主論文の要約

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学位論文題目

LABORATORY STUDIES ON THE EFFECTS OF TEMPERATURE ON THE EARLY LIFE STAGES OF JAPANESE FLYING SQUID AND WALLEYE POLLOCK

（スルメイカおよびスケトウダラの初期生活期に対する水温の影響に関する飼育実験研究）

In this study, laboratory studies on the early life history of an invertebrate species (Japanese flying squid, *Todarodes pacificus*) and a vertebrate species (walleye pollock, *Gadus chalcogramma*) were conducted to study their properties, behavior and response to particular sea surface environments, because both species spend on sea surface layer through their early life stages (*T. pacificus*: paralarval stage, *G. chalcogramma*: egg and larval stages). This study focused on the temperature effects of early life stage of *T. pacificus* and *G. chalcogramma* which is expected temperature due to global warming and climate changes.

The summaries of this study are as follows;

1. I developed new tank systems, which can independently change the upper and lower layers of the water column to produce thermal stratification.
   Temperatures in the water column were smooth change and stability at target temperatures. And thermocline in the water column formed at 30-40 cm depth (in *T. pacificus*), and 35-40 cm depth (in *G. chalcogramma*) (chapter 2).

2. For *T. pacificus* this study focused on the paralarval response to the surface warm water mass ranged from 20.5-30.0^{o}C. Mortality and behavioral responses at each temperature were examined for the free-swimming *T. pacificus* paralarvae (chapter 3).

   The number of days to 50% mortality (D_{50}) was longest (5.7 days) at 20.9^{o}C and decreased with increasing temperature to 5.06 days at 22.5^{o}, 5.13 days at 24.2^{o}, 4.0 days at 26.3^{o}, 3.4 days at 27.9^{o}C, and 1.2 days at 30.4^{o}C.

   Paralarvae responded differently to different surface water temperatures. When the mean temperatures in the upper half of the tank was 24.4-26.0^{o}C, paralarvae were significantly abundant

in the surface layer indicating that the paralarvae swam through the thermocline and reached the surface layer. Meanwhile, when the mean temperatures in the upper half of the tank were 29.7-29.8^{o}C, paralarvae also ascended from the bottom, but most paralarvae remained in the thermocline.

3. For *G. chalcogramma* this study focused on the larval response to the surface cold water mass from the Coastal Oyashio (<1.5^{o}C). Egg and larval specific density, mortality and behavioral response of temperature on the *G. chalcogramma* were examined through ontogenetic development (chapter 4).

   The mean specific density (σ_t) of eggs at the same development stage (< 1 day after fertilization) ranged between 22.55 and 23.06 and was significantly different across batches. On further development, the specific density slightly increased (mean σ_t 23.32-24.13) through *ca.* day 7, then decreased (mean σ_t 20.72-21.68) *ca.* day 10. Thus specific density of all eggs through the development before hatching were smaller than the density of the Coastal Oyashio water mass (σ_t 26.37, 2^{o}C and Salinity 33). Specific densities of larvae after hatching through starvation were σ_t 22.35-24.80 and smaller than that of Coastal Oyashio water mass.

   The days to 50% mortality (D_{50}) was longest (20.3 days) at 3.1^{o}C and D_{50} s at 0.3^{o} (17.7 days) and 1.6^{o}C (18.3 days) were intermediated between that of 3.1^{o} (20.3 days) and 4.9^{o}C (16.7 days). Thus D_{50} did not increase as the temperature was decreased.

   Larval responses to low temperatures varied depending on the rearing temperatures and developmental stages. Newly hatched larvae occurred most abundantly at the surface. When the upper/lower was 1.5/5.0^{o}C, mouth opening larvae (reared at 5.0^{o}C) changed the distribution to the lower half of the water column. The distribution of the larvae that had absorbed most of yolk-sac showed similar patterns to that of the mouth opening larvae. Larvae were distributed lower half of the water column and most abundantly in the bottom layers.

4. The results of this study have implications for understanding how the early pelagic life stages of *T. pacificus* and *G. chalcogramma* will respond to variable temperatures and extreme events associated with climate change. The thermal manipulations by experimental tank developed in the study may be particularly useful for simulating the effects of future temperature variability of extreme temperature events affecting sea-surface communities. In summary, numerous factors need to be considered while assessing the effect of temperature of the early life histories of *T. pacificus* and *G. chalcogramma*, including consistent small-scale temperature variability. The results of this study show that for these species, the variable temperature affects the early pelagic life stages. These findings can help better understand how climate change will affect the behavior and survival of the early life stages of these species in the scenario of climate change.