fed to the cod fry. The mean wet weight of the fry was then 20 gram and total length 12 cm.

DISCUSSION

Since 1977, cod larvae have been reared successfully in the laboratory in many countries (Howell in press, Laurence 1978), but there are scaling-up problems in rearing large numbers. Up to a few thousand cod fry have been reared in plastic bag experiments (Huse et al. 1983). The main aim of our activity is to produce cod fry for a restocking program, which demands a

large quantity of fry. The fry also should preferably be reared in a natural habitat to make them better able to survive in the open sea (Blaxter 1976). Preliminary tagging and release experiments at Flødevigen Biological Station in 1976 and 1977 seem to support this view, as about 10% tag return was reported from fry released at a size of about 10 cm (Moksness and Øiestad in press).

The three first years, only 10-15 000 cod reached the metamorphosed stage, in contrast to 800 000 in 1983. It seems essential to release the larvae some weeks before start of hydromedusae reproduction. The repeated release of cod larvae every 10 day ensured a steady grazing pressure on the first feeding food organisms which might explain the recruitment problem for the hydromedusae, although food organisms for the large hydromedusae were numerous. The decline in the fry population after metamorphosis, probably due to cannibalism, may be overcome in future experiments.

As the pond has a volume of 60 000 m^3, the mean density just after metamorphosis 15/m^3, and as most cod were distributed in the deeper part, the real local density was probably 100-1000 cod fry/m^3. This high density might explain the heavy cannibalism that reduced the number to about 100 000 fry.

Disease problems in the pond are difficult to monitor, as dying fish will by ingested by crabs. As no disease was observed among the subpopulation in the net cage, this should indicate healthy conditions for the main population. The pellet fed to the fry gave a proper diet, as it gave rapid growth and kept the fry in a healthy condition.

The steady supply of water from 40 depth might have been of great importance in keeping the water temperature low and renewing the bottom water. This bottom water, the most waste-loaded and contaminated in the pond, is seldom renewed naturally.

The tagging experiment will be carried out with cod larger than 15 cm for two reasons: (a) the tags used require a fish of minimum 15 cm and (b) fry of this size would have a better change of survival than 10 cm fry, due to fewer potential predators.

Most of the tagged cod fry will be released in the Austevoll region, and area with some hundred islands and covering an area of 350 km^2. In addition to having a population of fishermen it is a popular vacation area. The tagging experiment should give information on migration, growth, fishing pattern, natural mortality, and recruitment to the local stock.

ACKNOWLEDGEMENT

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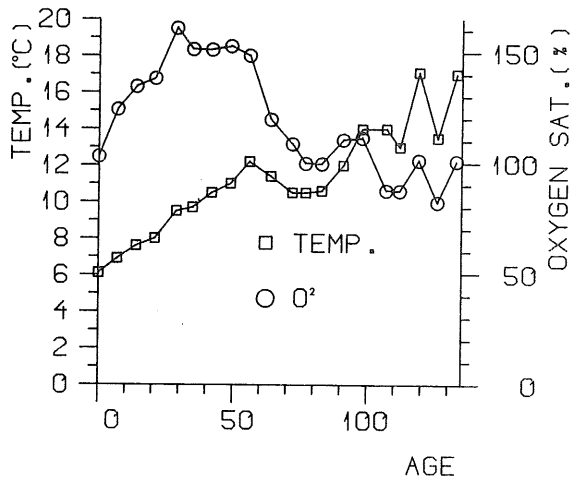

Fig. 1. Temperature and oxygen saturation at 4 m depth related to cod larval age in the 1983 pond experiment.

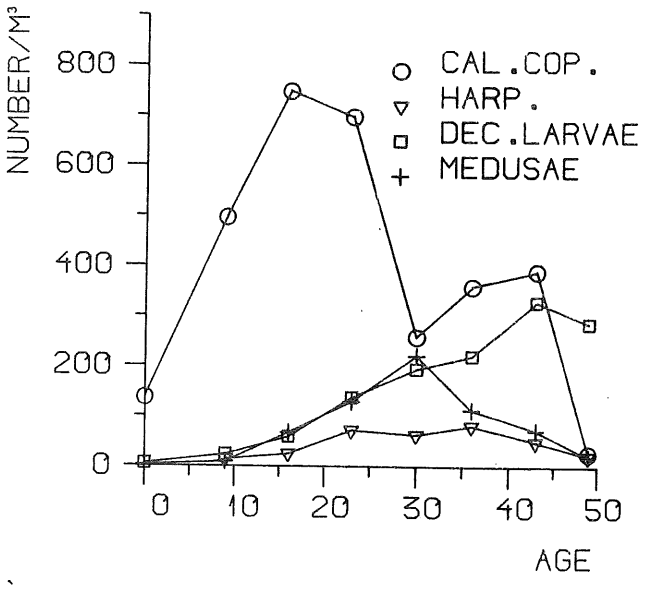

Fig. 2. The mean density per m^3 of calanoid copepods, harpacticoid copepods, decapod larvae and hydromedusae related to cod larval age (first group) in the 1983 pond experiment.

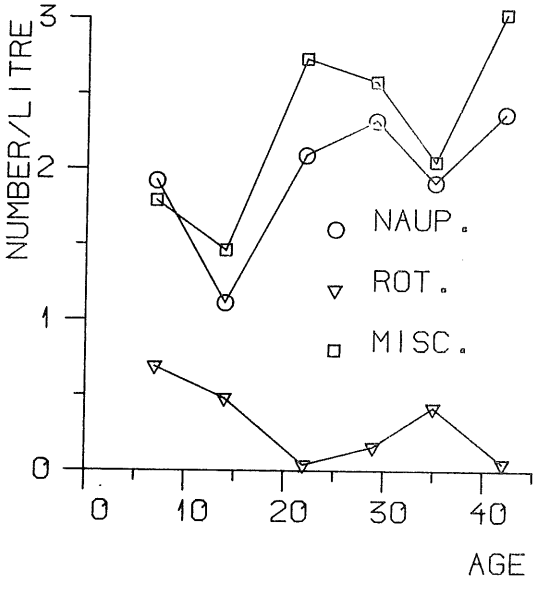

Fig. 3. Mean density per litre of nauplii, rotifers and miscelanous food organisms for first feeding cod larvae in the 1983 pond experiment.

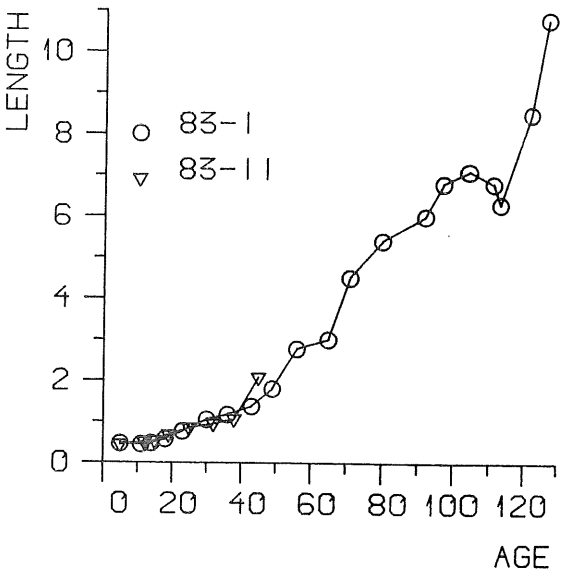

Fig. 4. Mean length of cod larvae in the 1983 pond experiment.

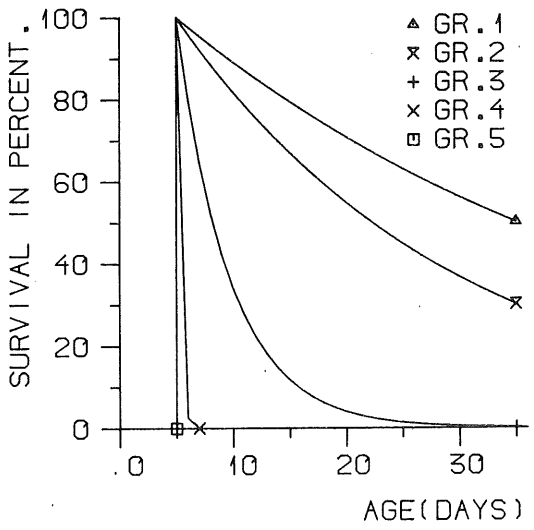

Fig. 5. Survival in percentage of the five cod population released in the pond in 1983 from release on day 5 post-hatching to metamorphosis.

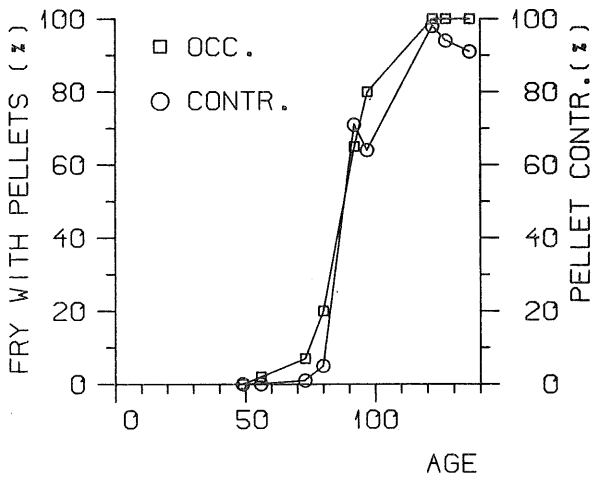

Fig. 6. The percentage of cod fry with pellets in the gut and the volume contribution from the pellet as percentage of the volume of food in the gut. Age refers to the first group in the 1983 pond experiment.

Table 1. Cod larva populations released, their size, feeding conditions, growth rate and survival.

Date of release	Population size	Initial food density+	SGR (%) 5-20	SGR (%) 20-metam	Survival (%) - 20	Survival (%) - metam
20 March	1 200 000	6	10 4	12.0	75	50
30 March	700 000	10	13.2	10.8	65	30
9 April	250 000	8	11.1	-	4	0
20 April	150 000	4	-	-	0	-
30 April	80 000	3	-	-	0	-

+ nauplii and rotifers/litre below 3 m depth