# 主論文の要約

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学 位 論 文 題 目

Stock assessment of elasmobranch in Southeast Asia using yield per recruit and spawning per recruit analyses

（東南アジアにおける板鰓類の YPR・SPR 解析を用いた資源評価）

**Background and Objectives**

The subclass Elasmobranchii comprises cartilaginous fishes that have a long history of evolution and adaptation that dates back to the early Devonian (400 million years ago). Because of their low resilience life histories with relatively long lifespans and slower growth rates than teleosts, elasmobranch biology and stock assessment have been studied worldwide. Despite the susceptibility of elasmobranchs to modern fishing methods, catch data of elasmobranchs, especially sharks and rays, are limited in many regions including Southeast Asia. As a result, stock assessment using data collected at the regional levels is limited. To develop a reliable data collection process, the Southeast Asian Fisheries Development Center (SEAFDEC) conducted a project during 2015-2016 called “Regional sharks, rays and skates data collection” at 11 pilot sites in 6 member countries. During the project, 163 tons of sharks and 253 tons of rays were landed. Using the data collected from the project, this study aimed to determine the stock status of elasmobranchs in Southeast Asia by conducting stock assessment with yield per recruit (YPR) and spawning per recruit (SPR) analyses.

**Materials and Methods**

The target species for the stock assessment were selected based on the availability and reliability of monthly length-frequency data, which should be continuous with at least 200 samples per year. The length-weight relationship of each species selected was analysed, and outliers were omitted. Length-frequency data were used to estimate growth parameters, such as average maximum length ($L_\infty$), growth rate ($K$), and growth performance index ($\Phi'$), using four methods namely *K*-Scan, Response Surface Analysis (RSA), ELEFAN combined with Simulated Annealing (ELEFAN_SA), and ELEFAN combined with Genetic Algorithm (ELEFAN_GA). Four sets of

provisional results were finalised based on the goodness of fit score ($R_n$), which was calculated from the number of peaks of monthly length-frequency and the number of peaks that were selected for fitting the growth curve. The score was provided along with the results. Total mortality ($Z$) and gear selectivity ($L_c$) were estimated using a length-converted catch curve. Natural mortality ($M$) was estimated based on the maximum age ($t_{max}$), which was estimated from various methods and summarised by the median of those results. Fishing mortality ($F_{curr}$) was determined from the difference between $Z$ and $M$. The growth parameters, mortality parameters, and length at first capture were used as inputs for the YPR and SPR analyses. Finally, biological reference points (BRPs) were derived from YPR and SPR analyses. They included target reference points, $F_{0.1}$ and $F_{30\%}$ for YPR and SPR analyses, respectively, and limit reference points $F_{max}$ and $F_{20\%}$ for YPR and SPR analyses, respectively.

**Results and Discussion**

A total of 32 stocks of sharks and rays were selected from 6 landing sites in 4 countries. All of the selected species showed isometric growth pattern based on the criteria of Froese (2006) except for the spadenose shark (*Scoliodon laticaudus*) from Myanmar, which resulted from a data collection error. The growth parameter estimation showed that 27 stocks had rapid growth rates, 4 stocks had average growth rates, and 1 stock of female whitespotted whipray (*Maculabatis gerradi*), the largest stingray found in this study, had a slow growth rate. The maximum age ($t_{max}$) estimated for the natural mortality ($M$) estimation showed that elasmobranchs in this study, $t_{max}$ varied widely from 3.16 years in male sharpnose stingray (*Telatrygon zugei*) from Malaysian waters in the South China Sea to 53.22 years in female *M. gerrardi* from Malaysian waters in the Andaman Sea. However, these results were estimated from empirical equations, therefore, the true $t_{max}$ of these species may have differed from these results. A sensitivity test showed that $L_\infty$ had the highest effect on changing the current fishing mortality, $F_{curr}$, (±3-17%) while $t_{max}$ had the smallest effect (±0.3-1.8%). The results of both YPR and SPR showed that in 7 stocks (22%), $F_{curr}$ exceeded the limit BRPs, while in 10 stocks (31%), $F_{curr}$ was below the BRP. For the selected stocks, the sub-region with the lowest exploitation rate was the South China Sea which was represented by only one country with a specific fishing ground. Based on the study results, the suggested management measures were fishing gear adaptation, establishment of marine protected areas, and zonation improvement.