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A PRELIMINARY NOTE ON THE ECOLOGY OF EGGS AND LARVAE OF THE ATLANTIC HALIBUT HIPPOGLOSSUS HIPPOGLOSSUS (L.)*

by

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ABSTRACT

Egg surveys were carried out in North Norway in the spawning season of the halibut *Hippoglossus hippoglossus* (L.) during January 1982. Eggs were looked for on the sea bed with Beyer's epibenthic closing net and at various depths in the water column with a Tucker trawl. Two spawning grounds were studied (Malangen and Sørøysund).

No halibut eggs were found on the bottom, but 53 eggs were found floating bathypelagically at various depths. They were most abundant in and below a zone of rapidly changing sea water density. Temperatures between 4.5 and 7.0^{o}C were observed; salinities ranged from 33.9 to 35.0^{o}/oo.

Neutral buoyancy salinities determined in the laboratory upon artificially fertilized eggs were significantly higher than the observed field salinities. Probably egg density varies from female to female, but the poor condition of the adult fish used for egg stripping may have contributed to the enhanced buoyancy.

*The authorship of this paper is equal and alphabetical.

Surveys with a pelagic trawl at several depths in Malangen ca 3 months after spawning (April 1982) failed to capture halibut larvae.

RÉSUMÉ

Note préliminaire sur l'ecologie des oeufs et des larves du flétan atlantique Hippoglossus hippoglossus (L.).

Des inventaires d'oeufs ont été effectués dans les eaux du nord de la Norvège pendant l'époque du frai du flétan Hippoglossus hippoglossus (L.) en janvier 1982. Les oeufs ont été échantillonnés sur les fonds marins à l'aide d'un filet épibenthique Beyer ainsi qu'à diverses profondeurs dans la colonne d'eau à l'aide d'un chalut Tucker. Deux frayères ont été étudiées (Malangen et Sørøysund).

Aucun oeuf de flétan n'a été recueilli sur le fond marin mais 53 oeufs ont été échantillonnés flottant bathypélagiquement à différentes profondeurs. Ils ont été les plus abondants dans et au-dessous d'une zone de changement rapide de la densité de l'eau de mer. Les températures observées furent entre 4.5 et 7.0°C et les salinités entre 33.9 et 35.0‰.

Les salinités de flottabilité neutre déterminées avec des oeufs fertilisés en laboratoire furent significativement supérieures à celles observées en mer. Il est probable que la densité des oeufs varie de femelle à femelle, mais il est possible que le mauvais état des poissons adultes utilisés pour le dépouillement des oeufs ait contribué à augmenter la flottabilité.

Des inventaires effectués à l'aide d'un chalut plagique à diverses profondeurs à Malangen environ 3 mois après l'epoque du frai (avril 1982) n'ont pas réussi a capturer des larves de flétan.

INTRODUCTION

In late autumn and early winter the Atlantic halibut *Hippoglossus hippoglossus* (L.) spawn at certain soft clay or mud bottom deep water localities (300 - 700 m) in the fjords and on the edge of the continental slope along the Norwegian coast (HJORT 1905, DEVOLD 1938).

Various aspects of the early development of this species are documented through studies of artificially fertilized and reared eggs and larvae (ROLLEFSEN 1934, SOLEMDAL & al. 1974, BLAXTER & al. in press, LØNNING & al. in press, RIIS-VESTERGAARD in press). However, very little research has been carried out on the ecology of halibut eggs and larvae in the field.

Artificially fertilized and reared halibut eggs and larvae are usually positively buoyant only in salinities considerably above those recorded on the halibut spawning grounds (SOLEMDAL & al. 1974, BLAXTER & al. in press, LØNNING & al. in press). A logical suggestion would thus be that early halibut development takes place at or very near the sea bed where the spawning also takes place. The few existing records of halibut eggs in the sea suggest, however, that they are bathypelagic, probably floating at great depths (ROLLEFSEN 1934, VEDEL-TÅNING 1936, DEVOLD 1938, 1939, 1943, MCINTYRE 1958). The morphology and ultrastructure of the eggs, and the embryonic development also suggest that the early developmental stages of the halibut are pelagic (LØNNING & al. in press). The few halibut larvae collected in the field were also found floating bathypelagically, though at somewhat shallower depths than the eggs (SCHMIDT 1904, JESPERSEN 1917, COX 1924, ROLLEFSEN 1934).

To clarify the contradictions between laboratory and field data, egg and larvae surveys were carried out on two halibut spawning grounds in North Norway in January and April 1982.

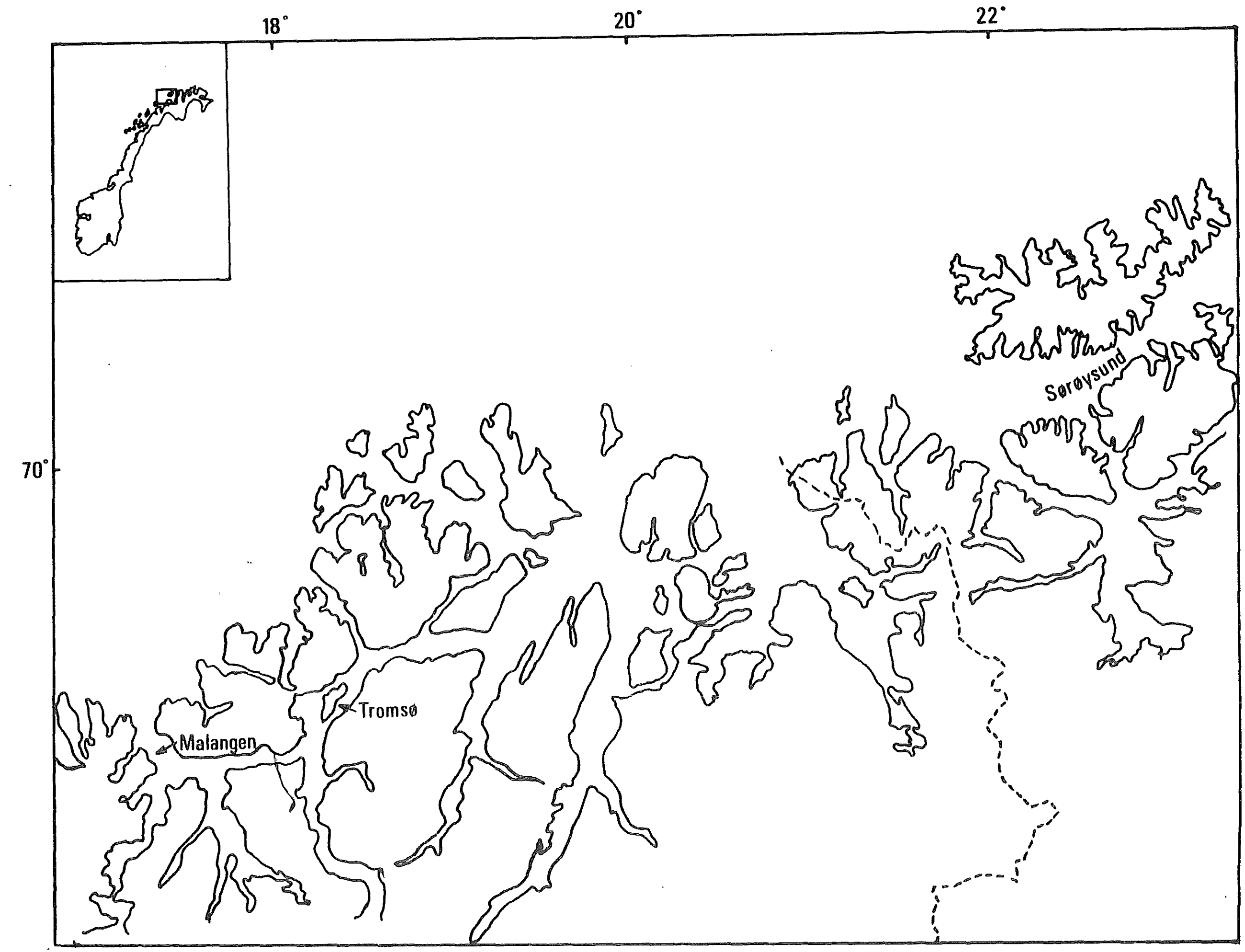

Figure 1. Map showing the localisation of the halibut spawning grounds in Malangen and Sørøysund.

MATERIAL AND METHODS

The egg- and larvae surveys took place on halibut spawning grounds in Malangen and Sørøysund, North Norway (Fig. 1).

Hydrographical data from various depths were recorded on January 14 in Malangen and on January 24 in Sørøysund using a Neill-Brown CTD-sonde connected to a Nord-10 computer.

Egg surveys in the water column were performed in both Malangen (January 14 - 20) and Sørøysund (January 24 - 30) using a Tucker trawl. A total of 39 horizontal hauls, each of 30 min. duration, were carried out at different depths in the two localities (Table 1). A Simrad trawl eye mounted on the trawl was employed to ensure correct sampling depths.

For a closer description of both the CTD-sonde/computer system and the Tucker trawl and Simrad trawl eye used in these investigations, see HOPKINS & al.(in press) and references therein.

To search for eggs on the sea floor, a Beyer's epibenthic closing net (see HESTHAGEN 1970) was used. A total of 10 hauls, each of 30 min. duration, were carried out with this equipment on the sea floor (ca. 350 m deep) of the Malangen spawning ground on January 14. To improve the chances of collecting particles (eggs?) lying on the sea floor, plenty

Table 1. Number of hauls carried out at the two sites using different sampling methods.

DEPTH (m)	MALANGEN			SØRØYSUND
	Tucker trawl	Beyer's epibenthic closing net	Pelagic trawl	Tucker trawl
25			2	3
50			3	
75	3		3	3
100	3		2	3
125	3			3
150	3		2	3
200	3			3
250				3
300	1			
350				2
BOTTOM		10		
TOTAL	16	10	12	23

of wire was given out to stir up the muddy bottom in front of the sledge.

Gillnet fishery of mature halibut with running milt and roe was performed in parallell with the egg surveys to confirm that spawning took place during the sampling periods.

Searches for halibut larvae were carried out on April 19 and 20 in Malangen, using a pelagic trawl with a fine net (mesh size 0.3 mm) in the cod end. Since the trawl cannot be closed during setting and heaving, it has to be accepted that some organisms may be collected in shallower waters than the hauling depths. 12 hauls of 30 min. duration were carried out in several depths in exactly the same areas where egg surveys took place in January (Table 1). Trawl depths were determined by measuring the wire length and angle.

The material obtained from the different surveys was dealt with immediately in the fresh state on board the ship. Thus, all halibut eggs and larvae were sorted out from the rest of the material and preserved in a solution of glutaraldehyde and paraformaldehyde in 0.05 M cacodylatebuffer (pH 7.2) for later determination of diameter and developmental stage. To ensure that no eggs or larvae were overlooked, all material collected was preserved in formalin and taken home for re-inspection in the laboratory.

RESULTS

Egg surveys on the bottom

The near bottom temperature, salinity and sea water density (σ_t) in Malangen during sampling were 7.1 ^{o}C, 34.75 ^{o}/oo and 27.3 respectively.

No halibut eggs were found during any of the 10 hauls with the Beyer's epibenthic closing net, though mud and sand in the samples and the capture of typically bottom dwelling polychaetes and mussels confirmed that the net had really

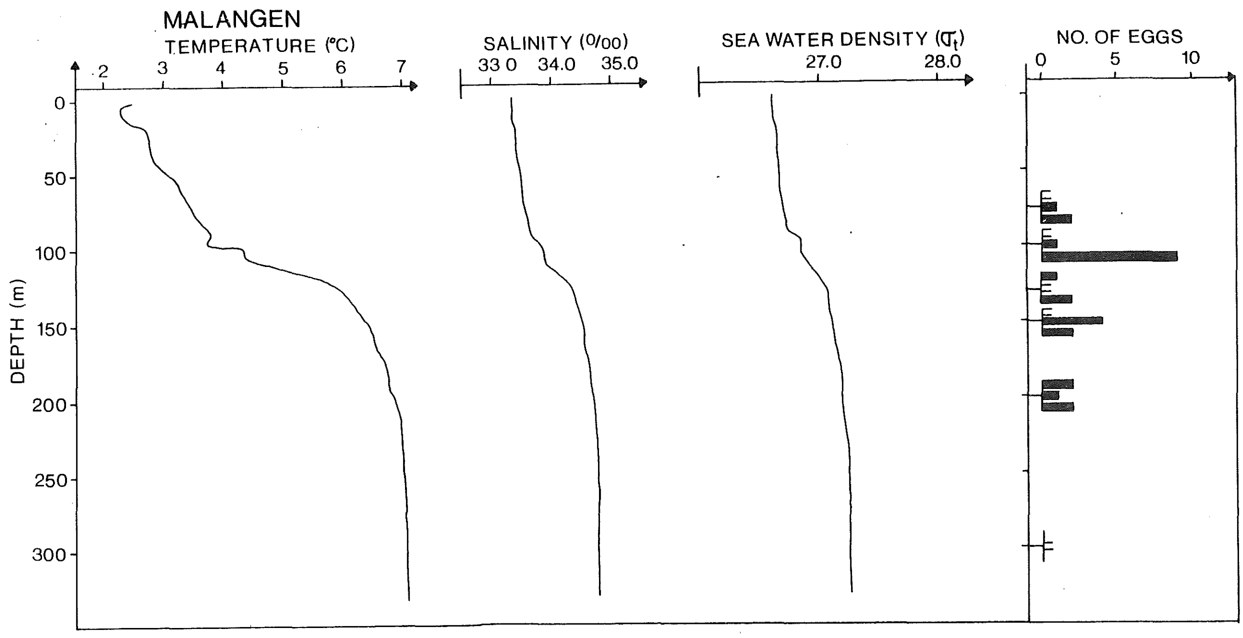

Figure 2. The distribution of temperature, salinity, sea water density and egg number per trawl haul according to depth on the location in Malangen.

been sampling on the bottom as intended.

<u>Egg surveys in the water column</u>

A total of 53 halibut eggs were collected in the 39 Tucker trawl hauls from various depths at the two locations (Figs 2 and 3).

Altogether, 27 halibut eggs were caught in 16 hauls in Malangen. During sampling, a region of rapidly changing water density was situated between depths of ca. 90 and 140 m (Fig. 2). In this region sea water density (σ_t) increased from an upper layer value of ca. 26.6 to a lower layer value of 27.3. The surface and bottom temperatures were 2.5 and 7.1^{o}C respectively, while salinity increased with depth from 33.35^{o}/oo at the surface to 34.75^{o}/oo 10 m above the bottom. In the upper cold and low salinity layer 3 hauls at 75 m depth gave a total of 3 halibut eggs. Within the region of rapidly changing water density 3 hauls in each of the depths

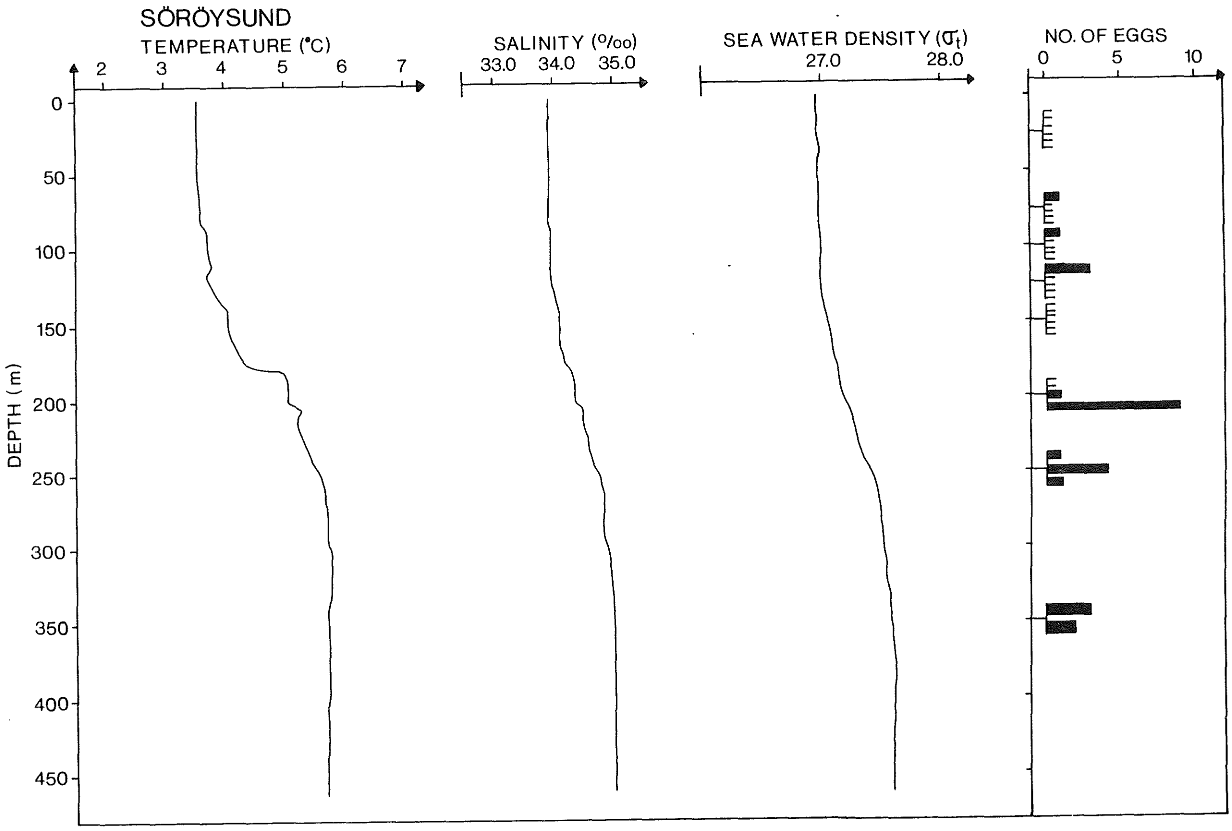

Figure 3. The distribution of temperature, salinity, sea water density and egg number per trawl haul according to depth on the location in Sørøysund.

100 and 125 m resulted in a total of 10 and 3 eggs respectively. In the warmer and more saline lower layer, a total of 6 and 5 eggs were collected in 3 hauls each at 150 and 200 m depths respectively. Eggs were not found at 300 m, but only one single haul was carried out at this depth.

In Sørøysund, a total of 26 halibut eggs were collected in 23 hauls. The region of rapidly changing water density on this location was located between 120 and 260 m depths during the sampling period (Fig. 3). From the upper to the lower part of this region, temperature increased from 3.7 to 5.7°C, salinity from 33.95 to almost 35.00°/oo, and σ_t from a little less than 27.0 to nearly 27.5. Very few eggs were found in the upper cold and low salinity water. Thus, in a total of 15 hauls at depths between 25 and 150 m inclusive, only 5 eggs were found. Within the region of rapidly changing water density, 3 hauls in each of the depths 200 and 250 m resulted in a total capture of 10 and 6 eggs respectively. In the lower warm and more saline layer, at 350 m depth 2 hauls gave a total of 5 eggs.

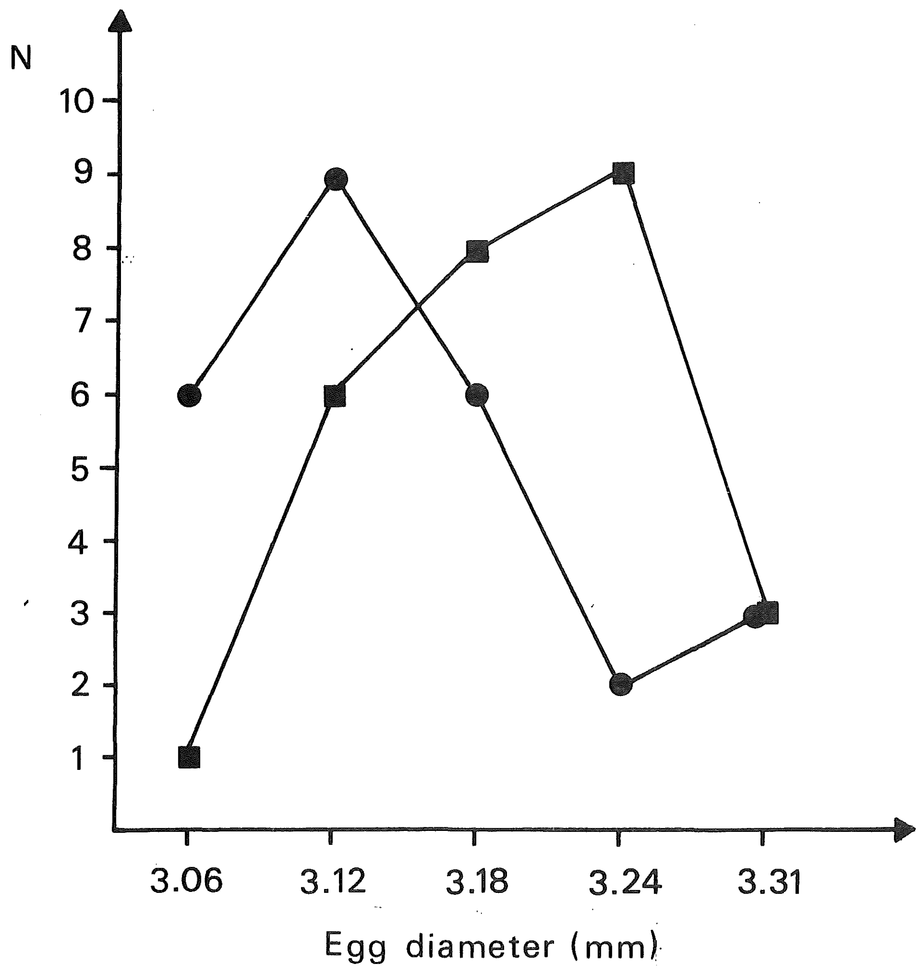

Figure 4. Diameters of the halibut eggs found bathypelagically on the two spawning grounds. (■——■):Malangen; (●——●):Sørøysund.

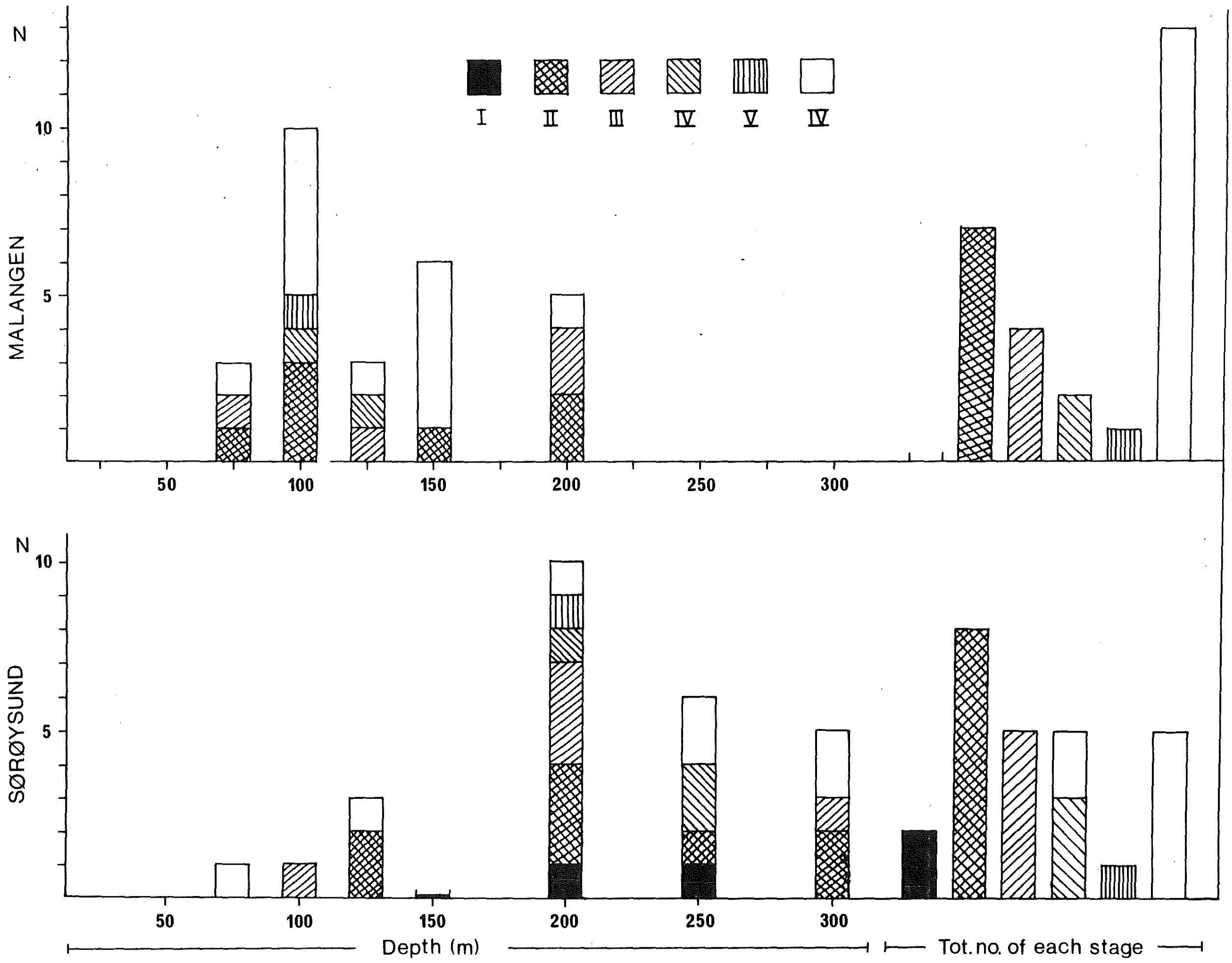

Figure 5. Developmental stages of the eggs found in Malangen and Sørøysund. I.Uncleaved or unfertilized. II.Blastula stage (4 days). III.Gastrula stage (4 - 6 days). IV.Embryo visible, blastopore open (6 - 10 days). V.Embryo with closed blastopore (10 - 18 days). VI.Impossible to determine egg stage.

Developmental stages of the eggs

Halibut eggs were identified according to diameter measurements (see RUSSELL 1976). From both sampling sites, the egg diameters ranged from 3.06 to 3.31 mm (Fig. 4). Average egg diameter in Malangen was 3.20 mm, in Sørøysund 3.15 mm. Eggs from other fish species were not recorded.

Developmental stages were classified according to ROLLEFSEN (1934) and LØNNING & al.(in press). The halibut embryo develops slowly compared with several other pelagic fish eggs, and hatches at a seemingly premature stage. At $5^{o}C$, the temperature where the majority of the eggs were found, hatching occurs ca. 18 days after fertilization (LØNNING & al. in press). Most of the eggs whose developmental stage could be determined were either blastulae or early gastrulae, i.e. early developmental stages younger than ca. 6 days (Fig. 5). This trend was evident at both sampling sites, and only 2 of the eggs were older than 10 days. Unfortunately, in several eggs the developmental stage could not be determined because of cytolysis before preservation (see Fig. 5). This was particularly true in Malangen, where almost half of the eggs were destroyed in this manner.

Eggs in various stages of development were found at almost all depths, and no relation between depth and developmental stage was found.

Surveys of larvae in the water column

None of the 12 hauls using pelagic trawl in depths from 25 to 150 m inclusive succeeded in collecting any halibut larvae. Several other fish larvae plus large amounts of Euphausiacids and Chaethognaths were caught in most hauls.

DISCUSSION

Eggs

Despite the high density in most laboratory reared halibut eggs (SOLEMDAL & al. 1974, BLAXTER & al. in press, LØNNING & al. in press), it proved impossible to establish their presence on the sea floor using Beyer's epibenthic closing net. According to Fredrik Beyer (pers. comm.) benthic fish eggs are definitely collected by this net. Since halibut spawning undoubtedly took place during the sampling period, these surveys gave no evidence of the Atlantic halibut having benthic eggs.

This suggestion is further emphasized from the Tucker trawl results. From Figs 2 and 3 it is evident that most eggs were found within and below the region of rapidly changing water density. This is consistent with earlier findings of DEVOLD (1939, 1943). It is also interesting to note that eggs of the Atlantic halibut's counterpart in the Pacific Ocean, the Pacific halibut Hippoglossus stenolepis SCHMIDT, exhibit a vertical distribution very similar to our records of Atlantic halibut eggs in Malangen and Sørøysund (see THOMPSON & VAN CLEVE 1936, VAN CLEVE & SEYMOUR 1953).

In both Norwegian areas most halibut eggs were found in depths with temperatures between 4.5 and 7^{o}C, salinities from 33.9 to 35.0^{o}/oo, and sea water densities (σ_t) varying from 26.8 to 27.5. The changes in both temperature and salinity between surface and bottom were greater in Malangen than in Sørøysund, and the eggs found in the former area were consequently distributed over a somewhat wider hydrographical range than those collected in the latter (see Figs 2 and 3).

All eggs collected during these investigations were found floating in salinities below 35^{o}/oo. These salinities are considerably lower than the neutral buoyancy salinities of 35.5 - 37.0^{o}/oo previously found in stripped, artificially fertlized and laboratory reared halibut eggs (see SOLEMDAL & al. 1974, BLAXTER & al. in press, LØNNING & al. in press). In the Pacific halibut, density determinations of eggs and larvae achieved from live specimens allowed to spawn voluntarily in captivity, indicated neutral buoyancy at a salinity of 31.5^{o}/oo which corresponds well with their distribution in nature (FORRESTER & ALDERDICE 1973).

If the records from Malangen and Sørøysund are truly representative of the field distribution of Atlantic halibut eggs it seems likely that the heightened neutral buoyancy of artificially fertilized eggs probably results from artifacts caused by handling during capture or subsequent laboratory maintenance. This view is further supported by data obtained in experiments conducted with eggs stripped from halibut sampled in Sørøysund during January 1982, one female giving eggs with neutral buoyancy of $34.8^{o}/oo$ (unpubl. data). Certainly, minor variations in neutral buoyancy in eggs from female to female may occur. This is indicated both from the considerably wide hydrographical range over which the eggs were distributed (Figs 2 and 3) and the lack of correlation between depth and developmental stage of the eggs found on both spawning grounds (Fig. 5). The large differences most often observed between artificially and naturally spawned halibut eggs, however, is more likely due to factors such as the rough treatment given to mature fish caught in gill nets, the rapid ascent from depths of 350 - 650 m to the surface and the stripping instead of natural spawning.

The widely varying neutral buoyancies determined from stripped and artificially fertilized and reared halibut eggs may of course reflect the real and natural condition also present in nature. A possible explanation of Figs 2 and 3 would then be that, since halibut egg densities seems to vary from fish to fish, only the low density part of the eggs would ascend from the sea floor, the rest being left at or very close to the bottom. The lack of eggs in the bottom surveys seems to strongly contradict this argument, but further bottom surveys (some with gear other than the Beyer's epibenthic closing net) together with Tucker trawl surveys just above the sea bed are necessary to shed more light upon this question.

Larvae

Considering the scattered and sparse occurrence of halibut larvae in nature, their absence from 12 pelagic trawl hauls does not totally exclude the possibility of their presence in the investigated areas. However, the capture of several other sparsely distributed fish larvae in many of the hauls suggest that the halibut larvae should be sought in areas of the Malangen fjord system other than those surveyed so far.

The majority of records of halibut larvae in the North Atlantic have been made from the upper water layers, mostly between the surface and a depth of 100 m (SCHMIDT 1904, JESPERSEN 1917, COX 1924, ROLLEFSEN 1934). It is thus not likely that larvae should occur in notable numbers below the investigated depths ($<$ 150 m) in Malangen.

The current system during spring in Malangen must be of the utmost importance to the distribution of both eggs and larvae. According to SÆLEN (1947), an inflow of salt and warm Atlantic water to the deeper layers occurs in March. This current will increase until May/June, while a surface current - strongest in summer - is running out of the fjord. The influence of the currents is hard to predict, however, as we know very little about the general vertical distribution of the larvae. Further research, including surveys for the newly settled bottom stages, is obviously necessary.

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