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Otolith-based analysis of the early growth and survival processes in Pacific bluefin tuna Thunnus orientalis(耳石分析によるクロマグロの初期成長・生残に関する研究)

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博士学位論文内容要旨
Summary

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論文題目 Title	Otolith-based analysis of the early growth and survival processes in Pacific bluefin tuna *Thunnus orientalis* （耳石分析によるクロマグロの初期成長・生残に関する研究）		

General Introduction

The spawning stock size of Pacific bluefin tuna (PBF; *Thunnus orientalis*) is now at a historically low level (about 11,000 tons) according to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean and the fraction of the PBF fisheries catch represented by immature fish has become dominant. Under such circumstances, it is crucial to obtain knowledge on the early life processes that shape recruitment into the adult population in order to carry out successful fisheries resource management. In this study I used otolith analysis-based body size back-calculation to examine various processes associated with the early growth and survival processes in PBF from two spawning grounds, namely the Nansei Islands area and the Sea of Japan. My thesis is divided in three chapters as follows.

Chapter 1. Evaluation of growth-dependent survival during early stages

＜Objectives and methods＞In the first chapter, I conducted a study to: (1) evaluate the hypothesis of growth-dependent survival in young PBF from the north-western Pacific Ocean; (2) identify critical developmental stages for survival; and (3) compare interannual differences in early growth. To this end, I compared the daily growth trajectories of a large number of larvae (standard length (SL) <15 mm), juveniles (15 ≤ SL ≤ 150 mm), and young-of-year (YOY; SL >150 mm) collected between 2011 and 2015. ＜Results and Discussion＞Otolith radius (OR) and SL were highly correlated and yielded a single relationship applicable for the five year-classes. Body size back-calculation showed that only larvae with fast, steady growth successfully transitioned to the juvenile stage whereas an ontogenetic analysis of daily growth rates revealed interannual differences only in larvae, and not in the larval stage of juveniles and YOY. Neither sudden decreases nor increases in growth rates were observed during the larval stage of any of the stages, suggesting that the observed variability in larval body size may be the result of individual differences in growth rates rather than of drastic, one-time events. Overall, the results of the present study

indicated that growth-dependent survival of larvae may be the most critical for PBF recruitment.

Chapter 2. Otolith-based analysis of the early growth history on different spawning grounds and nursery areas

＜Objectives and methods＞In the second chapter, I compared the growth history of YOY PBF from five year-classes (2011-2015) that were assigned to three cohorts based on estimated hatching date and capture site of each individual, namely those born in the Nansei Islands area and grown up in the Pacific coast of Japan, born in the Nansei Islands areas and grown up in the Sea of Japan, and born and grown up in the Sea of Japan. The results were discussed in relation to the available information on water temperature profiles during the spawning season and productivity in the two areas.

＜Results and Discussion＞Larval growth rates of PBF in the Sea of Japan were highly variable compared to those in the Nansei Islands areas and were not necessarily higher as expected from the inherent higher primary and secondary productivity of the Sea of Japan. The mean SL was higher in the Sea of Japan cohort than in the two Pacific cohorts in 2012 whereas the opposite pattern was found for 2014 and 2015. The apparent uncoupling of growth rates on food abundance in larvae in the Sea of Japan may be related to the inherent thermal instability and the proximity of winter in relation to the spawning season in this area, causing larvae to experience suboptimal temperatures for growth with increasing frequency. In contrast to larvae, local-born juveniles and Nansei Islands-born YOY living in the Sea of Japan had high growth rates compared to those in the Pacific in a manner that is consistent with the higher productivity in this area. These results also suggest that the growth rates of juveniles and YOY PBF may be less sensitive to decreasing temperatures or that older fish may have lower thermal optima for growth than larvae.

Chapter 3. Effects of birth date and water temperature on larval growth rates

＜Objectives and methods＞The third chapter was designed to compare the growth rates of larvae born successively later during the spawning season and to analyze the correlation of larval growth rates with water temperature. Using the same specimens and methods described in the second chapter, I assigned the early- and late-born specimens identified within each year as individuals born in the Nansei Islands area and the Sea of Japan, respectively. Next, the back-calculated body size for each day of life was used to estimate the mean instantaneous growth rates of individual larvae hatched in successive two-week periods during the spawning season in the two areas.

＜Results and Discussion＞This study revealed different growth trends between Nansei area and Sea of Japan larvae from hatching to about 20 days after hatching. Thus, while Nansei Islands-born larvae showed no clear hatch date-dependent differences in growth rates throughout the spawning season, those born in the Sea of Japan showed first an increase and then a decrease in growth rates towards the end of the spawning season. Moreover, there was a close association between the larval growth trend and the water temperature profile in the Sea of Japan but not in the Nansei area. Since the Nansei Islands area is characterized by lower primary and secondary productivity as well as more massive PBF egg/larval production than in the Sea of Japan, it is suggested the possibility that the observed hatch date and temperature effects may be food-dependent.

General Discussion

Overall, this study demonstrated the occurrence of growth-dependent survival during the larval stage in Nansei Islands-born PBF. In the analysis, conducted with larvae, juveniles, and YOY, it was also possible to demonstrate significant interannual differences in growth rates of larvae but not in juveniles and young-of-the-year. These evidences support the notion that the larval stage is the most critical for PBF survival. In an analysis conducted with YOY born/grown up in the Sea of Japan and in the Western Pacific, it was possible to demonstrate marked interannual variation in larval growth rates in fish born in the former but not in the latter area. This study provided evidence of a positive, likely food abundance-dependent correlation between temperature during the early larval period and larval growth rates. Finally, this study showed that the Sea of Japan supports better juvenile and YOY growth than the Pacific coast of Japan.