Fundamental study about maturity of longtail tuna off Futaoi Island in western Sea of Japan from tissue section observations from 2016 to 2019

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Abstract

In the Sea of Japan, there is not a study about maturity states of longtail tuna individuals. So, fundamental study about maturity of longtail tuna caught by a set net fishery off Futaoi Island in (western Sea of Japan) is obtained from gonad tissue sections. From gonad tissue sections, the most advanced group of oocyte (MAGO) is at the hydrated stage in July and the degenerated stage in September. And female longtail tuna caught for this study have many prenucleolus stage oocytes with MAGO. On the other hand, testis of male longtail tuna are in the jugged defecation stage in July and the absorption stage in September. Gonad tissue sections method using in this study will be useful for grasp of longtail tuna maturity.

1 Introduction

In general, tuna species in the Sea of Japan are caught using set net [1], purse seine [2], or line fishing [3] methods. Tuna species in the area are mostly bluefin tuna (*Thunnus orientalis*) and longtail tuna (*T. tonggol*). According to fishery statistics for the latest year (2017) [4], about 220 tons per year of tuna species have been harvested throughout the area. Kobayashi and Watanabe [5] report that longtail tuna species are among of the main fishing targets in the same area.

There is little or no information on longtail tuna compared to other main tuna species: Pacific bluefin tuna, Atlantic bluefin tuna *(T. thynnus)*, Southern bluefin tuna *(T. maccoyii)*, Albacore *(T. alalunga)*, Bigeye tuna *(T. obesus)*, and Yellowfin tuna *(T. albacares)*.

Because of insufficient information on longtail tuna, misleading judgments are frequently made on juvenile bluefin tuna and longtail tuna caught around the coast of Yamaguchi Prefecture in the western Sea of Japan. On the other hand, most of the tuna species caught in the eastern Sea of Japan are bluefin tuna.

Some studies on longtail tuna are as follows. Nakamura [6] reported that many longtail tuna were caught with set nets in Wakasa Bay (northwestern part of Fukui Prefecture) in September. Mohri et al. [7] identified the period June-October as the fishing season for longtail tuna off Futaoi Island, Shimonoseki City, Yamaguchi Prefecture.

Itoh et al. [8] identified the catch points of adult and juvenile longtail tuna in the Sea of Japan. And, Itoh et al. [9] considered 24-26°C to be the optimum water temperatures for longtail tuna. Mohri et al. [7] found the optimum water temperature for juvenile longtail tuna to be around 24°C off the eastern Sea of Japan off Yamaguchi Prefecture.

Two other studies except the above on the relationship between water temperature and catches of longtail tuna had the following results. 1) The water temperature was at the minimum value and it rose to the maximum value before Longtail tuna were caught in large numbers with a set net [10]. 2) The optimum average water temperature for catching longtail tuna was 25.56°C [11].

Dr. Chiang [12] reported on the maturity of longtail tuna individuals in coastal waters off Taiwan. But, there has not shown a significant result on the spawning season of longtail tuna in those areas. So, fundamental study about maturity of longtail tuna caught by a set-net fishery off Futaoi Island in western Sea of Japan is obtained from gonad tissue sections. In this study, we examine the maturity stage of longtail tuna using catch data from 2016 to 2019.

2 Material and Methods

The authors obtained longtail tuna individuals from a set net at Futaoi Island off Yamaguchi Prefecture in the western Sea of Japan. Fig. 1 shows the location of Futaoi Island and the position of the set nets. Futaoi Island is located at 34°06'N 130°47'E and the set net was placed in an area northern northeast of the island.

Firstly, the authors examined fork length and otolith of longtail tuna individuals. Then, we calculated relation between age and fork length.

Secondly, the authors measured their fork length and weight removing gonads and examined males and females. Furthermore, we calculated the gonad index (GI) in order to grasp the maturity stage with the following equation:

$$GI=W\cdot 10^4/L^3 \qquad \textbf{(1)}$$

Where W = gonad weight (g) and L = fork length (cm).

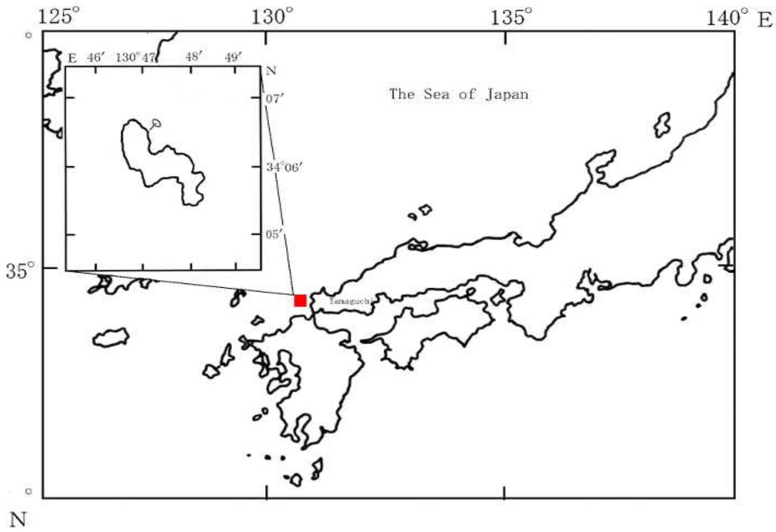

Fig.1 Location of Futaoi Island and set net.

In addition, we observed gonad tissue sections to judge maturity stages of longtail tuna. We took gonad tissue sections from 48 individuals. The details of these individuals refer to results and discussion.

We observed gonad tissue sections in the following four processes.

1. Gonads were fixed in Bouin solution with 10% formaldehyde.
2. After embedding with paraffin, slice tissue sections (6 μm) were made with microtome.
3. Double staining with hematoxylin and eosin was performed.
4. After observations with a microscope, images of tissue sections were taken.

We referred to the development stage of gonad (Table 1) and examined most advanced gonad oocyte (MAGO) from the images. In this study, maturity stages were judged from observation of these pictures and gonad index calculations for the same individuals. For the numerical value of gonad index, we set the standard about maturity stages for longtail tuna.

Table 1　Development of gonad.

Development stage of gonad	
female (oocyte)	male (testis)
Perinucleolus	Proliferation (Spermatogonia)
Yolk vesicle	Early sperm formed
Primary yolked	Advanced sperm formed
Secondary yolked	Defecation
Tertiary yolked	Absorption
Migratory nucleus	
Hydrated	
Degenerated	

3　Results and Discussion

The fork length composition of longtail is shown in Fig.2. According to the figures, the ranges of fork length were 40-65 cm with the largest individuals at 50-55cm in all cases.

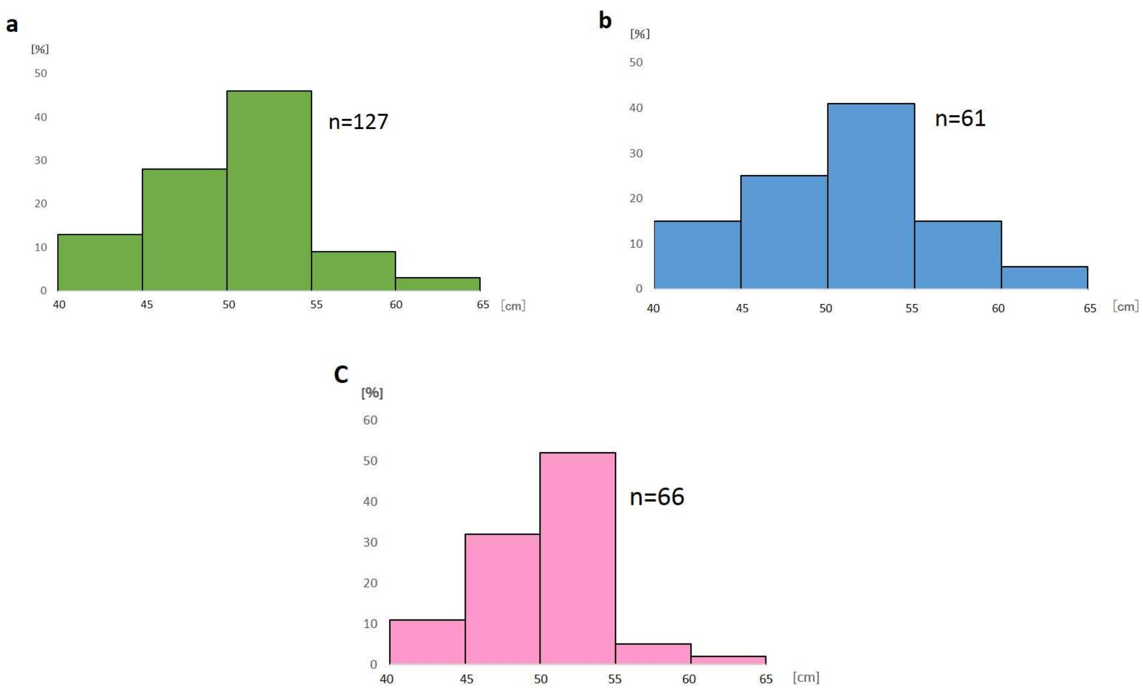

Fig.2　The fork length compositions of longtail tuna.
(a: male and female, b: male, c: female)

Fig.3 a-c presents relation between age and fork length. From these figures, the correlation coefficients squared of “male and female”, “male” and “female” were 0.4, 0.6 and 0.1, respectively.

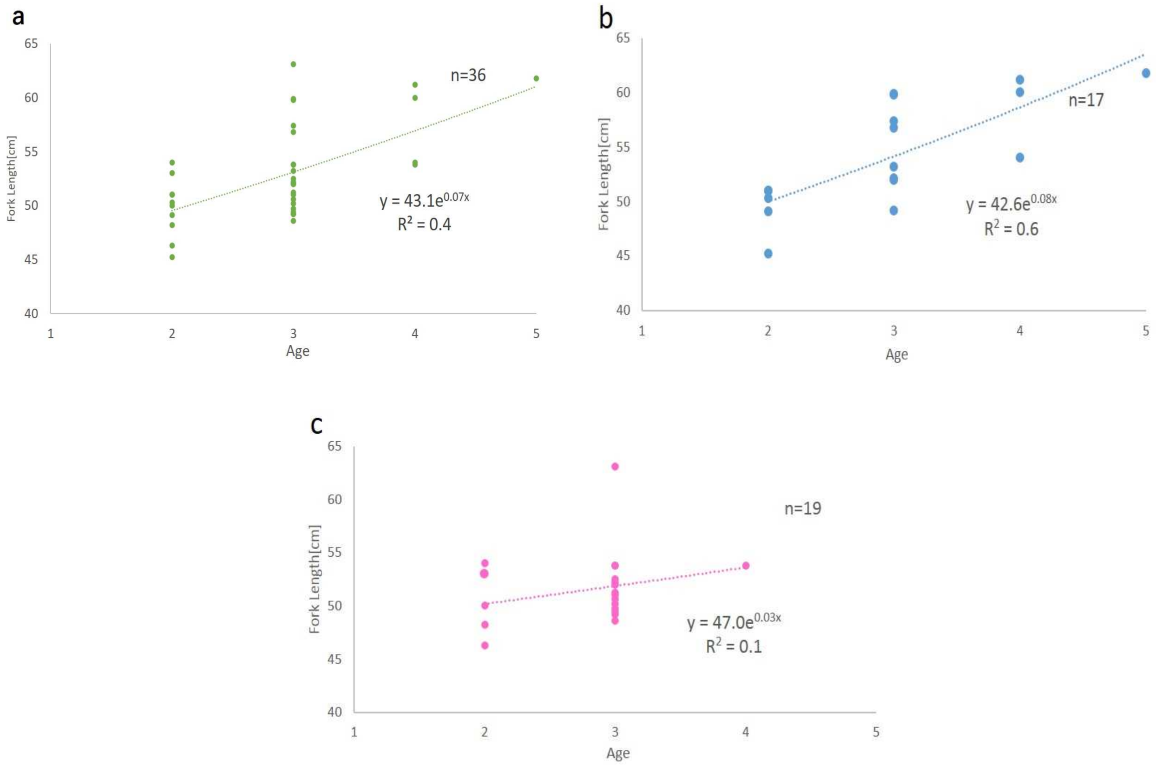

Fig.3 Relation between fork length and Age.
(a: male and female, b: male, c: female)

Judging from the figures, we considered that male longtail tuna would be 50 cm at 2 years, 54 cm at 3years, 59 cm at 4 years, and 63 cm at 5 years ($y= 42.6e^{0.08x}$, R^2=0.6).

Fig. 4 show images of gonad tissue sections of ovaries provided in 2016. From these figures, MAGO were tertiary yolked (July 8), hydrated (July 22), and degenerated (September 6). Accordingly, the authors judged longtail tuna to be mature in July and to have finished spawning in September. One longtail tuna caught on July 22 had many yolked stage oocytes with MAGO.

Fig. 5 represent images of gonad tissue sections of ovaries provided in 2019. According to the figures, development stages of gonad are primary yolked (June 13), tertiary yolked (July 25) and perinucleolus stage (August 23). Since June 13 individual had postovulatory-follicle (POF), we judged that this individual was after spawning. We consider that longtail tuna spawn multiple times same as bigeye tuna [13] in a season.

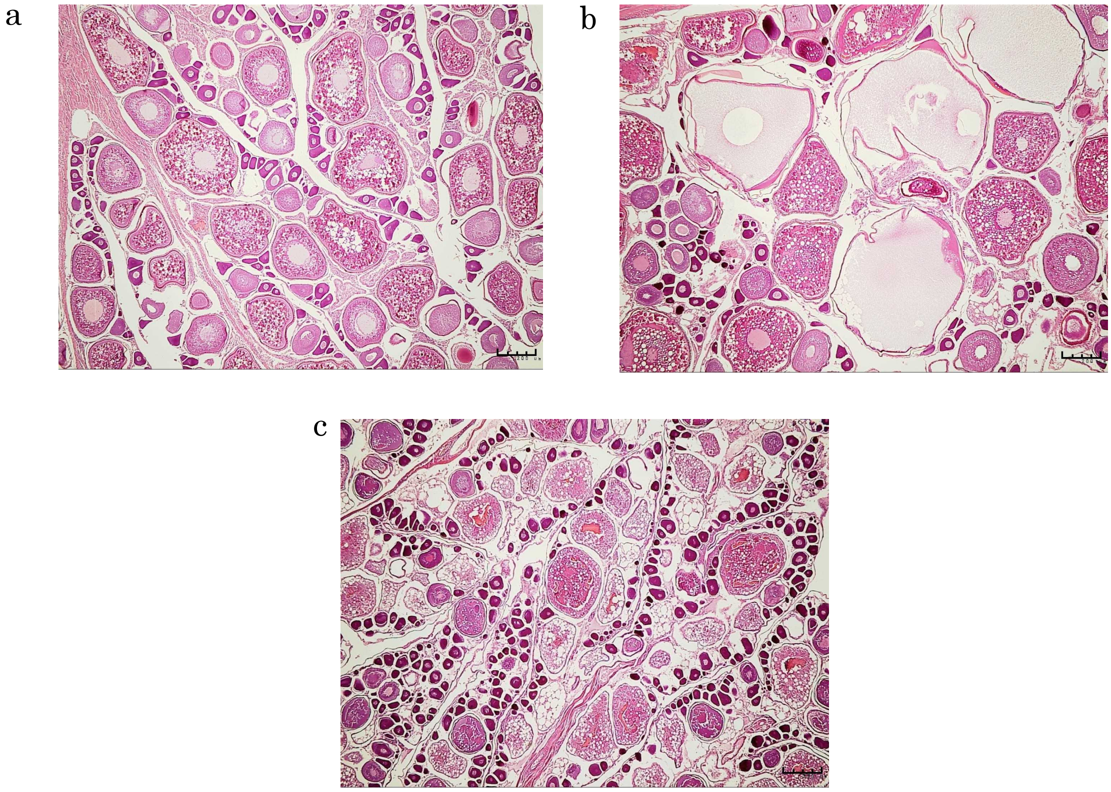

Fig.4　Images of gonad tissue sections of ovaries in 2016.(a: July 8, GI=8.7, b: July 22, GI=17.8, c: September 6, GI=2.0, one height of the scale: 200μm)

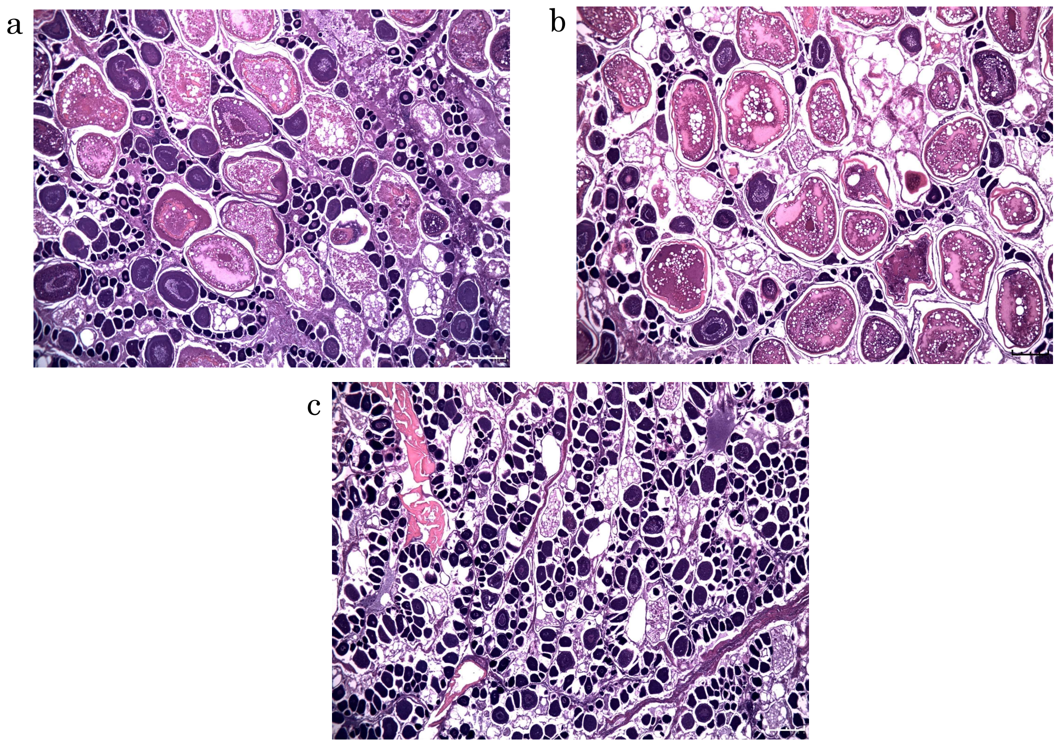

Fig.5　Images of gonad tissue sections of ovaries in 2019.(a: June 13, GI=4.7, b: July 25, GI=6.3, c: August 23, GI=2.1, one height of the scale: 200μm)

The images of tissue sections of testis provided in 2016 are described in Fig.6. From these figures, the development stages of testis of individuals were defecation stage (July 8 and 22) and absorption stage (September 6). Two of them in July had large cysts and spermiation was observed when they were dissected. Therefore, we judged that male longtail tuna perform spawning activities in July. In addition, we could not confirm cysts in the September individual.

Fig. 7 show images of tissue sections of testis caught in 2019. From the figures, the most developed stage was the defecation stage (June 28). The development stage of testis in August 2 individual had shifted from early to advanced sperm formed stage and may have sperminated multiple times.

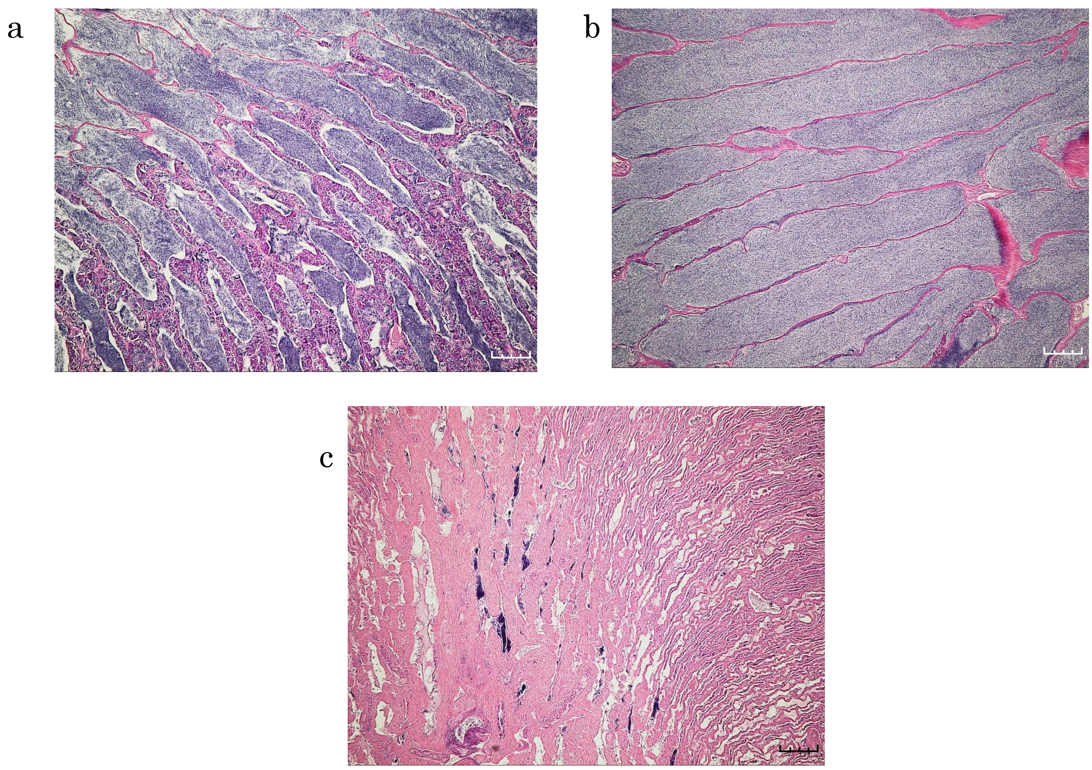

Fig.6 Images of gonad tissue sections of testis in 2016.
(a : July 8, GI=13.6, b: July 22, GI=12.4, c: September 6, GI=1.2,
one height of the scale: 200μm)

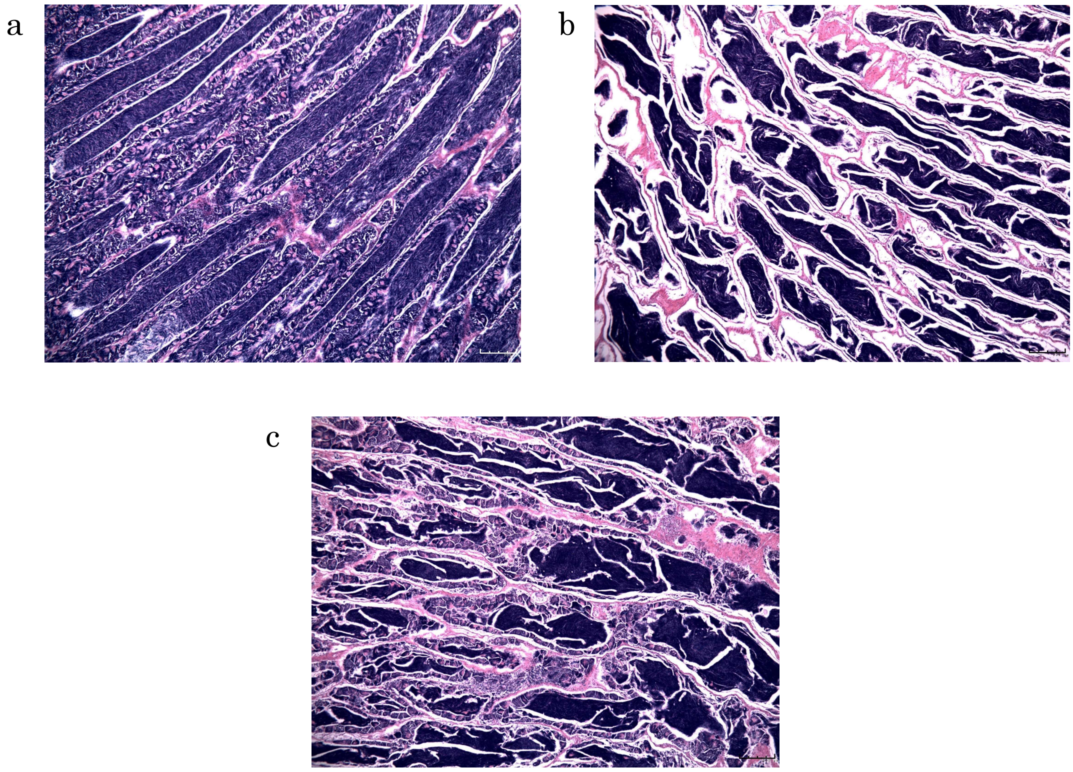

Fig.7 Images of gonad tissue sections of testis in 2019.
(a: June 28, GI=5.4, b: July 9, GI=6.7, c: August 2, GI=7.5,
one height of the scale: 200μm)

Fig. 8, 9, 10 and 11 present images of gonad tissue sections of ovary in 2017, ovary in 2018, testis in 2017 and testis in 2018. Likewise the authors observed images of gonad tissue sections of female and male individuals caught in 2017 and 2018. But we did not find more developed stages in all individuals. The earliest date caught these individuals from 2017 to 2018 was August 28. So, we considered longtail tuna finish spawning activity in late August.

From all gonad tissue sections, the most advanced stage of oocyte is at the hydrated stage in July. And female longtail tunas caught for this study have many prenucleolus stage oocytes with MAGO. On the other hand, testis of male longtail tuna confirmed in the jugged defecation stage in July.

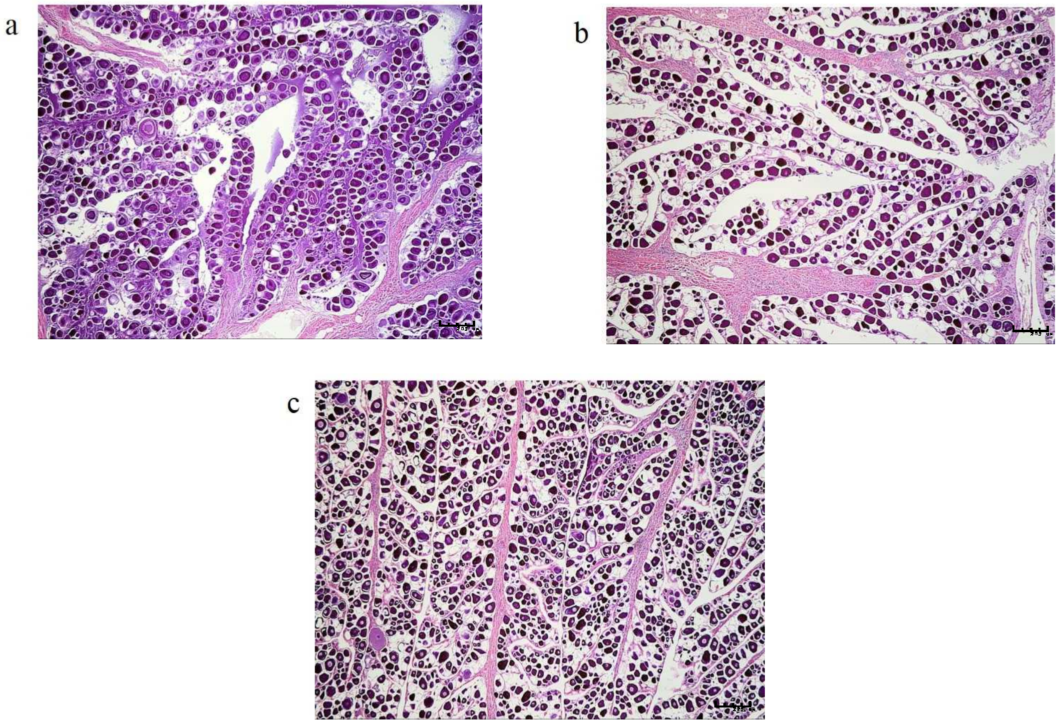

Fig.8 Images of gonad tissue sections of ovary in 2017.
(a : September 16, GI=1.6, b: October 2, GI=1.1, c: November 2, GI=0.7,
one height of the scale: 200μm)

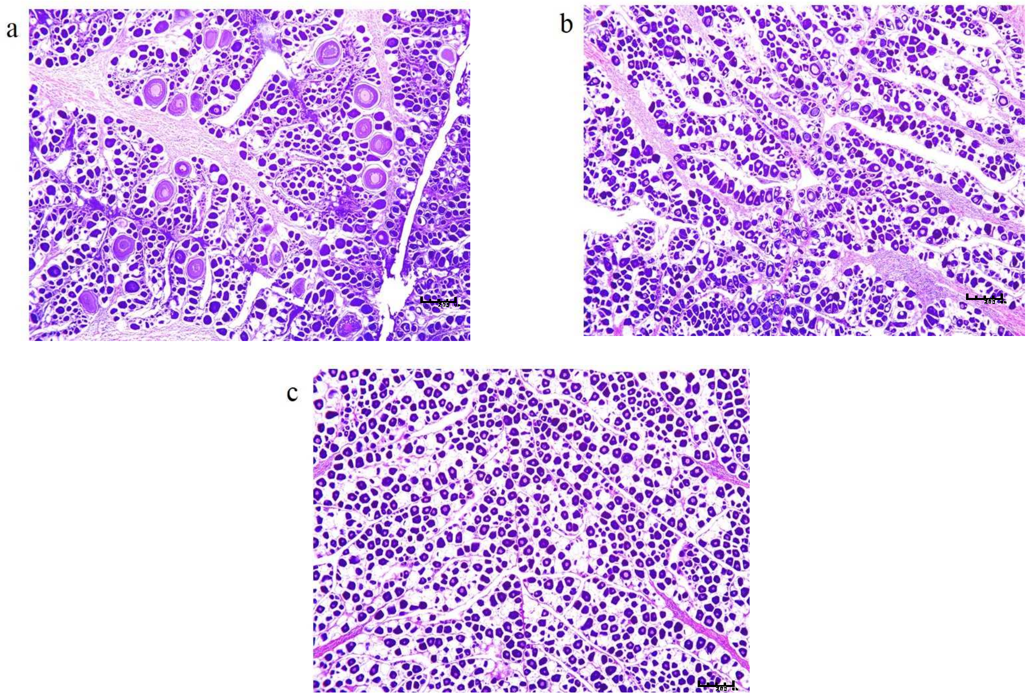

Fig.9 Images of gonad tissue sections of ovary in 2018.
(a : September 19, GI=0.4, b: October 4, GI=0.7, c: November 15, GI=0.6
one height of the scale: 200μm)

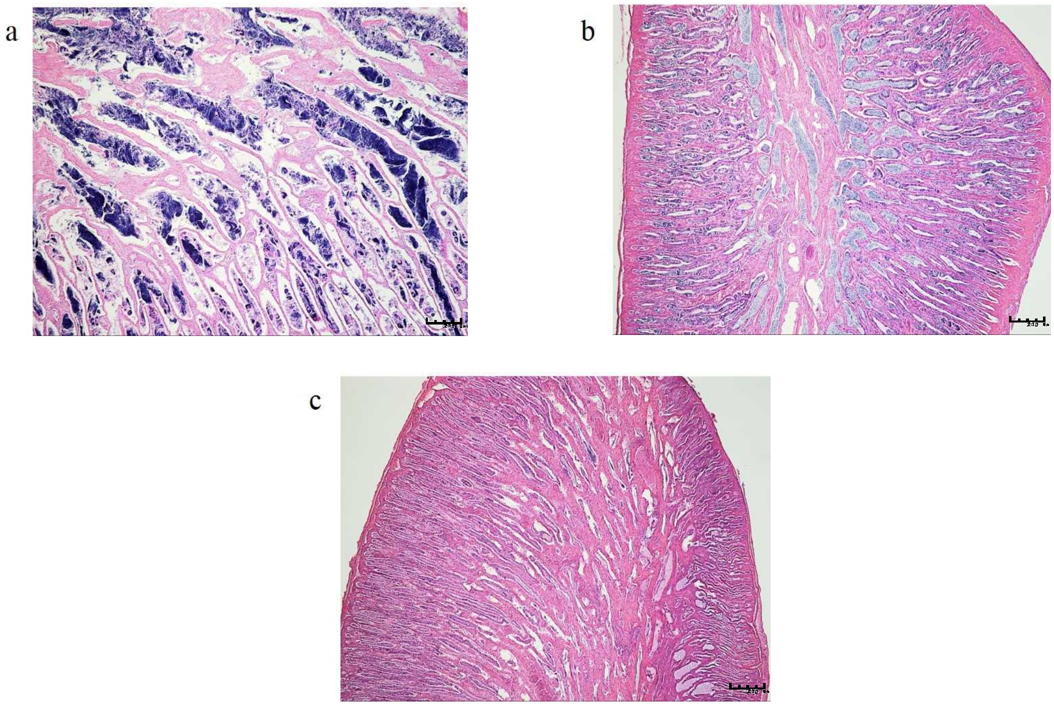

Fig.10 Images of gonad tissue sections of testis in 2017.
(a: September 16, GI=2.4, b: October 9, GI=0.6, c: November 2, GI=0.4, one height of the scale: 200μm)

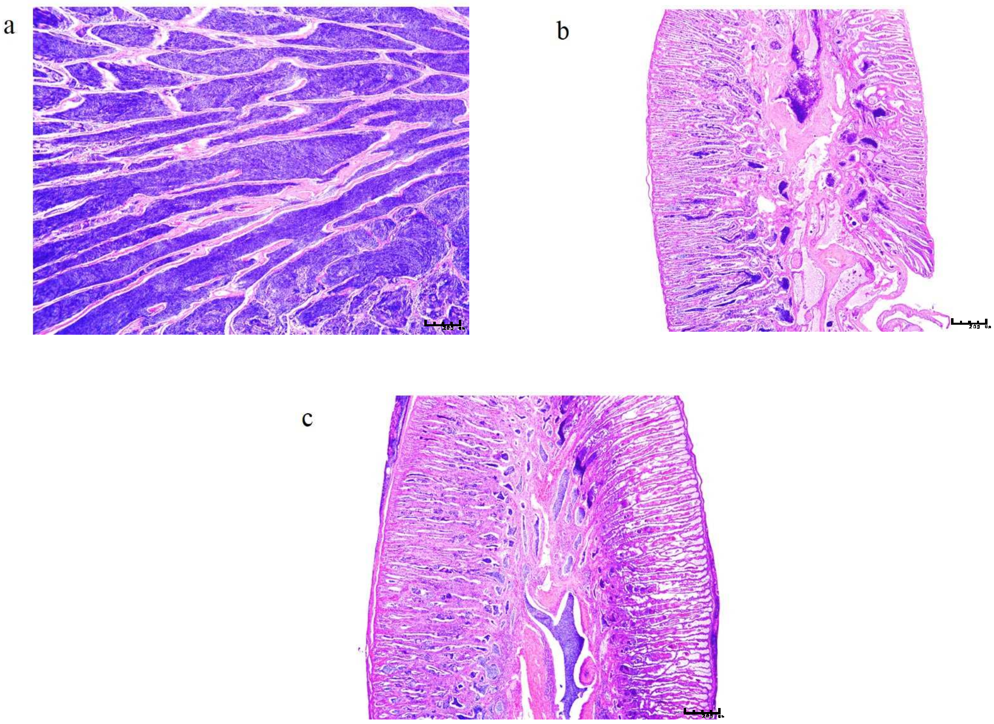

Fig.11 Images of gonad tissue sections of testis in 2018.
(a: August 28, GI=4.3, b: October 4, GI=0.2, c: November 15, GI=0.2, one height of the scale: 200μm)

4 Future Prospects in this Study

Gonad tissue sections method using in this study will be useful for grasp of longtail tuna maturity. The authors set the standard maturity for longtail tuna.

From these results, we consider that eggs, larvae and juveniles of longtail tuna appear after July around off Futaoi Island. To support their spawning activities in that area, we will collect samples using a ring net from a research vessel. Furthermore, their migration patterns after the spawning season are unknown, so we also need to install fish loggers on adults and analyze their migration routes.

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