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

Sheng-Ping Wang[1], Hung-Hung Hsu[2], Wei-Chuan Chiang[2,3],
I-Lu Lai[3], Shiu-Ling Lin[3]

1. National Taiwan Ocean University, Taiwan
2. Fisheries Research Institute, Taiwan
3. Fisheries Agency, Taiwan

ABSTRACT

A total of 273 gonad samples of southern bluefin tuna were collected during April to September in year of 2010-2014. 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. The smallest mature sample was the fish with fork length of 118cm. More mature female samples were regressed or regenerating stages during April to June.

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 ≥ stage 3. Stages 3 and 4 are reproductively active stages, and stages1-2 and 5-7 are reproductively inactive stages (Table 1).

3. RESULTS AND DISCUSSION

A total of 273 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 2010-2014. Female and male samples were 138 and 135 respectively.

Samples were collected in the waters of the southeast Indian Ocean (70°E-105°E, 29°S-38°S) (Fig. 1). The fork length of samples ranged from 90 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.

Part of histological sections of gonad samples (female samples of 2010-2013) 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 (64 of 92 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). Generally, reproductive biology for fish was focus on females and thus further analyses were also mainly conducted for female SBT samples.

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 GIS was 0.02 (Figs. 9-11).

Based on monthly proportion of gonadal developmental stages, more mature female samples were regressed or regenerating stages during April to June (Fig. 12) and these mature fishes might migrate to this area after reproductive activity.

REFERENCE

Chen, M.H., Chen, K.S., Chen, T.C., Sun, C.L., Chen, C.Y., 2013. Notes on the reproductive biology of southern bluefin tuna *Thunnus maccoyii* in the southwestern Indian Ocean. Indian J. Mar. Sci. 42, 419-424.

Farley, J.H, Davis, T.L.O., 1998. Reproductive dynamics of southern bluefin tuna, *Thunnus maccoyii*. Fish. Bull. 96, 223–236.

Farley, J.H., Hoyle, S.D., Eveson, J.P., Williams, A.J., Davis, C.R., Nicol, S.J., 2014. Maturity ogives for south Pacific albacore tuna (*Thunnus alalunga*) that account

for spatial and seasonal variation in the distributions of mature and immature Fish. PLoS ONE 9(1): e83017. doi:10.1371/journal.pone.0083017.

Thorogood, J., 1986. Aspects of the reproductive biology of the southern bluefin tuna (*Thunnus maccoyii*). Fish. Res. 4, 297–315.

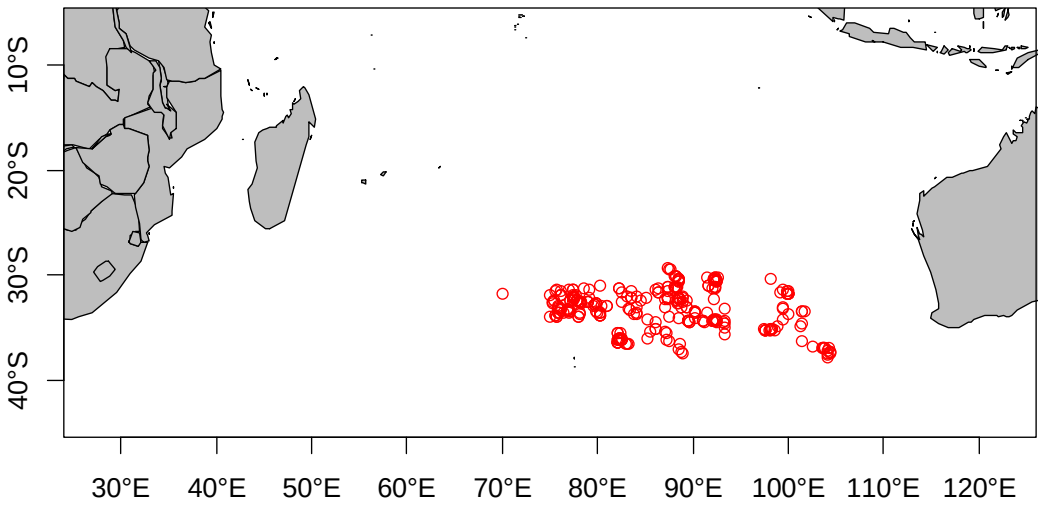


Fig. 1. Locations for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.

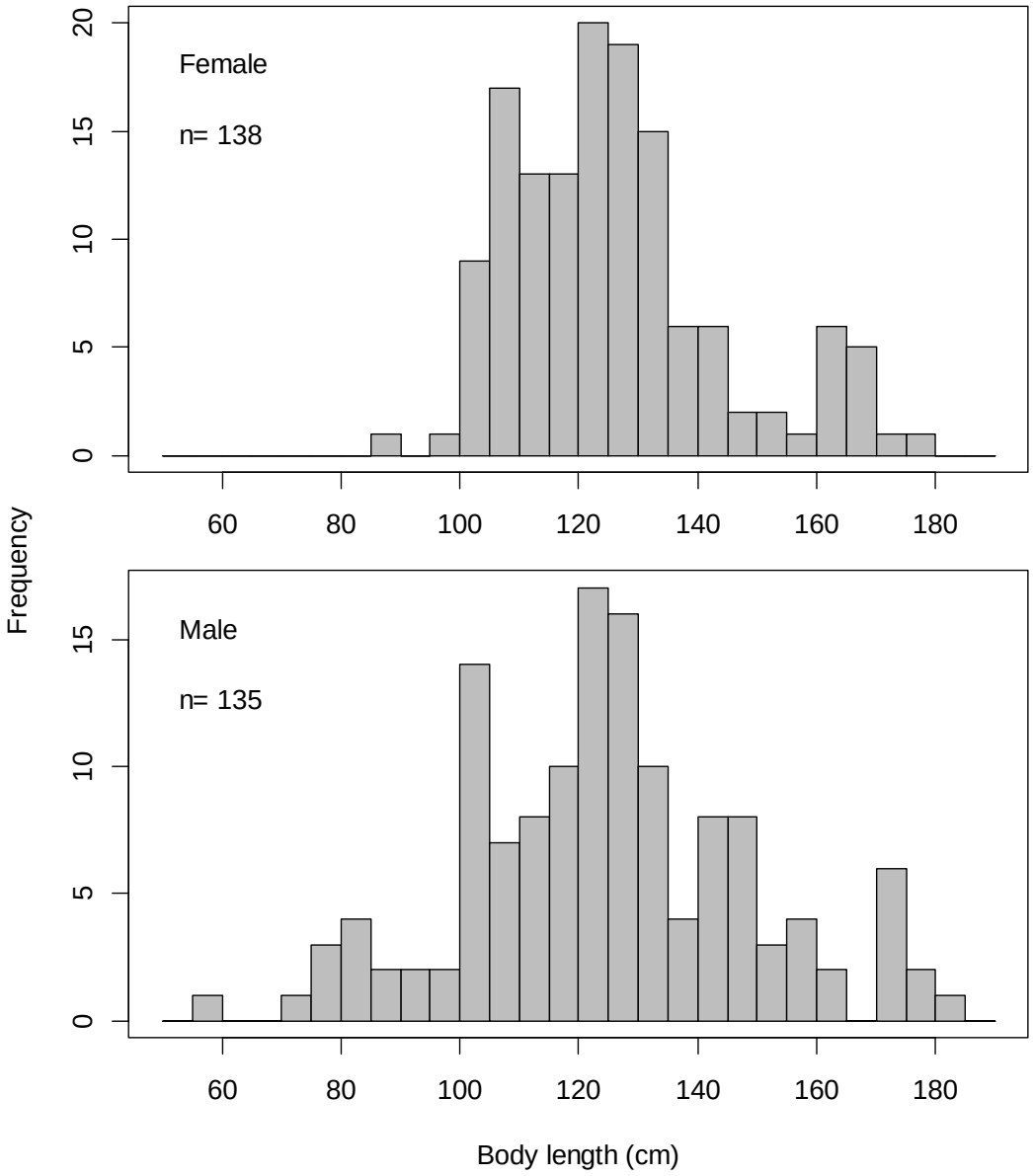


Fig. 2. Length frequency distributions (5 cm intervals) for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.

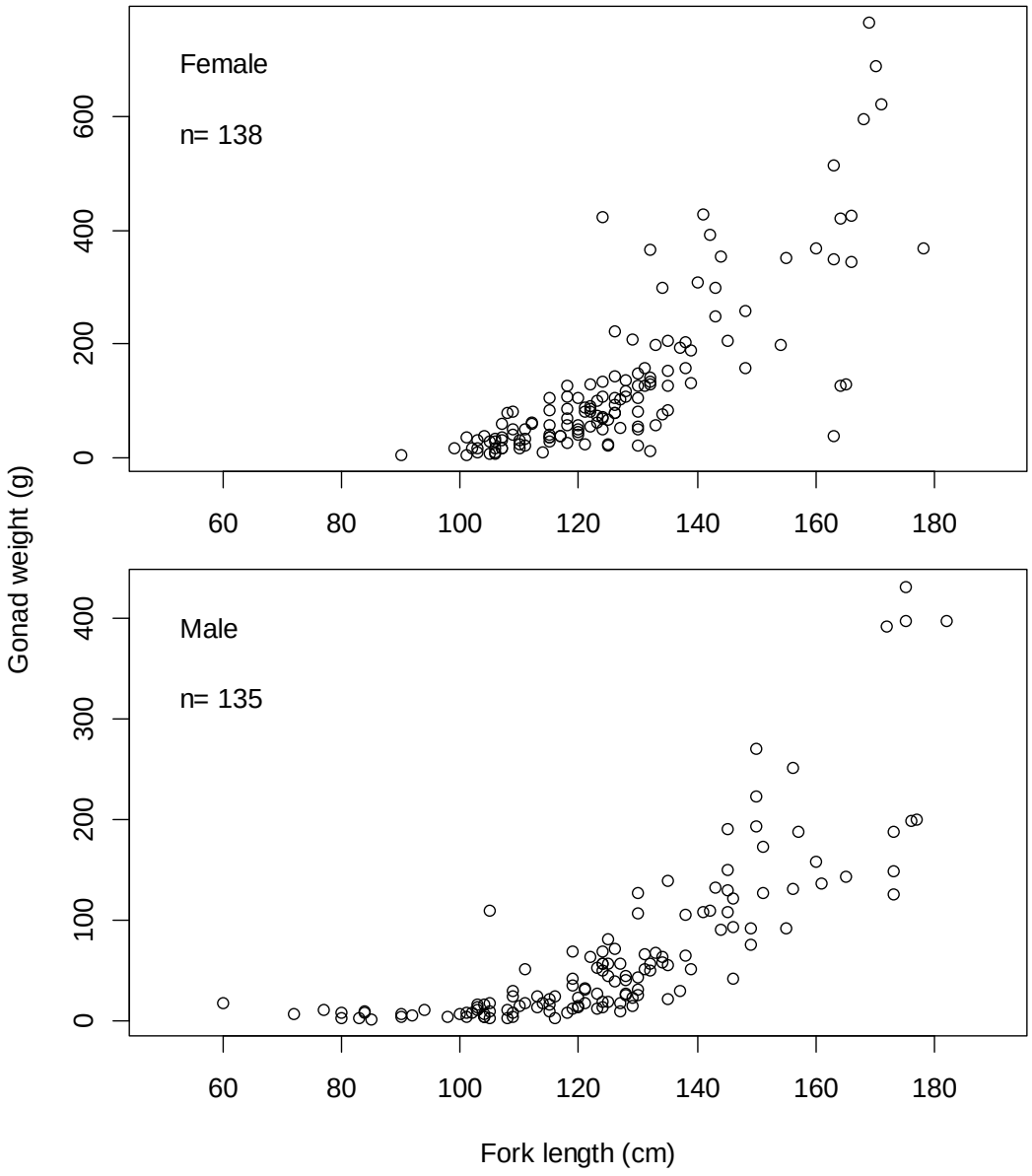


Fig. 3. Relationship between fork length and gonad weight for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.

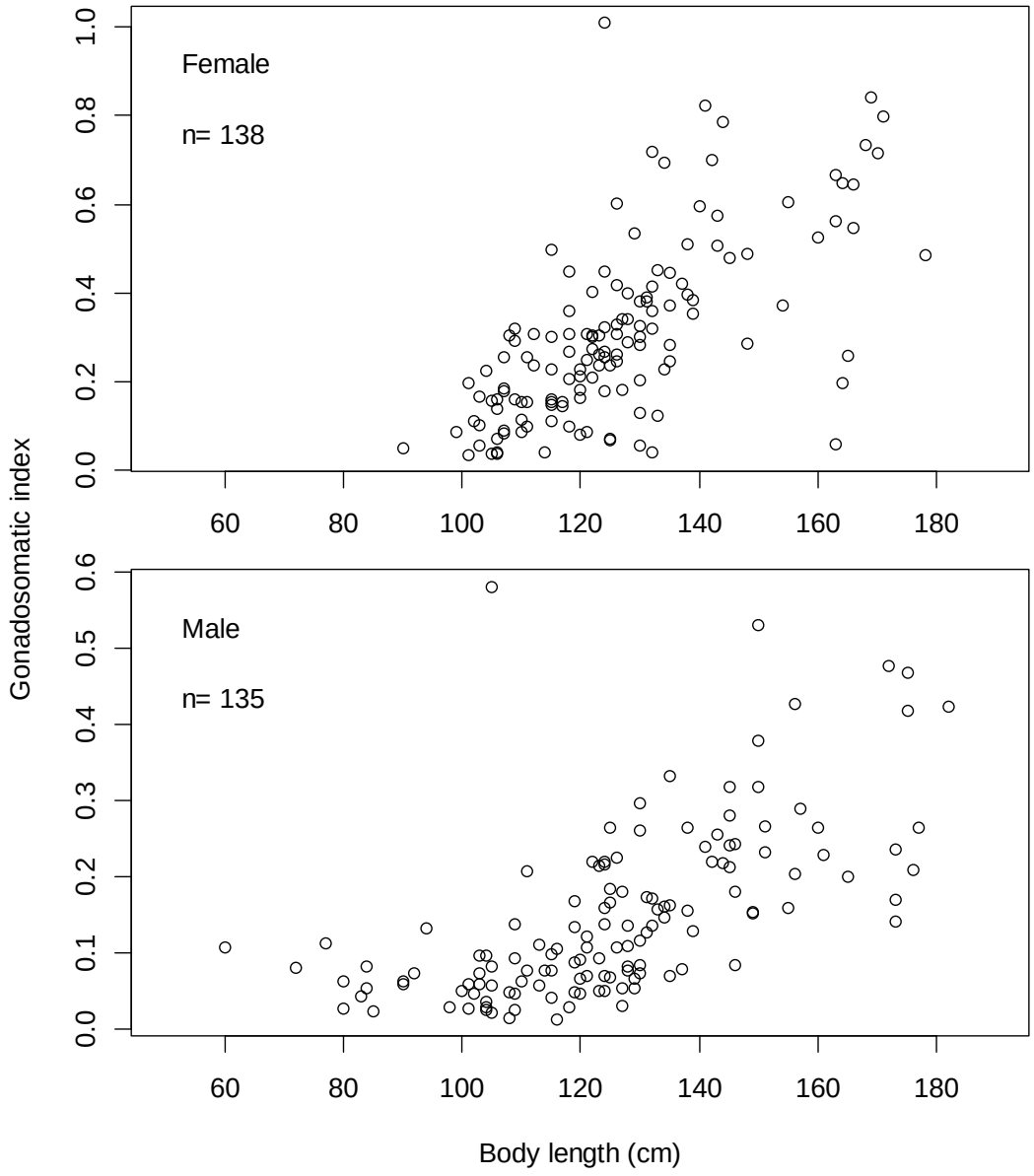


Fig. 4. Relationship between fork length and gonado-somatic index (GSI) for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2014.

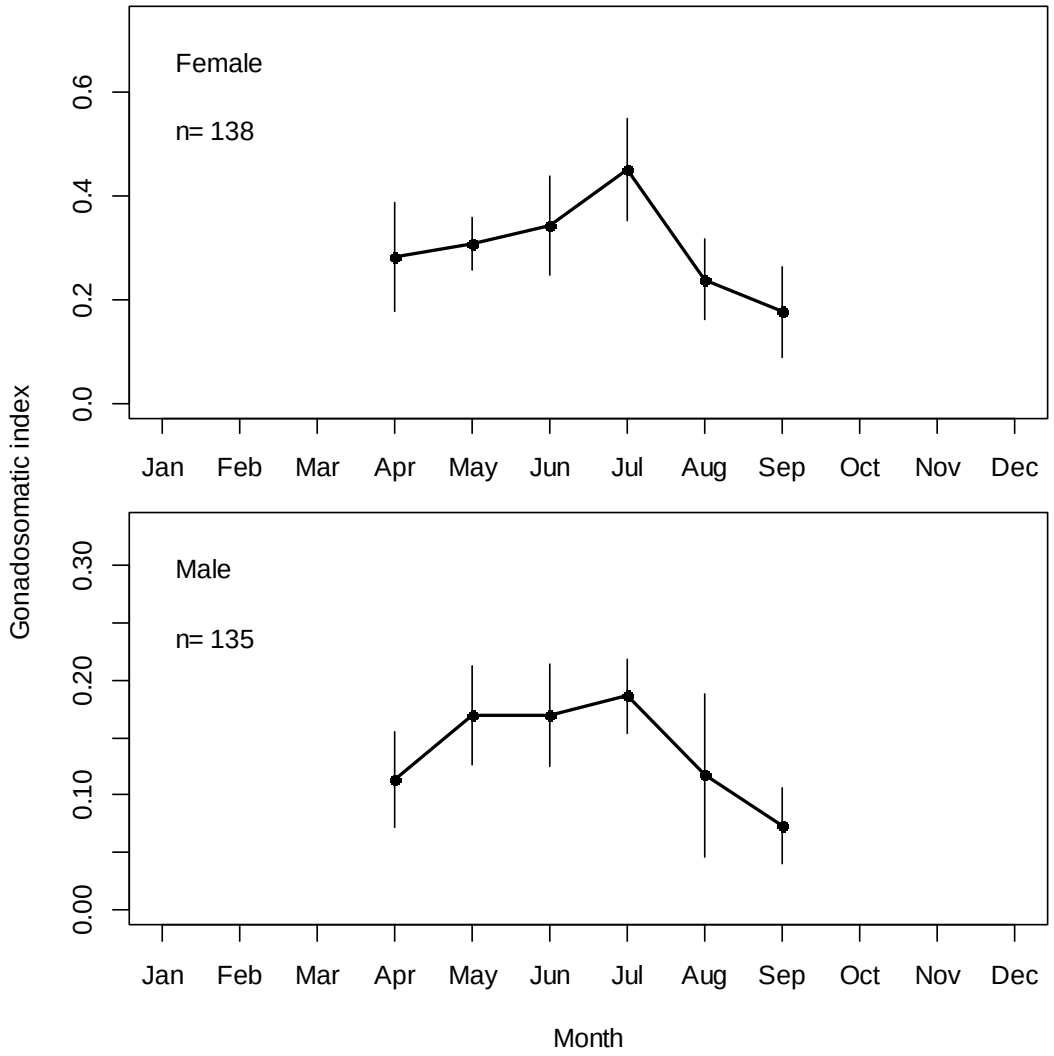


Fig. 5. Monthly trends of gonado-somatic index (GSI) for gonad samples of SBT collected Taiwanese scientific observer program. Vertical bars represent the 95% confidence interval for means during 2010-2014.

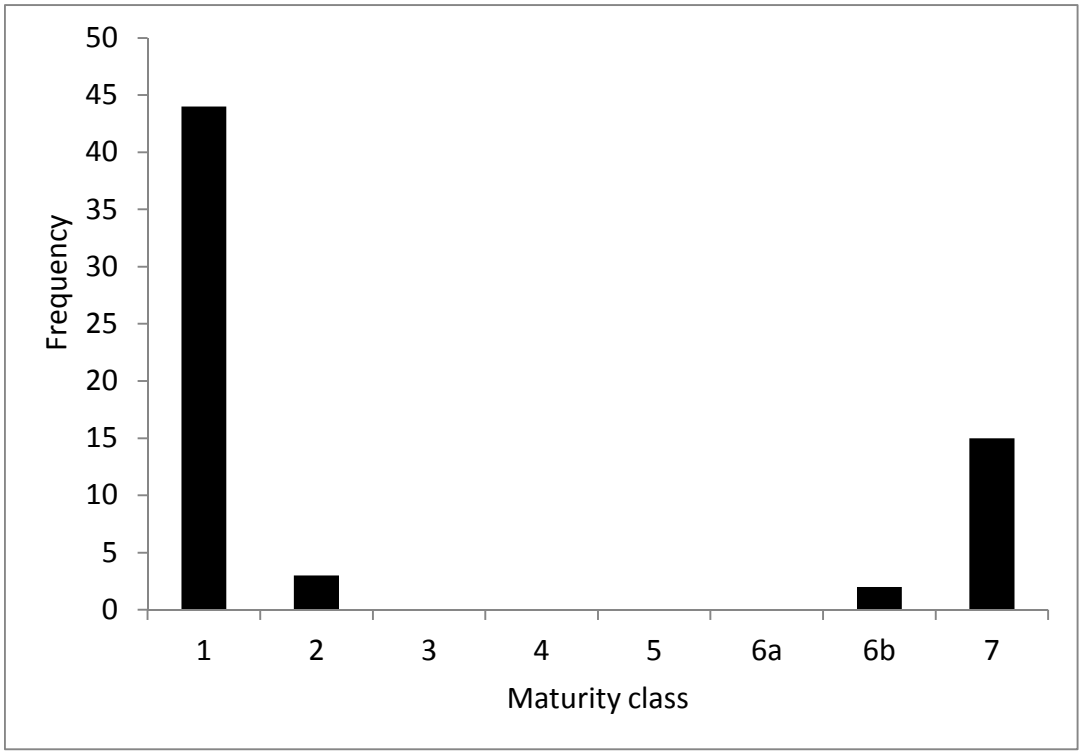
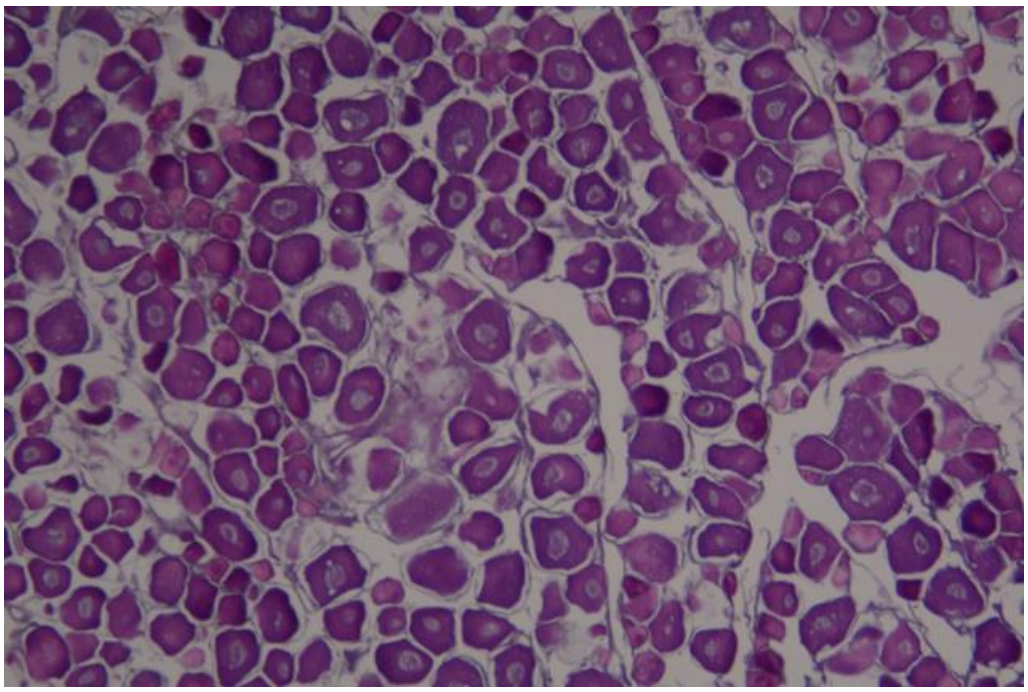
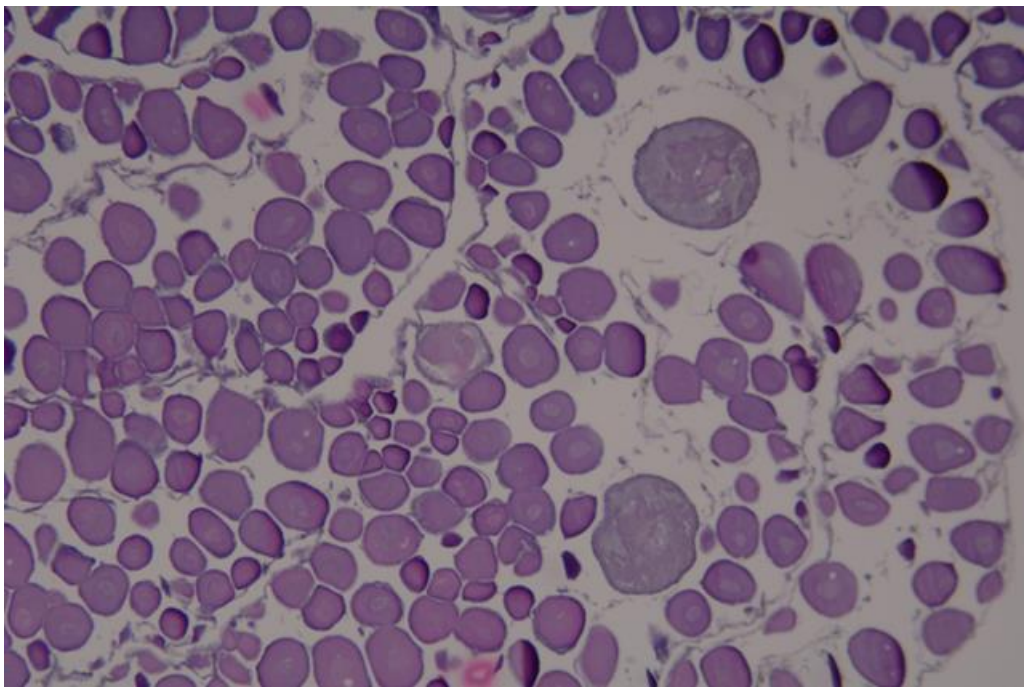


Fig. 6. Number of samples by maturity classes for gonad samples of female SBT collected Taiwanese scientific observer program during 2010-2013.

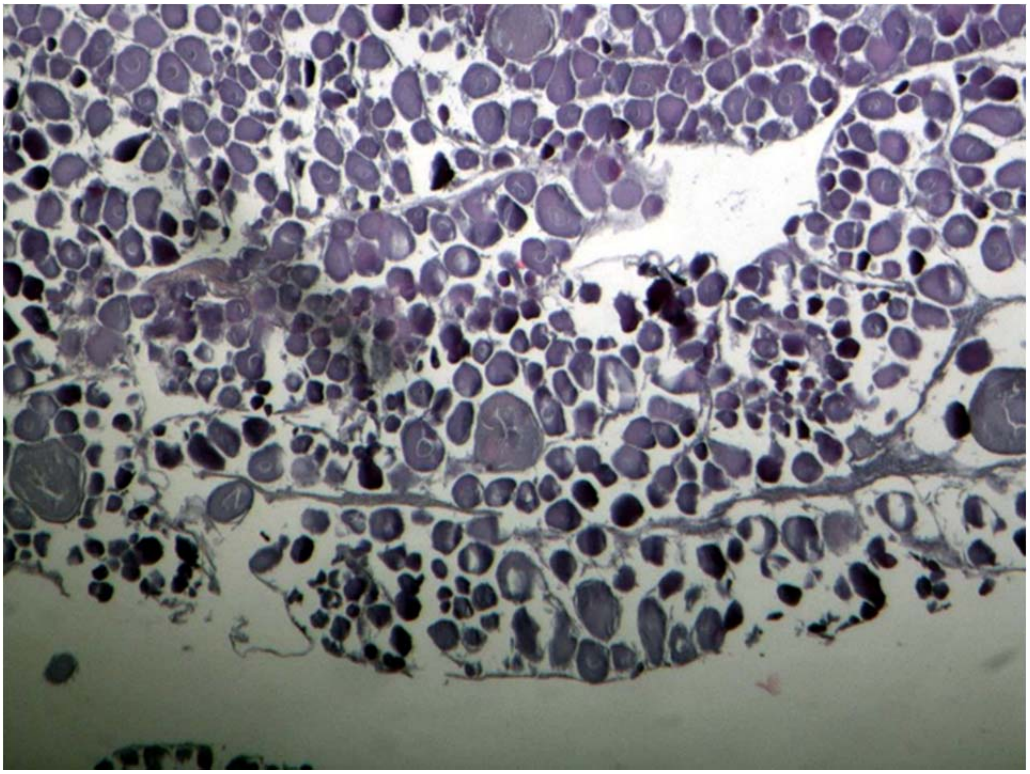


FL: 133cm, GW: 133.67g (Class 1, immature stage)

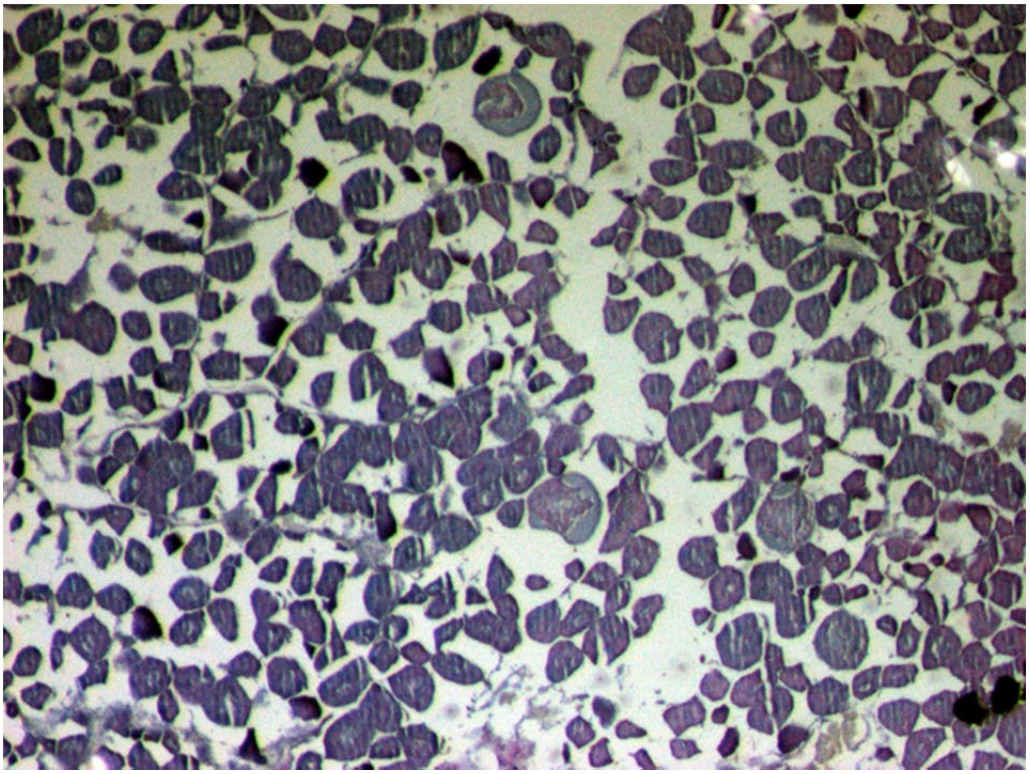


FL: 130cm, GW: 82.1g (Class2, developing stage)

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

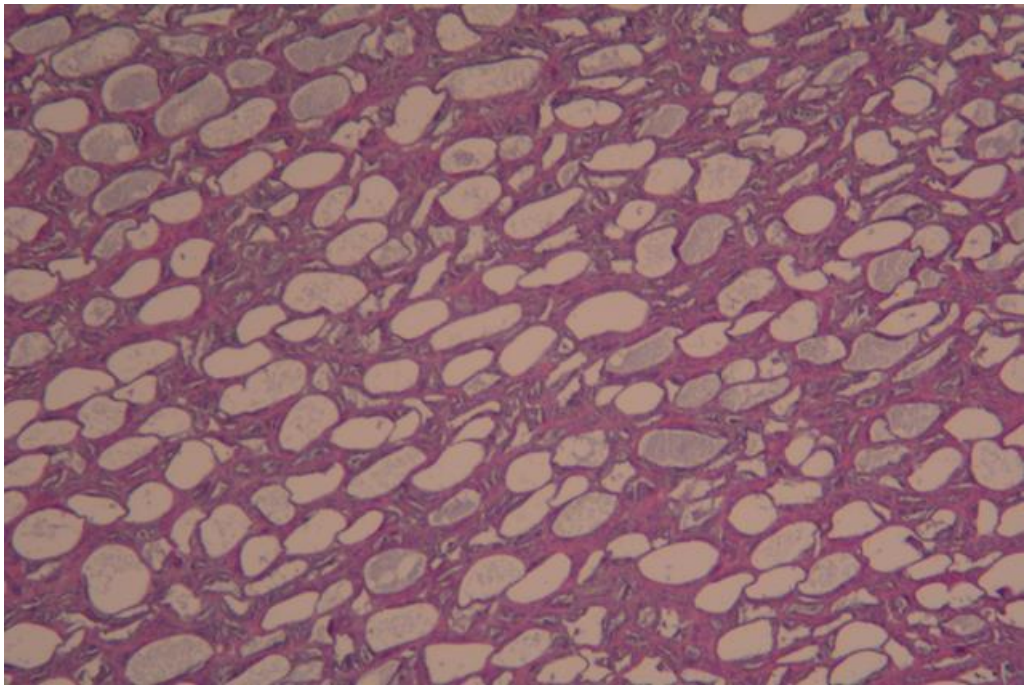


FL: 130cm, GW: 54.51g (Class 6b, regressed2 stage)

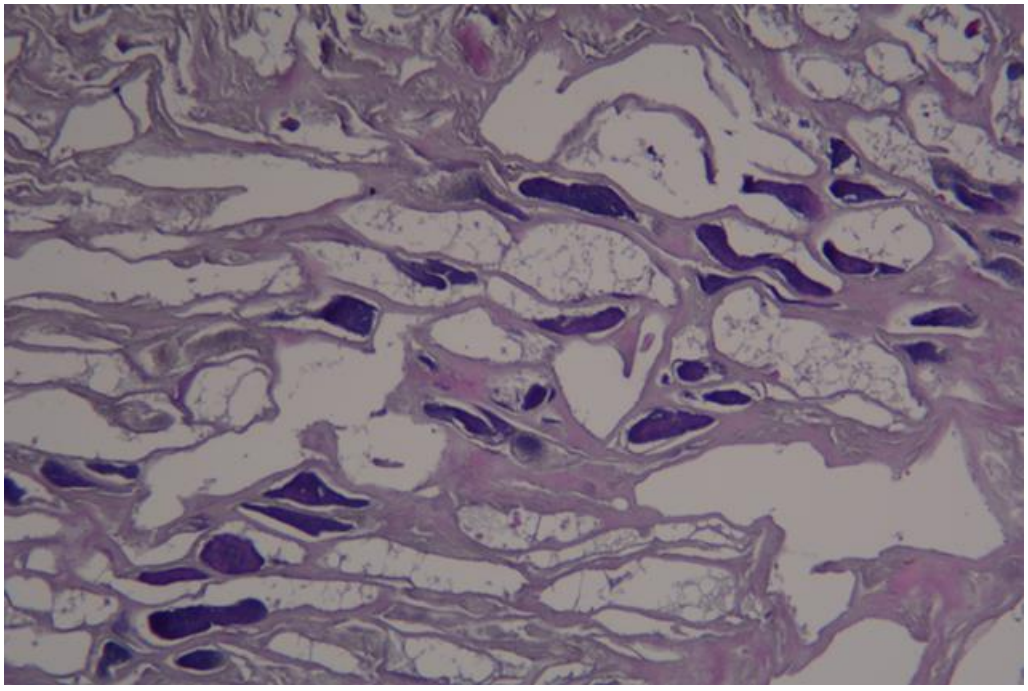


FL: 169cm, GW: 764.15g (Class 7, regenerating stage)

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.

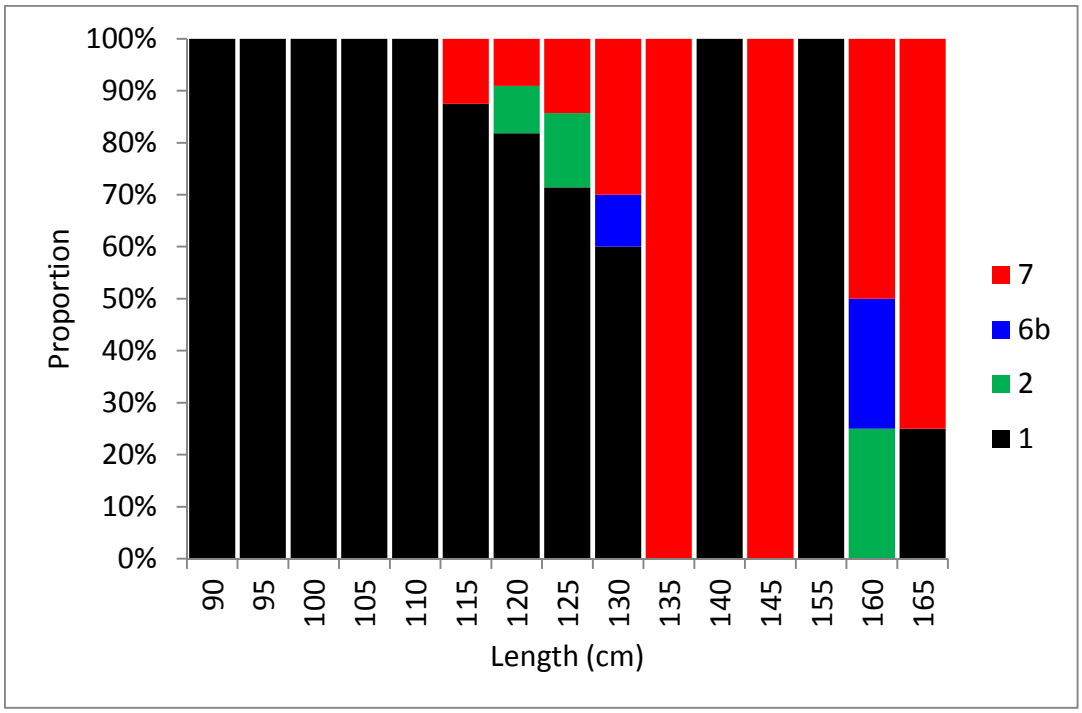


Fig. 91. Proportion of samples by maturity classes for gonad samples of female SBT collected Taiwanese scientific observer program.

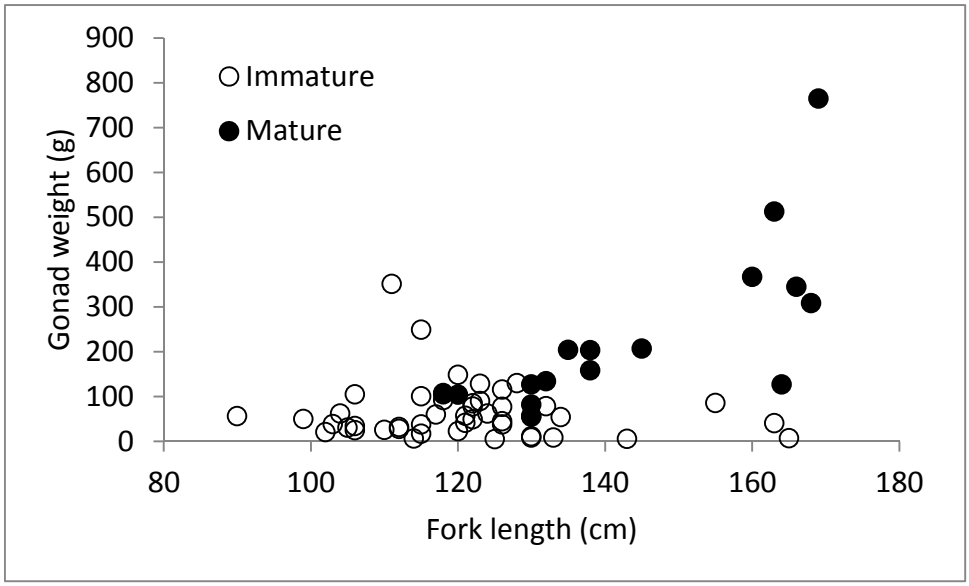


Fig. 10. Relationship between fork length and gonad weight by mature status for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2013.

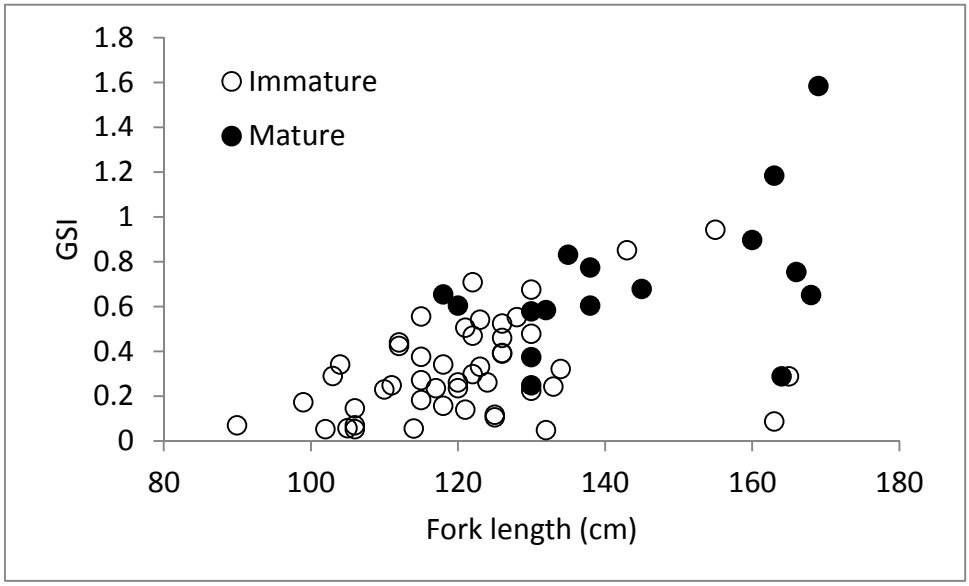


Fig. 11. Relationship between fork length and gonado-somatic index (GSI) by mature status for gonad samples of SBT collected Taiwanese scientific observer program during 2010-2013.

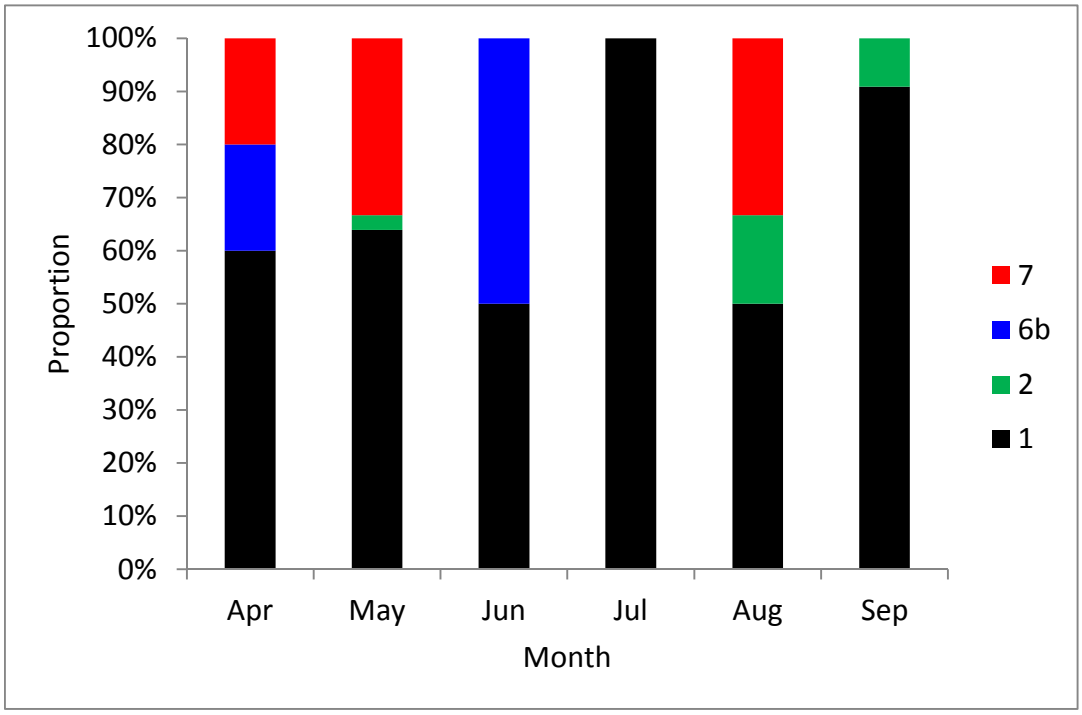


Fig. 12. Proportion of samples by maturity classes for gonad samples of female SBT collected Taiwanese scientific observer program during 2010-2013.

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	αand βatresia of yolked oocytes
1	Immature	lnactive	Immature	Unyolked,no POFs	Absent
2	Immature	lnactive	Developing	Early yolked,no POFs	Absent
3	Mature	Active	Spawning capable	Advanced yolked,no POFs	<50% αand βatresia may be present
4	Mature	Active	Spawning	Migratory nucieus or hydrated and/or POFs	<50% αand βatresia may be present
5	Mature	lnactive	Regressing-potentially reproductive	Advanced yolked,no POFs	≧50% αand βatresia present
6a	Mature	lnactive	Regressed 1	Unyolked or early yolked, no POFs	100%αand βatresia may be present
6b	Mature	lnactive	Regressed2	Unyolked or early yolked, no POFs	No αand βatresia present
7	Mature	lnactive	Regenerating	Unyolked or early yolked, no POFs	Absent