

Estimation of sexual maturity-at-length of the North Pacific albacore

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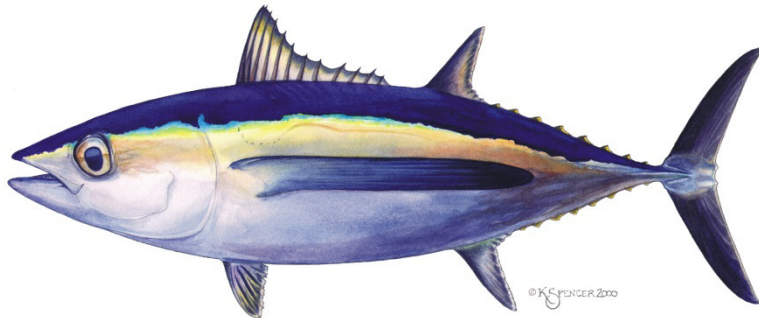
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Abstract

This working paper is aiming to estimate the maturity-at-length of North Pacific albacore, in an attempt to provide up-to-date information for future stock assessment of the albacore stock. In total, 293 specimens were collected from North Pacific Ocean dating 2001-2008, including 160 male and 133 female specimens, respectively. Sexual maturity of these samples was determined based on histological examination of testes or gonads. The maturity ogive of each sex using length-maturity data was constructed, and results were obtained as $P=1/(1+\exp(23.9271-0.2807L_F))$ for the male, and $P=1/(1+\exp(38.8609-0.4517L_F))$ for the female, where P is the probability of being mature at fork length L_F . The fork length at 50% maturity (L_{50}) were also estimated as 85.2 cm and 86.0 cm for the male and female, respectively. The 50% female maturity age was then obtained as 5.07 based on the female L_{50} .

Introduction

Information related to maturity at length of a fish stock is important for modeling the population dynamics. Although the reproductive biology of North Pacific albacore has been studied, little information is currently available on the relationship between maturity and length of this stock. Chen et al. (2010) investigated the gonadal development and sexual maturity based on histological examination, and presented results on sexual maturity, spawning season, spawning fecundity and batch fecundity of this stock. Furthermore, Chen (2011) estimated the maturity ogive of this stock based on pooled-sex maturity and length data, however, maturity-at-length curve of each sex was not presented individually. Hence, this working paper is aiming to investigate the relationships between sexual maturity and length of male and female North Pacific albacore, and also to estimate the female 50% maturity age, in an attempt to provide up-to-date information for future stock assessment of the albacore stock.

Materials and methods

Two hundred and forty-four albacore specimens were collected from the landing of Taiwanese longline vessels operated in the central and western North Pacific Ocean from October 2001 to April 2006. Additional 49 specimens were kindly provided by the National Research Institute of Far Sea Fisheries, Japan, which were mostly small size fish collected from the catches of pole-and-line vessels operated in the north-western North Pacific Ocean in the period June/2006-January/2008.

Sex of each specimen was identified and its fork length was recorded, then sexual maturity was determined based on histological examination of gonad using a classification scheme similar to that of yellowfin tuna (Schaefer, 1998). For each sex, the binomially distributed maturity data (immature or mature) were applied to logistic regression (Homsmer & Lemeshow, 2000; Kutner et al., 2004) to construct a length-maturity curve using the following equation:

$$P=1/(1+\exp(-(\beta_0+\beta_1 L_F))), \text{ where}$$

P is the probability of being mature at fork length L_F ,

β_0 and β_1 are the parameters to be estimated

Length at 50% maturity (L_{50}) can be estimated by substituting $P=0.5$ into the above equation. Moreover, female 50% maturity age was also calculated by substituting the female L_{50} into the sex-different von Bertalanffy growth equation reported by Xu et al. (2016), listed as the following,

$$L_t = 107.3(1-\exp(-0.266(t+ 1.01))),$$

where L_t is length at age t of the female North Pacific albacore.

The samples collection, measuring, sex identification and sexual maturity determination were all already conducted by Dr. K.S. Chen, and were described in details in his Ph. D. dissertation (Chen, 2011) and one of his published works (Chen et al., 2010). With the courtesy of Dr. Chen who kindly provided the original data, this working paper merely intends to re-estimate the relationship between sexual maturity and fork length, as well as age of the North Pacific albacore.

Results and discussion

In total, 293 albacore specimens were analyzed, including 160 males and 133 females. Most of these samples were collected from western and northern North Pacific Ocean (subarea A1, A2 & A3, Fig. 1), and only few of them came from central area of the Ocean (A4 & A5, Fig. 1). It is noted that these samples show a patchy distribution in terms of subareas as well as seasonality (Table 1), however, they cover a very wide area of the North Pacific Ocean.

Samples from A1 were mostly larger fish with a mode at 90-100 cm and ranging 75-115 cm, whereas specimens collected from A2 and A3 were fish of varied sizes, ranging 45-115 cm and 65-110 cm, respectively (Fig. 2). Only few specimens were collected from A4 ($n=6$) and A5 ($n=1$), and they were all larger than 100 cm in fork length. The length distribution of albacore in each area is consistent with the knowledge that larger fish tend to inhabit in subtropical and tropical waters whereas smaller fish were mostly found in temperate waters. In total, 293 albacore specimens covered a very wide range in fork length (45-118 cm), and it is believed that these samples include most of the age groups and varied maturity stages of the North Pacific albacore stock.

Based on the histological examination of gonad and maturity classification scheme, each specimen was categorized as immature or mature (Chen et al., 2010). Almost all the

fish, either male or female, from area A1, A4 and A5 (tropical and subtropical waters) were categorized as mature fish (Fig. 3). Only 20% or lower percentage of the specimen collected from area A2 reached sexual maturity. In Area A3, high percentage of mature male in contrast to low percentage of mature female was noted, and it might be explained by that in this area male specimens examined were much larger than the females (Fig. 2, A3).

For each sex and the pooled-sex, the binomially distributed maturity data (immature or mature) were applied to logistic regression (Hosmer & Lemeshow, 2000; Kutner et al., 2004), and results were obtained as shown in Fig. 4 and outlined as the follows:

$$P=1/(1+\exp(28.8136-0.3375 L_F))\dots\dots\dots\text{pooled-sex}$$

$$P=1/(1+\exp(23.9271-0.2807 L_F))\dots\dots\dots\text{male}$$

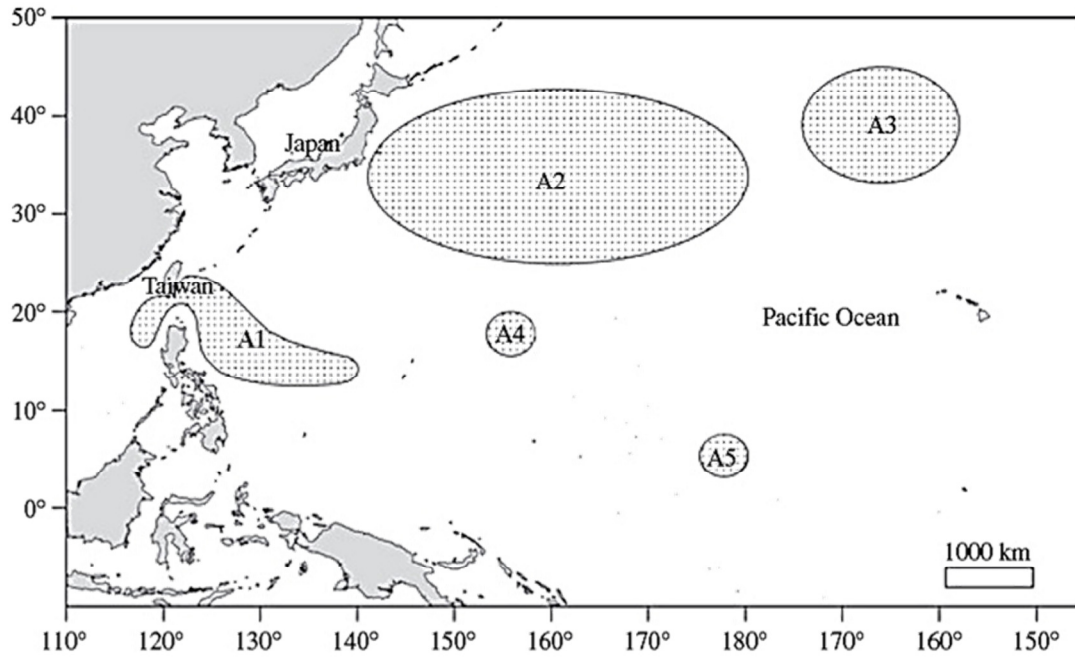
$$P=1/(1+\exp(38.8609-0.4517 L_F))\dots\dots\dots\text{female}$$

Where P is the probability of being mature at fork length L_F ,

The fork length at 50% maturity (L_{50}) was then back calculated as 85.3 cm, 85.2 cm and 86.0 cm for the pooled-sex, male and female North Pacific albacore, respectively. For the female albacore, its 50% maturity age was estimated as 5.07, using the sex-different von Bertalanffy growth equation (Xu et al., 2016).

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Courtesy of K. S. Chen


Fig. 1. Sampling areas ( ; A1-A5) of the North Pacific albacore specimens collected for maturity studies.

Table 1. Quarterly sample sizes of the North Pacific albacore collected from each sampling area. Numbers in the bracket denote female sample size.

Area of capture	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
A1	31(16)	77(44)	24(11)	4(3)	136(74)
A2	28(10)	29(10)		63(28)	120(48)
A3			10(5)	20(6)	30(11)
A4	6(0)				6(0)
A5				1(0)	1(0)
Total	65(26)	106(54)	34(16)	88(37)	293(133)

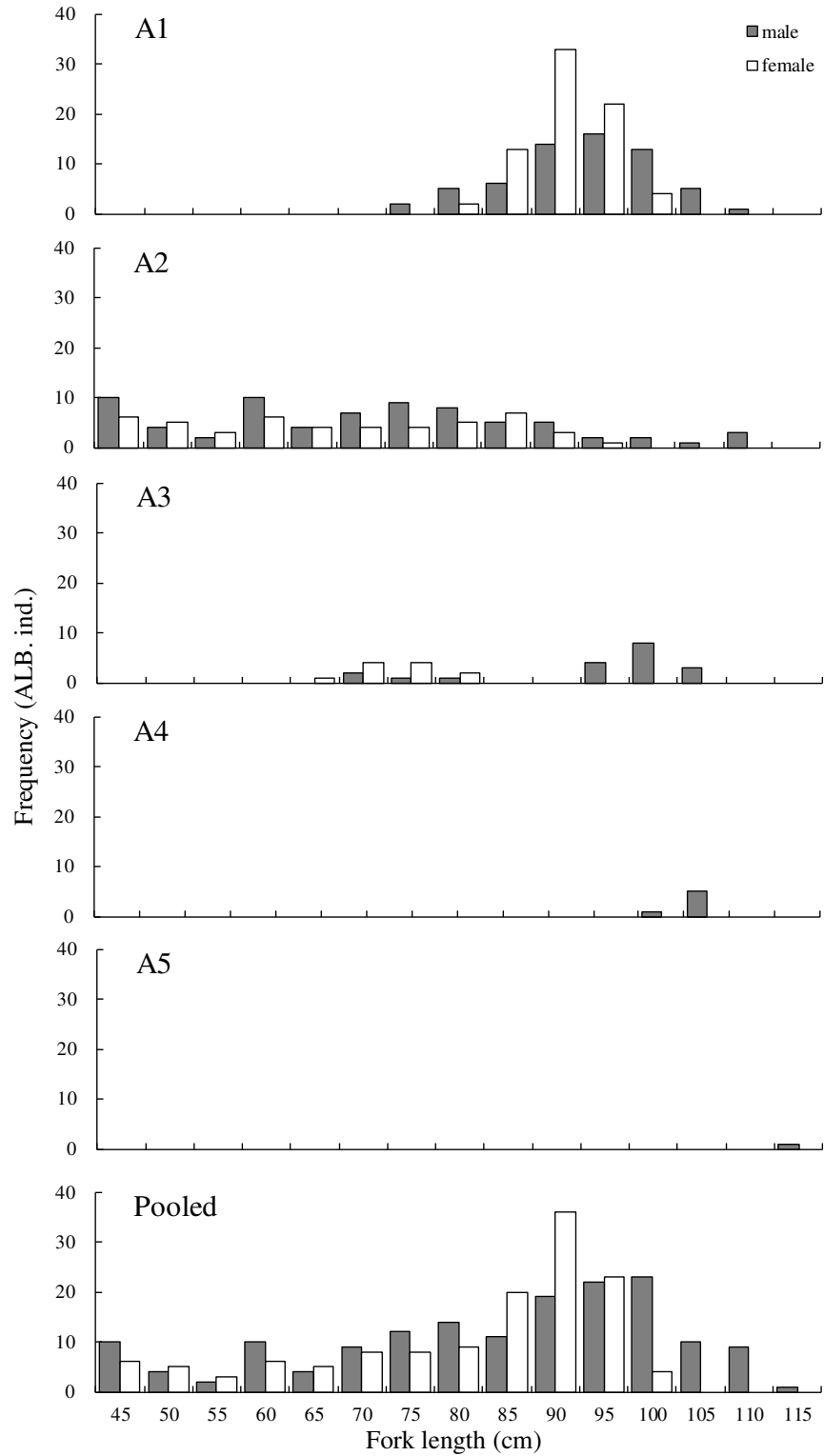


Fig. 2. Length distributions, by sex, of the N. Pacific albacore specimens collected for maturity analysis from area A1-5, and pooled areas.

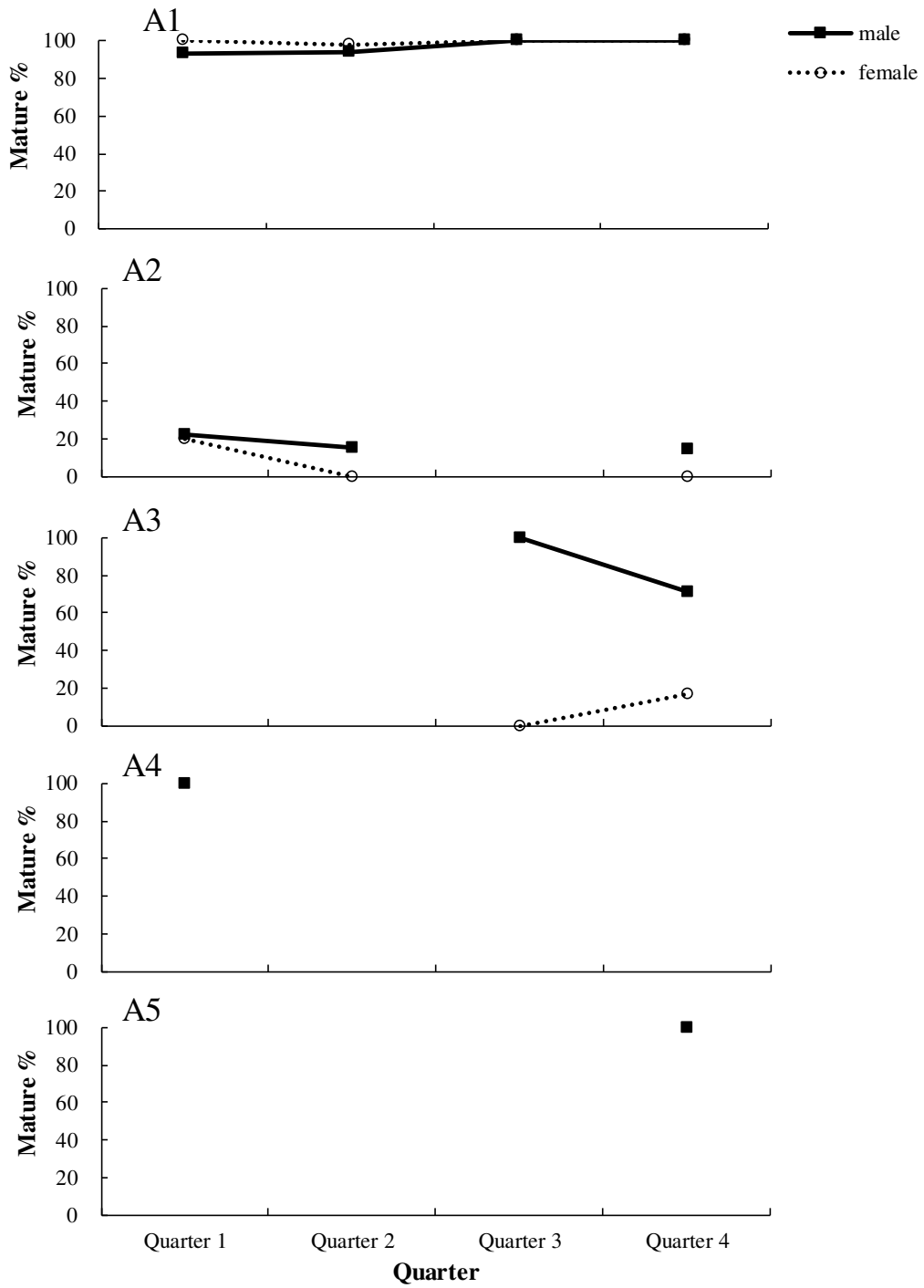


Fig. 3. Quarterly fluctuations of percentage maturity of the North Pacific albacore, by sex, collected from area A1-A5 and pooled areas.

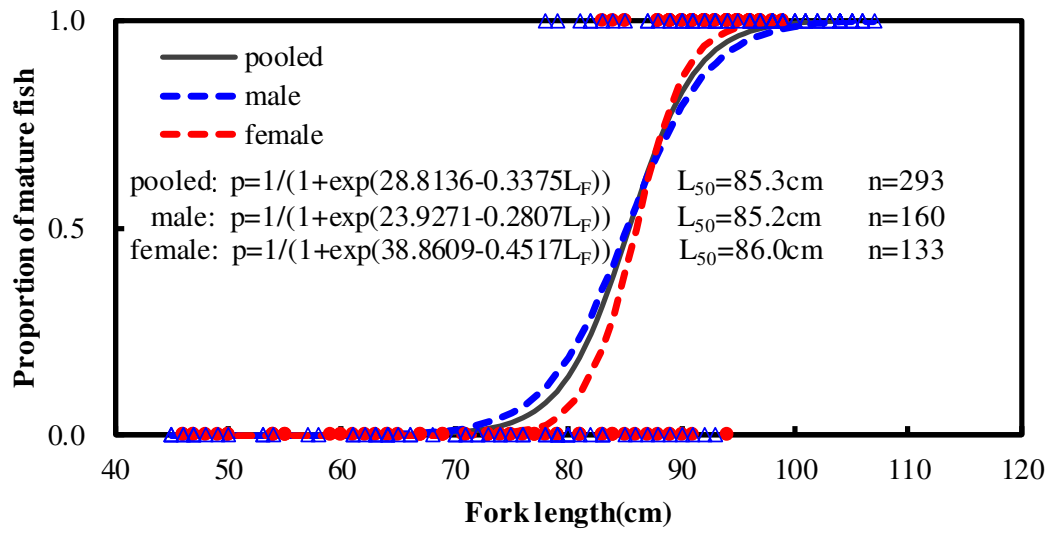


Fig. 4. Estimated length-maturity ogives for male, female and pooled-sex North Pacific albacore, respectively.