Maximum Sustainable Yield Assessment for Pelagic Fish in the Andaman Sea Thailand

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Abstract

Thailand is located in a tropical sea and is the habitat of multiple fish species. Thailand therefore classifies aquatic animals into 3 groups: demersal fish, pelagic fish, and anchovies for the convenience of management. Maximum sustainable yield (MSY) assessments are conducted annually for three groups of fish. Fox surplus production model was used to estimate the MSY of the aquatic species group. Among pelagic fish, the important economic fish are mackerel, sardines, and scads. The MSY of pelagic fish group in Andaman Sea was 118,042 tons at the fishing effort (F_{msy}) of 64,524 days. While, the catch in 2022 was 114,231 tons with the fishing effort of 49,264 days. Results showed that pelagic fishing is currently being conducted at fishing effort levels consistent with Fmsy. For monitoring a status of some species of pelagic fish that by using length-based Tomson and bells model. Three species were selected to estimate: short mackerel *(Rastrelliger brachysoma)*, Indian mackerel *(R. kanagurta)* and goldstripe sardinella *(Sardinella gibbose)* using length-frequency data in 2022. The results showed F-factor values of 3.2, 3.2, and 0.4 respectively indicating that the current fishing effort of short mackerel and Indian mackerel were lower than their fishing effort level which could produce MSY (Fmsy) while the current fishing effort of goldstripe sardinella was over its Fmsy level.

Key words: maximum sustainable yield, pelagic fish, short mackerel, Indian mackerel, goldstripe sardinella, Andaman Sea

1. Introduction

The Andaman Sea is an important fishing area in Thailand, located in the southeastern part of the Bay of Bengal. It is part of the Indian Ocean and is a semi-enclosed tropical sea. It is surrounded by Myanmar, Thailand, India, Indonesia and Malaysia and covers an area of approximately 797,700 square kilometers. It has an average depth of 1,096 m. and a maximum depth of 4,198 m. The produce of the Andaman Sea is divided into 3 groups as demersal fishes, pelagic fishes, and anchovy for the convenience of management among these, the most important economic fish were pelagic fishes.

Thailand's fisheries management system changed from open-access fishing to restricted-access fishing in 2015. The aim is to manage fisheries both inside and outside Thai waters for the sustainability of fishery resources. The Royal Ordinance on Fisheries 2015 determine that fishing licenses be issued based on biological reference points. The MSY is used in the annual assessment of three fish groups. The results of the MSY assessment are used to determine the Total Allowable Catch (TAC) for each species group, and TAC is allocated to each fishing vessel in Thai waters. It will be specified in the fishing license of both artisanal and commercial fishing vessels.

The purpose of this paper is to describe models used to estimate biological reference points for a group of pelagic fishes in the Andaman Sea by finding the maximum sustainable yield (MSY) and fishing effort at MSY (FMSY) by Fox surplus production model and assess the stock status of some species of pelagic fishes for monitoring by length-based Thompson and Bell Model.

2. Material and Methods

The data for estimation included the data collection of total catch (ton), fishing effort data between 2001 to 2022 from both artisanal fishing gears and commercial fishing which Thai purse seine was used as the standard fishing gear and the length-weight frequency (monthly data) in 2022 were recorded and collected by the Department of Fisheries of Thailand.

Estimating biological reference points for water management in Thailand uses MSY for 3 groups of species, i.e., demersal fish, anchovy, and pelagic fish, by using the Fox surplus production model (Fox, 1970). The Fox Model is a surplus production model that assumes Gompertz population growth under equilibrium conditions. As fishing effort increases

Biomass will decrease. This results in a negative relationship between catch per unit effort (CPUE) and effort. The estimation of the Fox model of catch per unit effort (CPUE) by equation;

$$\ln CPUE_i = c + dE_i$$

where $CPUE_i$ = catch per unit effort in year i

E_i = fishing effort in year i

c, d = regression coefficients

When c and d are estimated from the CPUE, the maximum sustainable yield (MSY) can be calculated according to the equation below.

$$MSY = -\left(\frac{1}{d}\right)e^{c-1}$$

And the estimation of fishing effort at MSY (F_{msy}) by equation;

$$F_{msy} = -\left(\frac{1}{d}\right)$$

To monitor the status of some species of pelagic in addition to estimating MSY using the Fox model by a group of species. To estimate the MSY for a single species, the length-based Tomson and Bells model is used. The Tomson and Bells model is a predictive model. It predicts the impact of changes in fishing effort by numerically calculating the population and biomass of the cohort.

For utilizing length-frequency data, Thompson and Bell expanded the model to a length-based model. For converting age to length, growth is assumed by von Bertalanffy's growth curve. Several calculations were conducted in order to observe the changes in fishing effort by multiplying the F-factor by the current fishing mortality. From the result, this analysis predicts MSY and F-factor for MSY. The equations are as follows;

$$Z_i = M + X * F_i$$

$$N(L_{i+1}) = N(L_i) * \frac{\frac{1}{H_i} - \frac{XF_i}{Z_i}}{H_i - \frac{XF_i}{Z_i}}$$

$$H_i = \left[\frac{L_\infty - L_i}{L_\infty - L_{i+1}}\right]^{\frac{M}{2K}}$$

$$C_i = [N(L_i) - N(L_{i+1})]\frac{XF_i}{Z_i}$$

$$\overline{w}_i = q\left[\frac{L_i + L_{i+1}}{2}\right]^b$$

$$Y_i = C_i \cdot \overline{w}_i$$

$$Y = \sum C_i \cdot \overline{w}_i$$

where Z_i = total mortality in the length class *i*

M = natural mortality

X = F-factor

F_i = current fishing mortality in length class *i*

H_i = natural mortality factor in length class *i*, calculated from natural mortality *M* and the parameters of von Bertalanffy's growth curve L_∞ and *K*

C_i = predicted catch in number in the length class *i*

$\overline{w}_i$ = average weight of the fish in the length class *i*, calculated from parameters of length-weight relationship *a* and *b*

The yield for length class i is calculated by C_i and $\overline{w}_i$ and total predicted yield Y can be calculated by the summation of Y_i, which is a function of F-factor X. Changing X, maximum yield Y can be found which is MSY, and the X providing MSY is the relative effort for MSY comparing to the current fishing effort.

3. Result and discussion

3.1 Fox model

The data used in the assessment is data from 1998 - 2022. The assessment results found that MSY is equal to 118,042 tons. The fishing effort at the MSY (Fmsy) is equal to 64,524 days. while, the catch in 2022 is equal to 114,231 tons and the Fmsy was equal to 49,265 days (Figure 1)

MSY and corresponding effort levels were compared with annual catch and effort figures used to assess the ecological sustainability of fish harvests. If the total catch exceeds the MSY level that shows fishery is not sustainable. Based on the result of the Fox model shows that pelagic fish in the Andaman Sea in 2022 was in the situation with no overfishing.

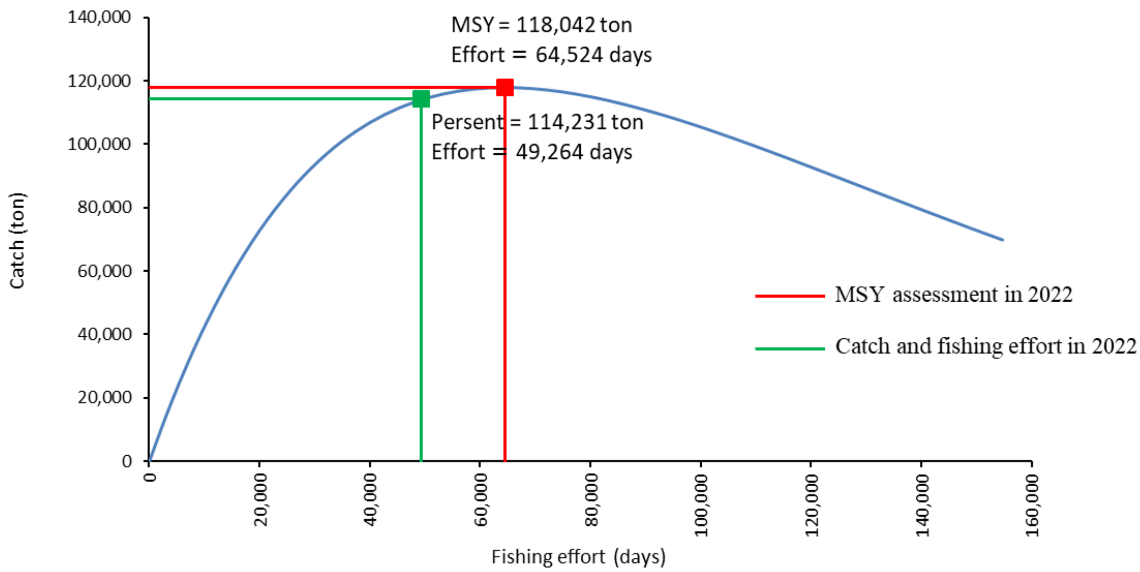

Figure 1 Maximum sustainable yield and fishing effort assessment of pelagic fish in the Andaman Sea, 2020 by using Fox surplus production model.

The catch of pelagic fish in the Andaman Sea in 2022 was lower than its MSY. This was due to the implementation of a fishing day scheme instead of catch control. Once the MSY assessment is finalized, the total allowable catch (TAC) is determined based on MSY. In 2022 – 2023, TAC was set at 95% of MSY. TAC is then allocated to artisanal fishing vessels, commercial fishing vessels operating low efficient fishing gear, i.e., gill net, and commercial fishing vessels operating highly efficient fishing gear, i.e., purse seine. The number of fishing days of purse seiners is determined by using CPUEs of different vessel sizes multiplied by various numbers of fishing days. The result of this step is estimated catch by vessels. The maximum number of fishing days, which the total estimated catch from all vessels does not exceed the TAC, is given to purse seiners. In 2021 - 2023, the number of fishing days for purse seiners is 255 days/year.

3.2 Thompson and Bell model

The pelagic fishes selected are three species to assess single-species MSY include Rastrelliger brachysoma; short mackerel, R. kanagurta; Indian mackerel, and Sardinella gibbosa; goldstripe sardinella. Length frequency data of selected species were collected from purse seine monthly from January to December 2022. However, length frequency data of neritic tunas were not used with the model due to they are transboundary species, and the length data obtained was considered not to cover the whole stock.

The results of three pelagic species disclosed that F-factor were 3.2, 3.2, and 0.4 respectively indicating that the current fishing effort of short mackerel and Indian mackerel is below the level of fishing effort. that produced 220% MSY (Fmsy) for both species. While the current fishing effort of goldstripe sardinella was over its Fmsy by 60% (Table 1).

Table 1 Maximum sustainable yield of some pelagic species in the Andaman Sea in 2022 by using length-based Thompson and Bell model

Scientific name	Common name	Catch in 2022 (ton)	MSY (ton)	F-factor	Status of fishing effort
Rastrelliger brachysoma	Short mackerel	11,302.00	12,780.00	3.20	220% under MSY
R. kanagurta	Indian mackerel	11,609.00	15,258.00	3.20	220% under MSY
Sardinella gibbosa	Goldstripe sardinella	13,342.85	14,261.21	0.4	60% over MSY

4. Conclusion

The MSY of the pelagic fish group in the Andaman Sea is currently being fished at levels below the MSY. The fishing effort level is consistent with Fmsy based on estimates using Fox surplus production model. While the result of the length-based Thompson and Bell model was used to monitor the status of a selected pelagic fishes 3 species showed that the current fishing effort of short mackerel and Indian mackerel were lower than their Fmsy by 220%. And the current fishing effort of goldstripe sardinella was over its Fmsy level by 60%.

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