Reproductive Characteristics of Big Eye
*Priacanthus macracanthus* in the East China Sea

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A total of 2,863 specimens of big eye *Priacanthus macracanthus* caught by bull trawl in the East China Sea and landed at Nagasaki Fish Market from May 1995 to February 1998, were examined to obtain information about their reproductive characteristics. From monthly changes in the gonadosomatic index, the spawning peak was estimated to be in May and June. From the distribution of oocyte diameters and histological observations of ovaries, the development process of oocytes was concluded to be of the group-synchronous oocyte development type. Maturation size was estimated to occur at 190 mm FL from the relationship between the fork length and the frequency of mature specimens. Batch fecundity was calculated to be about $7 \times 10^4$ at 190 mm FL and $23 \times 10^4$ at 250 mm FL from the relationship between fork length and number of mature eggs.

**Key words:** *Priacanthus macracanthus*, Reproductive characteristics, East China Sea

Big eye *Priacanthus macracanthus* is found in waters from southern Japan to the East China Sea, South China Sea, Andaman Sea, Indonesia and northwest and northeast Australia. This species distributes near the continental margin in depths of over 70 meters from the east of Cheju Island to the north of Taiwan in the East China Sea. South of $30^\circ$N its main distribution occurs at depths of 80 to 120 meters. The Japanese catch of this species from the East China Sea is taken by bull trawl and the majority of this catch is landed at the Nagasaki Fish Market. According to catch statistics about 5,400 tons were recorded in 1983, but subsequently the catch has gradually decreased and in 1996 was about 1,200 tons. Stocks of many species caught by bull trawl in the East China Sea have been decreasing, and Tokimura stated that more effective fishery management is necessary.

Recently information about age and growth of big eye in the East China Sea has been estimated from mesopertegoid readings. In the 1970's and 1980's, information on the reproductive characteristics of this species in the East China Sea including the spawning season was estimated from the distribution of larvae and juveniles and monthly changes of the gonadosomatic index.

The purpose of the present study is to update this information on the reproductive characteristics of big eye and to formulate management proposals of the fishery in the East China Sea.

**Materials and Methods**

A total of 2,863 specimens (1,140 specimens of male and 1,723 specimens of female) of big eye were used in the present study. They were caught by bull trawl in the East China Sea and landed at Nagasaki Fish Market from May 1995 to February 1998.

Figure 1 shows the location of stations where the present samples were caught by bull trawl. The ovaries were weighed and preserved in 10 percent buffered formalin. The gonadosomatic index (GSI) was calculated using the following equation:

$$GSI = \frac{GW}{BW} \times 10^2$$

**Fig. 1.** The East China Sea showing the location of stations where the specimens were caught by bull trawl. Each square indicates an official block.
where \( GW \) is the gonad weight and \( BW \) is the body weight in g. According to the comparison of the frequency distribution of oocyte diameter in each portion of ovaries, there was no difference in the maturation state between different portions of the two ovaries. Thus, a sample was taken from the middle part of the left ovary for measurement of the oocyte diameters and for histological observations. Oocyte diameters were measured to the nearest 0.05 mm with a Nikon Profile Projector (122 specimens), omitting those smaller than 0.05 mm in diameter. Ovary samples for histological observations were prepared using the paraffin method and stained with Delafield haematoxylin and eosin (83 specimens).

Results

Gonadosomatic Index and Spawning Season

Gonadosomatic index was calculated to estimate the spawning season of the fish. Figure 2 shows monthly changes of the gonadosomatic index of females from May 1995 to February 1998. Specimens with high values were observed from April to September, and a peak was observed in June in females. On the other hand, the index for males gave high values from March (Fig. 3). The peak of male GSI was observed in May and June, and the index was reduced after May.

Maturation of Oocytes

The maturation process was examined from the frequency distribution of oocyte diameter and from histological observations of oocytes. We adopted the stages defined by Sato and classified the maturation conditions into the following 4 phases. Oocytes under 0.05 mm were omitted after for phase II to clarify the distribution of developing and mature eggs.

Phase I: Oocytes smaller than 0.15 mm diameter, being at the chromatic nucleolus, peripheral nucleolus or yolk vesicle stages (Figs. 4; 5-I).

Phase II: Oocytes reach to 0.35 mm diameter with two modes, being from the peripheral nucleolus to the later yolk globule stages (Figs. 4; 5-II).

Phase III: The most advanced oocytes reach 0.55 mm, forming a distinct batch with a mode of around 0.45 mm diameter. Oocytes of more than 0.40 mm diameter are at the migrating nucleus stage (Figs. 4; 5-III).

Phase IV: The most advanced oocytes with a mode of

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Fig. 2. Monthly changes of gonadosomatic index in females from May 1995 to February 1998. X axis indicates frequency.

Fig. 3. Monthly changes of gonadosomatic index in males from May 1995 to February 1998. X axis indicates frequency.

Fig. 4. Frequency distribution of oocyte diameters in each maturity phase. Oocytes under 0.05 mm are omitted after phase II to clarify the distribution of developing and mature eggs.
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Fig. 5. Photomicrographs of ovaries in various maturation phase.
- pn: peripheral nucleolus stage
- yv: yolk vesicle stage
- eyg: early yolk globule stage
- lyg: later globule stage
- mn: migrating nucleus stage
- pm: prematuration stage
- efc: empty follicle cell
d: decaying oocyte.

Around 0.6 mm diameter reach the prematuration stage. In some specimens empty follicle cells and decaying oocytes were observed in the ovary as well as the developing oocytes (Fig. 5-V).

Maturation Size of Female
The big eye examined here were 304 female specimens landed at Nagasaki Fish Market in May and June of 1995, 1996 and 1997. Discrimination of mature specimens was defined from observations of mature eggs in the ovary. Since we could not find specimens with ovulated eggs in the present examination, the oocytes in the distinct batch at the migrating nucleus and the prematuration stage (Phase IV) were regarded as mature eggs. The relationship between the fork length and the frequencies of mature specimens is given in Fig. 6. Assuming that the 50 percent occurrence of mature specimens is the maturation size, this occurs at 190 mm FL.

Estimation of Batch Fecundity
We estimated batch fecundity from the relationship between the fork length (FL) and the batch fecundity (E) from 26 specimens (184-258 mm FL) collected during the spawning season. This relationship between the fork length and the batch fecundity is given in Fig. 7. The regression line is:

\[ E = 1.972 \times 10^5 e^{0.018FL} \]

The batch fecundity was estimated to be \(7 \times 10^4\) at 190 mm FL (2 years old), and \(23 \times 10^4\) at 250 mm FL (3 years old).

Discussion
From the monthly changes of the gonadosomatic index from May 1995 to February 1998, the spawning peak of big eye in the East China Sea was estimated in May and June. Yamada and Ikemoto\(^9\) stated that the spawning season of big eye in the East China Sea was from April to June from the appearance of larvae and juveniles in the East China Sea. Shojima\(^6\) examined monthly changes of the gonadosomatic index from April 1982 to March 1983, and reported that big eye in the East China Sea spawned from May to July. These results agree closely with the present study.

From the oocyte diameter distribution and histological observations of the ovaries, the development process of oocytes of big eye were concluded to show a group-synchronous oocyte development type. Rao\(^9\) reported that big eye spawned once in the spawning season. Lester and Watson\(^10\) concluded that many specimens in the South China Sea spawn twice in the season from observations of
mature ovaries. From histological observations of maturation ovaries in some specimens in the present study, empty follicle cells and decaying oocytes were observed in the ovary as well as the developing oocytes. Thus, big eye in the East China Sea are suggested as having two or more spawnings per season.

Maturation size was estimated at 190 mm FL at an age of 2 years old. The miniaturization of the maturation size with the decrease of stock has been reported in greater lizard fish Saurida wanieio, and yellow croaker Pseudosciaena polyactis, and yellow sea bream Dentex tumifrons. According to aural survey of broker at Nagasaki Fish Market, it was said that the specimens which have mature eggs in the spawning season have became smaller. Thus, the maturation size of the fish in the East China Sea is considered to have become smaller.

Batch fecundity was estimated to be $7 \times 10^4$ at 190 mm FL (2 years old), and $23 \times 10^4$ at 250 mm FL (3 years old). In the southwest of Taiwan, it was reported that the batch fecundity increased with growth, and the batch fecundity at 230 and 290 mm FL was calculated at $11 \times 10^4$ and $32 \times 10^4$. The batch fecundity was reported to $15 \times 10^4$ at 250 mm FL in the South China Sea, and the average batch fecundity from 196 to 244 mm FL was calculated to be about $11 \times 10^4$ in the Indian Ocean.

References