Buoyancy Determination of Eggs from the Cod (*Gadus morhua* L.)

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Introduction

On the spawning grounds of the arctic cod in Lofoten, the hydrographical condition in general is characterized by a cold upper layer of coastal water and a deeper layer of Atlantic origin and an intermediate layer with temperatures of about 5°C.

Already in 1881 JUEL had shown that there was a relation between the depth of the intermediate layer and the concentration of the arctic cod in the spawning area. This was later verified by GADE (1894). The depth of this layer varies from one year to another. The variation in depth is about 150 m between extremes.

SARS (1864) found that the arctic cod had pelagic eggs and he discussed the buoyancy and flotation in relation to the specific gravity of the egg. He also took the oil content of the egg into account. SARS discussed further the possible lethal effect of mechanical forces on the egg (e.g. wave action, etc.).

ROLLEFSEN (1929) has experimentally shown that the cod egg is easily destroyed by mechanical forces and he also discussed the effect of wind and waves on the spawn.

Due to these findings and the variable depth of the intermediate layer we found it necessary to investigate the buoyancy of the cod egg in relation to pressure, temperature and salinity.

The present paper deals with the measurable differences in compressibility of the egg in relation to sea water and the effect of different salinities and temperatures on the buoyancy of the cod egg. A more detailed study of the ion exchange in the cod egg will be published elsewhere by one of the authors.

Material and Methods

In order to investigate the buoyant effect of the oily components in the egg, a pressure chamber (Fig. 1) was constructed from plastic-coated brass. In this chamber a hydrostatic pressure corresponding to 500 m depth can be produced. There is no flow of water in the chamber, but the temperature is controlled by

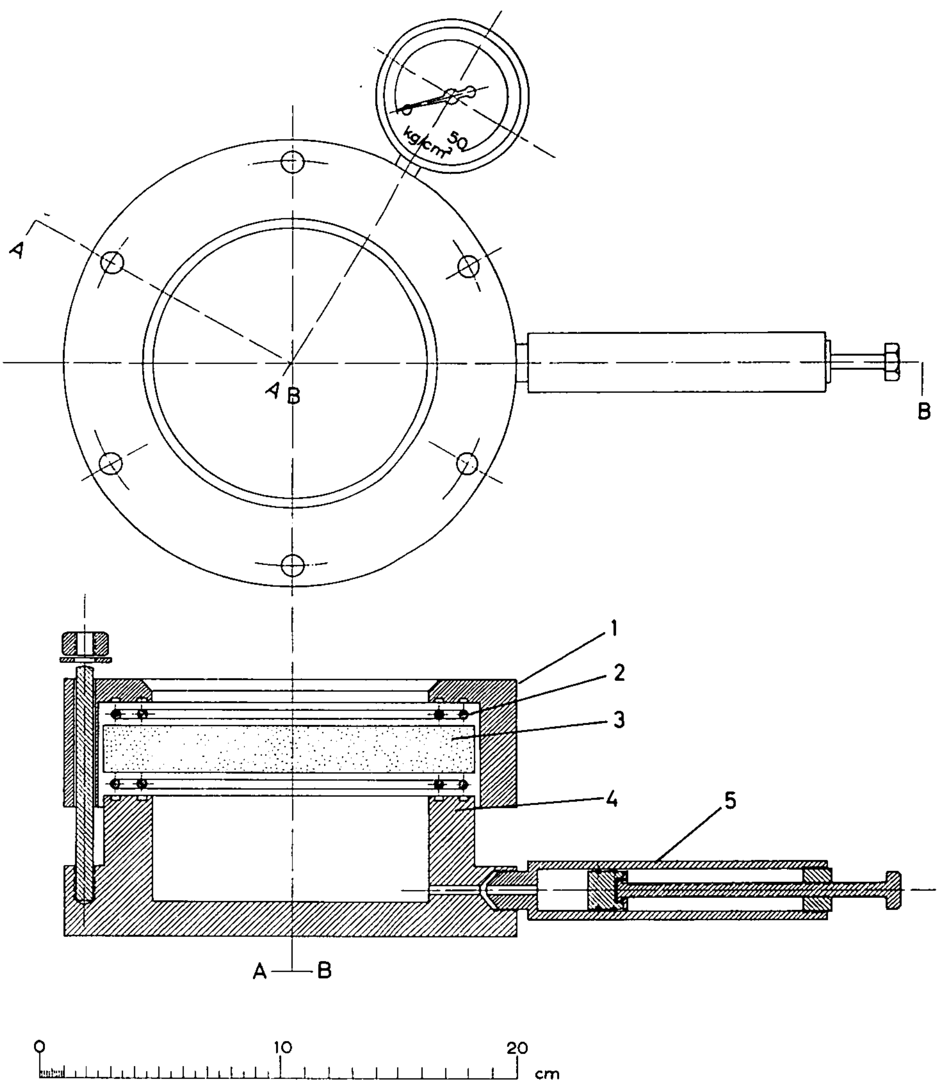

Figure 1. Side and plan view of pressure chamber. 1, Cover; 2, O-rings; 3, Glass window; 4, Chamber; 5, Pressure plunger.

submersion into a thermostatically controlled water bath. The eggs and sperms were taken from mature cod in the Lofoten area. All pressure measurements were performed at sea in the ship's laboratory. In the pressure chamber with no circulation the eggs could be kept alive from fertilization to the morula stage. All other stages were developed in open jars with running water. Additional experiments were performed at Fiskeridirektoratets Havforskningsinstitutt's laboratory in Bergen with eggs from a coastal stock of cod.

To test their flotation at different salinities, batches of eggs were transferred to a series of measuring cylinders containing sea water diluted to different

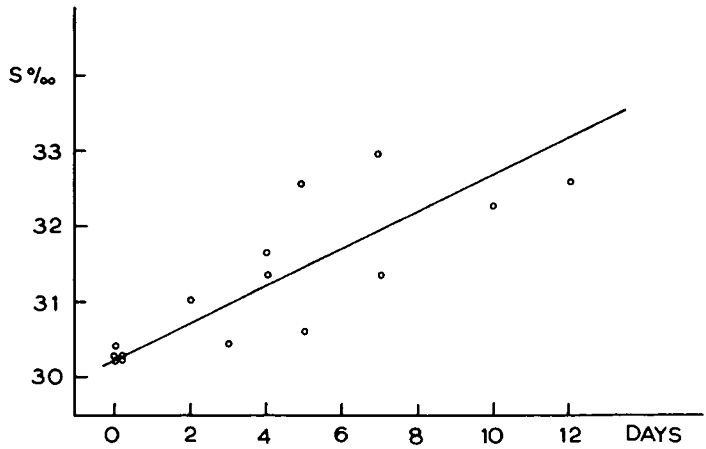

Figure 2. Salinity at which the majority of the eggs are buoyant, plotted against days after fertilization.

degrees. The cylinders were kept in a thermostatically controlled water bath in order to avoid convection currents in the water column. The salinity of the water was determined by titration. The buoyancy of the eggs was determined by observing the salinity at which the major part of the eggs were flotating, i.e. at least 70%, while there were some at the bottom and at the surface. With experience it is possible to detect differences in egg buoyancy to the nearest 0·5‰ salinity, corresponding to a 0·04% difference in density. Experiments were performed on batches of eggs from 10 females. The eggs for the experiments were chosen with regard to the following criteria: sphericity, clearness, and regularity of cleavage. It was found that batches of eggs of lesser quality had a higher density than the perfect ones.

Results and Discussion

Due to the great variation in the depth of the intermediate layer, it was of interest to investigate how far the buoyancy of the cod eggs was dependent or independent of the hydrostatic pressure corresponding to the depth where they were spawned. It has frequently been observed that the cod leave the intermediate layer during spawning and concentrate above the intermediate layer, especially if this is situated in a deep position.

By testing the eggs in the pressure chamber, they were found to be independent of the hydrostatic pressure. All stages, from the single cell to hatched larvae were tested at pressures corresponding to depths from 0–500 m depth. Changes of hydrostatic pressure produced no effects on the flotation of the egg. In the newly hatched larvae no gas lumina were present. Using water from the brackish surface layer in the pressure chamber, the eggs were found to be buoyant in the chamber at all pressures equivalent to the whole depth range of the intermediate layer.

By using different salinities of the water, the flotation of the eggs showed a marked dependency on the salinity, i.e. the specific gravity of the surroundings. As seen from Figure 2, cod eggs fertilized and reared at 34‰ are buoyant at a salinity of about 30‰ at fertilization. Their density steadily increased during development until it was nearly equal to the sea water at hatching (15 days). It is well known that cod eggs are found in salinities lower than 12‰ (STRODTMANN, 1906) in the Baltic. As we only have tested eggs fertilized at 34‰, it is impossible to ascertain whether this low density is a characteristic of the Baltic cod population or simply acquired by spawning at low salinity. In experiments with eggs kept at 29‰ for 24 hrs they failed to adjust their density so as to be buoyant at this salinity. It seems therefore that once the buoyancy is established (before or upon spawning) the eggs are unable to adjust their density to a lower level. Experiments performed at 2°C and 12°C failed to yield any difference in egg buoyancy. The thermal expansion of the egg must therefore be considered nearly equal to that of the sea water. Salinity experiments were also performed in the pressure chamber. The salinity in the pressure chamber was then adjusted to be 0·5‰ higher than the buoyancy of the eggs. The eggs would thus just be floating at this dilution. An increase in density of the eggs of 0·04% relative to the water would thus be registered as a tendency towards sinking. Two batches of eggs, one freshly fertilized, the other 7 days after hatching were tested. A pressure of 50 atmospheres corresponding to 500 m depth was used. No tendency towards sinking was registered.

It must be concluded therefore that neither pressure nor the presence of a thermocline will hinder cod eggs spawned at a considerable depth from reaching the surface. On the other hand, low salinities at the surface will keep the egg below this layer. A surface layer of low salinity can possibly protect the egg to some degree from being destroyed by the mechanical forces of the waves (SARS, 1864; ROLLEFSEN, 1929).

In areas where spawning takes place in water masses of considerably higher salinity than the surface water, a detailed analysis of the depth distribution of the eggs would be of great interest in view of the present findings.

Acknowledgement

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Summary

The effect of salinity, pressure and temperature on the buoyancy of the cod egg has been investigated. The buoyancy of the egg is found to be independent of pressure and temperature, but is markedly influenced by the salinity.

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