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Population Dynamics of the Caroun Croaker *Johnius carouna* (Cuvier, 1830) in Coastal Fishing Ground in the Middle Gulf of Thailand

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Abstract

The stock status of coastal species is currently of high concern among the people. In the Gulf of Thailand, Croakers are important economic species commonly found in the coastal fishing ground, especially in Nakhon Si Thammarat province. The population dynamics of the Caroun croaker, *Johnius carouna* (Cuvier, 1830), was investigated using length-frequency distribution data collected from February 2019 to January 2020. The length-weight relationship equation suggested that *J. carouna* is isometric growth. The asymptotic total length (L_∞) and curvature growth (K) were 22.28 cm and 0.72 year^{-1}, respectively. Based on L_∞ and K, the total mortality rate during the study period was estimated at 3.66 year^{-1}; natural mortality and fishing mortality rates were estimated at 1.62 and 1.74 year^{-1}, respectively. While biological data revealed that matured size was 15.3 cm, the fishing data suggested that the average catch size (15.12 cm) was slightly smaller than the matured size. The exploitation rate was 0.52 year^{-1}. The result from this research suggests that current fishing pressure is slightly high. This study suggested that increasing catch size by increasing mesh size of gillnets seems to be a better solution to improve *J. carouna* stock in Thasala fishing ground in the future.

Keywords: Croaker population, Local fishery, Coastal species, Fishery management

Introduction

Croakers or drums are important fishery resources in the shallow warm seas and estuaries of the world. The Caroun croaker (*Johnius carouna*) is one of the coastal fish widely distributed along shallow coastal waters. Based on catch composition, this fish species is dominantly observed from the north to southern China to the West India, especially Gulf of Thailand [1]. *Johnius carouna* is euryhaline and can be found in freshwater, brackish-water and marine habitats but frequently occurs in coastal zone because they serve as the main feeding ground for *J. carouna*, which feeds on small fish, crustaceans, worms and insects [1]. As the stock of most target economic species is overfishing and rare [2], the next economic species such as croakers are subsequent fishing target. Although the current state of *J. carouna* has not yet been evaluated and scientific support for improving stock status is currently limited, demand and fishing pressure on this species is thought to have increased. This is because *J. carouna* became dominant in numbers when considering catch composition from coastal fishing ground.

One of the important fishing grounds of *J. carouna* in the Gulf of Thailand is Thasala coastal area, Nakhon Si Thammarat province. Several types of bottom gillnets can catch croakers in this zone, such as croakers gillnet, shrimp gillnet, local mackerel gillnet, etc. The fishermen in this zone have experienced a decrease in *J. carouna* population, which resulted in a limited catch. This is possibly due to the over-fishing of this species. In Thasala fishing ground, fishers applied restored methods e.g., constructing artificial fish habitat to increase fish abundance in the fishing area.

Recently, there is no established information on the biology and population dynamics of *J. carouna* in Thai waters. The population dynamics and size at maturation of *J. carouna* in Thasala coastal area are desired to support appropriate fisheries management. Therefore, this paper presents the population parameters and the relative yield per recruit of *J. carouna*. The findings are necessary to understand stock situation and can be applied for improving Caroun croaker stock in coastal zone area, Southern Thailand.

Materials and methods

Three sampling sites were selected (**Figure 1**), and fixed by using the Garmin-GPSmap 76CSx. The field samplings were conducted from February 2019 to January 2020. Samplings were conducted monthly during the spring-tide period in general coastal fishing ground within 5,000 m from coastal line. The fish samplings were conducted by using 3 dominant gillnets caught Croaker, which are drum gillnet, shrimp gillnet and mackerel gillnet. Every type of sampling gears was operated during day time (7 am - 2 pm). Three sampling stations were designed to represent Thasala coastal area, and 3 replications for each gear were collected at each station. Fish samples were packed and kept in ice then brought to Walailak University about 20 km from the coastal line. Species identification was made, and *J. carouna* in the subsamples were measured in terms of total length (TL, to the nearest 0.1 cm) and weighted (to the nearest 0.1 g).

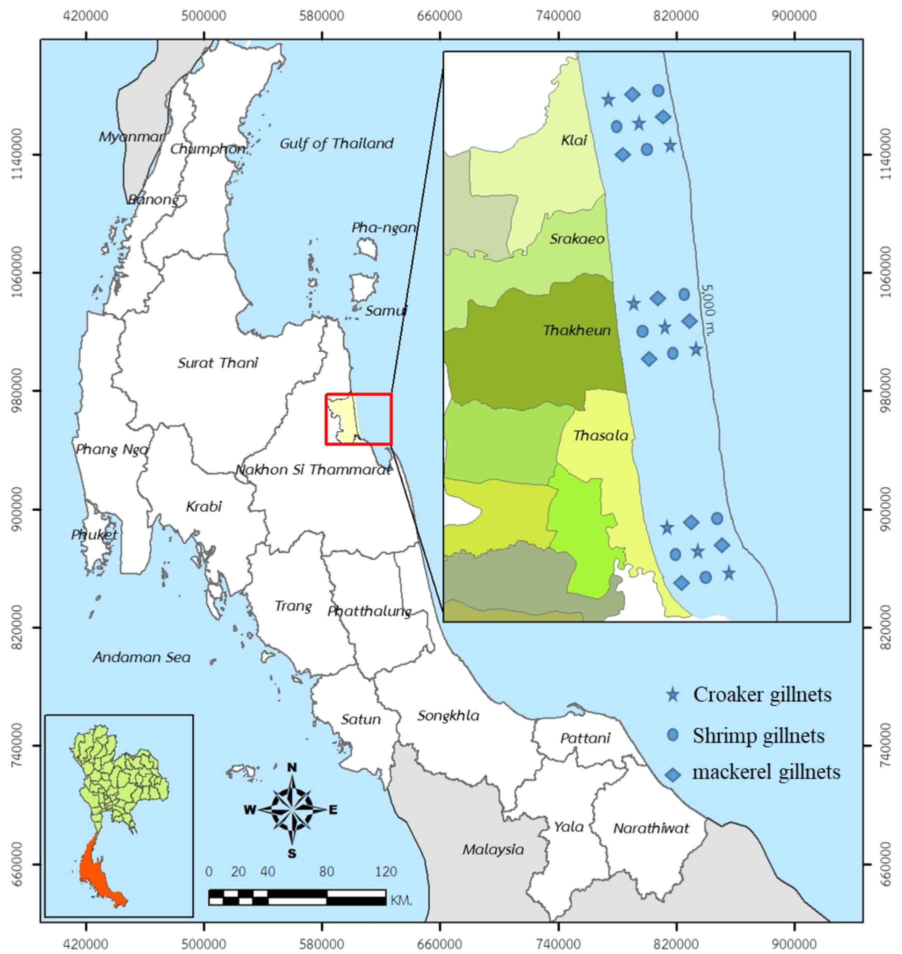

Figure 1 Thasala coastal area and sampling sites.

Data analysis

Length-weight relationship was calculated by fitting power function (Eq. (1)) [3].

$$W = aL^b \tag{1}$$

where W represents weight (g); L represents total length (cm), a is the intercept (condition factor) and b is the slope (growth coefficient). The constraints a and b and the coefficient of determination (R^2) were calculated using power regression to show the correlation level of the relationship. Test of b as 3 was also performed to confirm the isometric growth. Length frequency data (LFD) was classified into 0.5 cm intervals. The "FiSAT II" (FAO-ICLARM Stock Assessment Tool) software [4] was used as a tool for predicting parameters for the von Bertalanffy growth formula (Eq. (2)):

$$L_t = L_\infty[1 - \exp(-K^{(t-t_0)})] \tag{2}$$

where, L_t is the predicted length at age t (cm), L_∞ is the asymptotic length (cm), K is the curvature parameter (year^{-1}) and t_o is the "age" at which $L_t = 0$ [5]. L_∞ and K were estimated as described by [6] and t_o was therefore obtained from the empirical equation (Eq. (3)) [7]:

$$\log10(-t_0) = -0.3922 - 0.2752\log10(L_\infty) - 1.038\log10(K) \tag{3}$$

Phi-prime value ($\emptyset$) is applied for validation of growth parameters estimation that obtained from Eq. (4) [8]:

$$\emptyset = \log10(K) + 2\log10(L_\infty) \tag{4}$$

Maturity size of *J. carouna* was estimated by using logistic function model (Eq. (5)) [10].

$$P_L = \frac{1}{1+e^{(a+bL)}} \tag{5}$$

where, P_L is the proportion of matured fish per total fish, L is mid-length of size class interval, a and b are constants.

The natural mortality rate (M) was estimated from the empirical linear relationship model of Pauly (1980), using an average surface water temperature (T) in Thasala coastal zone of 30.0 °C (Eq. (6)).

$$\log10(M) = -0.0066 - 0.279\log10(L_\infty) + 0.6543\log10(K) + 0.463\log10(T) \tag{6}$$

The LFD were converted to age - frequency distribution via Eq. (7):

$$t = \left[(\frac{1}{K})\ln(\frac{L_\infty}{L_\infty - L_t})\right] + t_0 \tag{7}$$

The total mortality rate (Z), was then estimated from the length-converted catch curve in which the natural logarithms of the numbers in each age class were plotted against age [10,11]. The fishing mortality rate (F) was calculated as Z - M and the exploitation rate (E) was then estimated as F/Z. The recruitment pattern was figured out through LFD and incorporated the parameters from VBGF. Probabilities of capture were estimated from the selection of LFD. The analyses of the Y'/R were performed by the FiSAT II program. The input parameters of Y'/R model are the asymptotic length (L∞), the curvulture parameter (K) and natural mortality rate (M) [12].

Results and discussion

A total number of 1,232 individuals (513 males and 719 females) were analyzed. Length range of *J. carouna* were 8.0 - 22.5 cm and average length was 15.7 ± 1.50 cm. Weight range of fish samples were 9.4 - 150.1 g. and the average weight was 49.6 ± 15.9 g. This data showed that various sizes of collected fish were included as this was a requirement of input data for estimating crucial parameters related to population dynamics.

The length-weight relationship of male, female and total *J. carouna* (Eqs. (8) - (10)) had high R^2 value (0.89, 0.84 and 0.87, respectively) and the exponent was not significantly different from 3 (p-value > 0.05).

$$W = 0.0111L^{3.036} \tag{8}$$

$$W = 0.0151L^{2.9332} \tag{9}$$

$$W = 0.0117L^{3.0223} \tag{10}$$

From constructed equations, it is assumed that males and females *J. carouna* are an isometric species (i.e. the increase in weight is same proportional to the length; **Figure 2**). Length-Weight relationship of fish and shellfish have been studied widely in all parts of the world by several researchers because it is an initial study for population dynamics study that is very important information supporting fishery management plan [13]. Different values for the exponent coefficient (b) for differed fish species and locations related to variation of ecological conditions have been recorded [14]. Previously, a pioneer researcher pointed out that the exponent coefficient (b) computed from length and weight relationship is usually 3 [15]. However, later researchers [16] argued that the b value is very close to 3 but varies from 2.5 - 3.5. These statements could be supported by the previous work carried out for various other Croaker species for example, 3.034 for *Otolithes cuvieri* in Bombay waters of India [17], 3.030 for *Johnius dussumieri* in Beibu Gulf of China [18], 3.100 for *Nibea soldado* in Sibuti River, Sarawak of Malaysia [19], 2.630 for *Otolithes ruber* in southwestern coast of Taiwan [20], 3.069 for *Daysciaena albida* in Narreri Lagoon of Pakistan [21]. Therefore, this b value cannot be simply compared for consistency as these are different species and habitats.

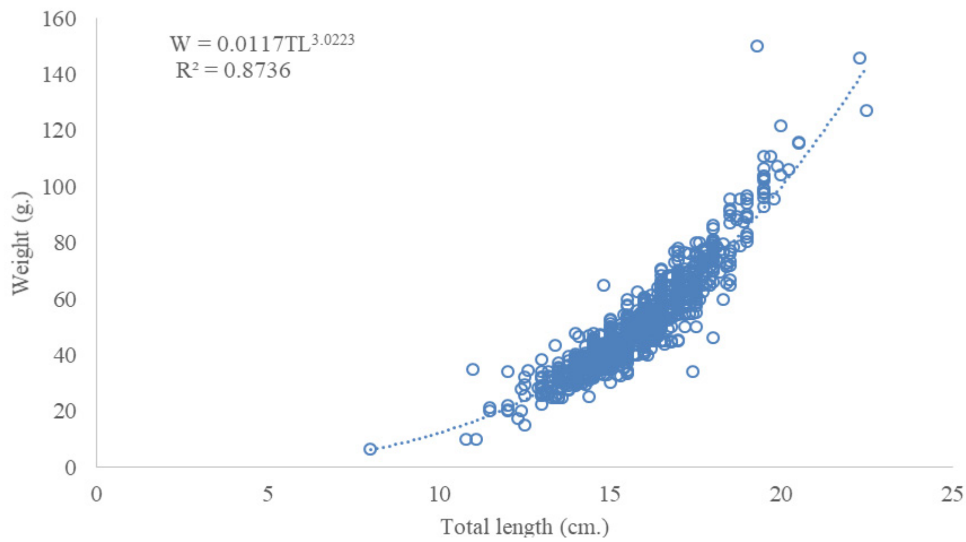

Figure 2 Length-weight relationship of total fish samples.

The growth curves superimposed on monthly LFD are shown in **Figure 3**. Growth parameters from the von Bertalanffy growth formula for *J. carouna* were estimated as $L\infty$ = 22.28 cm and K = 0.72 $year^{-1}$. For these estimates through ELEFAN I, the index of goodness-of-fit of the growth curve (Rn) was 0.198. Principally, growth parameters are crucial factors in modelling aquatic ecosystems. There are many factors, such as environmental surroundings, food availability and hydrological conditions among different geographical and seasonal situations could influence the development of marine animals [22,23]. Unfortunately, there is no publication related to growth parameters of *J. carouna.* Therefore, the discussion on variation of growth parameter of this species is very limited. However, considering other Croaker species in Asian stock, the difference of growth parameters of same species but different habitats is published such as the $L\infty$ of Donkey croaker observed from Brunei Darsm (29 cm), Malaysia (30 cm) and India (36 cm) [24-26]. Phi prime was used as reliability index for the estimated growth parameters. The result suggested that the phi prime value of *J. carouna* was 2.55 which was similar to phi prime value from another study that investigated growth parameters of *Dendrophysa russelii* (∅ = 2.54) in the inner Gulf of Thailand [27].

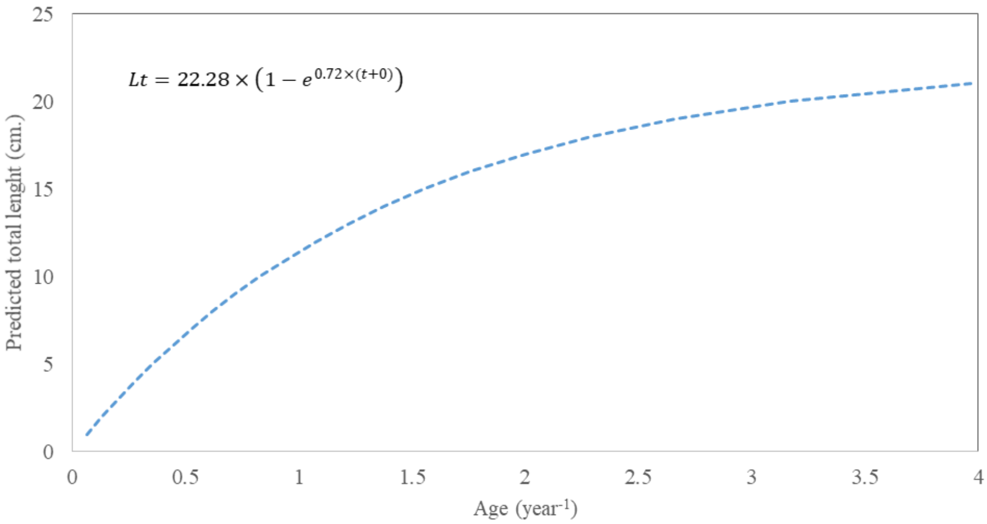

Figure 3 Predicted growth curve of *J. carouna*, based on Von Bertalanffy's growth function.

The length at 50 % of maturity, L_m of *J. carouna* was 15.3 cm (**Figure 4**), indicating it takes about 1.5 year to approach L_m. From the length converted catch curve, the total mortality (Z) was 3.36 $year^{-1}$, with an R^2-value = 0.9901 and a confidence interval of the Z-value were between 3.06 and 3.66. While natural mortality (M) was 1.62 $year^{-1}$, from the obtained values of M and Z, therefore, the F-value was 1.74 $year^{-1}$ and the exploitation rate (E) was 0.52 (**Figure 5A**). From the probability of capture analysis (**Figure 5B**), LC_{50} of *J. carouna* was 15.12 cm, which was slightly smaller than maturity size (15.3 cm). This finding indicated that the current fishing gears, several types of gillnets, caught slightly small fish are slightly overexploited because the fishermen catch small fish ($LC_{50} < Lm_{50}$).

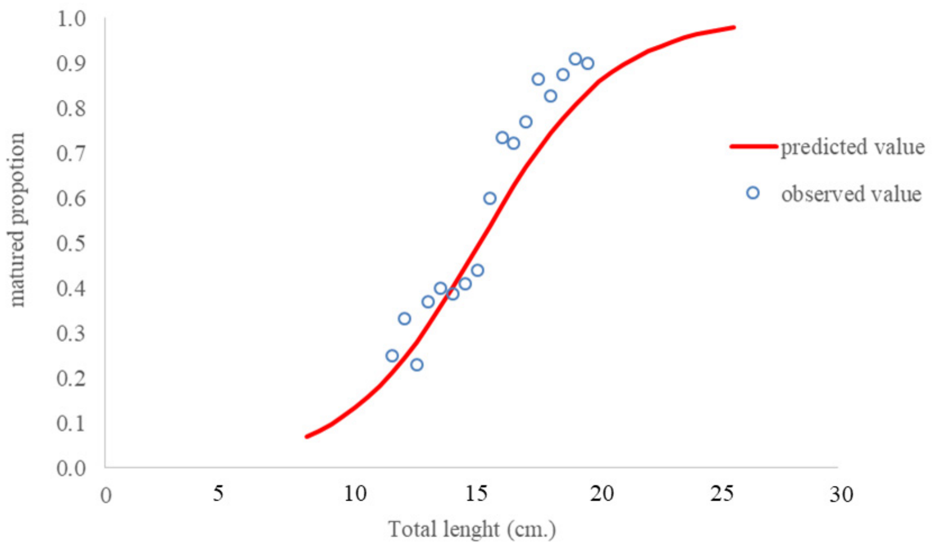

Figure 4 The length at 50 % of maturity of *J. carouna* in Thasala coastal zone.

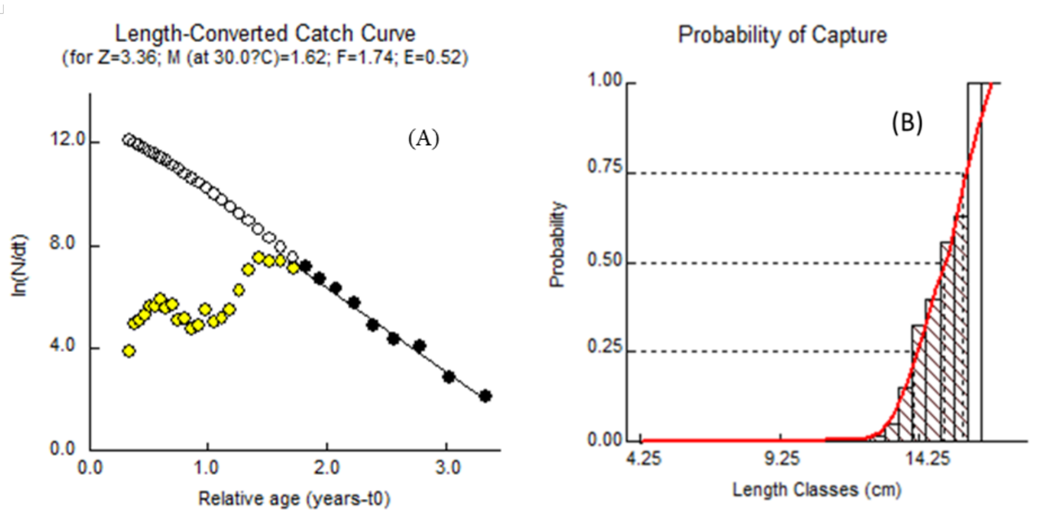

Figure 5 Length converted catch curve (A) and probability of capture (B) of *J. carouna* in Thasala coastal zone.

The recruitment was continuous with a single peak per year. The peak of recruitment was found in the seasonal-change periods that are the late summer season change to the early rainy season, between May and October (**Figure 6A**). A trend of over-exploitation was observed because the exploitation rate (0.52) was higher than optimum level (E = 0.5). The higher value of E is indicative of over-fishing during the studied period. This assumption is based on [28], in which suitable yield is optimized when F = M, (i.e. when E is more than 0.50 the stock is generally considered to be over-fished). Although E_{max} (0.703), from relative yield per recruited study, implied that fishers can increase fishing effort to *J. carouna* stock, the biological data disagreed with that way because the capture size is recently smaller than maturity length. Therefore, retaining fishing effort level but increase capture size, by increasing mesh size of gillnets seems to be better solution for Thasala fishing ground. Moreover, by increasing Lc, a yield of *J. carouna* will be increased and improve *J. carouna* stock in Thasala fishing ground. .

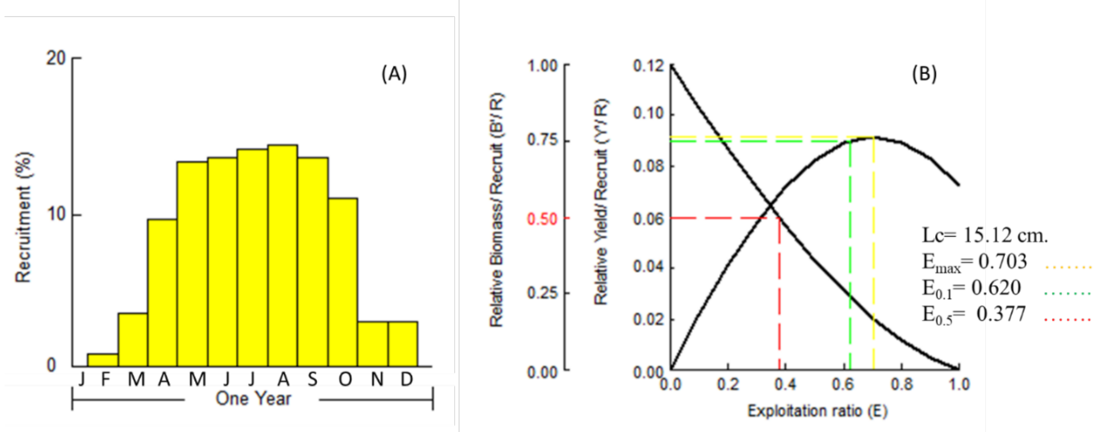

Figure 6 The percentage monthly recruitment (A) and Relative yield per recruitment (B) of *J. carouna* in Thasala coastal zone.

Conclusions

The findings of this study indicated that *J. carouna* population is currently faced with quite high fishing pressure situation in the area of study. The result from yield per recruitment suggested that the increase of captured fish size (> 15.3 cm) by increasing local bottom gillnet mesh size, or operating fishing zone will be a better solution for *J. carouna* fishery. In addition to the best of our knowledge, as no academic publication currently exists on the population dynamics of *J. carouna*, the parameters obtained from this study are useful fundamental factors applicable in future fishing management trials as well as in technical restoration studies.

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