Study on early life history characteristics of the snow crab Chionoecetes opilio under laboratory conditions

[課程博士・論文博士共通]

博士学位論文内容要旨
Abstract

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論文題目 Title	Study on early life history characteristics of the snow crab *Chionoecetes opilio* under laboratory conditions		

The snow crab, *Chionoecetes opilio*, is distributed in cold waters off Alaska, Canada, Russia, Greenland, Japan, and Korea and is an important fishery resource in these regions. In Japan, most snow crabs have been caught in the eastern part of the Sea of Japan since the late 1990s; thus, this is the most important snow crab fishery in the region. Annual stock density of snow crabs peaked in 1970 and then declined greatly during the 1970s–1980s because of overfishing. Stock densities were restored after the 1990s to approximately one-third of the male and one-half of the female peaks, but the possible causes of the stock recovery have not been discussed. In general, the pelagic larval phase plays an important role in sustaining the population by facilitating larval dispersal and recruitment. Therefore, it is important to elucidate the effects of these factors on larval survival and development to understand the stock dynamics of the species. Moreover, estimating age and growth of a commercially harvested species provides life history trait information that is important for fisheries management, e.g., lifespan, age at recruitment, age at first capture, age at maturity, and cohort identification. A captive rearing experiment is an effective way to elucidate the life history of a crustacean. However, the biology and ecology during the early snow crab lifecycle is not well documented because of low larval survival under laboratory conditions. The objective of this study was to add to the basic knowledge of snow crab early life history characteristics under laboratory conditions.

We examined the effects of temperature and salinity on larval survival and development, as these factors regulate basal metabolic rate and feeding activities. The optimum temperature ranges for larval survival were 5–16°C for hatching to second zoeae, 5–14°C for hatching to megalopae, and 5–14°C for megalopae to the crab stage. The optimum salinity ranges for larval survival were 20–38 for hatching to second zoeae, 26–38 for hatching to megalopae, and 28–36 for megalopae to the crab stage. The relationships between temperature or salinity and larval period were elucidated. Moreover, the threshold temperatures, calculated from heat summation theory equations for larval development, were estimated to be −2.24 to 0.63°C; they decreased with larval development as an adaptation to deeper vertical distribution during later larval stages.

Several studies have considered snow crab zoeae feeding ecology but not during the stages following megalopae. Therefore, the megalopae food consumption pattern was examined using *Artemia* nauplii. The megalopae food requirement was estimated to be ~190% of dry body weight of the first-instar crab. Two-segmented regressions provided good fits for the relationship between the number of days after metamorphosis and the cumulative number of *Artemia* consumed. The mean post-metamorphic breakpoint time in the rate of food consumption corresponded to intermediate of late premoult during the moulting cycle. A positive correlation was observed between crab size and the number of *Artemia* consumed during the entire megalopal period.

Body density is an important parameter when modeling larval vertical distribution in the water column. Thus, ontogenetic changes in larval body density were investigated in relation to moult stages, which were determined based on integumentary changes occurring during the snow crab larval moulting cycle. The moult-stage characteristics were based on a microscopic examination of changes in the integument, particularly the telson. The larval cuticle changed from a spongy structure to become conspicuously thicker and more solid

in appearance during stages A–C. The epidermis retracted from the cuticle during stage D, and new setae and appendages formed. Body density of larval snow crabs was lowest just after moulting, increased significantly during stage C, and then increased gradually to reach a plateau at 1.0897–1.0931 g cm^{-3} during stage D. The larvae developed a density greater than that of seawater during the entire larval period.

Snow crabs change their spatial distribution in relation to temperature and the bottom substrate after settling on the sea bottom. They also change their distribution seasonally according to reproductive and growth status. Among environmental factors, water temperature is the most important factor influencing moulting and the intermoult period, which determine growth. Therefore, captive experiments were conducted using laboratory-born juvenile crabs during the early settlement phase (instar I–VII) to elucidate the effect of temperature on moulting and growth. Growth indices (size increases at moulting in mm and in percentage of premoult carapace width) were significantly higher in crabs reared at 5°C than in those reared at other temperatures. The relationship between mean temperature and the intermoult period of each instar was described by a heat summation theory equation. The thermal constant tended to increase and the threshold temperature tended to decrease with the increase in mean premoult carapace width of each instar. Size- and temperature-dependent growth models were developed for juvenile snow crabs from these variables.

Wild-born immature crabs (carapace width, 16.2–42.9 mm) caught from the Sea of Japan were cultured at the natural habitat temperature (approximately 1°C). The growth indices and intermoult period were significantly affected by premoult carapace width, but sex did not affect these variables. Furthermore, premoult carapace width and days after moulting significantly affected the probability of moulting, and we developed a moulting probability model based on these variables. The model revealed that the number of days during the intermoult period when moulting occurred in 50% of instars VI, VII, and VIII was estimated to be 234, 284, and 346 days, respectively.

Finally, snow crab life history was estimated by referring to ecological and environmental information on their natural habitat. As a result, the durations from hatch to terminal moult instars were estimated to be 4–9 years in male crabs and 5–7 years in female crabs.