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HAVFORSKNINGSINSTITUTTETS EGG- OG LARVEPROGRAM (HELP)

COASTAL CONCENTRATIONS OF 0-GROUP NE-ARCTIC COD

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ABSTRACT

Investigations in 1987 and 1988 aimed at catching and utilizating wild cod fry as seed fish in commercial aquaculture have demonstrated that, at the time of year when the main brood of the year is drifting pelagically offshore, 0-group NE-Arctic cod are also concentrated in shallow waters along the outer exposed coast of Finnmark. This segment of the new yerclass, which has hitherto been asssumed insignificant, and, therefore neglected in 0-group assessments, may in years with weak year classes represent as much as 10% of the annual brood.

INTRODUCTION

Investigations in 1987 and 1988 aimed at catching and utilizing wild cod fry (0-group) as seed fish in commercial aquaculture have provided data revealing that coastal concentrations of 0-group NE-Arctic cod constitute a significant segment of the year class and cannot, therefore, be neglected as in previous assessments. The present report is a preliminary review of findings relevant to the main theme of this work-shop.

METHODS

During the periods Aug. 17 - Sept. 3, and Oct. 13 - 20 1987 the outermost coastline of Western Finnmark from Sørøy to Nordkyn (Fig. 1) was surveyed with a 45 ft. fishing vessel equipped with a standard Simrad EL echosounder and a small meshed Danish seine. In 1988 Aug. 22 - Sept. 16 the investigation was repeated with our institute's 47 ft. research vessel, also equipped with a small meshed Danish seine for sample fishing, but with the Simrad EY M and EY 200 echosounders and QD integrator for fish detection and quantification. This year the coverage included the outermost coastline from Fugløy in Troms to Syltefjord in Finnmark (Fig. 1). During the first week of the cruise the performance of the seine and behaviour of fish fry were attempted observed with underwater TV operated from a self-propelled ROV.

The survey methodology applied in both years constituted daytime echo-search along a zig-zag path from shore to approx. 40-50 m bottom depth, and sample fishing with the seine when applicable. Significant catches were kept alive in deck tanks to evaluate catching and transport mortalities.

In 1988 detailed echo-integrator mini-surveys were carried out in selected localities where echo recordings and sample fishing suggested dense concentrations of cod fry, an example of which is shown in Fig. 2.

The echo signals from the cod fry schools were integrated in the bottom channel (up 5 m from bottom) with settings as follows:

Frequency	38 kHz
TVG	20 logR
Attenuator	0
Source level	115.3 dB
Voltage response	0 dB
Instrument constant	0.31
Pulse duration	1 ms
Gain	-34.9 dB

Integrator readings for each cable length steamed were used to calculate the fish density as described by Dalen and Nakken (1983):

$$(1) \quad N = M \cdot CF$$

$$(2) \quad CF = \frac{10^{(-TS/10)}}{4\pi}$$

N = number of fish per square nautical mile
M = integrator value
CF = conversion factor
TS = target strength

As far as we know, no reliable in situ measurements of target strength of cod smaller than 10 cm have been done untill now. Mamylov (pers. comm. by Egil Ona) did recently measure TS of cod above 10 cm, and suggested the following relation between fish length and TS for cod above 15 cm:

$$(3) \quad TS = 21.8 \log(L) - 72.7$$

where
L = root mean square length of fish calculated from sample fishing

The TS for fish smaller than 15 cm will most likely be somewhat larger than expected from the regression, because the wave length is larger than the extent of the swim bladder. We still chose to use the TS values as derived from (3) in our abundance estimates, since threshold effects for single fish of this small size may compensate for the over-estimate.

The distribution of 0-group cod in the areas not covered by the detailed integrator surveys was mapped more coarsely. The areas covered in 1988 are indicated by the shaded areas on the map of Fig. 1. Significant aggregations of cod fry schools were always found in narrow belts along the shore line with fairly uniform crosswise width. The locations of the schools recorded by echosounder were plotted on maps, from which the shore line extension of the aggregations were measured.

The echo records were compared with those of the integrator surveys, for which calculations of numbers of fish fry per cable length of shore line extension were done. The various local aggregations were divided into different density groups, and fish abundance calculated by multiplying measured school extensions with given densities per cable. By summing the estimated numbers of fish of all significant fry aggregations located, a minimum estimate of the total number of 0-group cod in the investigated area was obtained.

RESULTS

Results of specific relevance to the theme of this workshop may be grouped under two headings:

Distribution and behaviour

Already during the first days of operation in 1987 small near-bottom schools of cod fry were typically located in depth of less than 35 m very close to the shore line. These were easily detected by echosounder during day time (Fig. 3), and when bottom conditions permitted they could be caught with the seine.

In 1987 the outermost coastline from Ofjord (Sørøy) to Nordkyn (Fig. 1) was coarsly investigated. More detailed surveys were made in the Sørøy area, where small cod fry schools were found to be abundant in specific localities of Ofjord and Gamvikfjord. Less extensive echo-recordings were made at various other locations, but successfull sample fishing verifying these to be of 0-group cod were made at only 4 places: Mefjord (Sørøy-E), Mylingen (off Hammerfest), Sørhamn (Rolvsøy) and at the entrance of Kjøllefjord (Fig. 1)

The more extensive coverage in 1988 revealed little or no cod fry in the outer coastal areas west of Sørøy, as well as in the middle part of the Finnmark county, from Hammerfest to Honningsvåg (Fig. 1). In two north faced areas of Sørøy, Ofjord/Sandfjord in the West and Finnfjord/Gamvikfjord/Tarhalsen in the East, dense concentrations of 0-group cod were located. Similarly, dense cod fry school aggregations were found at several localities in Eastern Finnmark, the most extensive ones at the entrance to the Tanafjord and in Syltefjord (Fig. 1).

Typically, cod fry schools were found in bays with abundant driftwood, suggesting that recruitment of fish fry into these bays come by wind driven surface currents.

Another clue to the origin of these fish fry concentrations is near shore echo recordings of pelagic layers similar to those of plankton and 0-group fish found offshore during the annual Barents Sea 0-group surveys. In 1987 such recordings were made over the deep part of Gamvikfjord (Fig. 4), and sample fishing showed the presence of 0-group cod. Again in 1988 such pelagic near surface recordings were made near Loppa, off Stålet (Sørøy) and off Nordkyn.

Particulary in 1988 school aggregations were distributed in narrow belts very close to the shore line. Usually the recor-

dings of cod fry extended from the sea bed and 2-3 meters up in waters of 10 to 35 m bottom depth (Fig. 3). Both horizontal distribution and density of schools clearly varied with time of day, and at night the fish fry dispersed and were not detected by echosounder.

In 1987 0-group cod were found almost exclusively in locations void of other, larger fish. Individual catches of the same day in nearby localities at Ofjord indicated schooling by size within very narrow length ranges. These observations are interpreted as survival traits reducing mortality by predation by other fish and by cannibalism.

In 1988 no similar protective distribution pattern was evident, and 0-group cod were frequently found and caught together with 0-group saithe and I- as well as II-group cod. Except for those of the very small cod fry taken Aug. 26 1987 in Gamvikfjord, the mean lengths of the Aug./Sept. catches in the Sørøy area fit well together (Fig. 9) and suggest a growth from about 45 mm to nearly 90 mm in four weeks. The fry from Eastern Finnmark of early September 1988, although varying considerably in mean length, also fit well into such a growth pattern and did not seem to differ from those in the West in any other aspect.

Only very few underwater TV observations of fish near the seine were made because turbid water greatly reduced the range of vision. However, clear reactions of the cod fry avoiding the approaching wings of the seine were observed.

Abundance estimates

In 1988 extensive echo surveys were carried out in three different fjords in Finnmark: Ofjord and Gamvikfjord at Sørøy, and Sandfjord east of Nordkyn (Table 1). The largest concentration of 0-group cod was found in Gamvikfjord with an estimated number of cod along the western shore line of 3.6 mill., at an average density of 520.000 per square cable. In Ofjord west the estimated number was 2.2 mill (67.000 per square cable), and in Sandfjord 1.1 mill. (68.000 per square cable). These figures should be regarded minimum estimates as no attempts have been made to correct the data for fish lost in the echo sounder bottom dead zone. Furthermore, the vessel regularily had difficulties in extending the tracks close enough to the rocky shore to record the innermost border of the schools, where the density was often highest. The width of the school areas as well as the densities are therefore probably underestimated.

Parallell to our survey an experimental fishery of cod fry for aquaculture purpose was carried out in the Sørøy area by a commercial fishing vessel. Within a period of about three weeks this vessel caught about 600.000 0-group cod at a very limited location in Gamvikfjord (at Seglhammar, Fig. 2). This

location was included in our acoustic survey in Gamvikfjord. The fry were caught in quantities of 50 to 100.000 per day. After the fishing vessel had left for the day, the echo recordings of cod fry appeared just as dense as when the fishing started. This confirms that the fish fry density in the area was indeed very high, at least of the order of magnitude found by the integrator survey.

The measurements of fish density in these selected localities were then used as a basis for a rough estimate of the total number of 0-group cod in the outer part of Finnmark covered by our investigation. Multiplying the shore line extensions of the school aggregations with the estimated density per cable gave a total number of 27 mill. 0-group cod in the investigated area.

Localities with minor school recordings or discontinuous distribution are not included in the total estimate. Areas where echo recordings suggested aggregations of 0-group cod, but where bottom conditions inhibited verification by sample fishing, are also excluded. Furthermore, there are certainly cod fry schools in localities not covered by our survey tracks. Also, in the judging procedure to determine the density of the recorded aggregations, low values were always chosen if in doubt. In addition we know that the school densities from the detailed echo surveys most likely are minimum estimates. This leads to the conclusion that a total of 40 mill. probably is more correct than the exact computed number. However, bearing in mind the many uncertainties of the estimates, they are not submitted as an accurate assessment of the coastal segment of the 0-group NE-Arctic cod stock, but rather as an indication that the portion of the stock inhabiting the coastal areas are larger than hitherto believed.

DISCUSSION

Haug and Solemdal (1986) found demersal 0-group cod to be abundant in Ofjord during July 1986, and in reviewing this and earlier observations Solemdal (1986) concluded that these were small cod, which "normally" at this size and time of year are being pelagically transported offshore, but which accidentially have "stranded" in shallow coastal waters. He further postulated that the abundance of 0-group cod that are passing the coastal areas from Troms to North Cape during their pelagic drift probably is sufficient to fill the capacity of the available suitable (attractive) bottom biotopes whether the year class is big or small.

The present investigations during two years with rather poor year classes of NE-Arctic cod (Sundby et al. 1988) have confirmed that also in such years concentrations of 0-group cod are present in certain shallow water localites at the Finnmark coast, at least in the Sørøy area. The evidence therefore suggests that this is rather the rule, recurring every year, than something occurring only occasionally under special favourable conditions.

The distribution in August/September of these 0-group cod certainly must be determined by their origin and previous transport in the water masses. The fact that they have been found in fair numbers already from July onwards in some of the outermost, weather exposed locations of the coast, but with diminishing and abruptly ending abundance at the entrances of the larger fjords (e.g. Laksefjord and Tanafjord in 1988), strongly suggests that they are recruited from the offshore drift of NE-Arctic cod.

This conclusion is supported by the recordings also in near shore waters of the typical pelagic, irregular layers of plankton/fish fry normally found at the same time of year offshore in the Barents Sea. They confirm that segments of the offshore pelagic drift do end up in coastal bays, probably as a result of wind-driven currents.

The overall abundance of coastally distributed 0-group cod might therefore be expected to reflect the annual year class strength, on which effects of annual as well as short term variations in the current system are superimposed, However, since the "holding capacity" of the suitable coastal locations most likely is restricted, first of all by food availability, it is conceivable that the coastal abundance may not be determined primarily by the year class strength, but rather by the "holding capacity". In other words, as postulated by Solemdal (1986), the suitable habitats will in general always be fully utilized regardless of year class strength. This implies that in years of low year class strength the coastal abundance will be of greater significance than in years with rich year classes, and the coastal segment thereby may play the role of a buffer resource.

While the precision of the quantitative assessments presented in the previous chapter leaves much to be desired, the figure of 30-40 millions 0-group cod in early September 1988 at the outer Finnmark coast is probably a conservative estimate. Thus, in a year with a poor year class of NE-Arctic cod, which earlier is reported to consist of 300-600 mill. individuals (Hylen 1984), the coastal segment may be in the order of 10% of the total brood.

The experience gained during these investigations has in our view also clear implications with regard to pre-recruit survey methodology. Thus, the restricted local distribution of cod fry in very narrow belts in shallow waters along certain shore lines, sometimes at only one side of a bay, but not the other, evidently implies that such concentrations cannot be reliably detected and assessed by a standard, "blind", random spot sample survey with a large research vessel. Furthermore, since these are fish already of a size large enough to exhibit clear avoidance reactions to the fishing gear, the design and operational perfomance of the fishing system applied are greatly determining the quantitative results of the sample fishing.

REFERENCES

Dalen, J. and O. Nakken 1983. On the application of the echo integration method. Coun. Meet. int. Coun. Explor. Sea, 1983/B12:30p. (Mimeo.)

Haug, T. and P. Solemdal 1986. Rapport fra tokt med F/F "Johan Ruud" i Vest-Finnmark 14.-26. juli 1986. Cruise report, University of Tromsø and Institute of Marine Research, Bergen, 1986:10 p. (Mimeo.)

Hylen, A. 1984. Yearclass strength of North-East Arctic cod at the 0-group stage. In: E. Dahl, D.S. Danielssen, E. Moksness and P. Solemdal (Eds.), The Propagation of Cod Gadus morhua L. Flødevigen rapportser. 1984: 847-854.

Solemdal, P. 1986. Innsamling av torskeyngel - et supplement til de planlagte utsettingsforsøk med "kunstig" yngel. Lecture held at the Annual Meeting of the Association of Norwegian Marine Scientists 1986:9p. (Mimeo.)

Sundby, S., H. Bjørke, A.V. Soldal and S. Olsen 1988. Mortality rates during the early life stages and year class strength of the Arcto-Norwegian cod (Gadus morhua L.). Int. Coun. Explor. Sea, Early Life History Symp. 1988, no 20, 23p.

Table 1. Records of echo integration surveys and abundance estimates in selected localities.

LOCATION	DATE	TIME	ROOT MEAN SQUARE LENGTH OF FISH (mm)	TARGET STRENGTH (dB)	TOTAL NO OF FISH (x1000)	DISTRIBUTION AREA (cb^2)	SHORE LINE EXTENSION (cb)	NO PER CABLE OF SHORE LINE EXTENSION (x1000)
Ofjord, Nova	26.8	08.30	63.6	-55.2	843	3.4	4	211
Ofjord, west	29.8	17.40	69.5	-54.3	2.210	33.1	23	96
Gamvikfjord, west	31.8	15.15	71.3	-54.1	3.596	6.9	12	292
Sandfjord, Nordkyn								
east	6.9	06.30	78.2	-53.2	455	10.1	14	32
west	6.9	07.30	78.2	-53.2	640	6.0	16	40

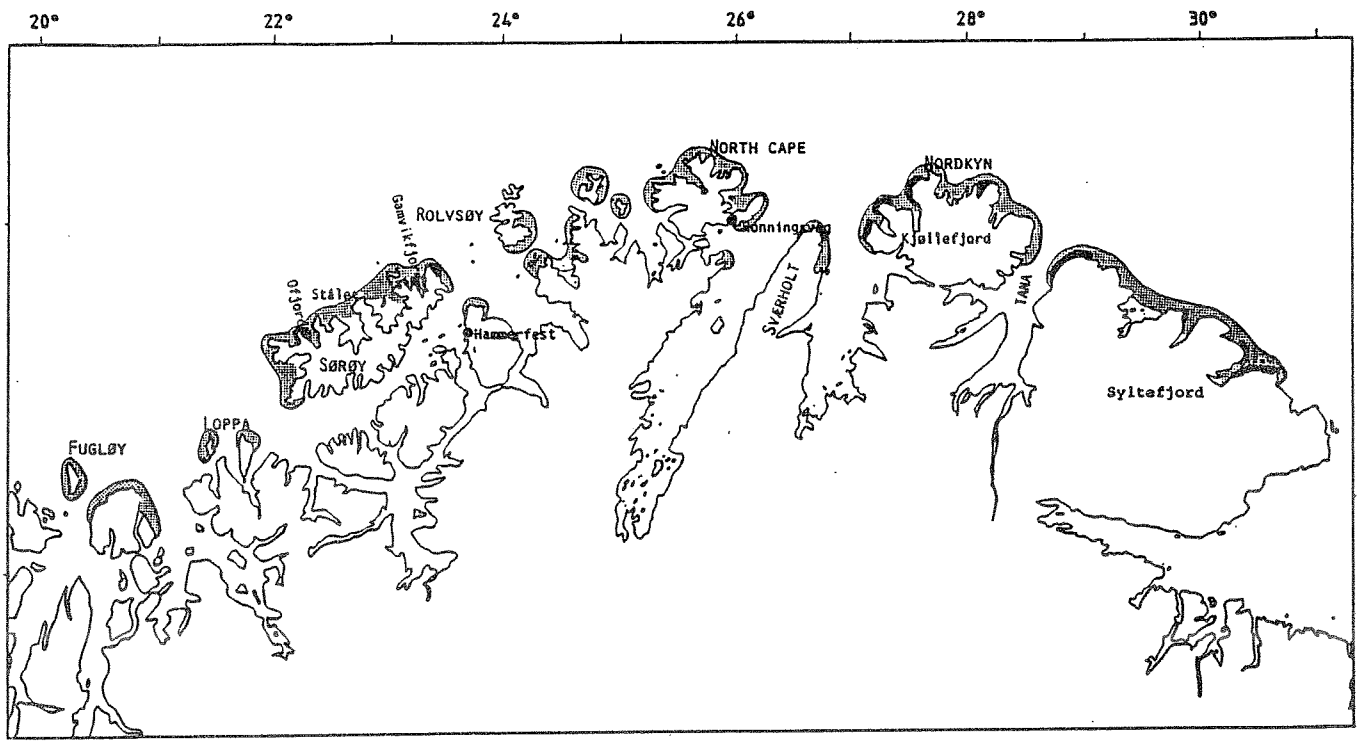

Figure 1. Area of investigation (shaded). Black areas are locations where significant concentrations of 0-group cod were found. (August 22 to September 16, 1988).

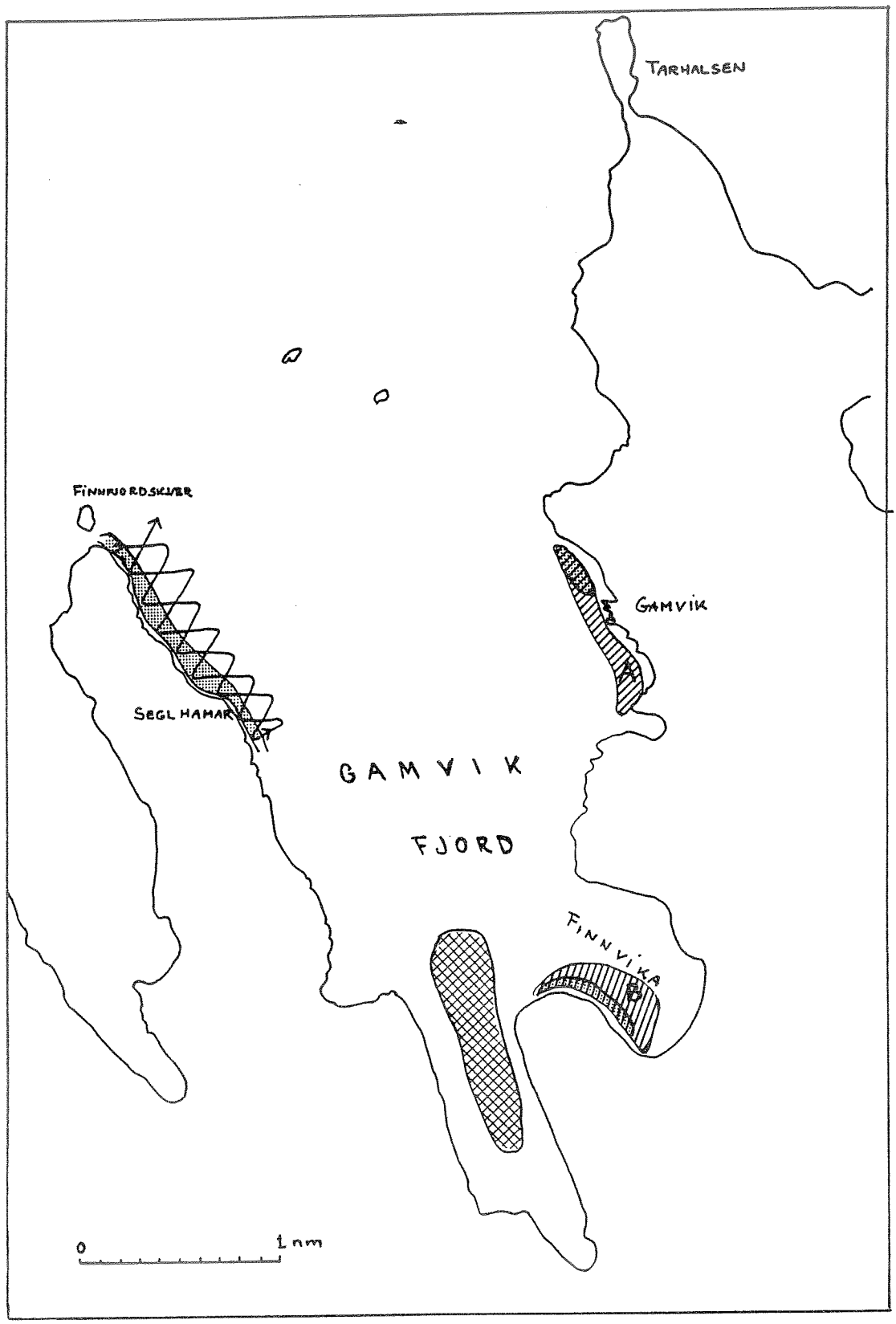

Fig. 2. Locations with 0-group cod school concentrations in Gamvikfjord

Pelagic recordings in 1987

Near bottom concentrations in 1987
A in August, B in October

Near bottom recordings in Aug./Sept. 1988

Integrator cruise track

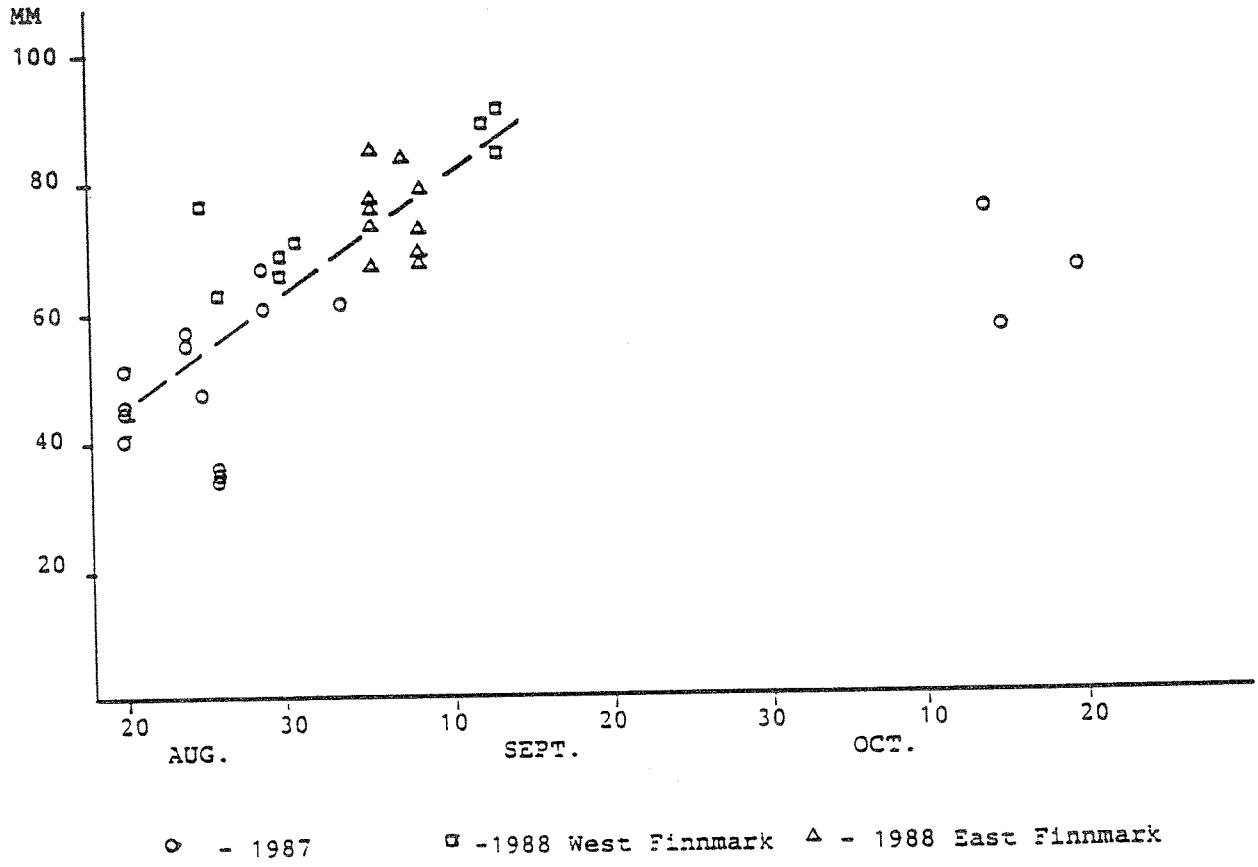

Fig. 3. Mean lengths of cod fry plotted against date of capture.

Oversikt over tidligere utkomne rapporter.

1987

Nr. 1 P. Solemdal og P. Bratland: Klekkeforløp for lodde i Varangerfjorden 1986.

Nr. 2 T. Haug og S. Sundby: Kveitelarver og miljø. Undersøkelser på gytefeltene ved Sørøya.

Nr. 3 H. Bjørke, K. Hansen og S. Sundby: Postlarveundersøkelser i 1986.

Nr. 4 H. Bjørke, K. Hansen og W. Melle: Sildeklekking og seigyting på Møre 1986.

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A computer realization.

Nr. 18 T. Westgård, A. Christiansen og T. Knudsen: Forskerkart. EDB-presentasjon av marine data.

Nr. 19 R. Sætre og H. Bjørke: Oljevirksomhet på Møre. Konsekvenser for fiskeressursene.

Nr. 20 S. Mehl, K. Nedreaas, O.M. Smedstad and T. Westgård: 0-group saithe and herring off the Norwegian coast in April-May 1988.

Nr. 21 P. Fossum: Loddelarveundersøkelsene 1988.

Nr. 22 R. Sætre, H. Bjørke and P. Fossum: Studies on herring larvae off western Norway in 1987.

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Nr. 23 Aktivitetene i 1988