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Otolith sampling of adult North Pacific albacore tuna *Thunnus alalunga* for precise age and growth estimation

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Abstract
National Research Institute of Far Seas Fisheries, Japan (NRIFSF) has been collecting data and biological samples of adult albacore *Thunnus alalunga* for more precise age and growth estimation, especially to reveal the effect of sexually dimorphic growth of this species. With brief introduction of collected data, this document reports the otolith sample collections in recent years and preliminary analysis for age determination of adult albacore.

Introduction
Age and growth estimation of albacore (*Thunnus alalunga*) has been conducted for various age-recording traits with various methods as the age and growth are the key variables for precise estimation of stock status of this species. Bony parts are prime target for the purpose, such as spines and vertebrae. Recent age determination manuals (e.g., Chen and Holmes, 2015; Chen et al., 2012) recommend scientists to use otolith for age estimation, which become the major methods for precise age estimation used worldwide.
Since the sex-dimorphic growth of albacore tuna has been discussed in recent stock assessments, National Research Institute of Far Seas Fisheries of Japan (NRIFSF) started collecting otolith samples of adult albacore with sex information attached. Though the age determination project is still ongoing, the preliminary results and sample collections are presented in this document.

Materials and Methods
264 otolith/otolith pairs (141 males and 123 females) of albacore in the fishery-targeted size range were sampled and stored for age estimation since 2016 to the present (Nov. 2019). All the samples were obtained from catch of commercial fishing vessels.
Among the samples, 10 (5 males and 5 females) of large individuals (89.2-114.0 cm in fork length; FL) were selected for preliminary analysis of age estimation. Thin-sectioned samples were prepared according to the age estimation manual and other publications (Chen et al., 2012 and Chen and Holmes, 2015), and micro-increments and annual rings were counted. Otolith samples were sectioned along with vertical axis through the core, and micro-increments and annual rings were counted separately in an outside lab and our research lab, respectively. Reading was conducted by one reader for once in both micro and annual increments.

Results and Discussions
Otolith samples mainly 70-85 cm FL were collected (Figure. 1) from commercial fishing vessels operated in the western north Pacific Ocean (Figure. 2). The maximum size of male was 114.0 cm while it was 104.0 cm in female. The

phenomenon of male's dominancy around the maximum size of caught albacore has been discussed among scientists, and the sexually dimorphic growth was indicated to be one of the explanations for it.

Otolith samples with sex information has been collected to investigate the sexual differences in growth and age, and as a starter, 5 males and 5 females of around the maximum length in our samples were analyzed in 2018 with thin-sectioning methods which is shown in Figure. 3. It indicates that readable micro-increments were significantly less than daily increments that should be deposited, which was consistent with previous study reported by Williams et al. (2013). In addition, the daily increment formation was confirmed by surface reading (Laurs and Nishimoto, 1985), while annual ring formation was confirmed by thin-sliced otolith (Farley et al., 2013). As assuming the micro-increments read in the thin-sectioned samples does not represent daily age of fish, the annual rings that observed in thin-sectioned methods by other publications (Chen et al., 2012 and Chen and Holmes, 2015) are to be introduced in this document.

The relationships between micro-increments, annual rings, fork length and sex were shown in Figure 4. The largest individuals of both sexes were analyzed, and number of micro-increments did not indicate particular differences between male and female. However, none of estimated ages in female did not exceed 6 years old while the oldest male was estimated to be 10 years old. Chen et al. (2012) resulted that the oldest female sample in their analysis was 10 in over 90 cm FL, thus further analysis with more samples is required to properly interpret the results as only 10 (5 males and 5 females) individuals were analyzed caught in limited area in the analysis.

To advance the studies of sex-dimorphic growth of albacore as shown in Chen et al. (2012) and Xu et al. (2014) and understand the role of sex in albacore growth, it is required to analyze spatial differences in age for both males and females and age proportion after adults joined reproductive activities for further investigation of sex roles in albacore biology.

Reference

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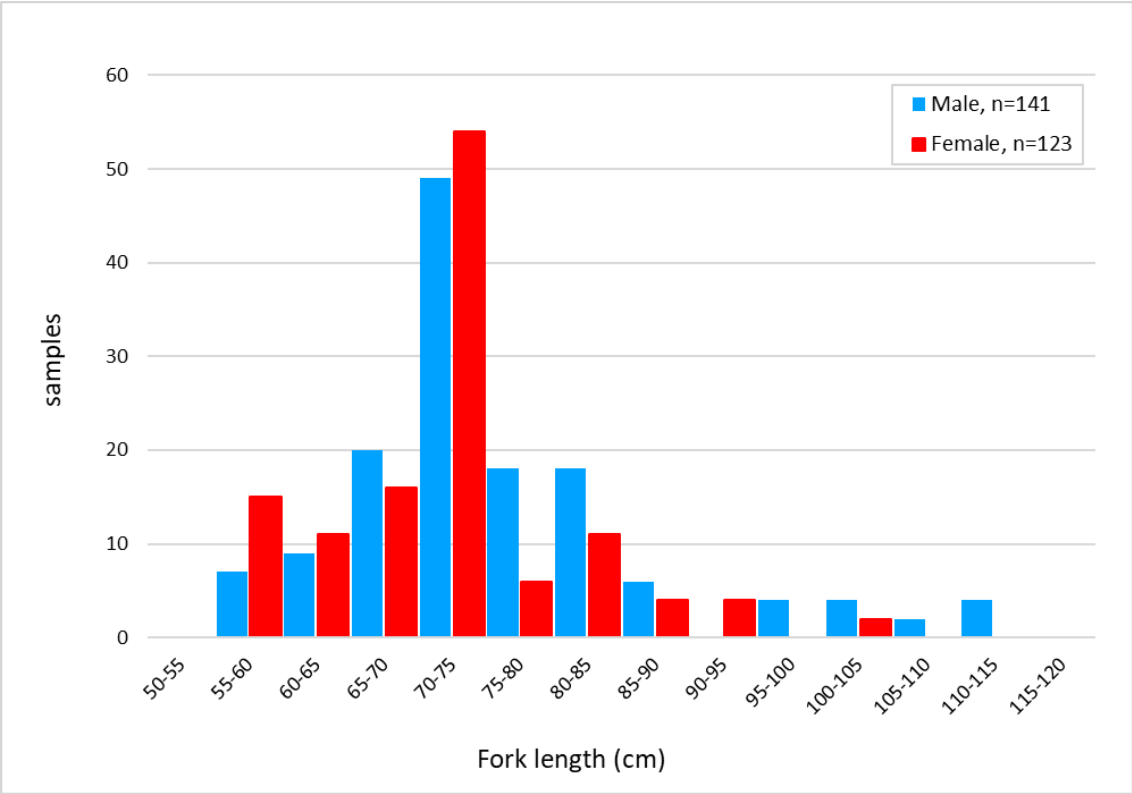

Figure 1. Fork length distribution of adult albacore otolith samples collected in the period of 2016-2019.

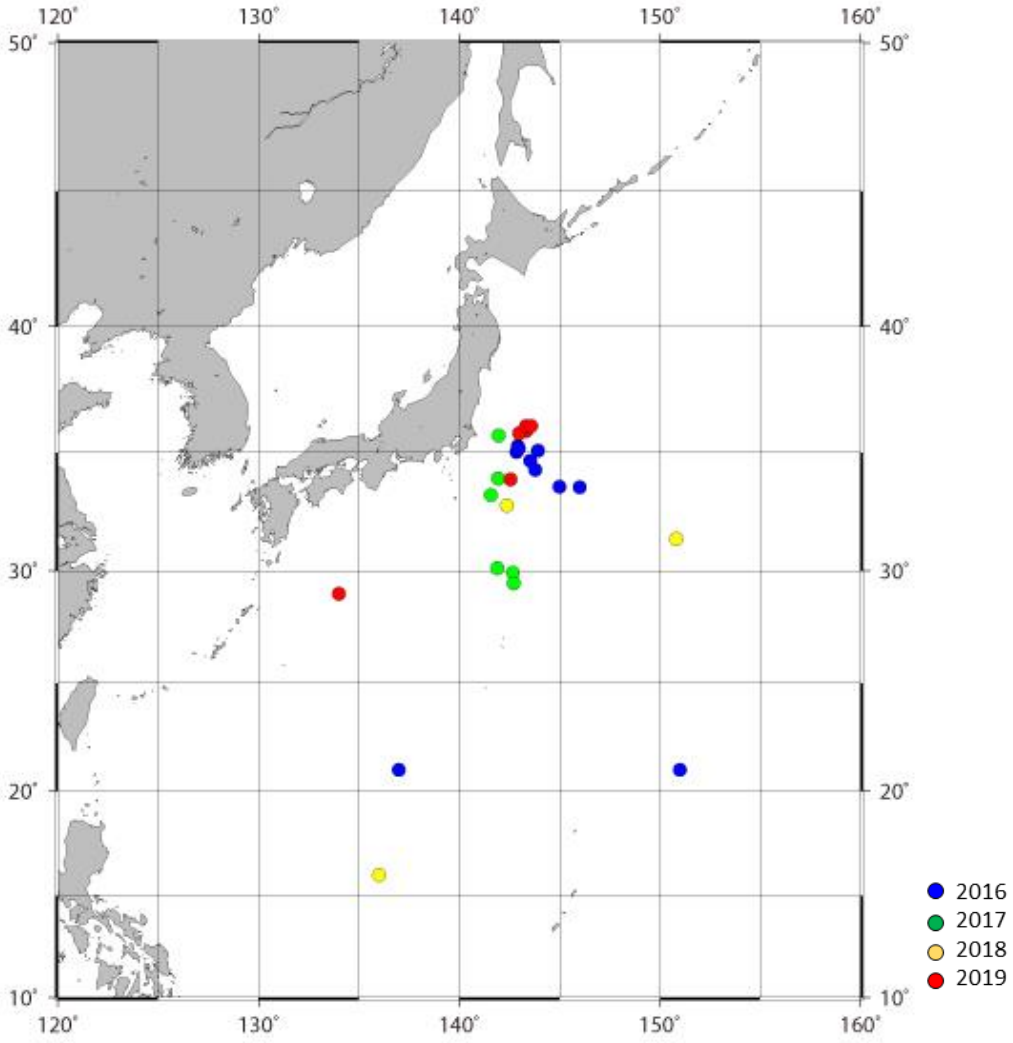

Figure 2. Sample locations of albacore otolith collected from 2016 to 2019 . Color of the dots represent sampling year.

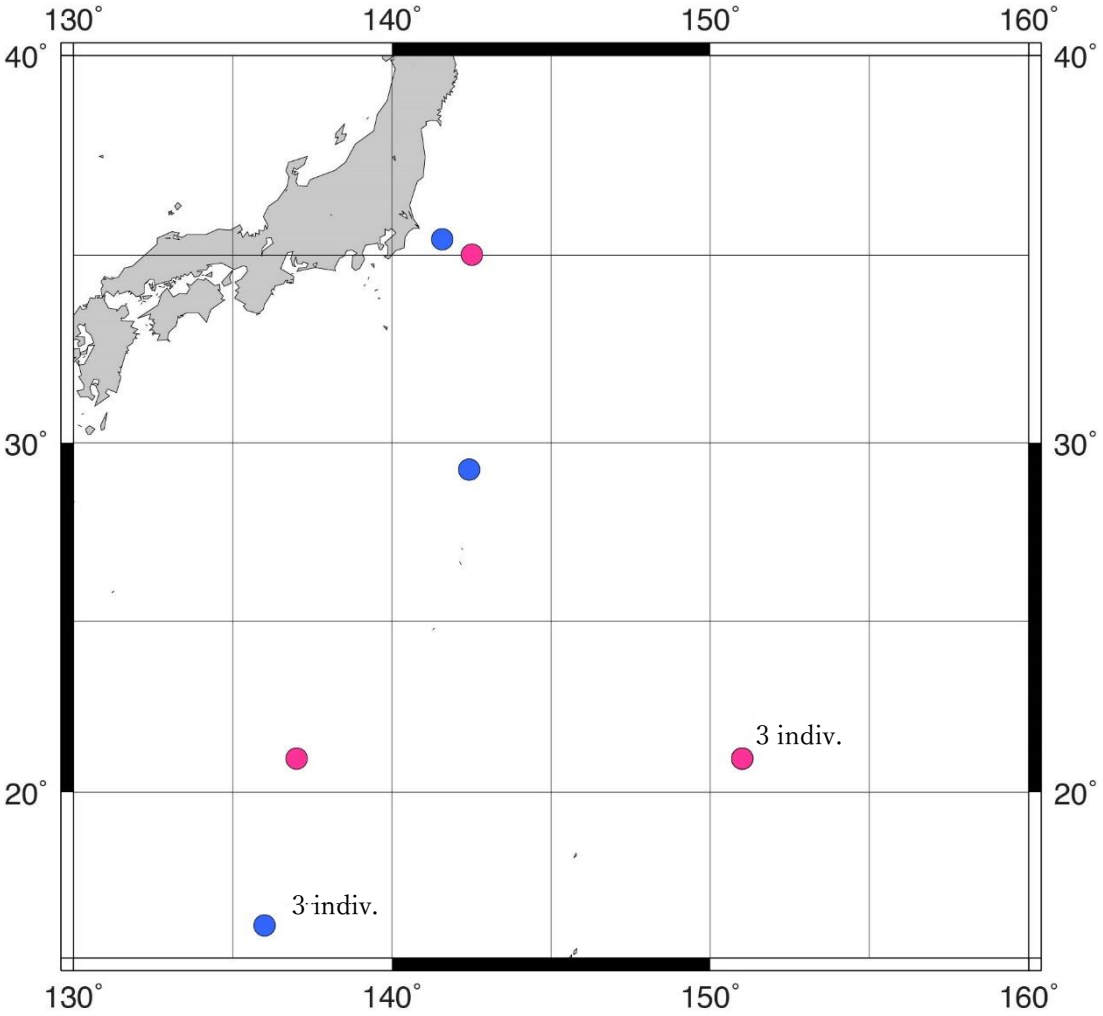

Figure 3. Sample locations of albacore otolith used for age analysis. Blue dots are of male samples, and pink dots are of female samples.

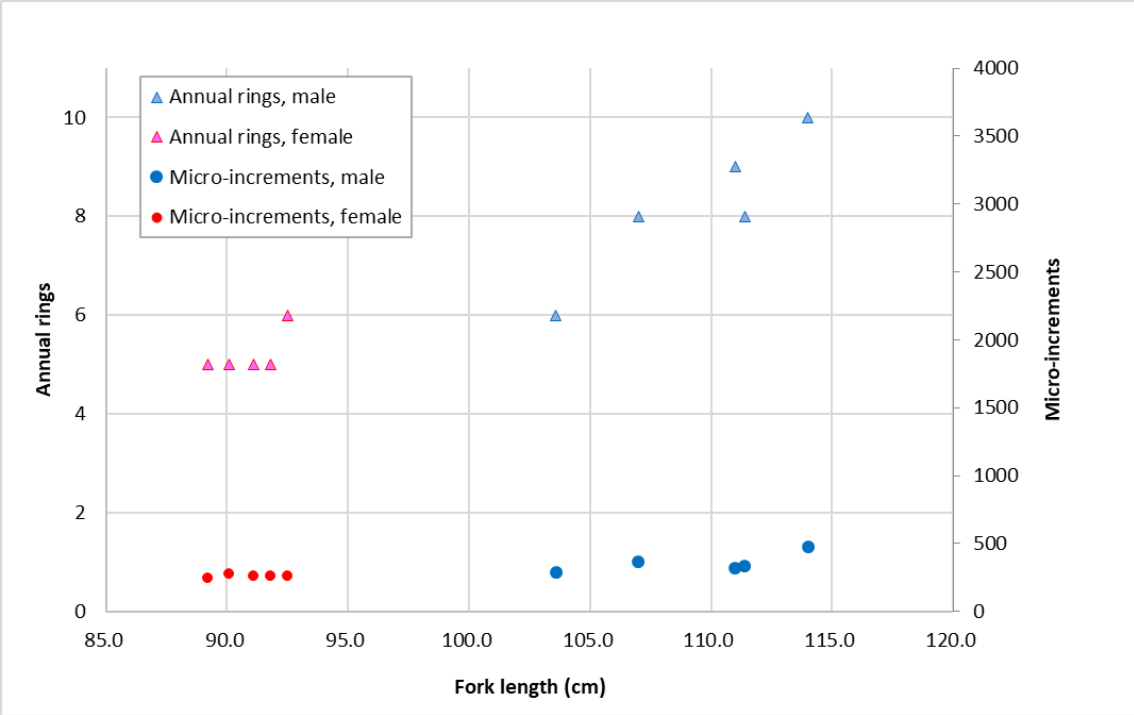

Figure 4. Comparison of the numbers of micro-increments and annual rings between males and females.

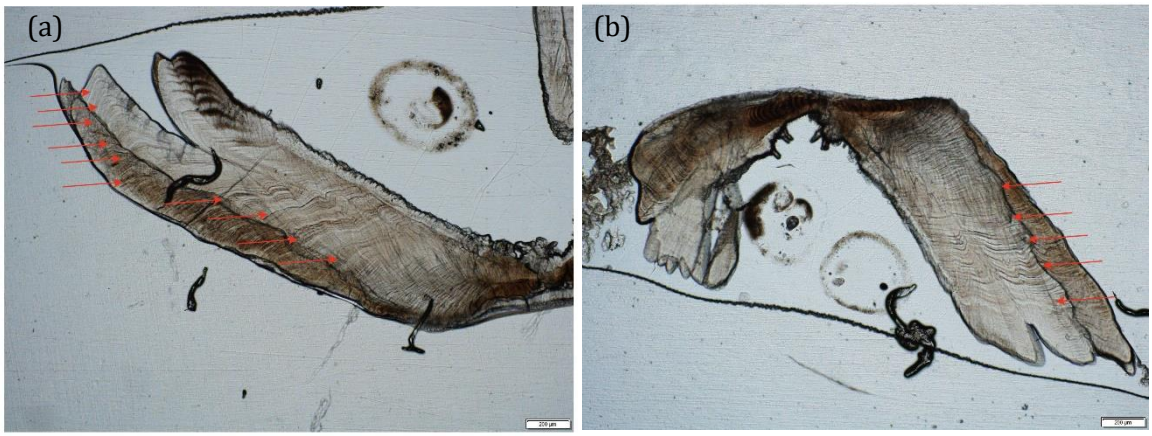

Figure 5. Examples of thin-sectioned otolith samples with potential annual rings indicated by red arrows. (a) Male, 114 cm FL, (b) Female, 89.2 cm FL.