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The Propagation of Cod *Gadus morhua* L.

SPAWNING AREA AND DISTRIBUTION OF 0-GROUP COD,
Gadus morhua L., ON THE MØRE COAST.

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ABSTRACT

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This paper deals with the location of some major spawning grounds for cod, *Gadus morhua* L., on the Møre coast. The density distribution of adults prior to spawning and the 0-group fish later on was recorded. The two parts of the investigation were carried out in March-April and August respectively in 1981-1983.

The prespawning distribution was recorded using acoustic techniques and abundance estimates were given. Based on these results spawning grounds were proposed. To give precise borders of the spawning grounds a plankton collector, the Juday net, was used to estimate the density distribution of cod eggs.

The 0-group were sampled whilst in the process of settling to the bottom. Its distribution was obtained using a pelagic trawl for the free-swimming specimens and a beach seine for the bottom settled ones.

The results limited the major spawning to the southern part of the investigated area. Main spawning grounds were Borgund Fjord, Goksøyr Bay, Flåvær Channel and Bremanger Bay. Local spawning areas were recorded in 1983.

Abundance estimates suggest that between 6 and 11 million specimens were present in the area during the investigation in winter 1982 and 1983. The fish abundance was significantly more southerly in the later part of the spawning periods.

The investigation on 0-group cod indicates that nursery areas on the Møre coast are limited to the shallower and less

exposed locations. The highest concentrations of 0-group cod were found in the shallow fjords around the island of Smøla and in Borgund Fjord.

INTRODUCTION

The area investigated is shown in Figs. 1 and 2 together with the geographical names referred to in this paper. The area is located at the north west coast of Norway.

Spawning of the north-east Arctic cod, *Gadus morhua* L., takes place on locations in nearshore waters off the north west (Møre coast) and northern coasts of Norway (Fig. 1) (Ellertsen et al., 1980). North-east Arctic cod as well as coastal cod spawn on the Møre coast. The general biology, migration and size of this spawning population have been the subject of investigations for some years (Godø, 1977, 1981; Godø and Toresen, 1980; Godø et al., 1982).

The purpose of this paper is to summarize the results of these investigations with regard to the location of the spawning grounds and the nursery areas. The investigations of the nursery grounds must be regarded as a kind of pilot investigation, as we beforehand had very few suggestions about what to expect during this search.

The investigation was carried out as a cooperative work between the Institute of Marine Research (IMR) and the Department of Fisheries Biology (DFB). The various cruises were carried out in March - April and August in 1981 and 1982 and in March 1983.

MATERIALS AND METHODS

The spawning investigations were carried out in March - April, while the 0-group and the nursery areas were studied in August.

The periods of investigation were as follows:

12-27 March 1981
6-14 March 1981
3-10 August 1981
16-25 March 1982
25 March-7 April 1982
4-11 August 1982
6-15 March 1983
14-30 March 1983

The vessels were equipped with a 1600 meshes x (200-20 mm) pelagic trawl and a 1800 or 1560 meshes x (80-20 mm) bottom trawl. A 0.1m^2 or 0.5m^2 Juday net with mesh sizes $180\mu\text{m}$ and $500\mu\text{m}$ were used in the vertical plankton hauls. The beach seine was 50m x 4m with 9mm meshes. A 38kHz echo sounder (Simrad EK-38 or EK-400) connected to a Simrad QD integrator or a NORD-10 computer integration system supplied the acoustic data.

In Fig. 2 are shown the station lines during the cruise in spring 1982, which is very close to the planned station lines for all the spring cruises.

The acoustic integration system on board the vessels was used to estimate the abundance of cod. Trawl stations were taken along the station lines in order to separate cod, saithe (*Pollachius virens* L.) and haddock (*Melanogrammus aeglefinus* L.) which give a similar reflected echo using acoustic methods (Dalen and Smedstad, 1979; Godø et al., 1982).

The egg sampling was carried out with a Juday net hauled from 50 or 20 m depth to the surface. In order to limit the spawning grounds, egg sampling was done frequently during the cruises, particularly in those areas showing high concentrations of cod according to the acoustic measurements.

The eggs were sorted according to Russell (1976). Cod eggs were separated from other gadoid eggs by size. Cod eggs included eggs between 1.2 and 1.6 mm. Age determinations were done according to Strømme (1977).

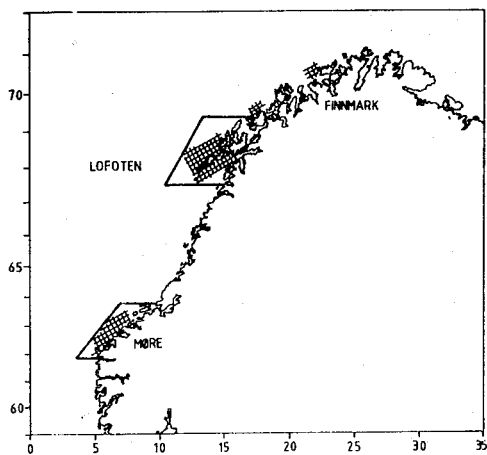


Fig. 1. The Norwegian coast. Spawning grounds of north-east Arctic cod are included. Adapted from Godø et al., 1982.

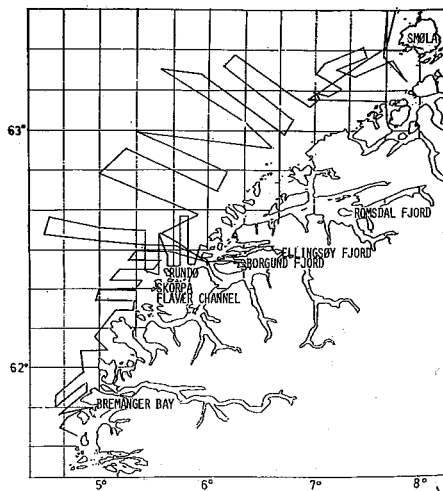


Fig. 2. The Møre area. Names referred to in this paper and representative station lines for the surveys.

Additional egg sampling were done to supply data on spawning period curves from the main spawning grounds.

Local spawning grounds, suggested by a questionnaire among fishery advisors in 1982, were studied in 1983. One bay was chosen arbitrarily on the map to give a reference to the general concentration, if any, of cod eggs in the waters.

Trawl and beach seine stations were taken during the autumn cruises in 1981 and 1982 to investigate the nursery areas of cod. To investigate various possibilities of distribution of fry, as many stations as possible were spread over the whole area.

A large variety of species were found at the stations, but only the cod data will be presented here.

The pelagic trawl was mainly towed at surface for 30 min thus sampling the upper 20 m. The bottom trawl was hauled alternatively for 30 or 60 minutes. The beach seine was usually set in inlets starting at a depth of approximately 7-10 m.

RESULTS AND DISCUSSION

To give the density distribution of the spawning stock, abundance estimates were calculated on all the spring cruises. In Figs. 3A, 4A and 5B are given the estimates that are close in time to the highest egg concentrations. The measurements of these are given in Figs. 3C, 4C,D and 5D. In Figs. 3B, 4B and 5C are given the locations of the Juday net hauls carried out in the various years.

Figs. 5A,B and 4C,D, together with Figs. 3C and 5D, illustrate the southward migration of the cod and the concentration of spawners and spawning products at four locations, Borgund Fjord, off the island of Rundø, Flåvør Channel and most southerly Bremanger Bay.

Details about the acoustic abundance estimates are given by Godø et al. (1982, 1983). The estimates gave a total of approximately 6 million fish in 1981 and 1983 and approximately 11 million fish in 1982.

Fig. 5D also shows the local spawning grounds investigated. They are enclosed in circles and the one with no eggs is the arbitrarily chosen reference location.

In Figs. 6 and 7A,B,C are shown the time series of Juday net hauls carried out at spawning locations in 1982 and 1983. Each point in Borgund Fjord represents three stations in the fjord. Each point on the other curves represent two parallel hauls at each station. The curves give the time period of sampling. Borgund Fjord is the only location presented both years. The curves are similar shaped in both years although the rise of the curve is some 10 days later in 1983. Figs. 4A and 5B indicate less than 10% of the fish abundance recorded in Borgund Fjord in 1982 to be present in 1983. However, a late, final covering of Borgund Fjord in 1983, from 25-30 March, gave an estimate of some 150 thousand specimens in the fjord.

Some comments are needed on the relative proportions of young eggs (1-2 days) in the hauls. The low proportions in

Borgund Fjord and off Skorpa might suggest that we did not sample at the exact spawning spots.

In Borgund Fjord there is an outward-running surface current and an inward-going deeper current (Slotsvik, 1979). If the eggs are laid close to the bottom, they may be carried inwards while they are rising to the surface and thus not be sampled before reaching the age of two days.

The time of most intense spawning varied off Rundø and Skorpa in 1983 (Figs. 7A and 7B). The acoustic observations indicated at the same time that a significant migration (recorded as variation in abundance) occurred between the two locations.

The curves give a clear indication that these locations are spawning grounds and that we were present during the time of heaviest spawning.

The results from the cruises in August are presented in Figs. 8 and 9.

In 1981 we concentrated the investigation on the fjords around and between Borgund Fjord and Romsdal Fjord. Cod fry were found free swimming in Romsdal Fjord, Ellingsøy Fjord and the inner part of Borgund Fjord. No 0-group cod was found close to the deep bottom of the fjords. In 1982 we also trawled in the offshore waters from 100 to 150 m and extended the area of investigation further north. No cod fry was found offshore or in the central parts of the fjords. Beaches in Borgund Fjord, Romsdal Fjord and at the island of Smøla were found to be nursery areas for cod. The numbers of cod fry seemed to be highest in the shallow locations, but the bottom substratum also seemed to be important. The muddy beaches at the shallow east part of Smøla contained almost no 0-group cod.

This indicates that fry of cod change from a pelagic to a near-bottom life in the period July to August.

The more exposed beach locations in the outer fjords and islands were not examined as an earlier investigation with beach seine on 0-group saithe indicated no cod fry at these

locations (T. Jakobsen, Institute of Marine Research, Bergen, personal communication, 1983).

CONCLUSION

Spawning grounds on the Møre coast supported a spawning population of some 6-11 million specimens. The spawning took place in late March to early April. The major spawning was concentrated in a few locations. Only one location was inside a fjord, the others were in the open sea. Minor local spawning grounds were recorded.

Cod fry were found free-swimming in a surface layer in the inner fjords. Bottom settled fry were found at sheltered shore localities.

If the main nursery areas are found in the sheltered inshore regions, it necessitates an offshore recruitment migration to some of the major fishing grounds.

The medium depth areas (15 to 100 m) were not investigated and important nursery areas may be located at such depths offshore as well as in the fjords.

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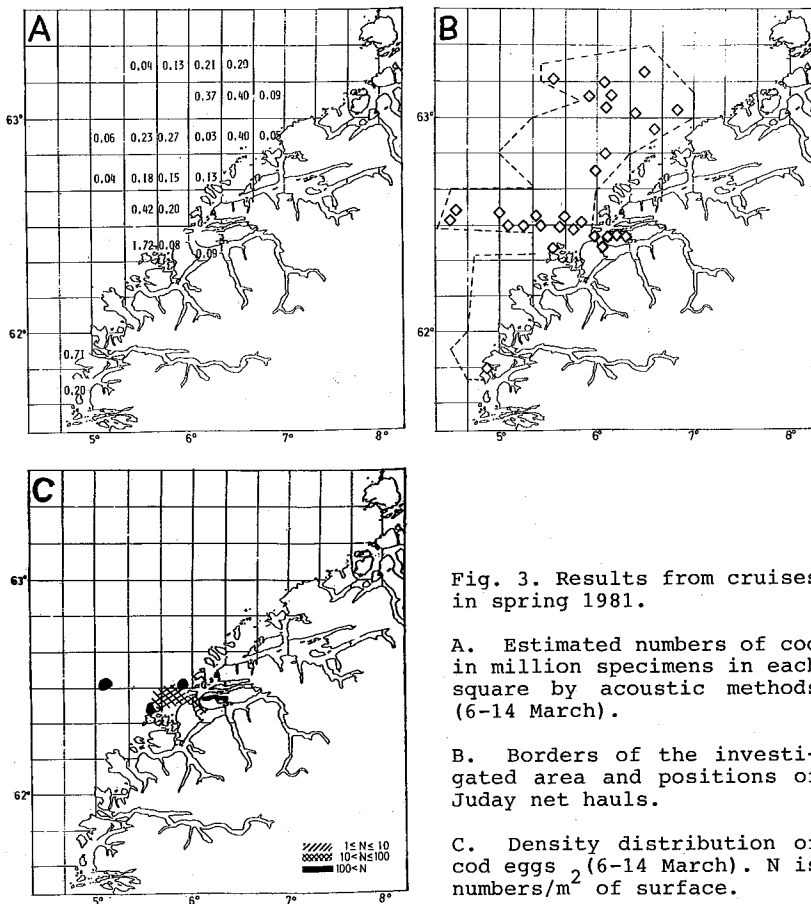


Fig. 3. Results from cruises in spring 1981.

A. Estimated numbers of cod in million specimens in each square by acoustic methods (6-14 March).

B. Borders of the investigated area and positions of Juday net hauls.

C. Density distribution of cod eggs (6-14 March). N is numbers/m² of surface.

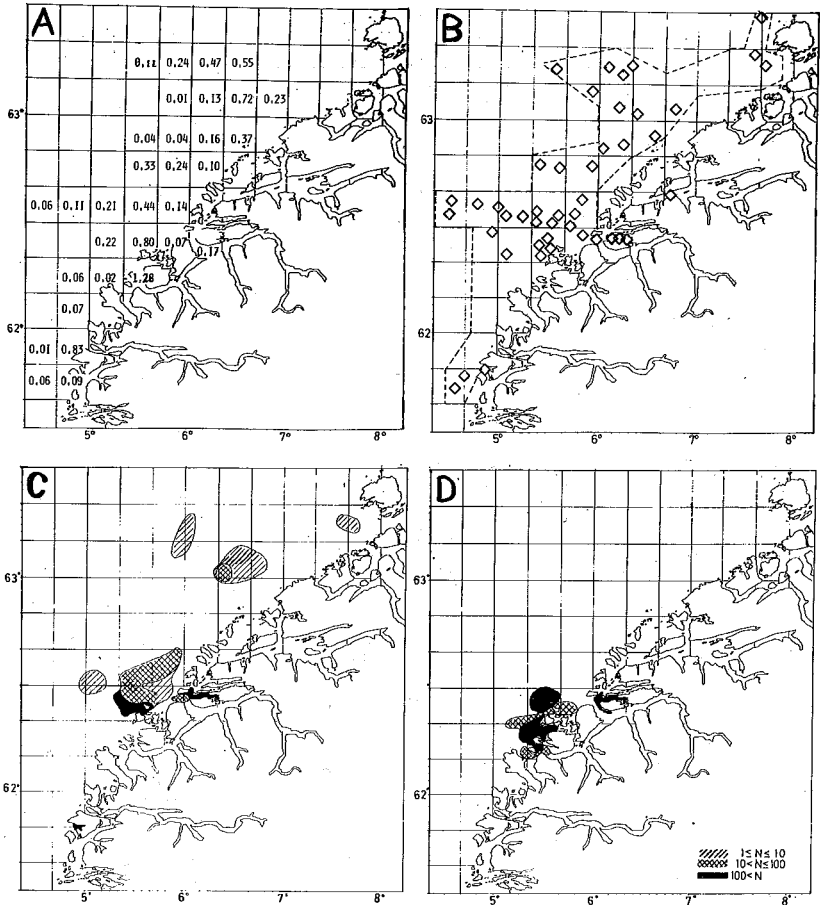


Fig. 4. Results from cruises in spring 1982. A. Estimated numbers of cod in million specimens in each square by acoustic methods (25 March-7 April). B. Borders of the investigated area and positions of Juday net hauls. C. Density distribution of cod eggs (25 March-4 April). D. Density distribution of cod eggs (4-7 April). N is numbers/m² of surface.

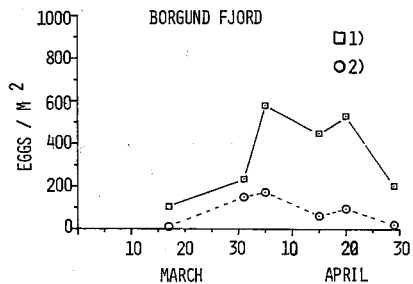


Fig. 6. Spawning development curves for Borgund Fjord, 1982.
 1) All cod eggs found/m² of surface.
 2) Eggs of age 1 and 2 days/m² of surface.

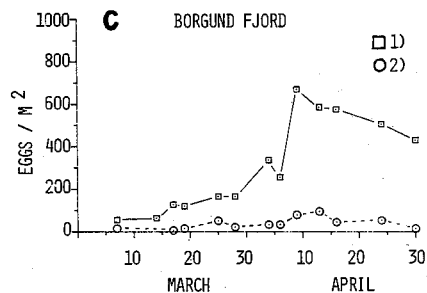
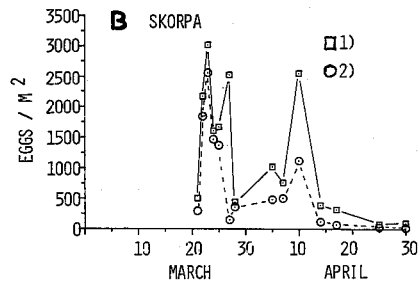
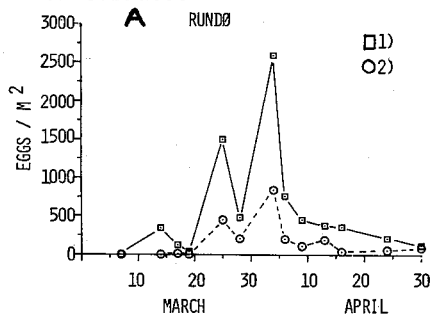


Fig. 7. Spawning development curves for 1983.
 A. Off the island of Rundø. B. The location Skorpa in Flåvær Channel. C. Borgund Fjord.
 1) All cod eggs found/m² of surface.
 2) Eggs of age 1 and 2 days/m² of surface.

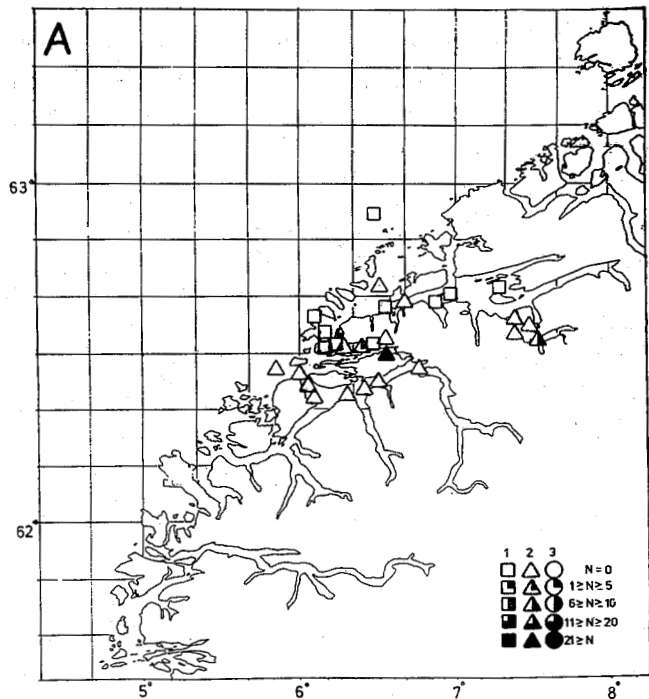
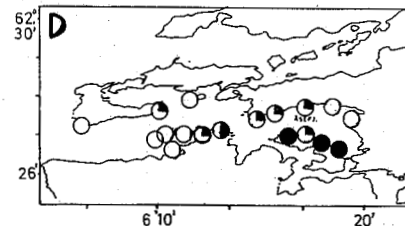
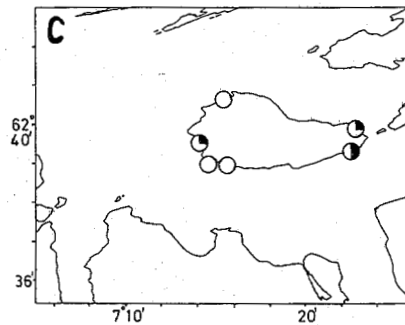
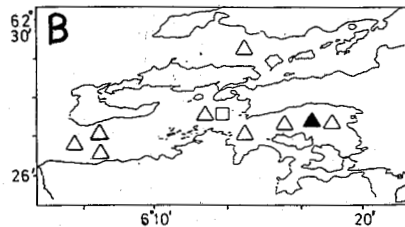


Fig. 8. Results from the autumn cruise 1981. Number of cod fry found in each location from 1) Bottom trawl hauls 2) Pelagic trawl hauls 3) Beach seine hauls. N is the number of cod fry in each haul. A. Shows the bottom and pelagic haul stations in the overall area except Borgund Fjord. B. Shows bottom and pelagic trawl stations in Borgund Fjord.



C. Shows beach seine hauls in Romsdal Fjord. D. Shows beach seine hauls in Borgund Fjord.

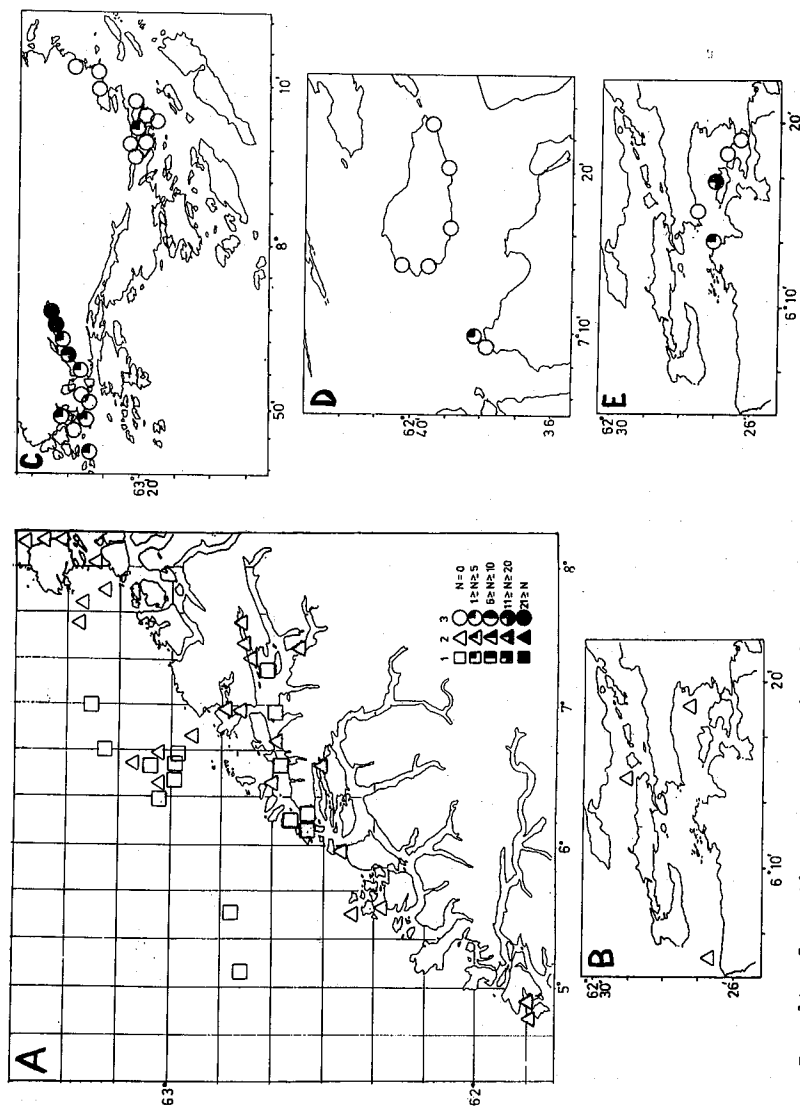


Fig. 9. Results from the autumn cruise in 1982. Legend as in Fig. 8. A. All bottom and pelagic trawl stations except those in Borgund Fjord. B. Pelagic trawl stations in Borgund Fjord.

C. Beach seine hauls at the island of Smøla.
 D. Beach seine hauls in Romsdal Fjord
 E. Beach seine hauls in Borgund Fjord.