

# Procedure to estimate catch numbers at age in the Pacific stock of Japanese anchovy

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## Introduction

In this document, we show the procedure to estimate catch numbers at age in the Pacific stock of Japanese anchovy *Engraulis japonicus*. This stock distributes along the Pacific coastal waters of the Japanese archipelago and north of the Kuroshio Extension, that is Kuroshio-Oyashio transition zone, and this stock is mainly caught by set nets, boat seines, and small-sized purse seines in the 18 prefectures (Fig. 1). To obtain data for estimating catch numbers at age, researchers in each prefectural institute investigate monthly landings and scaled length compositions of the fish landed at the major landing ports. The surveys of scaled length composition of the fish are basically conducted once to three times a month during the fishing season, although the fishing season and the frequency vary from prefecture to prefecture..

Annual catches of the Pacific-stock Japanese anchovy by Japanese fisheries in recent years were usually equivalent to that of the Tsushima Warm Current (TWC) stock which is distributed in the Sea of Japan and the East China Sea. For example, the mean catch of the Pacific stock from 2017 to 2021 was about 45 thousand tons, whereas that of TWC stock was 47 thousand tons.

## Data and methods

We divided the 18 prefectures into four areas based on geographic and local fishery characteristics (Fig. 1). Data of monthly landing weights and body length compositions

of landing fish are obtained from a survey by prefecture. The landing data is collected by month, prefecture, location, and gear type. The length data is collected on the monthly basis from each prefecture by measuring fish length to compose a length frequency with a bin width of 0.5 cm. These length composition data are combined by area (Fig. 2) and converted to the catch numbers at age by using age-length key (Fig. 3).

Firstly, a monthly catch-weighted length composition in an area ( $A_{i,t}^a$ ) is calculated from the length composition  $B$  and catch data  $C$  of each prefecture as follows,

$$A_{i,t}^a = \sum_s (B_{i,t}^{a,s} \times C_t^{a,s}) \quad [1]$$

, where  $B_{i,t}^{a,s}$  is a relative frequency of fish at length-bin ( $i$ ), month ( $t$ ), prefecture ( $s$ ), and area ( $a$ ).  $C_t^{a,s}$  is the catch weight at month, prefecture and area. Then, we incorporate information on body weight at each length-bin ( $BW_i$ ) to calculate weight of fish for each length composition  $D$  as follows,

$$D_{i,t}^a = A_{i,t}^a \times BW_i \quad [2]$$

, where  $BW$  is obtained from a power regression model of scaled length:  $BW$  (g) =  $0.010 \times SL^{3.00}$  (cm). Coefficients of the power regression model were estimated from the length-weight relationship (pooling all areas) for each year and were averaged over 10 years from 1998 to 2007. The mean  $\pm$  S.D. of exponent and multiplier are  $3.002 \pm 0.194$  and  $0.010 \pm 0.0037$ , respectively. These coefficients were confirmed to see if these are still applicable today; for example, in 2021, the exponent was 3.002 and the multiplier was 0.0089. Then, a relative frequency of length composition based on the weight is calculated again as follows,

$$E_{i,t}^a = \frac{D_{i,t}^a}{\sum_{i=1}^{max} D_{i,t}^a} \quad [3]$$

Using the above composition data, the catch numbers at length, month, and each area ( $N_{i,t}^a$ ) (Fig. 2) are calculated as follows,

$$N_{i,t}^a = \frac{E_{i,t}^a \times \sum_s C_t^{a,s}}{BW_i} \quad [4]$$

When a monthly length composition data is missing from a certain prefecture, the relative frequency of length composition of data-available prefectures are combined within the area and applied to the catch where length data is missing.

Next, a catch number at age ( $y$ ) ( $N_{t,y}^a$ ) is calculated using an age-length key as follows,

$$N_{t,y}^a = N_{i,t}^a \times ALK_{i,t} \quad [5]$$

, where  $ALK_{i,t}$  is an age-length key in each length-bin, and month (Fig. 3). A monthly single age-length-key using cohort slicing method is used for each area in this stock. The ages of Japanese anchovies were treated as age-0, age-1, age-2, and age-3. The monthly ALKs of this stock were created from age determination data ( $n = 26,220$ ) conducted in four prefectures—Hokkaido in Area North-East, Ibaraki in Area East, Chiba on the border between Area East and Area Middle, and Kochi in Area West—between 2000 and 2017.

Since the estimated catch at age in eq [5] is based on the landing data from major landing ports, there is a possibility that regional catch data is different from the total catch of an area in the statistics published by the Fisheries Agency of Japan. In such

case, the catch numbers at age for each area is stretched using the official catch statistics. Sum of the catch numbers of all areas is used as the catch numbers at age of the Pacific stock (Fig. 4).

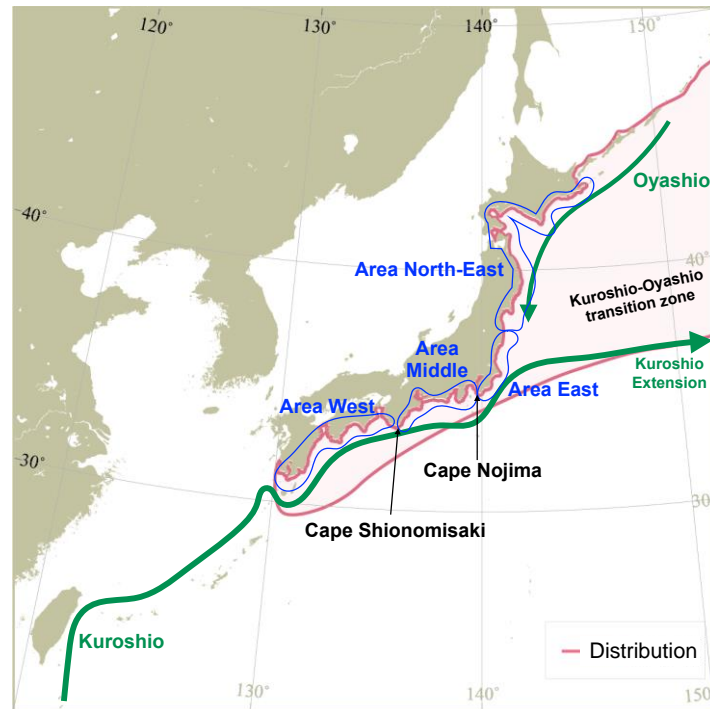


Fig. 1. Distribution of the Pacific stock of Japanese anchovy. The four areas enclosed by solid blue lines represent fishing ground divisions for estimating catch numbers at age.



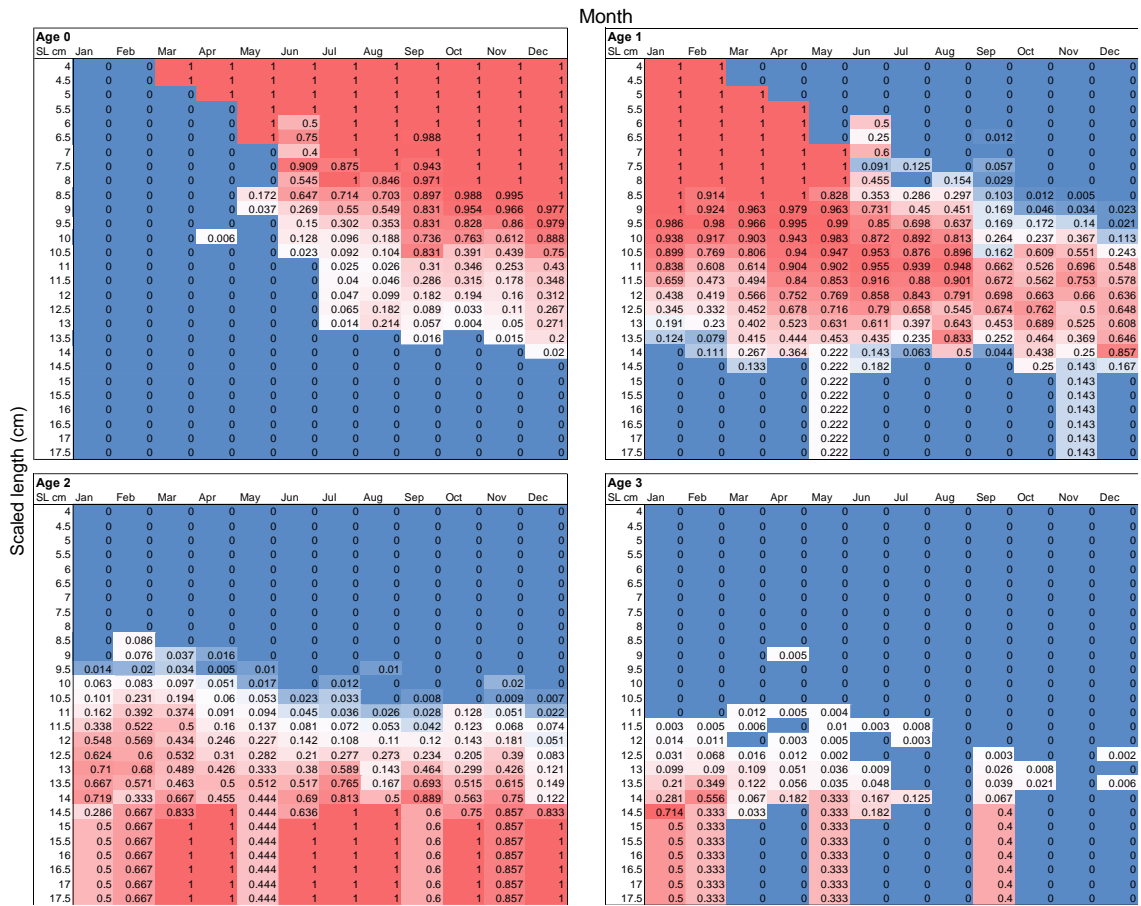


Fig. 3 Age-Length Key by month. Blue cells indicate 0% probability of presence, red cells indicate 100%, and a white to red gradient indicate values within 0% and 100%.

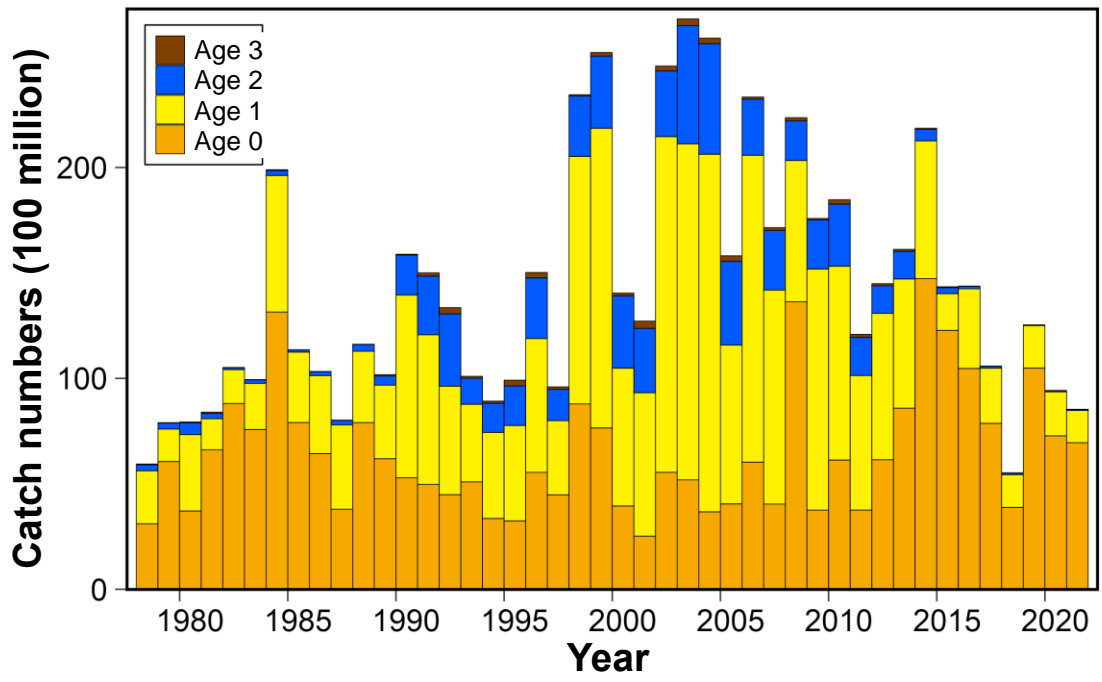


Fig. 4 Annual catch numbers at age.