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The Propagation of Cod *Gadus morhua* L.

YEARCLASS STRENGTH OF NORTH-EAST ARCTIC COD AT THE 0-GROUP STAGE

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ABSTRACT

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On the basis of recent developments in artificial propagation of cod fry it has been suggested that propagated cod fry may be released in the Barents Sea and the Svalbard region, the feeding areas of North-East Arctic cod. The aim would be to improve the periodical bad state of this stock.

The North-East Arctic cod is spawning from February to April, and the first abundance index of a new yearclass is assessed at an age of six months by midwater trawl survey. Estimates of yearclass abundance (VPA) vary between 115 and 1818 million fish at age 3, a much smaller range than indicated by the 0-group survey indexes for six months old cod.

In August/September the 0-group cod are distributed in the Barents Sea, around Bear Island and along West-Spitsbergen. Strong yearclasses have a much wider distribution than poor ones. Information from this survey may be used in planning the release of artificially propagated cod fry, which could then take place in September.

Because of lack of reliable basis for estimating the natural mortality of cod, especially on the younger age groups, the number of cod fry in September cannot be precisely estimated. However, for a reasonable range of natural mortalities, the number of fry needed to raise a poor yearclass to a strong one at the 0-group stage would be in the order of 2600-5200 million.

Artificial propagation of cod fry would have to start in March, but it may be stopped later in years with high natural production of fry in order to reduce the effects of density dependent growth.

Artificially propagated fry should have to be released in the most suitable areas. Observations on hydrographical and

food conditions are therefore needed for the most suitable time. In order to avoid a high degree of cannibalism, the distribution of 1-3-group cod would also have to be taken into account.

A programme for artificial propagation of North-East Arctic cod fry would be justifiable in years or periods with low potential yearclass strength. However, our state of knowledge about the many factors involved does not at present justify such an extensive programme.

INTRODUCTION

Propagation of cod larvae started in 1885 at the Flødevigen Biological Station in order to increase the yearclass strength of local cod stocks along the south coast of Norway (Dannevig, 1982). The cod larvae were released when part of the yolk sac still was intact. Data from these experiments were analysed by Tveite (1971). He concluded: "As a variation in yearclass strength, the liberation of cod larvae could not be significantly separated from other natural sources". Experimental propagation of cod was resumed in the seventies by Øiestad and Kvenseth (1981) at the Institute of Marine Research. They succeeded in producing cod fry beyond the yolk sac stage.

It has been suggested that propagated cod fry might be released in the Barents Sea and the Svalbard region, the feeding areas of North-East Arctic cod. The aim would be to increase the recruitment to the North-East Arctic cod stock in periods when the naturally produced yearclasses would be poor.

Even if all technical problems in mass propagation and transportation of cod fry are solved, there are still problems which have to be evaluated: how to decide when the fry should be released and how many cod fry should be released each year in the different parts of the potential area.

Cod biology

North-East Arctic cod are spawning during February-April along the Norwegian coast from 61°N to 70°30'N, with the main spawning area in Vestfjorden. Eggs and larvae follow the current northward, and cod fry at a length of 25-114 mm are observed in August/September in the Barents Sea, around Bear

Island and along West-Spitsbergen (Anon., 1981). Strong yearclasses are distributed over a much wider area (Fig. 1) than poor yearclasses (Fig. 2). Years with low temperatures in the Barents Sea are characterized by a more western distribution of the 0-group cod than warmer years. In general, most of the 0-group cod is observed in water masses with temperatures of 3-6°C, mostly between depths of 25 to 50 m.

Variation in yearclass strength

The first index of the yearclass strength is assessed at an age of six months (Randa, 1984). Such data are available for the period 1965-1982, and the abundance indices vary between < 0.01 and 2.87 (Table 1). However, some learning effect may have taken place in the survey, and the indices of the first four yearclasses should be disregarded.

Yearclass abundance estimated by virtual population analyses (VPA) at the beginning of their fourth year of life, varies

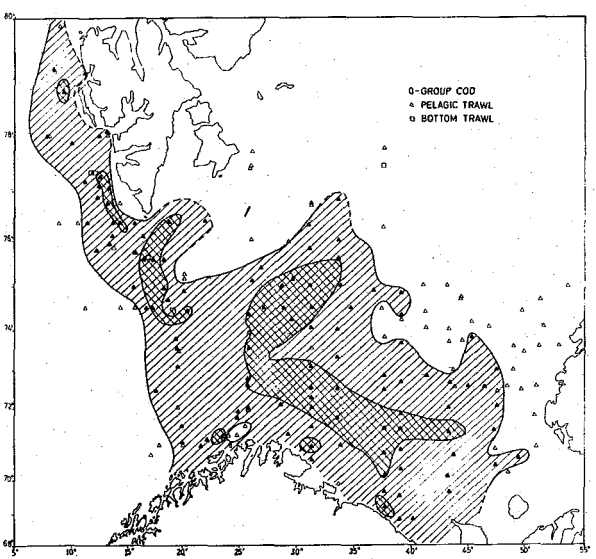

Fig. 1. Distribution of 0-group cod in August/September 1970. Double shaded: dense concentrations. Anon., 1972.

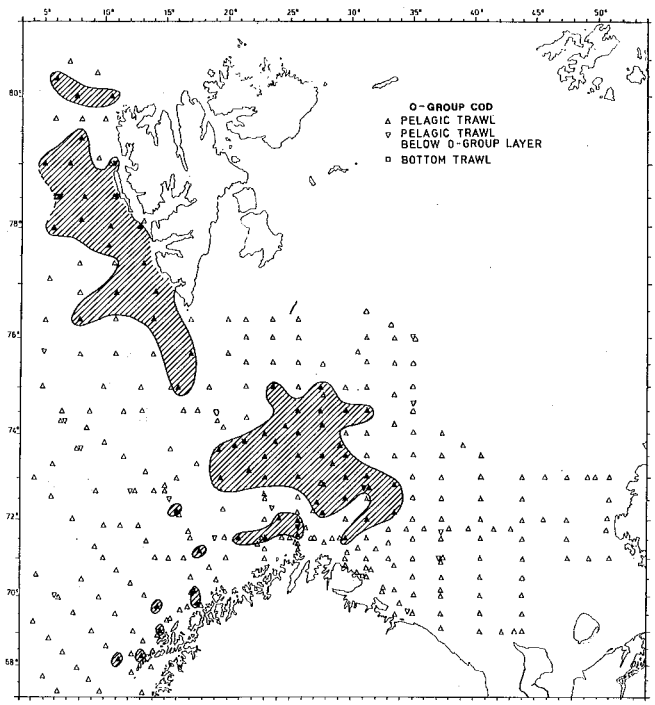

Fig. 2. Distribution of 0-group cod in August/September 1980. Anon., 1983a.

between 115 and 1818 million (Table 1). The basis for these assessments is the total number of fish landed by age and by year. Some cod are discarded at sea in their third and fourth year of life. These are not included in the data base, and the yearclass abundance will therefore be underestimates.

Observations from the 0-group survey which take place in the last part of August and the first days of September, would be of great help in planning the release of cod fry. This would justify the use of September as a potential period to release the fry. Information about the abundance of naturally produced yearclasses at this time in the spawning year would therefore be of significant help in planning the extent of the artificial propagation of cod fry. These numbers can be assessed by back-calculation from numbers of three year old cod (Table 1). Natural mortality rates which are needed for these calculations

have to be assumed. A natural mortality M = 0.20 has been used for age group three and older. This figure is not based on any precise estimate, and the natural mortality on the younger age groups is even more uncertain.

Back calculation of a poor, an average and a strong yearclass has been made for five arrays of natural mortality, assuming fishing mortality (F) on 0,1 and 2 year old cod to be zero (Table 2). At an age of six months the abundance of a poor yearclass would be between roughly 300 and 600 million fry, depending on the natural mortality arrays. Respective figures

TABLE 2

Back-calculation of yearclass size from age three to six months (1 September) for five arrays (A-E) of natural mortality. Numbers in million.

Age group	M	Poor Yearclass	Average Yearclass	Strong Yearclass
A				
0-gr.	0,2	292	1100	2899
1	0,2	275	1029	2712
2	0,2	225	843	2221
3 1)		184	690	1818
B				
0	0,4	347	1300	3425
1	0,3	303	1138	2997
2	0,2	225	843	2221
3 1)		184	690	1818
C				
0	0,5	438	1641	4325
1	0,4	371	1389	3661
2	0,3	248	931	2454
3 1)		184	690	1818
D				
0	0,4	468	1755	4623
1	0,4	410	1536	4046
2	0,4	275	1029	2712
3 1)		184	690	1818
E				
0	0,5	591	2216	5838
1	0,5	500	1876	4942
2	0,5	303	1138	2997
3 1)		184	690	1818

1) Based on VPA-data in Table 1.

for an average and a strong yearclass would be 1100 to 2200 million and 2900 to 5800 million fry. Raising a poor yearclass to an average would therefore require a propagation of 800-1600 million six months old fry. If a poor yearclass is to be raised to a strong one, a production of 2600-5200 million fry would be needed.

TABLE 1

North-East Arctic cod. Yearclass strength.

	Indices	
Yearclass	0-group[1]	VPA[2] Number.10-6
1957		791
8		919
9		730
1960		473
1		340
2		779
3		1582
4		1294
1965	<0.01	177
6	0,03	115
7	0,09	197
8	0,03	405
9	0,27	1016
1970	2,87	1818
1	1,00	524
2	0,83	620
3	2,49	616
4	0,51	372
1975	1,50	794
6	0,25	241
7	0,63	(175)
8	0,19	(257)
9	0,32	(190)
1980	0,10	
1	0,11	
2	0,66	

1) Randa, 1984
2) Anon., 1983b

DISCUSSION

At this stage of knowledge, no forecast of yearclass strength can be assessed in the beginning of the spawning season. Therefore, in order to be safe, production of cod fry would have to be started in March. In years with high natural production of cod fry the artificial propagation programme can be limited or even stopped before the releasing time in September.

Assuming all technical difficulties involved in the production and transportation of several millions cod fry are solved (Table 2), the most suitable feeding areas have to be chosen. It would therefore be necessary to take hydrographical and food conditions as well as the distribution of I-III group cod within the potential area into consideration. This would secure the best natural living conditions for the 0-group cod and a low level of cannibalism by the I-III group cod (Ponomarenko, 1965) Relevant observations for evaluation of these factors would be collected during the 0-group survey in August/September.

Density dependent growth has been observed in several fish stocks, North-East Arctic cod included (Sætersdal and Cadima, 1960). This is evaluated to be the consequence of limitation of food. An artificial increase in yearclass strength would therefore under special circumstances cause reduced growth, and the net effect of the propagation would be less than expected.

Cod is feeding on capelin and pandalid shrimps (Ponomarenko and Yaragina, 1978; Smedstad, Institute of Marine Research, personal communication, 1983). A general increase in yearclass strength would therefore reduce the present high stock level of capelin and shrimp. However, this subject needs further studies before any conclusions can be drawn.

The North-East Arctic cod is at present in a bad state (Anon., 1983b). Several poor yearclasses are recruiting the exploited stock and the spawning stock may in the next few coming years be at such a low level that the probability of producing good yearclasses would be highly reduced. Propagation of cod fry would in such periods be beneficial, but even such circumstances require a proper management of the stocks, which

involve problems the administrators have been faced with during the last 30 years. However, with the present state of knowledge on the survival of 0-group cod and the possible effect of artificial propagation on yearclass strength of natural populations an extensive programme for artificial propagation of North-East Arctic cod fry is not justified.

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SECTION VII

Panel Discussion

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J. C. Gamble