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The Propagation of Cod *Gadus morhua* L.

TAGGING AND RELEASE EXPERIMENTS ON 0-GROUP COASTAL COD
(*Gadus morhua* L.) REARED IN AN OUTDOOR BASIN

E. Moksness¹ and V. Øiestad²

- 1 Flødevigen Biological Station
N-4800 ARENDAL Norway
- 2 Institute of Marine Research
P.O. Box 1870
N-5011 NORDNES Norway

ABSTRACT

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Juvenile coastal cod (*Gadus morhua* L.), hatched in the laboratory and reared in a large outdoor basin at Flødevigen Biological Station, were tagged and released in coastal waters in southern Norway. They were released at an age of 6 months and a length of about 10 cm. Tag return to 1 January 1980 was about 4% of the 712 cod released in 1976 and 10% of the 371 released in 1976 and 10% of the 371 released in 1977. About 90% of the cod were caught by anglers, in the area of release. The tagged cod showed the same growth rate as wild cod in the same area. The relatively high percentage recapture of cod released in 1977 might indicate a potential high survival rate of released cod reared in large basins.

INTRODUCTION

In 1946, Rollefsen (1946) initiated a release programme with 200,000 metamorphosed larvae in the Trondheim Fjord. The larvae were hybrids between founder (*Platichthys flesus*) and plaice (*Pleurnoectes platessa*), a hybrid which did not exist

naturally in the release area. The aim of using the hybrid was to verify a release programme for plaice. In succeeding years, "large numbers" of these hybrids were captured by fishermen, (Sundnes, University of Trondheim, personal communication, 1983) but no results or conclusions from the experiments have been published.

Early in the 1960's, a similar release programme was performed in the United Kingdom (Shelbourne, 1964). However, the laboratory reared juvenile plaice had a low avoidance ability to predators in the sea (Anon., 1966) and the planned large scale release programme was therefore postponed. Blaxter (1976) suggested that juvenile fish reared in the laboratory were too "naive" to avoid predators and had not learned to capture moving prey, so that they would easily be exhausted if they tried to hunt escaping organisms.

In 1976 experiments were initiated at Flødevigen, raising cod beyond metamorphoses in a large outdoor basin. The rearing experiments with cod in 1976 and 1977 produced each year about 4,000 juveniles. About 1,100 of these were tagged and released. Recapture rates were of primary interest, but data on fishing patterns, migration, and individual growth were also valuable.

MATERIALS AND METHODS

The basins used to rear juvenile cod are located at Flødevigen Biological Station, outside Arendal in Southern Norway. Eggs spawned naturally in an indoor spawning basin at the Station were incubated in the laboratory. Five days after hatching the larvae, still with a remnant of yolk sac, were transferred to a 4,400 m³ basin (Ellertsen et al., 1981). The larvae fed on naturally occurring zooplankton in the basin for five months. In 1976, 200,000 yolk sac larvae were transferred to the basin, and the following year, 170,000. At termination of the experiments in 1976 and 1977, 4,000 (2%) and 3,900 (2.3%) juveniles, respectively, had survived. Their length frequencies are shown in Fig. 1.

Numbered steel tags, designed for 0-group herring, were used

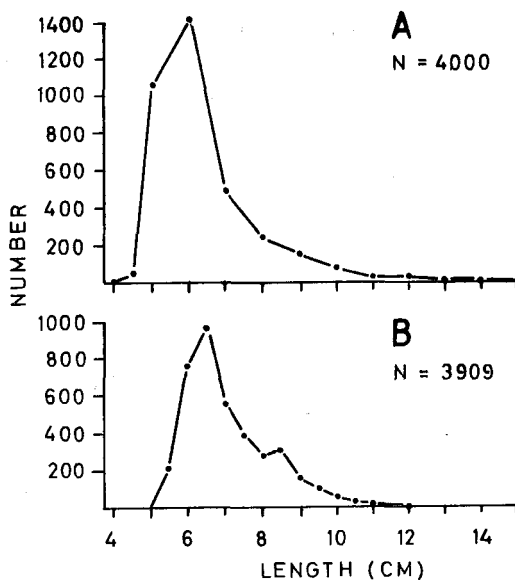


Fig. 1. Length-frequency distribution of cod fry at termination of the basin experiments in 1976 (A) and 1977 (B). Fry age about 5 months both years.

to tag juvenile cod. A small hole (0.7 mm) was drilled in each tag and 5-7 cm of nylon twine (no. 1 in 1976 and no. 2 in 1977) was threaded through the hole. The juveniles were starved for 48 h and then anaesthetized with MS-222 (tricaine methane sulphonate). Their bellies were cut with a scapel and the tag was introduced with a tagpump. Because of the size of the tag, only fish larger than 7 cm could be tagged. The twine protruded from the puncture in the belly (Fig. 2). This tagging method was used by Gundersen (1963) on sprat.

The fish were kept in the laboratory for 24 h after the tagging. About 1% of the fry died within this time.

In 1976, 425 tagged fry were released in early August and 287 in late September. In 1977, 371 cod fry were released in late September. The length-frequency distribution of the tagged fry is shown in Fig. 3. The release took place in Flødevigen Bay (Fig. 4). In both years, groups of tagged fry (37 and 47 fry respectively) were also established in the laboratory in 2.5 m³ aquaria.

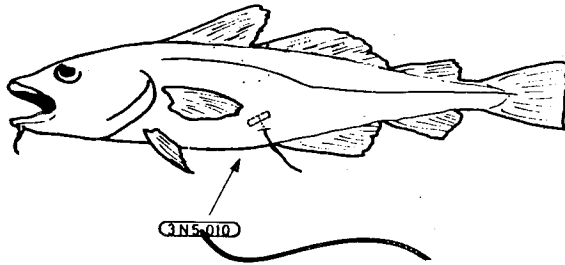


Fig. 2. A tagged cod fry with nylon twine protruding from the puncture in the belly.

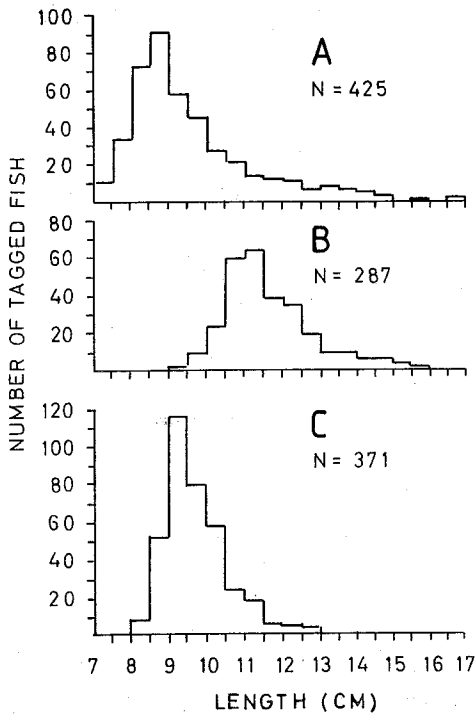


Fig. 3. Length-frequency distribution of 5 month old cod fry tagged in August 1976 (A), and of 5 month old cod fry tagged in September 1976 (B) and of 6 month old cod fry tagged in September 1977 (C).

The daily length increments (DLI) were given by:

$$DLI = \frac{L_2 - L_1}{t_2 - t_1},$$

where L_1 and L_2 are length at time of release (t_1) and at time of capture (t_2) respectively.

RESULTS

The 1976 release

From the release in August, 13 tags (3.1%) recovered and from the release in September, 14 tags (4.9%). This gives an overall reported recapture of 27 fish or 3.8%. Most were recaptured in Flødevigen Bay, but three fish were caught south of Flødevigen (Fig. 4). Most of the fish were taken by angling (67%), three (11%) were taken by gillnets, four (15%) with traps and two (7%) by beach seine.

The length-age relationships for tagged fish are given in

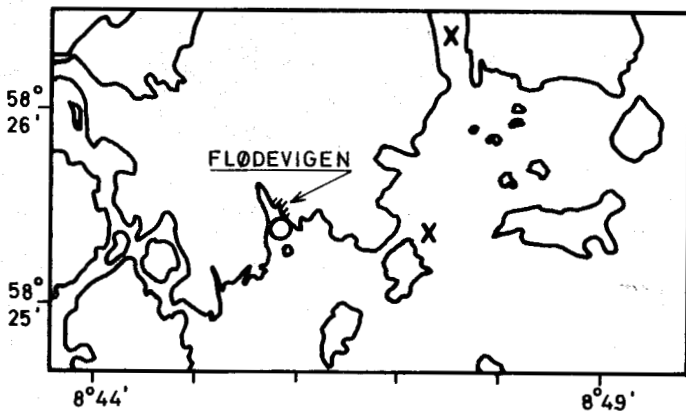


Fig. 4. A map of the release area for juvenile cod with release position (black circle) outside Flødevigen and the two most distant recapture locations indicated (x).

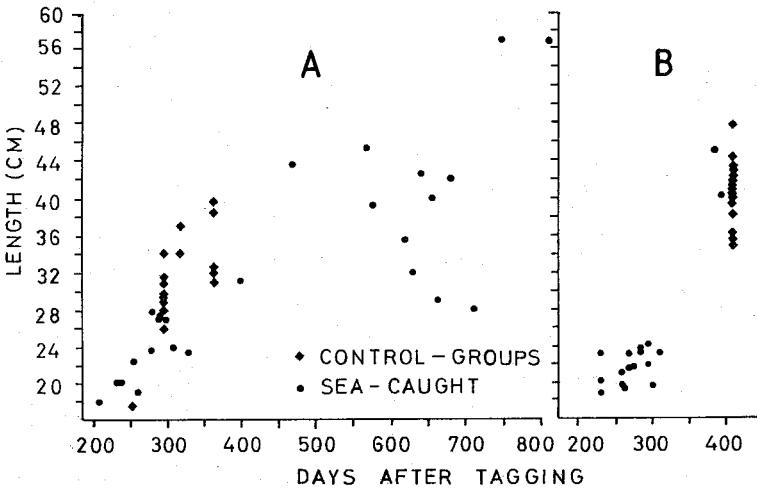


Fig. 5. Age - length relationship of tagged cod at recapture () for fry released in 1976 (A) and 1977 (B). Lengths of cod in the control groups in the laboratory are indicated for both years (x).

Fig. 5. The daily length increment from the first release was 0.46 mm and from the September release 0.44 mm, giving a mean of 0.45 mm of the fish released in 1976.

The control-group in the laboratory, kept together with 0-group plaice, had high mortality during the first autumn and four fish lost their tags. This group's daily length increment was 0.65 mm for the first year. Individual lengths are given in Fig. 5.

The 1977 release

From the 1977 release, the total number of reported recaptures was 38, or 10.2%. All were recaptured in Flødevigen Bay area. One fish was caught in a trap and the others by angling. The length-age relationships are given in Fig. 5. The mean daily length increment was 0.48 mm.

In the control-group in the laboratory, only one fish died during the first year after tagging and none of the fishes lost their tags. The daily length increment was 0.66 mm during the

first year. The length data are shown in Fig. 5.

All the fishes were caught by sportmen and no returns were reported by commercial fishermen.

DISCUSSION

The daily length increment (0.44-0.48 mm) in the release experiments was in agreement with results obtained by Løversen (1946). He tagged mainly one to two year old wild cod and released them in the same area as in this report. On the basis of Løversen (1946) the daily increments, from release to recapture (within two years) are calculated to approximately 0.47 mm.

Investigations on juvenile cod along the Skagerrak coast by using beach seines have been performed by the Flødevigen Biological Station since 1917. On the basis of these data using the mean length at 0- and I-group stage from one year to another the daily length increments are calculated to be between 0.42 and 0.47 mm. These calculations also correspond with the daily length increment of the tagged cod. This indicates that cod reared in a basin and then released do not have greater problems than wild cod in capturing prey organisms.

The length increment of the tagged cod in the laboratory from the 0- to I-group stage was higher (0.66 mm/day) than in the sea. It corresponds to the length increment of untagged cod raised in the laboratory (an observed increase of 0.67 mm/day, unpubl. data). This indicates that tagging of cod does not influence growth rate, as also indicated by the data from the sea.

Mortality caused by the tagging of cod kept in the laboratory in 1976 may have been high because many of them were smaller than 9 cm (Fig. 3), and because the nylon twine was thicker in 1976 than in 1977. Plaice in the same aquarium might also have bitten the nylon twine (as indicated by the tag loss in this group), preventing the wound in the belly from healing. Corresponding tag loss was not observed in 1977, when the cod were alone in the aquarium.

The cod released were extremely stationary, as 93% were recaptured in the Flødevigen Bay area (Fig. 4). Løversen (1946)

reported from his tagging experiments that 50% of the tagged cod were recaptured less than 1 km from the point of release and 93% less than 5 km away. This was verified by Danielssen in 1971. (Danielssen, Flødevigen Biological Station, personal communication, 1983). Dahl (1906) also reported that coastal cod were stationary. The distance of migration of reared cod in this experiment did not exceed that observed on wild cod in the same area. Given that most of the cod were captured by angling, a reported recapture of 10%, as in 1977, is fairly high. Tveite (1984) suggested that the 1976 yearclass was good, based on comparing the catches of young cod in beach seines, while the 1977 yearclass was poor. This might explain the higher recapture rate and the lower migratory rate of the 1977 released cod.

A few conclusions could be drawn from this small-scale release experiment. The growth rate of cod reared in a basin does not differ from that of wild coastal cod; reared cod are very stationary, as are most coastal cod.

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