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**MATURATION, SPAWNING
AND EGG DRIFT
OF ARCTO-NORWEGIAN HADDOCK**
(*Melanogrammus aeglefinus*)

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PROBLEMS INVESTIGATED

1. Are the main spawning areas of Arcto-Norwegian haddock located north or south of Røst, Northern Norway ?

Russian and Norwegian scientists disagreed on the location of the main spawning sites of the Arcto-Norwegian haddock. Since 1959 annual cruises along the Norwegian coast north to about 73° N latitude, collecting ichthyoplankton, were carried by the Soviet Union, planned and lead by dr. Baranenkova from PINRO, Murmansk, and sum st, an island off Lofoten, to be the main spawning sites.

On the basis of maturity studies on the parent fish (Sætersdal 1954) and pelagic egg sampling (Wilborg 1960) the Norwegian scientists indicated that the continental slope south of Røst to about 65 ° N was the main location of haddock spawning.

2. What is the spawning period of haddock ?

3. What is the rising velocity of the haddock eggs from the spawning sites, and the final vertical distribution of the eggs?

METHODS AND STRATEGY

The vertical net haul surveys, sampling in the upper 200 meters, were combined with bottom trawl stations and oseanographic crosssections on the continental slope.

Concentration and developmental stages of the haddock eggs, in a 6-stage system and condition and maturation stage of parent fish, were investigated.

Maturation were staged according to a standard scale 1-5, with 1=maturing and 5=spent.

The haddock eggs were identified by isoelectric focusing by Mork et al. (1983).

AREAS AND IDENTIFICATION

In 1987 the investigated area north of Røst was divided into subareas, Fig.1., to study the proportion of cod and haddock eggs, Table 1. In nearshore areas the cod eggs dominate, but along the continental slope of Tromsøflaket the haddock eggs constitute 90%.

Concerning haddock egg concentration in the northern area in 1987, Fig.2., the slope of Tromsøflaket and the Vestfjord are the main spawning sites. Table 1 shows the similar concentration of haddock eggs on the 2 main spawning sites, Tromsøflaket and the Vestfjord. The spawning depth in these two areas differs, being 400-500 along the continental slope of Tromsøflaket and only about 200 meters in the Vestfjord.

The northerly current along the continental slope is reflected in the egg developmental stages, as seen in Fig. 3.

The location of the areas A-C are shown in fig.1. From a majority of newly fertilized egg in the southern area older stages are found further north.

The maturity stage of the females in the three areas also clearly show a delay in maturation from south to north, Table 2. The maturity index, M_i , is simply the mean of the different maturity stages in the catches of mature haddock.

EGG ABUNDANCE AND STAGE OF MATURITY

Fig.2, Fig.4 and Fig.5 show the abundance of haddock egg, all egg developmental stages pooled, for the years 1987, 1988 and 1996 from the continental slope of Tromsø-flaket. Fig.6 includes distribution of haddock eggs from the area south of Røst in 1987.

The max. egg concentration north of Røst was about 30 per m² surface in 1987.

From 1987 distribution profiles of haddock on the continental slope of Tromsøflake were carried out, Fig.7.

Large numbers of spawning haddock were found down to depth of 500 meters, in temperatures of 5-6 °C., and probably the spawning occurs in still deeper water.

In 1988 the max. egg concentration was only 10 per m², but this year the spawning was close to the end, see maturation index in table 2, due to a somewhat later survey period.

In 1996 very low abundance of spawning haddock were found at the same spawning sites investigated in 1987.

A maturity index of 3.4 from 27 haddock females is similar to the index in 1987. The egg concentration this year is higher than the preceding years, reaching a max. of more than 100 eggs per m².

Concentrations of pelagic haddock were observed migrating eastward from the spawning sites in the middle of May 1996, indicating that the main spawning was over in the middle of May.

A small part of the pelagic migrating haddock was still in a spawning condition.

Haddock eggs south of Røst are very scanty and small numbers of mature haddock were caught by bottom trawl, Fig.6.

TIMESERIES

From the long timeseries by Soviet investigations on the distribution of haddock eggs, Mukhina (1992) have compiled and classified types of haddock spawning, showing spawning west of the continental slope of Tromsøflaket at depths larger than 1000 meters during many years, Fig.8.

SPAWNING PERIOD AND INTENSITY

In 1987 the spawning sites at the continental slope of Tromsøflaket and the Vestfjord were visited four times.

The egg concentration was estimated on the basis of a series of vertical net hauls. The results are shown in fig.9, demonstrating a more or less identical peak of spawning for the two main spawning sites at the end of April.

This is one month later than the peak spawning of the Arcto-Norwegian cod, the Vestfjord being its main spawning site.

SP. GRAVITY AND VERTICAL DISTRIBUTION OF HADDOCK EGGS

Measurements of the sp. gravity of haddock eggs in a density column were carried out in 1996 to calculate the rising velocity of the eggs. Fig.10 shows the sp. gravity of eggs from four females, developing in 4 ° C. The intraspecific variation in sp.gravity is large, with a mean value almost identical to eggs of the Arcto-Norwegian cod. The rising velocity of the eggs were calculated to be 170 meters in 24 hours for the lightest eggs and only 40 for the heaviest eggs.

The vertical distribution of haddock eggs sampled with a MOCNESS is shown in Fig. 11, together with the mean egg developmental stage indicated.

Highest concentrations are found in the upper 50 meters.

CONCLUSIONS

1. The main spawning sites of the Arcto-Norwegian haddock are located north of Røst, as earlier suggested by Russian scientists. The continental slope of Tromsøflaket is a significant, pure, haddock spawning site, and spawning occur at least down to 500 meters. In coastal water of Northern Norway cod and haddock eggs are found in the same water masses.
2. Spawning of Arcto-Norwegian haddock south of Røst along the continental slope down to 65 ° N seems to be limited.
3. Peak spawning at the main sites occurred at the end of April both along the continental slope of Tromsøflaket and the Vestfjord, at latitudes 72° and 68° N., respectively.
4. Large intraspecific variation in the sp. gravity of haddock eggs have strong influence on the rising velocity from the spawning sites. From depth of 500 meters it takes 12 days of the heaviest eggs to reach the surface layer, but only three days of the lightest eggs. Haddock eggs are concentrated in the upper 50 meters.

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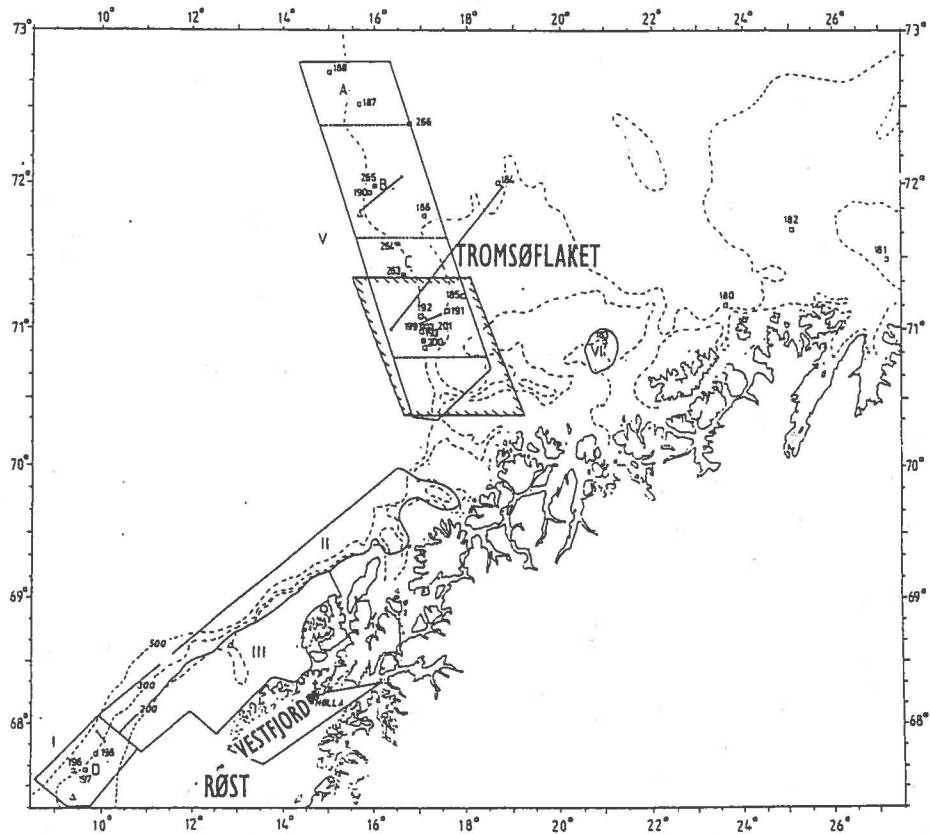


Fig. 1. Area of investigation north of Røst 1987 and 1988.
 □: Bottomtrawl stations. △: Pelagic trawl stations. Areas I-VI was investigated for egg developmental stages. Subareas A, B, C and D was a.o. investigated for acoustic estimates of stock size and egg developmental stages.
 —: Hydrographical sections.

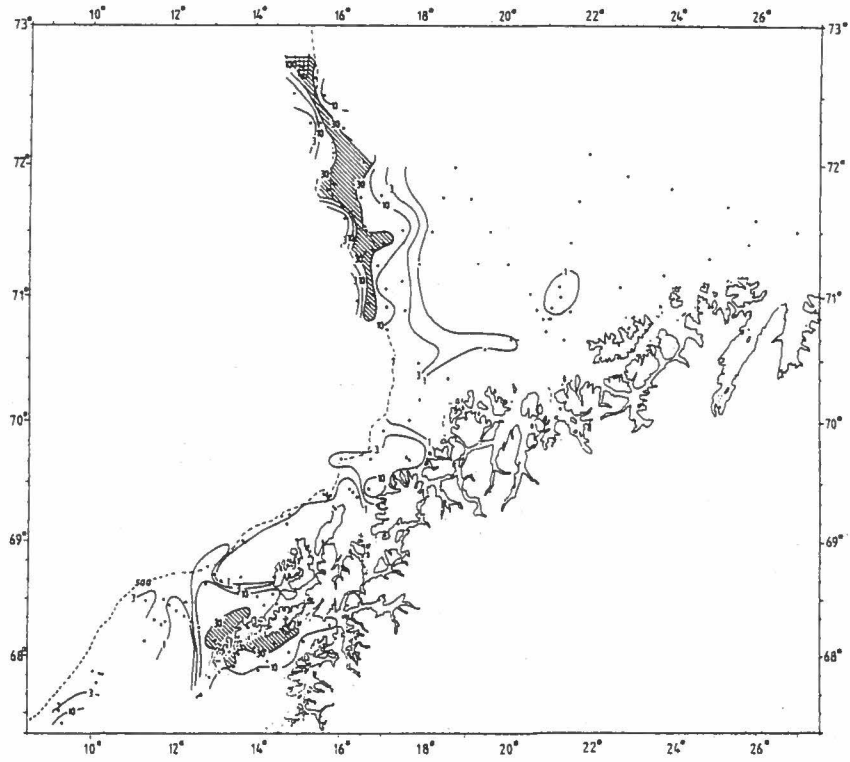


Fig. 2. Distribution of haddock eggs in numbers per m^2 surface.
All developmental stages included. April 22- May 14, 1987.

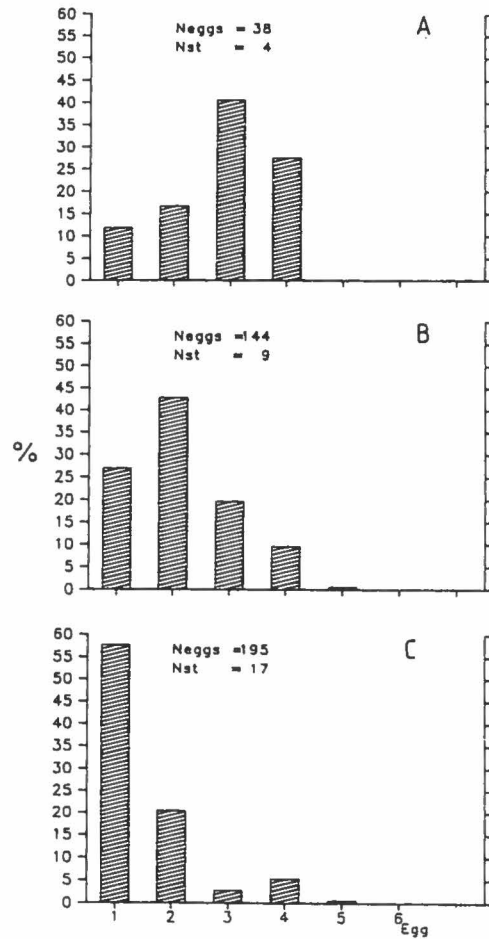


Fig. 3. Distribution of egg developmental stages in subareas A-C (see Fig. 1)
 Neggs = Number of eggs, Nst = Number of stations

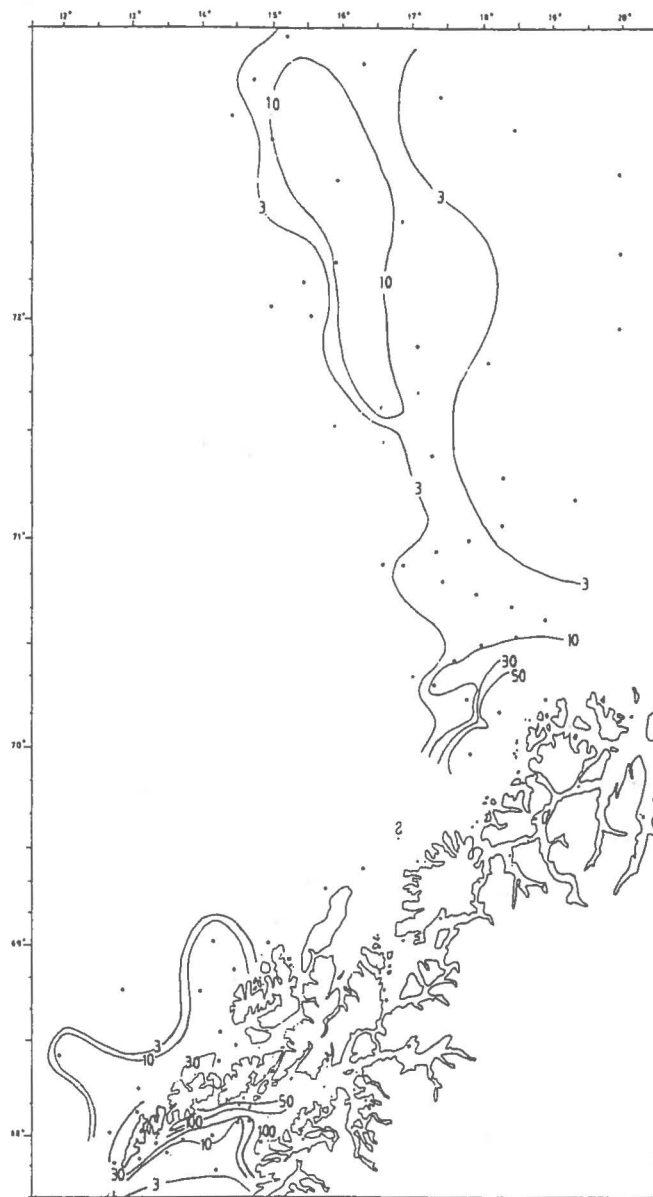


Fig. 4. Distribution of haddock eggs, per m² (12-23 May 1988)

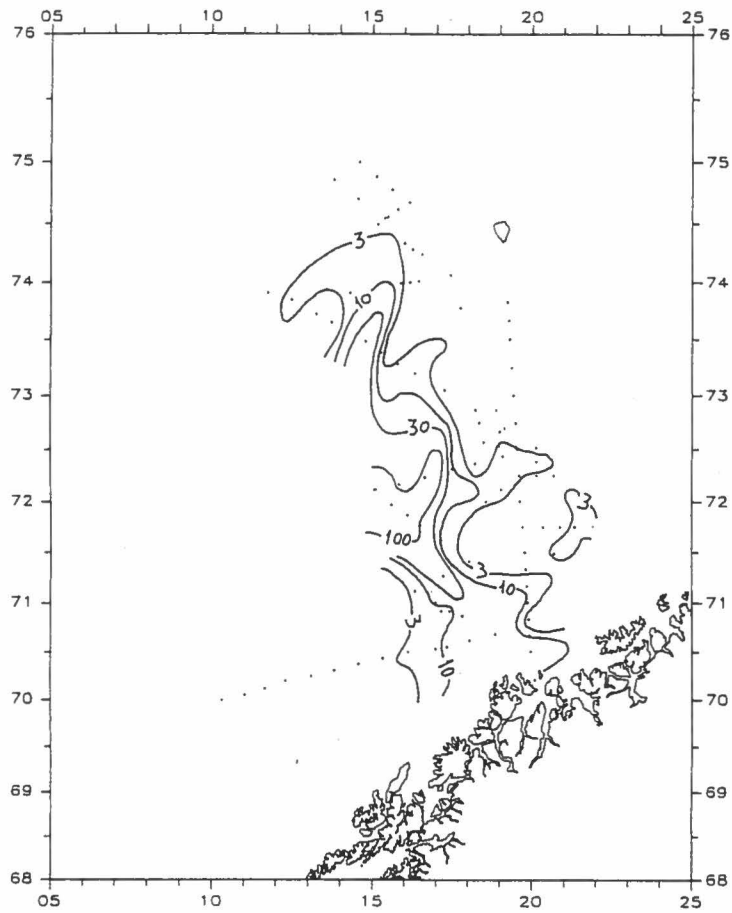


Fig.5. Haddock-eggs, all developmental stages, nos. per m², 04.-16. May 1996

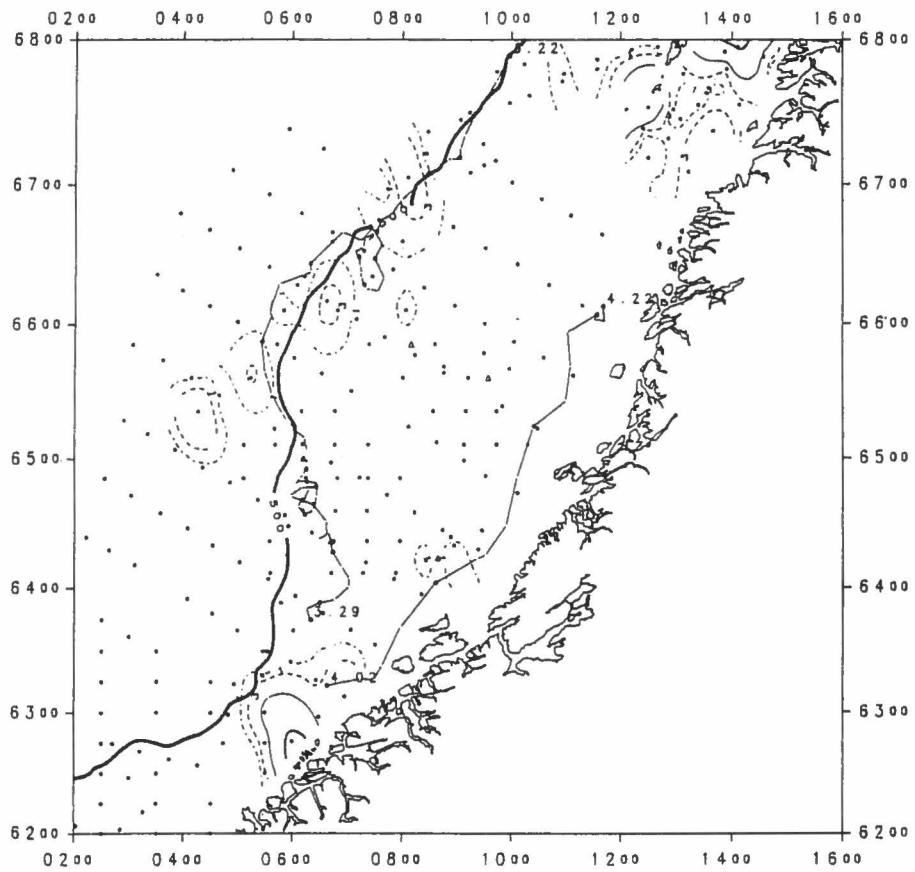


Fig.6. Distribution of haddock eggs in numbers per m^2 surface south of Røst. April 27. - May 23. 1988. All developmental stages included.
 △: Bottom trawl stations. ▲: Bottom trawl stations with catch of haddock.

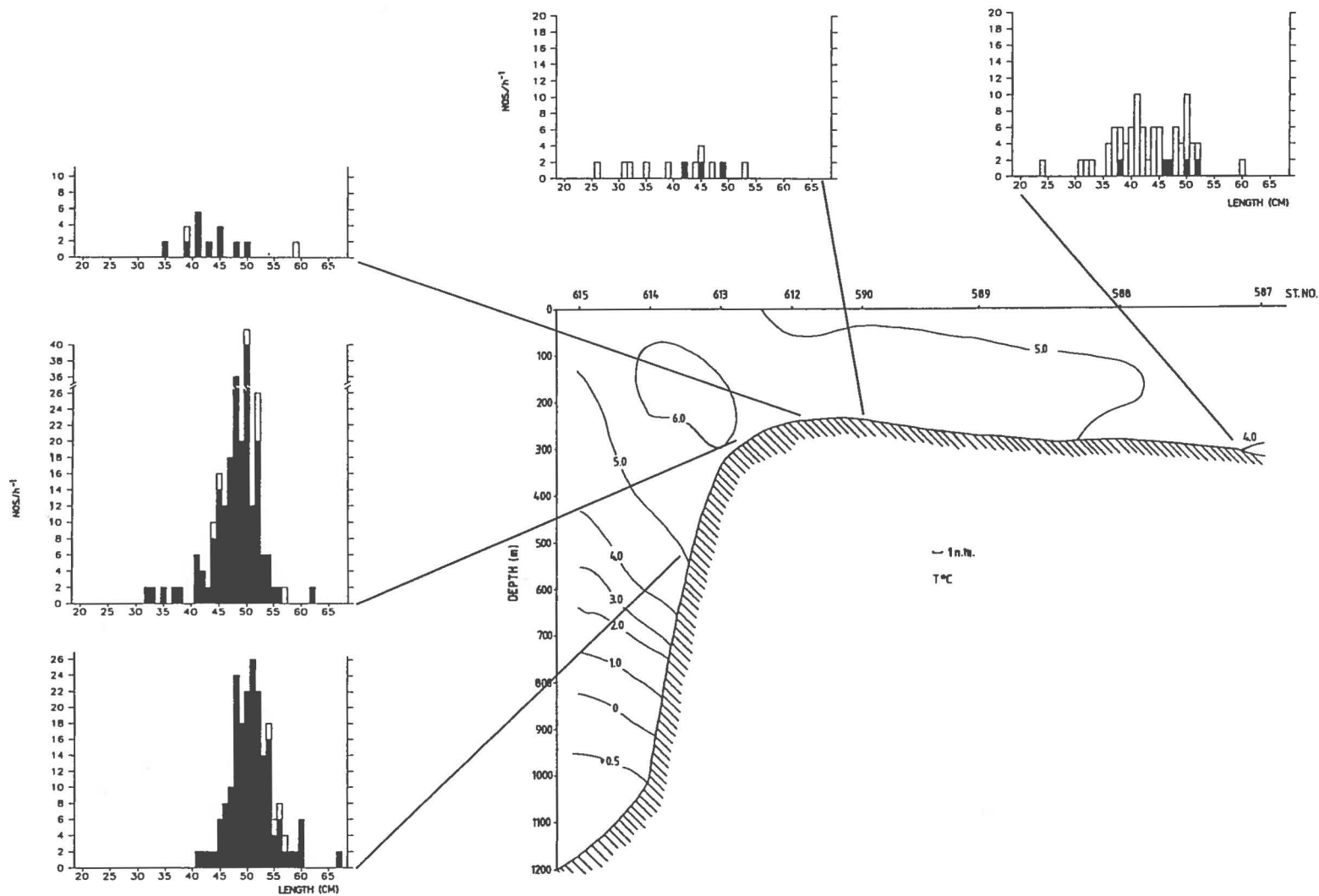


Fig.7. Maturity, length distribution and number per trawl hour of female haddock. Temperature distribution ($^{\circ}\text{C}$) on a section from the western bank area and the continental slope of Tromsøflaket in area C. ■: Mature haddock females. □: Immature haddock females.

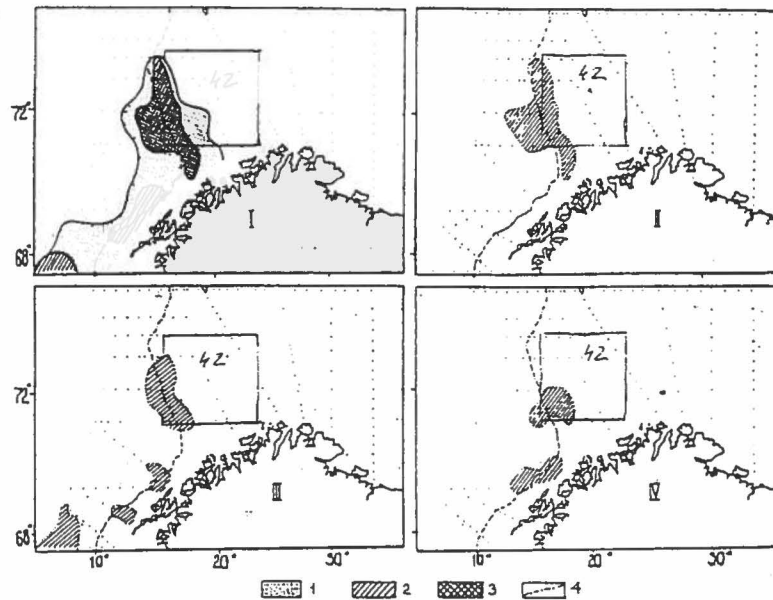


Fig. 8. The spawning area of haddock.

I- The total spawning area.

II- The first spawning scenario. (1960, 1971, 1973, 1980, 1981, 1989, 1990)

III- The second spawning scenario. (1962, 1963, 1969, 1970, 1974, 1976, 1979, 1983, 1985)

IV- The third spawning scenario. (1959, 1961, 1968, 1975, 1982)

1- Low spawning intensity.

2- Mean spawning intensity.

3- Strong spawning intensity.

4- 1000 m isobath.

42- Kopytov bank (Tromsøflaket)

(Mukhina, 1992)

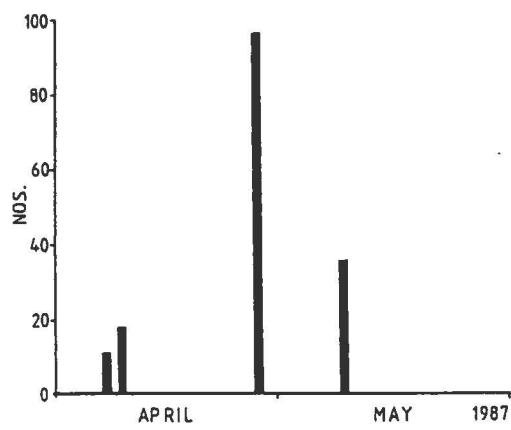
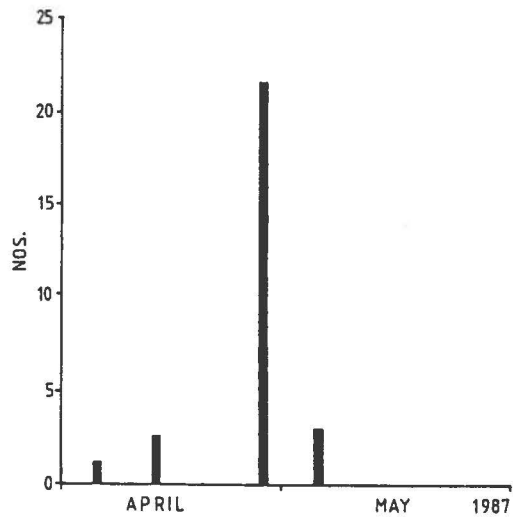


Fig. 9. Number of haddock eggs per m² surface at Vestfjord, (below) and Tromsøflaket (above). Numbers represent stages I-IV. (See Fig. 1 for investigated area)

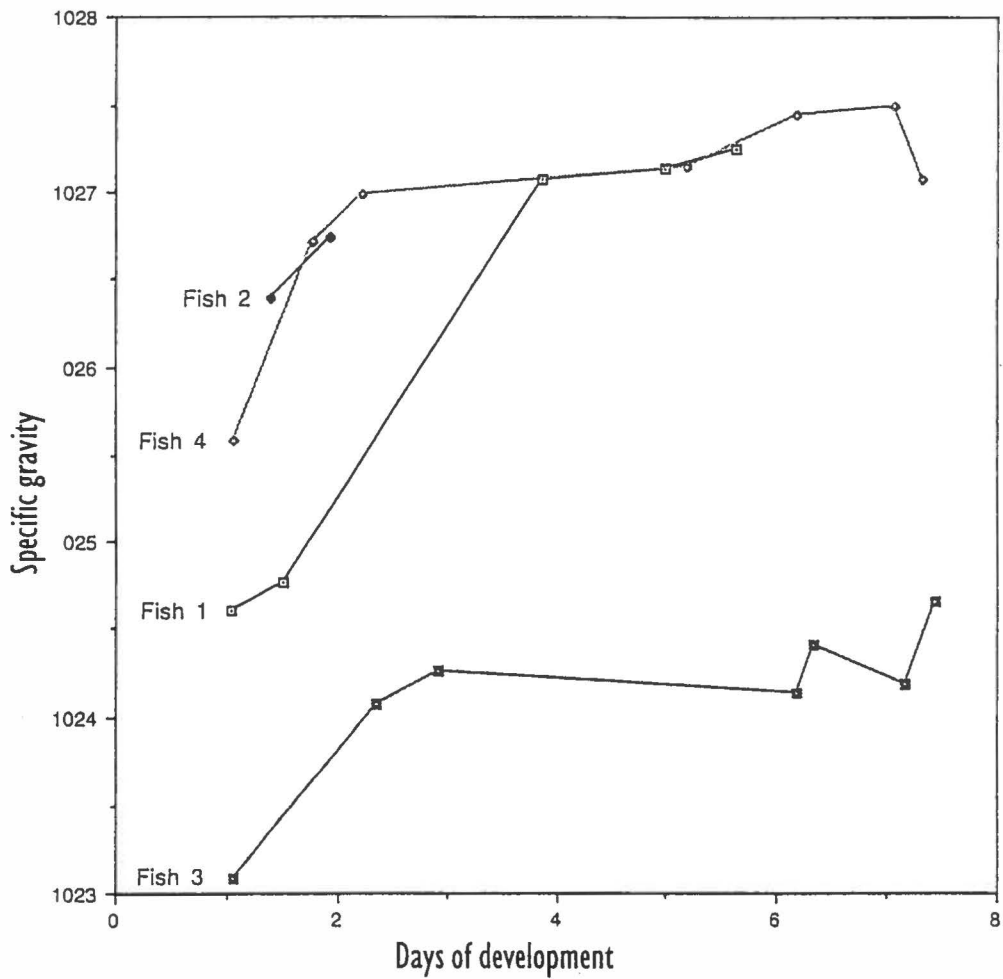


Fig. 10. Specific gravity of eggs in different stages of development from four haddocks.

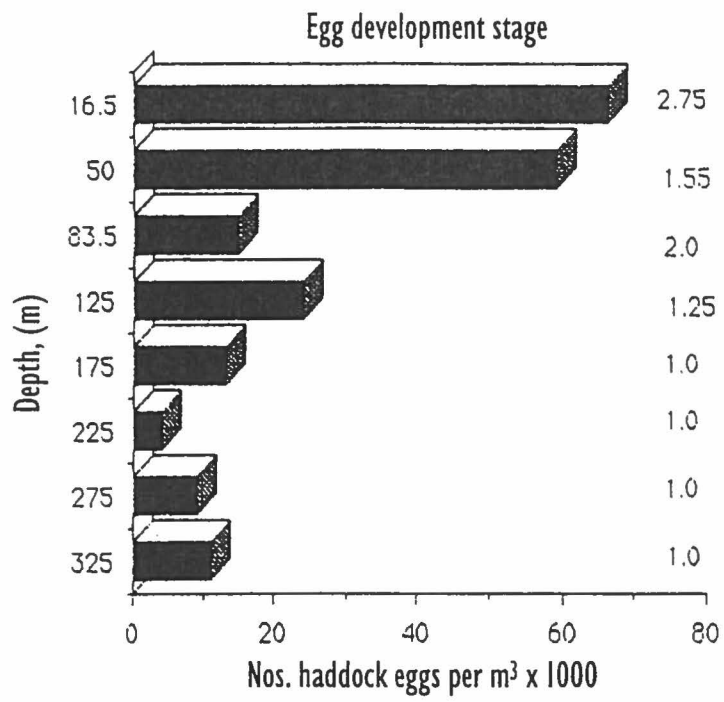


Fig. II. Vertical distribution of haddock eggs collected by MOCNESS-sampler on the NW part of the Tromsøflaket.

| Area Station | Degree of maturity (%) | | | | | Mi |
|--------------------|------------------------|------|------|------|------|-----|
| | 1 | 2 | 3 | 4 | 5 | |
| A 188,187 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| B 186,190 | 68.3 | 1.6 | 3.2 | 14.2 | 12.7 | 2.0 |
| 1987 C 191,192,193 | 1.8 | 12.2 | 21.8 | 37.4 | 26.8 | 3.8 |
| C' 199,200,201 | 0.0 | 0.0 | 3.2 | 64.5 | 32.3 | 4.3 |
| D 196,197,198 | 0.0 | 2.7 | 21.6 | 70.3 | 5.4 | 3.8 |
| A 266 | 0.0 | 3.3 | 0.0 | 26.7 | 70.0 | 4.6 |
| 1988 B 265 | 0.0 | 0.0 | 0.0 | 33.3 | 66.7 | 4.7 |
| C 262,263,264 | 0.0 | 0.0 | 5.2 | 37.9 | 56.9 | 4.5 |

Tab. 2. Maturity of female haddock in areas A (April 26), B (April 26-27), C (April 28-29) and D (May 2) at Tromsøflaket and Røstunga in 1987 and 1988 (May 20-22). C': Area C sampled (May 5-6). Mi: Maturity index. See Fig. 1 for area code.

| | Cod | | Haddock | |
|--|------|------------------|---------|------------------|
| | % | N/m ² | % | N/m ² |
| I Røstunga | 20.0 | 0.9 | 80.0 | 3.4 |
| II Continental slope Røst - Tromsøflaket | 83.9 | 13.3 | 16.1 | 2.5 |
| III Continental shelf Røst - Langøy | 70.8 | 15.4 | 29.2 | 6.4 |
| IV Lofoten / Vestfjord area | 79.8 | 109.9 | 20.2 | 27.8 |
| V Continental slope of Tromsøflaket | 10.6 | 3.2 | 89.4 | 27.3 |
| VI Nygrunnen | 64.5 | 1.1 | 35.5 | 0.6 |

Tab. 1. Percentage and concentration of haddock and cod eggs from six areas on the continental shelf and slope in north Norway 21. April - 15. May 1987. (See Fig. 1)