Does the extent of ice cover affect the fate of walleye pollock?

Jun Yamamoto, Mio Osato and Yasunori Sakurai

Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan
E-mail: sakurai@fish.hokudai.ac.jp

Introduction

In the late winter and early spring, walleye pollock, *Theragra chalcogramma*, spawn pelagic, individual eggs at mid-water depths. Some of the spawning grounds occur below sea ice, such as in the Sea of Okhotsk, but the effect of cold, low-saline water derived from melting sea ice on eggs is not well known. The present study examined the effect of cold, low-saline water on the survival and hatching success of walleye pollock eggs.

Materials and Methods

Live adult pollock were collected by rod fishing in late January 2007 and 2008 at the mouth of Funka Bay, southwestern Hokkaido Japan, which is known as the main spawning grounds of the Pacific Stocks occurring around Japan. The fishes were moved to, and reared at, 5°C and two different salinities (29.1 in 2007 and 33.0 in 2008) in a 10-ton circular tank. The naturally spawned eggs were collected and maintained under 35 different temperature and salinity conditions (seven temperatures; –1.0, 0.0, 2.0, 5.0, 7.0, 9.0, 11.0°C: five salinities; 24.0, 27.0, 30.0, 33.0, 35.0) to examine the optimal temperature and salinity range for normal hatching, and the developmental time for the each condition. This study used the egg developmental stage model of Kendall and Kim (1989). To clearly understand the movement of eggs in the spawning grounds, the change in their buoyancy during development was examined by liner density column (Coombs, 1981). A summary of the density gradient columns is shown in Table 1.

Table 1 Summary of the density gradient columns.

Temperature (^{o}C), top/bottom	5.0/5.0
Salinity, top/bottom	18.0/42.0
Density (σt)	14.0/33.0

The density of the eggs in the column was determined by density cubes of 14.8, 20.0, 24.9, 30.0σt (Martin Instrument Company). The vertical velocities of the eggs in the spawning grounds of Funka Bay, and Nemuro Strait, eastern Hokkaido, which is known as the spawning ground of the Nemuro Strait Stock, were estimated using the Stokes law (Sundby, 1983).

Results and Discussion

The hatching rate of normal larvae ranged from a low of less than 2°C to a high of 9°C, but showed no significant differences over the salinity range examined (Fig.1). This indicates that temperature < 2.0°C is not favorable for hatching and the success of normal hatching is controlled by temperature rather than by salinities. Additionally, there were no differences in the hatching days after the fertilizations and the developmental stages among the salinities, suggesting that developmental time was also controlled by temperature.

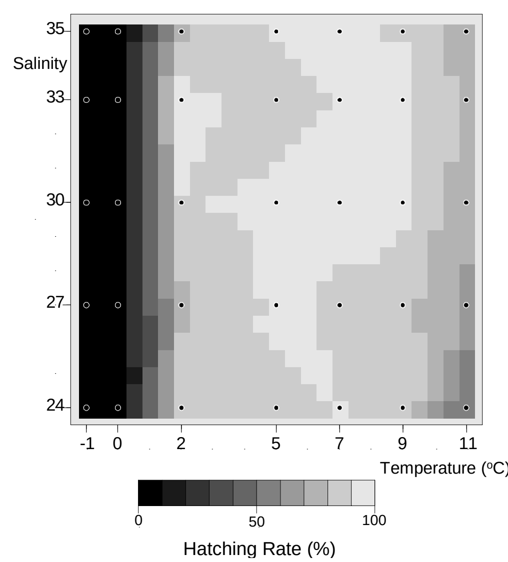

Fig. 1 Hatching rate (%) at 35 different temperature and salinity conditions.

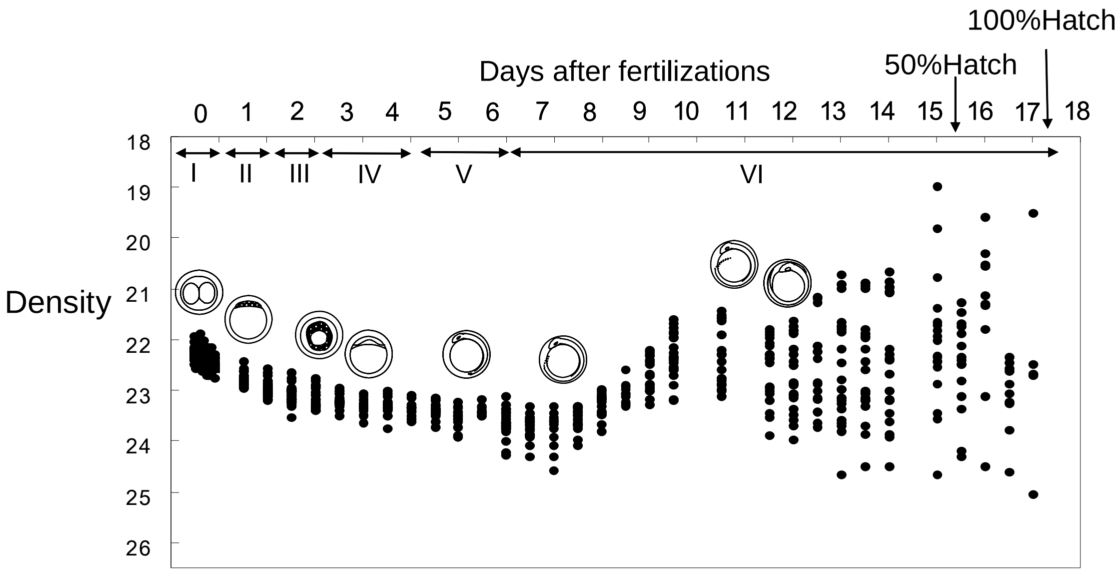

Fig. 2 The change in the density (σt) of the egg during development. Note the inverted *y* axis.

Although, the eggs were spawned in different water properties in 2007 (temperature 5°C, salinity 29.1, density 23.0σt) and in 2008 (temperature 5°C, salinity 33.0, density 23.8σt), the buoyancy of the eggs soon after fertilization showed no difference. Coombs *et al.* (2004) showed that the buoyancy of eggs is affected by the ratio of the volume of the vitelline mass, with almost the same osmotic pressure to the adult, and the volume of the peri-vitelline space, in which the osmotic pressure is almost equal to the sea water. The pollock eggs have a much larger volume of the vitelline mass than that of vitelline space. Thus, the primary buoyancy of the egg is probably determined by the adult. The change in the density of the egg during development is shown in Figure 2. The density ranged from 19.0–25.1(σt), and gradually increased by stage VI (late stage), after which the change in densities varied. The estimated vertical velocities of eggs were 10.8 m/s in Funka Bay and 9.6 m/s in the Nemuro Strait, which indicates that the eggs reach the surface in approximately 7 h in Funka Bay and 21 h in the Nemuro Strait after spawning. It suggests that eggs are exposed to the surface cold water in the early developmental stage. Nakatani and Maeda (1984) suggested that eggs are able to resist cold temperatures after the morula stage. The stage of developmental upon reaching the cold water is probably one of the key factors determining the success of hatching.

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