

## Updated analysis for gonad samples of southern bluefin tuna collected by Taiwanese scientific observer program

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### ABSTRACT

This study analyzed 356 gonad samples of southern bluefin tuna collected during April to September in year of 2010-2015. The fork length of samples concentrated between 100 and 135 cm. For both sexes, GSIs increased from April to July and then revealed decreasing trends. The sexual maturity stages were determined based on developmental stages of histological sections of gonad samples. Most samples were designated as immature stage and some samples were developing stage. Very few samples designated as mature but they were reproductively inactive. More mature female samples were regressed or regenerating stages during April to June, while all of male samples were regenerating stages during June to August.

### 1. INTRODUCTION

Several studies have been conducted for the reproductive biology of southern bluefin tuna (SBT), *Thunnus maccoyii*. Thorogood (1986) investigated the development of SBT gonads collected from waters off the south eastern and southern coasts of Australia. The results provided information on age-at-first-maturity, gonad Index, ova size-frequency and fecundity of SBT. Farley and Davis (1998) investigated the spawning dynamics of SBT using ovaries obtained from fish caught on the spawning ground in the northeast Indian Ocean and the main feeding ground in the southern Ocean. Chen et al. (2013) investigated the sexual maturity of SBT based on the morphological and histological observations of the gonad samples collected by observers deployed on Taiwanese vessels in the southwestern Indian Ocean.

To collect scientific information on SBT, the scientific observers started being deployed on board and conducting the observation program of SBT in 2002. The biological samples, including otoliths, muscle tissues, stomach and gonads of SBT,

were carried out by observers on board. In this paper, we presented the updated analysis for gonad samples of SBT collected by Taiwanese scientific observer program.

## 2. MATERIALS AND METHODS

Gonad samples of SBT were collected by scientific observers deployed on Taiwanese longline vessels operated in the Indian Ocean. The measurement of fork length and body weight, sex, and sampling date and location were recorded for each specimen.

Because the measurements of body weight were not recorded by observers, a length-based gonado-somatic index (Chen et al., 2013) was adopted in this paper:

$$GSI = \frac{GW}{L^3} \times 10^4$$

where GSI is the gonado-somatic index, GW is the weight of gonad and L is the fork length.

The sexual maturity stages were examined and determined based on histological sections of gonad samples. Since the criteria of gonadal developmental stages were not available for SBT, the criteria of Farley et al. (2014), which were used for albacore in the southern Pacific Ocean, were adopted to categorize the gonadal developmental stages for SBT. Developmental stages were classified into the (1) immature stage, (2) developing stage, (3) spawning capable stage, (4) spawning stage, (5) regressing - potentially reproductive stage, (6) regressed stage, and (7) regenerating stage. Individuals were designated as mature if the most advanced oocytes were indicative of  $\geq$  stage 3. Stages 3 and 4 are reproductively active stages, and stages 1-2 and 5-7 are reproductively inactive stages (Table 1).

## 3. RESULTS AND DISCUSSION

A total of 356 effective gonad samples of SBT were collected during April to September (i.e. the first fishing season of Taiwanese SBT longline fishery) in year of 2010-2015. Female and male samples were 178 and 178 respectively.

Samples were collected in the waters of the southeast Indian Ocean (65°E-105°E, 29°S-38°S) (Fig. 1). The fork length of samples ranged from 89 to 178 cm and 60 to 182 cm for females and males respectively, with both concentrated between 100 and 135 cm (Fig. 2).

The gonad weights obviously increased with the growth of body lengths for both sexes (Fig. 3). Generally, the relationship between GSI and body length revealed similar

trend for both females and males, which the GSI obviously increased with body length. However, the increasing patterns in the relationship between GSI and body length were somehow unapparent for some samples (Fig. 4).

Fig. 5 shows the monthly trends of GSI for females and males. For both sexes, GSIs increased from April to July and then revealed decreasing trends. Since the samples were collected only from April to September, monthly trend of GSI cannot be explored for entire year.

Histological sections of 292 female gonad samples collected from 2010 to 2014 were examined, and the sexual maturity stages were determined based on developmental stages. Preparations of histological sections were failed for some samples due to frozen preservation process. About 70% of gonad samples (205 of 292 samples) can be used to examine their gonadal developmental stages.

Based on the observations, the gonadal developmental stages of most samples were designated as immature stage and some samples were developing stage. Very few samples designated as mature but their gonadal developmental stages were regressed or regenerating stages (i.e. reproductively inactive stages) (Figs. 6 and 7). In this study, we also examined the gonadal developmental stages for some male samples. Most males were immature and only few samples were designated as mature but spent stage (Fig. 8).

For females, there was no mature fish observed for fishes with fork lengths less than 115cm. The smallest mature sample was the fish with fork length of 118cm, and its gonad weight was 22.8g and GSI was 0.12 (Figs. 9-11). For males, no fish with fork lengths less than 145cm was mature (Fig. 9), and gonad weight and GSI for the smallest mature sample were 130.6g and was 0.32 respectively.

Based on monthly proportion of gonadal developmental stages, more mature female samples were regressed or regenerating stages during April to August, while all of mature male samples were regenerating stages during June to August (Fig. 12). The analyses of this study implies that mature fishes might migrate to the fishing ground of Taiwanese SBT fishery after reproductive activity.

## REFERENCE

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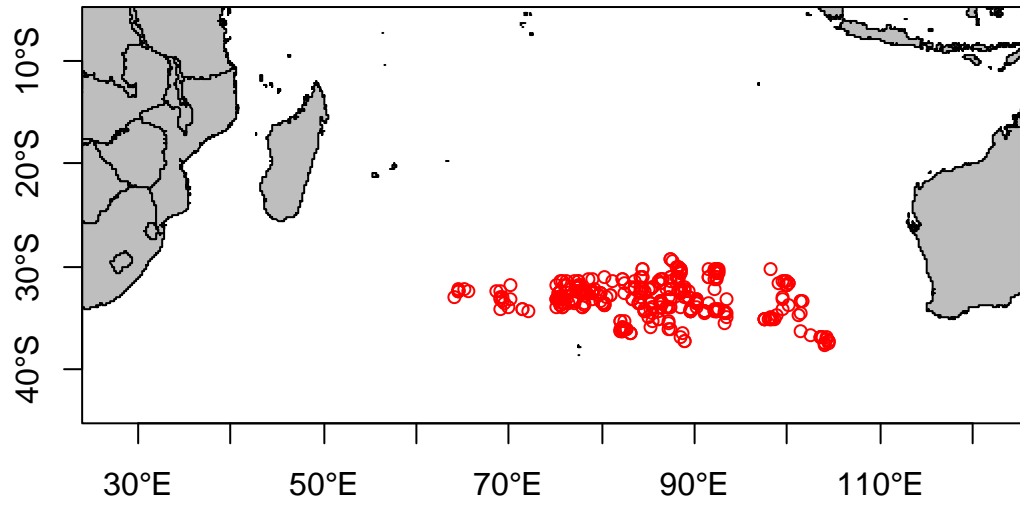


Fig. 1. Locations for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2015.

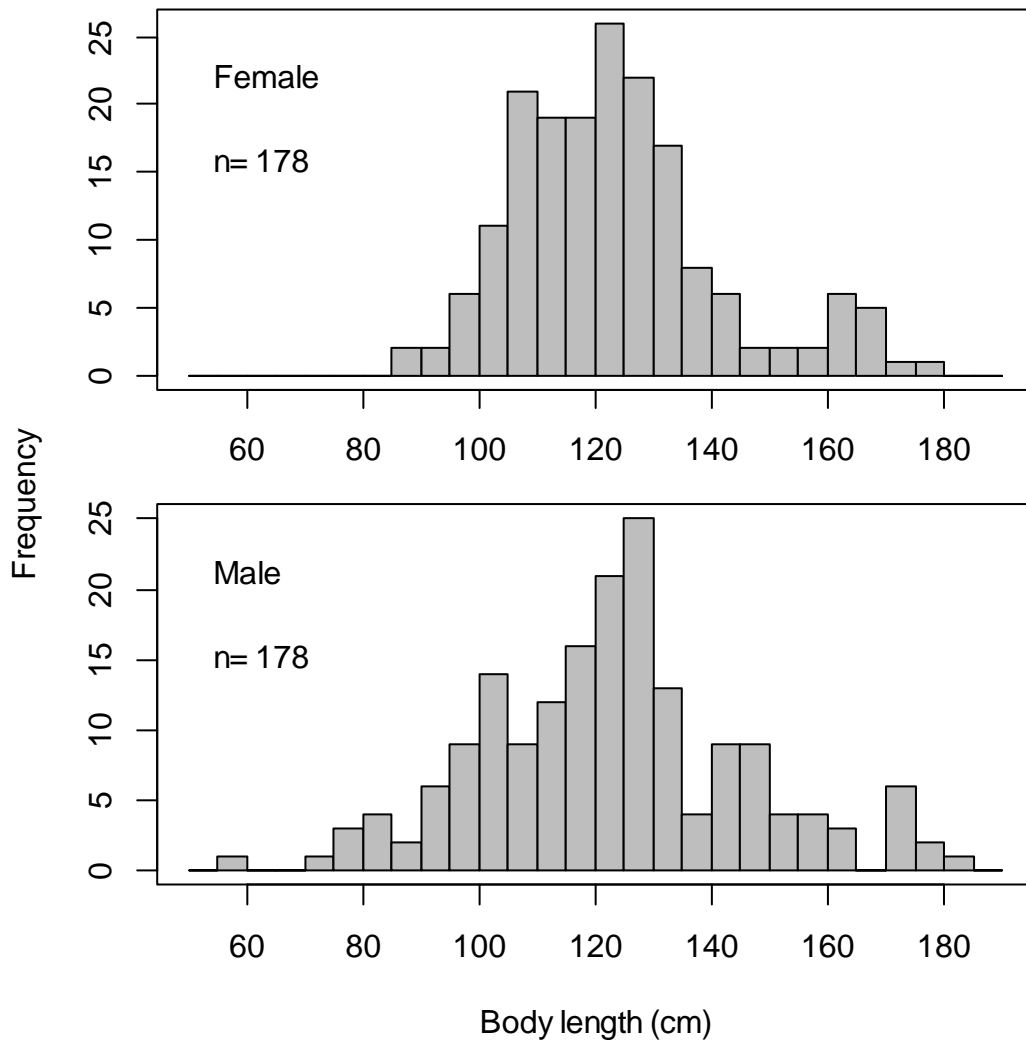


Fig. 2. Length frequency distributions (5 cm intervals) for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2015.

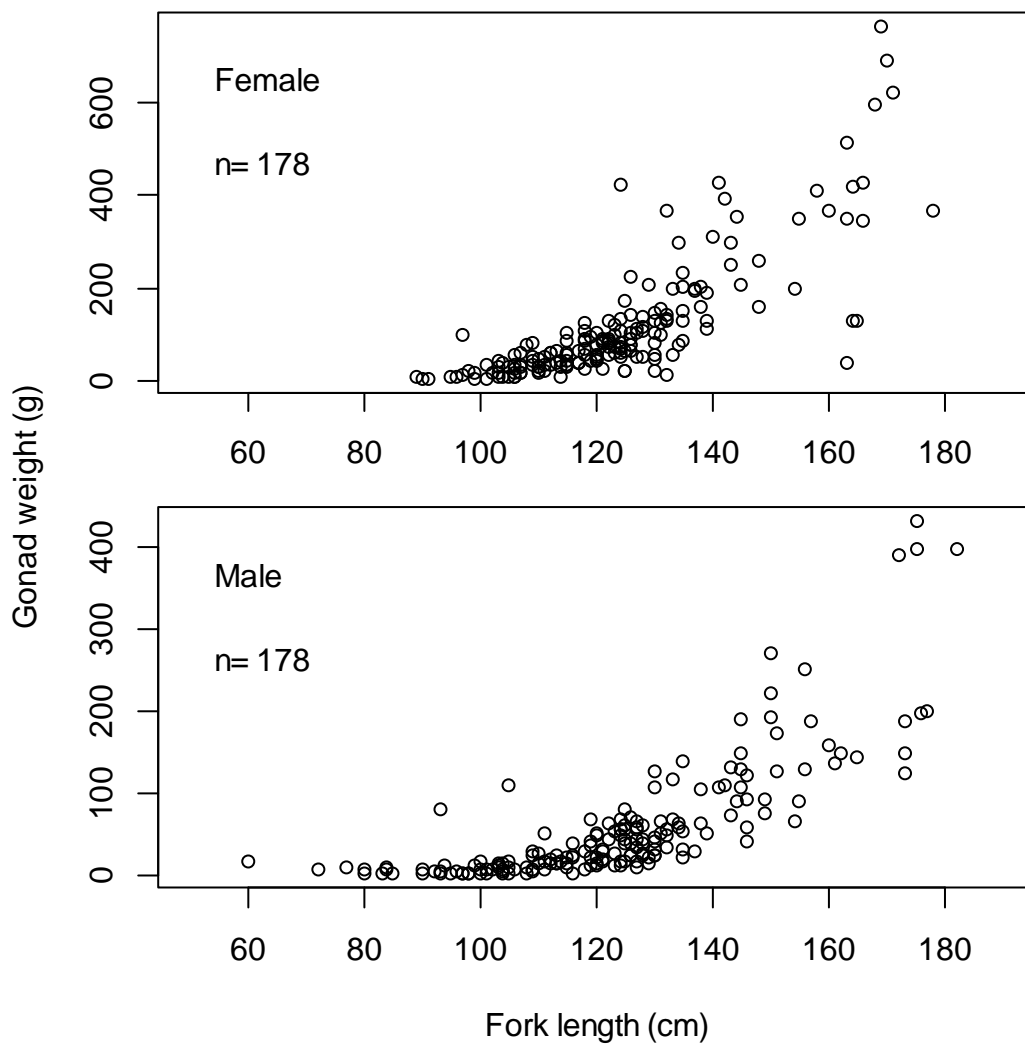


Fig. 3. Relationship between fork length and gonad weight for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2015.

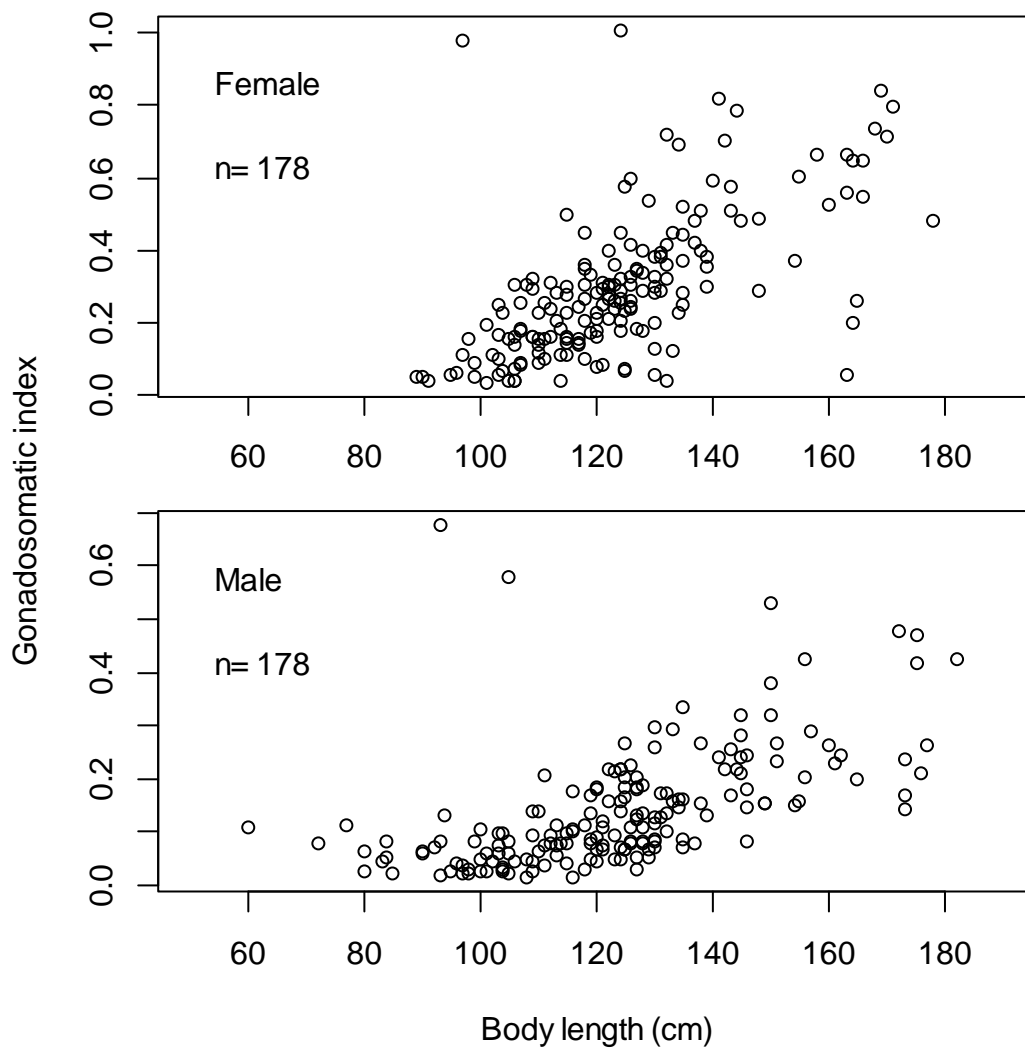


Fig. 4. Relationship between fork length and gonado-somatic index (GSI) for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2015.



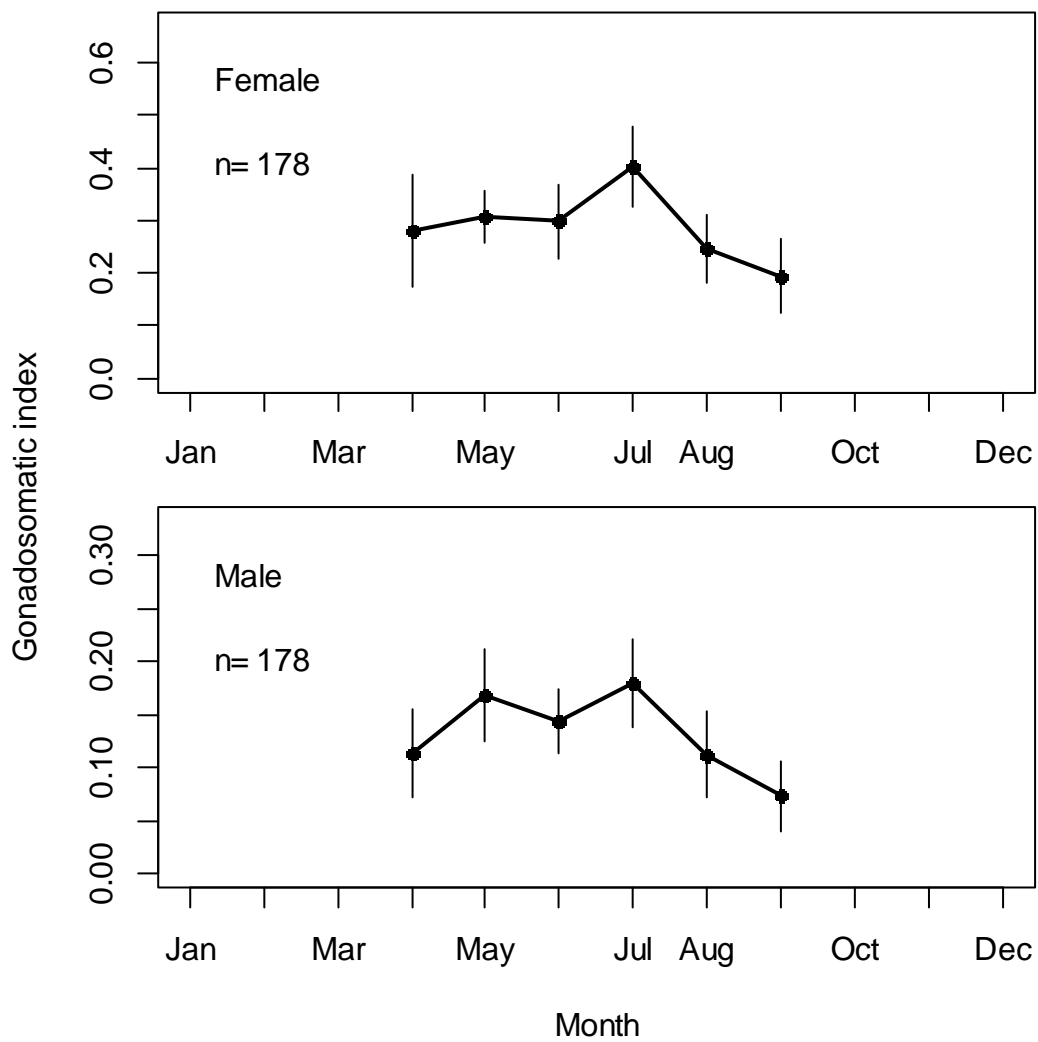


Fig. 5. Monthly trends of gonado-somatic index (GSI) for gonad samples of SBT collected Taiwanese scientific observer program. Vertical bars represent the 95% confidence interval for means during 2010-2015.

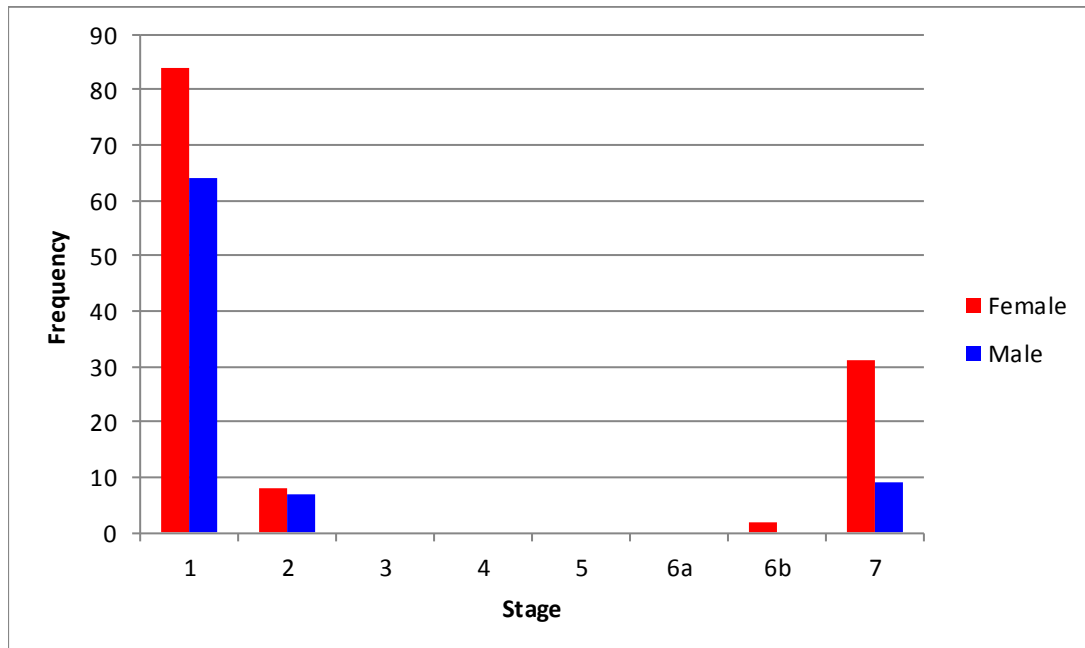
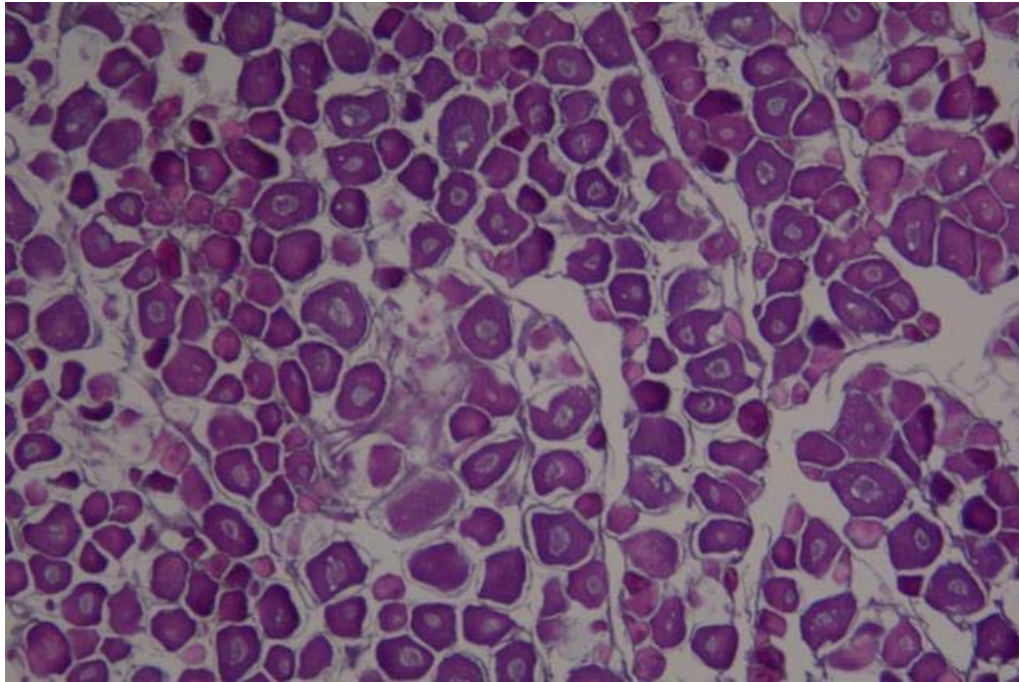
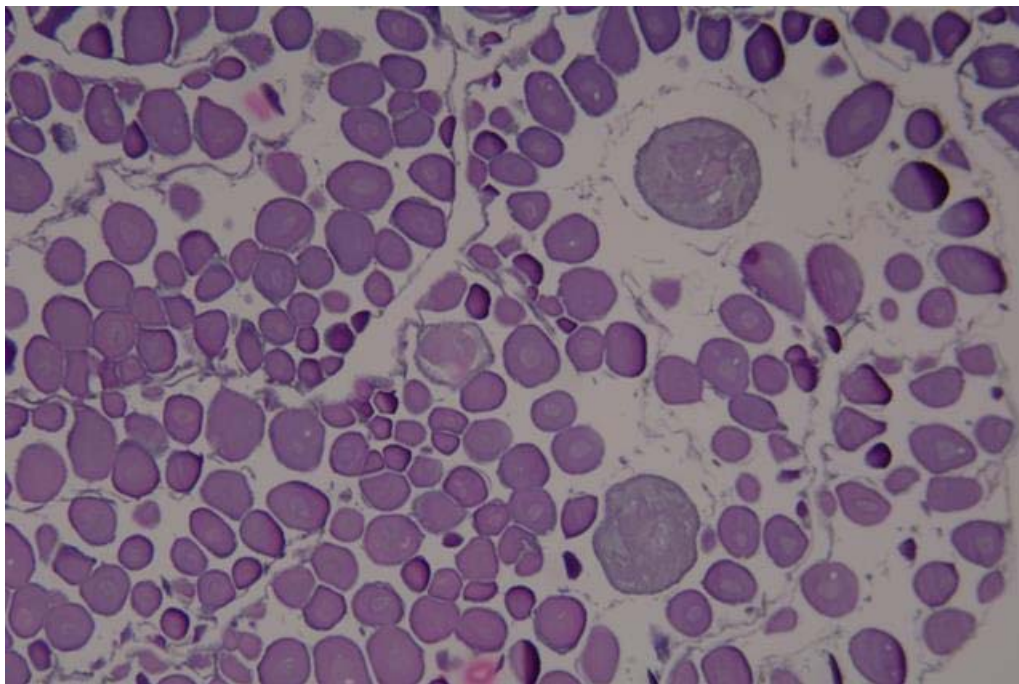


Fig. 6. Number of samples by maturity classes for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.

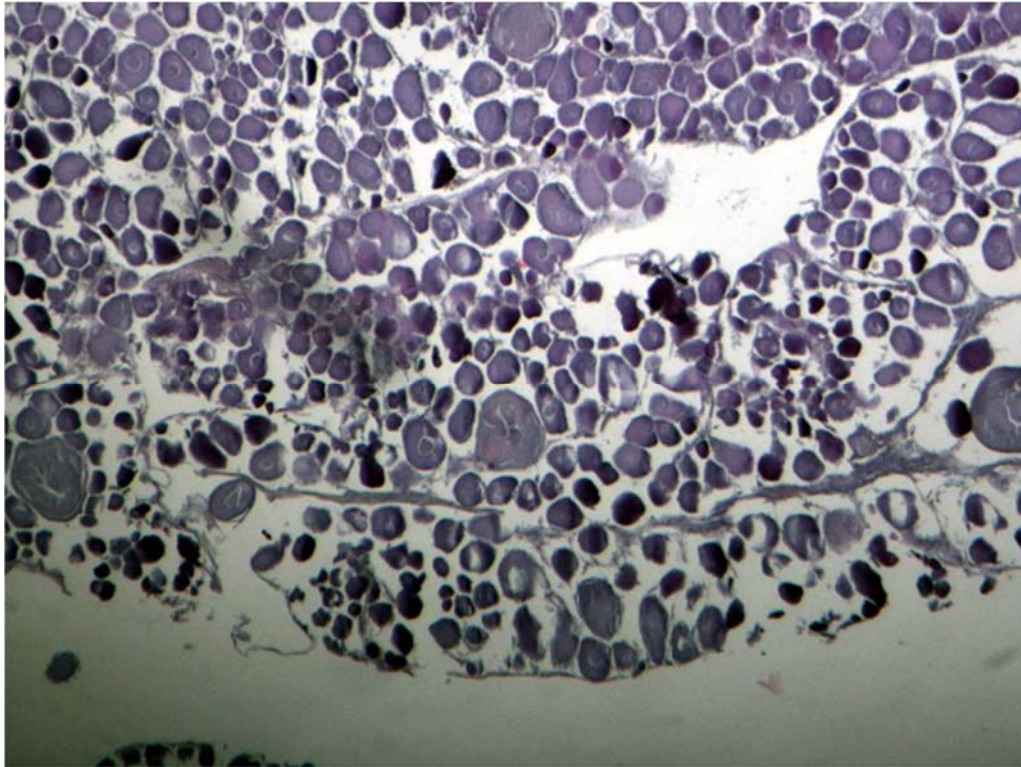


FL: 133cm, GW: 133.67g (Class 1, immature stage)

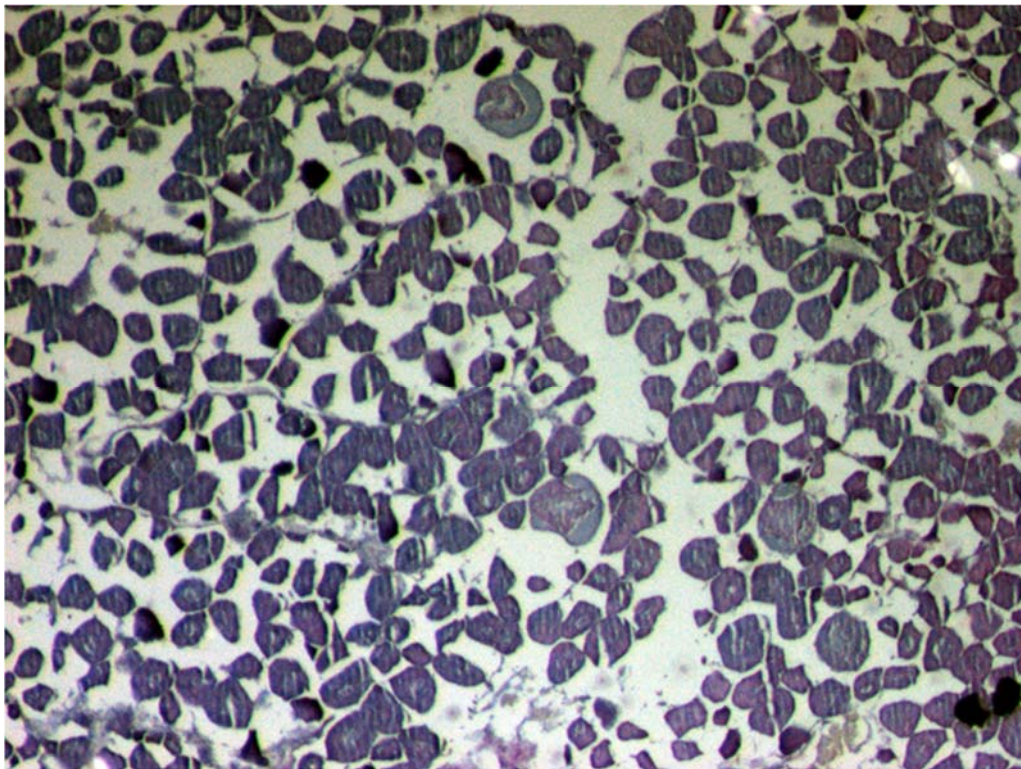


FL: 130cm, GW: 82.1g (Class2, developing stage)

Fig. 7. Histological sections and measurements of oocytes for gonad samples of female SBT collected Taiwanese scientific observer program during 2010-2014.

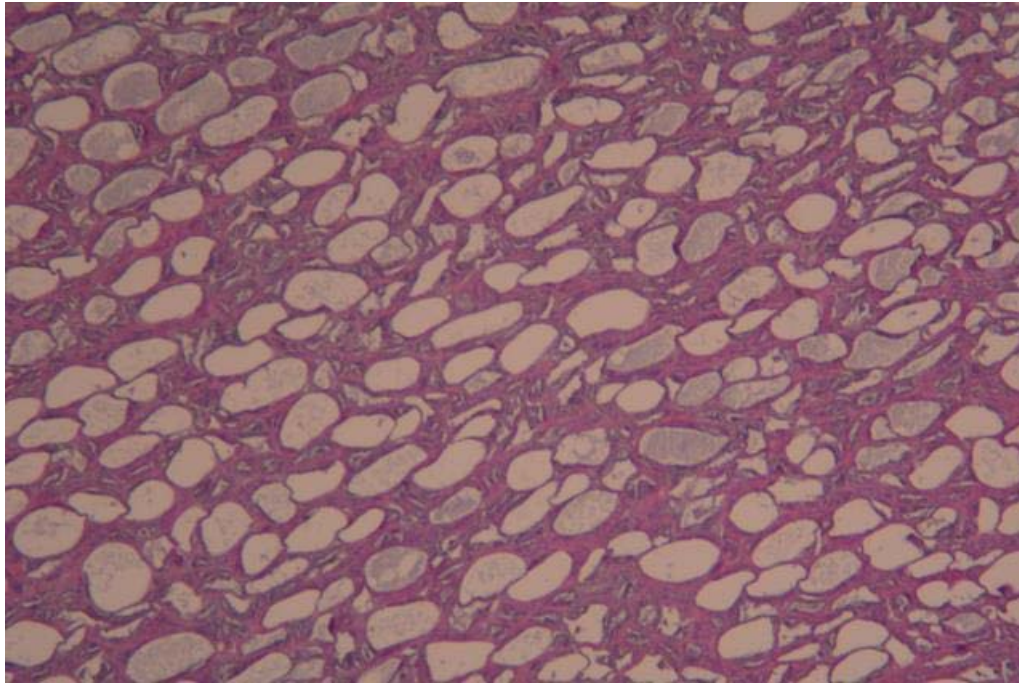


FL: 130cm, GW: 54.51g (Class 6b, regressed2 stage)

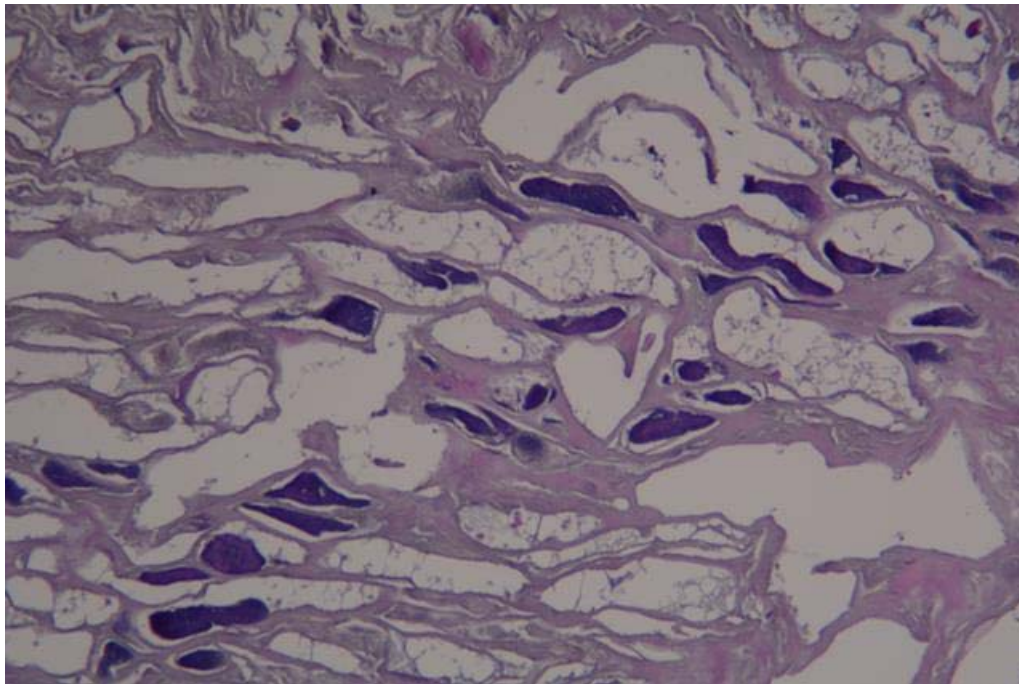


FL: 169cm, GW: 764.15g (Class 7, regenerating stage)

Fig. 7. (continued).



FL: 125cm, GW: 18.94g (immature stage)



FL: 127cm, GW: 17.87g (spent stage)

Fig. 8. Histological sections and measurements of oocytes for gonad samples of male SBT collected Taiwanese scientific observer program during 2010-2014.

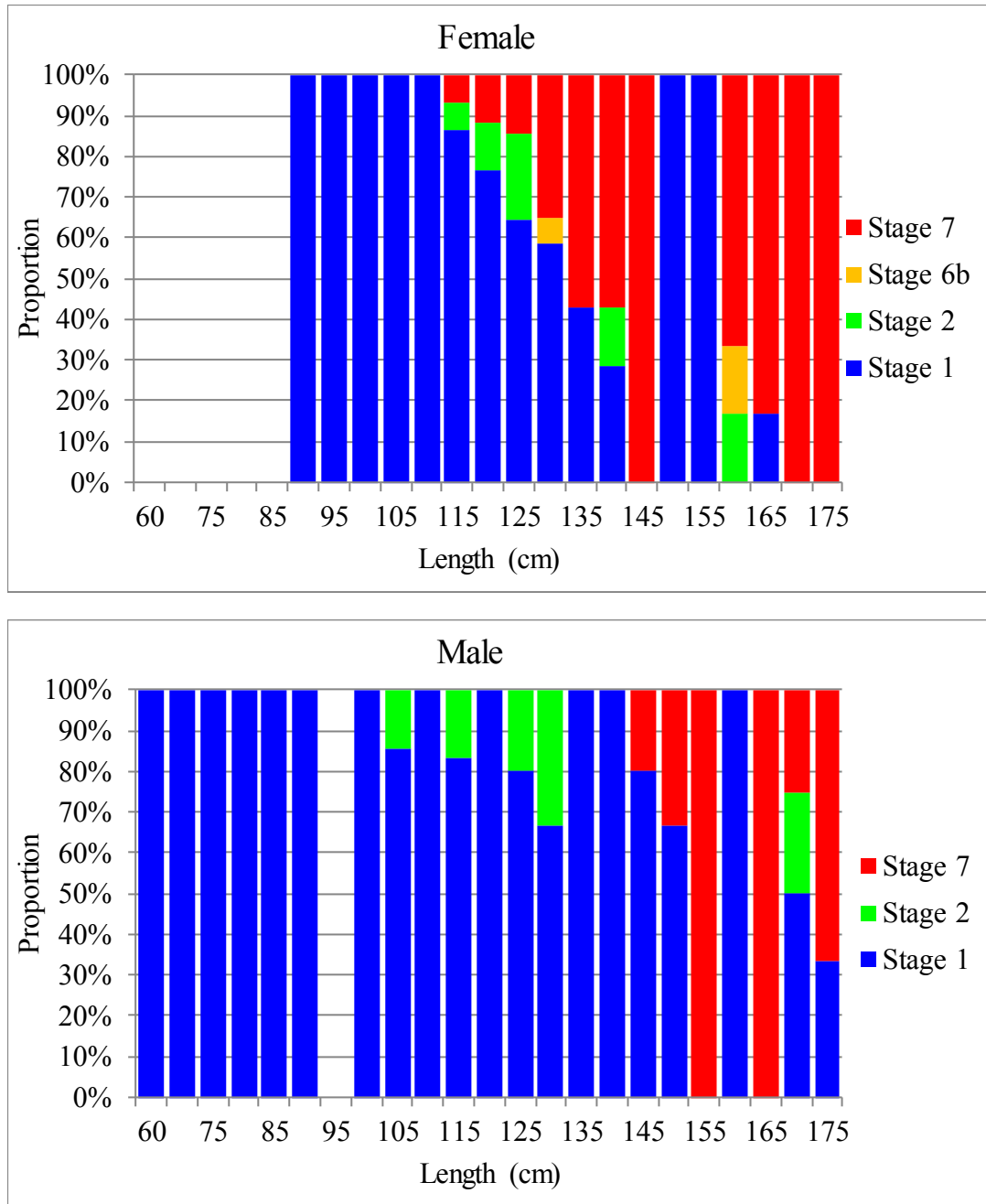


Fig. 91. Proportion of samples by maturity classes for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.

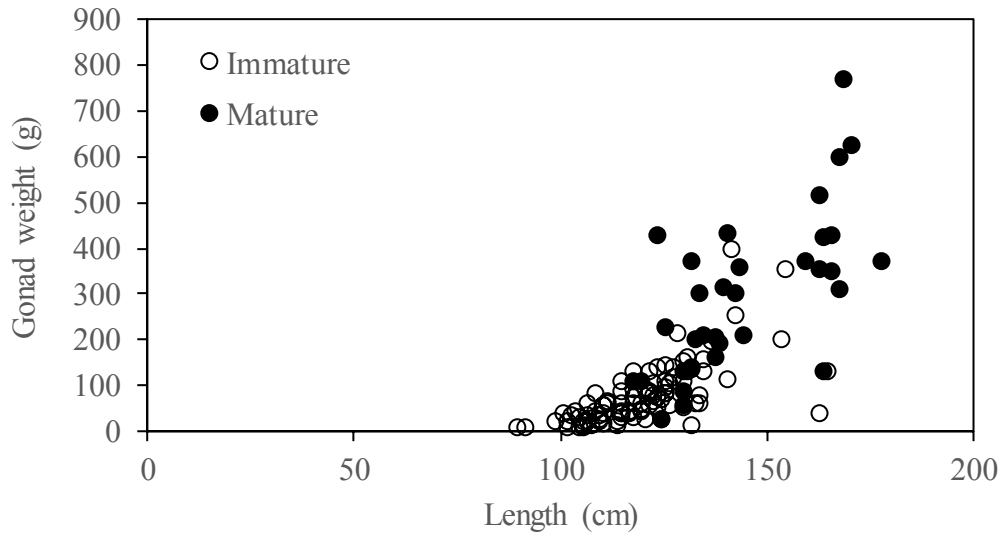


Fig. 10. Relationship between fork length and gonad weight by mature status for gonad samples of female SBT collected Taiwanese scientific observer program during 2010-2014.

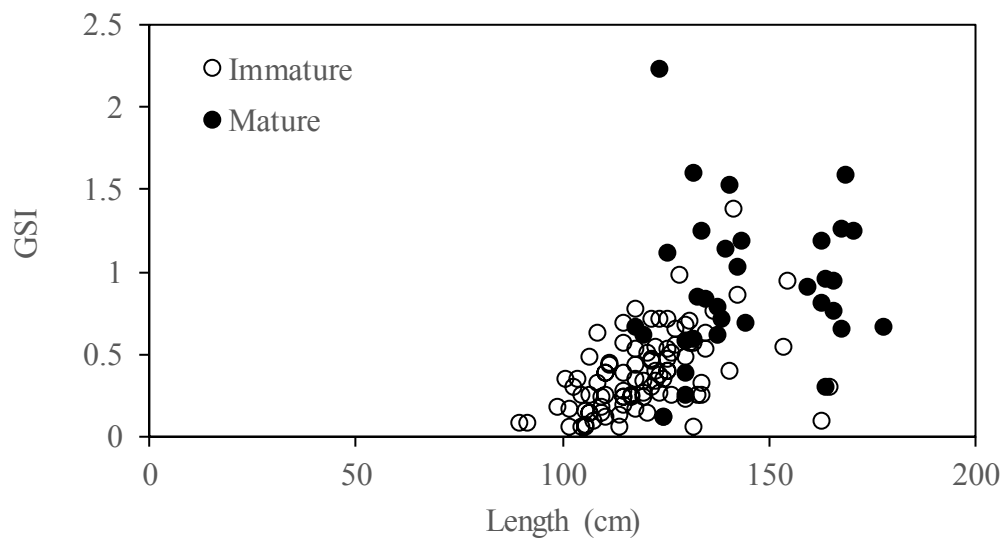


Fig. 11. Relationship between fork length and gonado-somatic index (GSI) by mature status for gonad samples of female SBT collected Taiwanese scientific observer program during 2010-2014.

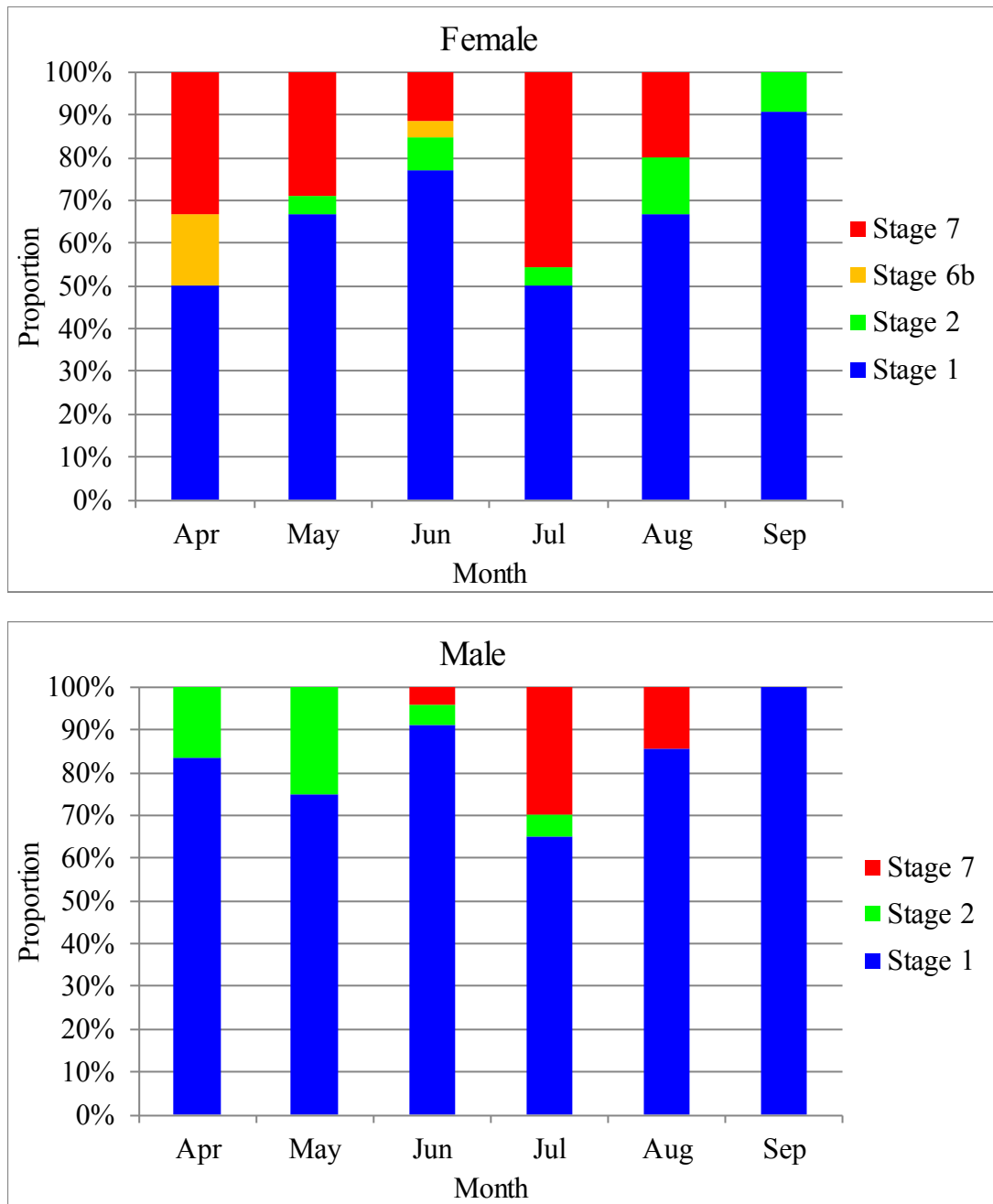


Fig. 12. Proportion of samples by maturity classes for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.



Table 1. The criteria of gonadal developmental stages for albacore in the southern Pacific Ocean (Farley et al., 2014).

Class	Maturity status	Activity	Development class	MAGO and POF stage	$\alpha$ and $\beta$ atresia of yolked oocytes
1	Immature	Inactive	Immature	Unyolked,no POFs	Absent
2	Immature	Inactive	Developing	Early yolked,no POFs	Absent
3	Mature	Active	Spawning capable	Advanced yolked,no POFs	<50% $\alpha$ and $\beta$ atresia may be present
4	Mature	Active	Spawning	Migratory nucleus or hydrated and/or POFs	<50% $\alpha$ and $\beta$ atresia may be present
5	Mature	Inactive	Regressing-potentially reproductive	Advanced yolked,no POFs	$\geq$ 50% $\alpha$ and $\beta$ atresia present
6a	Mature	Inactive	Regressed 1	Unyolked or early yolked, no POFs	100% $\alpha$ and $\beta$ atresia may be present
6b	Mature	Inactive	Regressed 2	Unyolked or early yolked, no POFs	No $\alpha$ and $\beta$ atresia present
7	Mature	Inactive	Regenerating	Unyolked or early yolked, no POFs	Absent