Some Biological Parameters of Bigeye and Yellowfin Tunas Distributed in Surrounding Waters of Taiwan

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ABSTRACT

Biological information including seasonal/quarterly and/or sex-specific condition factors (CF), gonadosomatic index (GSI), fork length-body weight relationship (FL-BW) and sex ratios were examined for bigeye and yellowfin tunas distributed in surrounding waters of Taiwan. Results showed that fork length-body weight (FL-BW) relationship for bigeye tuna can be described as $BW = 5.856 \times 10^5 \times FL^{2.7884}$, and $BW = 3.799 \times 10^5 \times FL^{2.8537}$ for yellowfin tuna. The GSI value, in general, was higher in spring and summer (i.e., January to July) for yellowfin tuna, indicating that spawning activity of this species may mostly occur in the first half of the year. Condition factor of yellowfin tuna fluctuated seasonally for both sexes. There were essentially no relationship between GSI and CF, and between CF and sizes of fish for both species, indicating that change in CF seems to be not related to their maturity, and that feeding condition for different sizes of fish were similar for both species. In addition, sexual dimorphism with male fish predominant in almost all seasons and size classes for both species were discussed.
INTRODUCTION

The bigeye and yellowfin tunas are two of the most important tuna species distributed in surrounding waters of Taiwan. Total catch of these species landed in domestic ports of Taiwan has reached about 17,000 mt in 2001. Such an amount has accounted for about 34% of the total domestic catch of tuna and tuna-like fish in offshore tuna longline fishery.

Biological information such as age, growth, length, weight and sex ratio … etc. were important for not only understanding life history, but also for the stock assessment of the species. Thus, collection of biological information became the 1st step on studying fishery biology of the species. These information also are required for consideration of management measures of the species in the future. In this study, we reported biological information of two most dominant tuna species caught in the offshore tuna longline fishery operating in surrounding waters of Taiwan. We wish to establish basic and required biological information for future uses in stock assessment and management of these two species.

MATERIALS AND METHODS

Biological parameters of bigeye and yellowfin tunas were collected from Tung-Kang, the largest tuna longline fishing port of Taiwan from November 1999 to November 2000. These vessels mostly operate in surrounding waters of Taiwan (Figure 1). However, length and weight information were continuously collected in the same port up to February 2002. Body length (in centimeter) and initial weight (in kilogram) of fish were recorded after auction was completed for each shipment. Fish were then, processed by removing their fins, gills, guts, gonads...etc. completely. For each fish, the removed internal organs were then, gathered, weighted and recorded. Gonad weight and sex ratio were recorded separately. Because length and weight of some samples could not be recorded during processes of fish, thus, samples used for a specific analysis may differ in size. The condition factor (CF), gonadosomatic index (GSI) and sex ratio for each species were calculated as:
CF = [(whole weight – gonad weight)/(fork length)^3] * 10^5

GSI = (gonad weight/(whole weight-gonad weight)) * 100

Sex ratio = (number of female fish/total number of fish)

The CF and GSI were analyzed by species, sexes, seasons and sizes of fish. Statistical methods including t-test, ANOVA and covariance analysis were used to identify differences between sexes, sizes of fish and among seasons. All analyses were done using SAS program.

**RESULTS AND DISCUSSION**

**Fork length – body weight relationship**

Figure 1 showed the fork length - body weight relationship for male and female bigeye tunas collected in this region. Because covariance analyses showed no statistical difference (both slop and intercept) between sexes (Figure 2A), we decided to include all data (up to February 2002), which did not contain sex information for bigeye tuna, in the analysis (Figure 2B). The sexes-combined data showed that the following equation can be used to describe length – weight relationship of bigeye tuna:

\[
BW = 5.856 \times 10^5 \times FL^{2.7884}
\]

For yellowfin tuna, the fork length - body weight relationship for male and female fish were also no difference (Figure 3A). The sexes-combined result including data collected up to February 2002 (Figure 3B) showed that the following equation can be used to describe length – weight relationship of the yellowfin tuna:

\[
BW = 3.799 \times 10^5 \times FL^{2.8537}
\]

**Gonadosomatic Index and Condition factor**

Figure 4 showed monthly changes in gonadosomatic index (Figure 4A) and condition factor (Figure 4B) of yellowfin tuna. The GSI value, in general, was higher in spring and summer (i.e., January to July) for yellowfin tuna, indicating that
spawning activity of this species may mostly occur in the first half of the year.

Sex maturity for yellowfin tuna has been reported to be at about 52 cm (Bunag, 1956), 120 cm (Yuen and June, 1957) or 110 cm (Kikawa, 1962), depending upon regions. However, Kikawa (1962) indicated that female yellowfin attain first maturity at more than 110 cm in the western and central Pacific longline fishing grounds, although a few individuals were found to be matured at length between 80 to 110 cm. If it was true, then, all fish collected in this study can be considered as matured fish, and the GSI index may be considered as representative of spawning activity of fish. Wild (1994) reported that yellowfin tuna could spawn year-round in the northern equatorial waters of the western and central Pacific. However, Suzuki et al. (1978) also indicated that spawning of yellowfin tuna in the western and central Pacific Ocean in the Northern Hemisphere mostly occurred during spring and summer, thus, his result is consistent with the result presented in this study.

The condition factor of yellowfin tuna fluctuated seasonally for both sexes (Figure 4B). The relative high values occurred in February and May-July while low value occurred in March-April and September. Because GSI during March-April was not the highest, variations in CF observed here may reflect seasonal differences in feeding condition of fish. There was essentially no relationship found between GSI and CF for bigeye and yellowfin tunas (Figure 5A), indicating that changes in CF of fish are not related to their maturity for both species. Possible reasons are that fish collected here were not matured enough (i.e., did not contain hydrated eggs or matured gonads) to show the correlation, or feeding condition was not affected by maturation process of fish. More researches on feeding and spawning behaviors are necessary to clarify such a relationship.

There were also no relationship found between CF and sizes of bigeye and yellowfin tunas (Figure 5B), indicating that feeding condition for different sizes of fish were similar for both species. However, caution need to be paid in interpretation of this result as size of fish collected in this study only covered a range between 100-180 cm for both species.
Sex ratio

Our study also indicated that male fish predominant in almost all seasons and size classes for both yellowfin and bigeye tunas, although sex ratio were not statistically significant different in all season and size classes (Tables 1 and 2). A similar situation also can be found in the eastern Pacific region where a rapid decline in the percentage of female yellowfin around 140 cm was evident in all data sets examined (Wild, 1994). There was also a general tendency of predominance of male fish for bigeye tuna over the entire size range encountered (Kume, 1969). The dominance of males became more prominent as the size increased. They also reported no discernible seasonal change in sex ratio by size classes, although predominance of male fish also was observed depending upon sea surface temperature and areas. Possible explanations for these results are that female fish may experience differential mortality, growth and vulnerability to the fishery. Thus, further examinations on causes of sexual dimorphism for both species are required.

REFERENCES


Figure 1. Map showing sampling area of this study.
Figure 2. Fork length – body weight relationship for bigeye tuna with sex separated (A) and with sex combined (B) data.

BW = 5.856 x 10^{-5} \times FL^{2.7884}

n = 428 (Combined)

Female n = 48

Male n = 67
Figure 3. Fork length – body weight relationship for yellowfin tuna with sex separated (A) and with sex combined (B) data.
Figure 4. Monthly changes in (A) gonadosomatic index and (B) condition factor for yellowfin tuna collected in surrounding waters of Taiwan.
Figure 5. Relationships between gonadosomatic index and condition factor (A), and condition factor and fork length (B) for bigeye and yellowfin tunas collected in surrounding waters of Taiwan.
Table 1. Sample size by sexes and quarters for bigeye tuna and yellowfin tunas.

<table>
<thead>
<tr>
<th>Species quarter\sex</th>
<th>Bigeye</th>
<th>Yellowfin</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter sex</td>
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<td>male</td>
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<tr>
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</tr>
<tr>
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<td>7</td>
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</tr>
<tr>
<td>Q3</td>
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<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Q4</td>
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<tr>
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<td>230</td>
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</tbody>
</table>

* Chi-square test: significant at 5% level

Table 2. Sample size by sexes and sizes of fish for bigeye tuna and yellowfin tunas.

<table>
<thead>
<tr>
<th>Species length (cm)</th>
<th>Bigeye</th>
<th>Yellowfin</th>
<th></th>
</tr>
</thead>
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<td></td>
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<td>male</td>
</tr>
<tr>
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<tr>
<td>sum</td>
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</table>

* Chi-square test: significant at 5% level