Blast from the past:
a brief summary on the past studies for bottom fish stocks in the Emperor Seamounts area

by

Kota Sawada and Taro Ichii

Oceanic Ecosystem Group, National Research Institute of Far Seas Fisheries,
Japan Fisheries Research and Education Agency, Japan

This paper may be cited in the following manner:

Sawada, K. and Ichii, T. 2020. Blast from the past: a brief summary on the past studies for bottom fish stocks in the Emperor Seamounts area. NPFC-2020-SSC BFME01-WP04. 9 pp.

Blast from the past:
a brief summary on the past studies for bottom fish stocks
in the Emperor Seamounts area

Kota Sawada and Taro Ichii

Oceanic Ecosystem Group, National Research Institute of Far Seas Fisheries,
Japan Fisheries Research and Education Agency

Abstract

Although scientists worked on bottom fish stocks in the Emperor Seamounts area have applied several approaches of stock assessments, most of them were not successful in specifying the way to exploit those stocks sustainably. We summarize the past attempts and related studies, in order to recognize the difficulties which hindered those attempts and to gain a foothold for further approaches. It is also intended to be useful as a guide to the related literature.

Introduction

Scientists worked on bottom fish stocks (especially North Pacific armorhead *Pentaceros wheeleri* and splendid alfonsino *Beryx splendens*) in the Emperor Seamounts area have applied several approaches of stock assessments for more than a decade (including works conducted in the Scientific Working Group and associated workshops in Preparatory Conference before the establishment of NPFC and its SSCs). Unfortunately, most of those approaches were not successful in specifying the way to exploit those stocks sustainably. However, we find it worthwhile to summarize the past attempts and related studies, in order to recognize the difficulties which hindered those attempts and to gain a foothold for further approaches, at the start of the new Small Scientific Committee on Bottom Fish & Marine Ecosystems. This summary is also intended to be useful as a guide to the related literature, especially meeting documents of NPFC and its Preparatory Conference, some of which are difficult to find.

North Pacific Armorhead

Biology and life history

North Pacific armorhead *Pentaceros wheeleri* (hereafter “armorhead”) is known for its unique life history characteristics (reviewed by Kiyota et al. 2016): long pelagic life, large body size at settlement (= recruitment) to the seamounts, cease of body length growth (i.e. determinate growth) and gradual loss of body weight/depth after settlement. Due to those characteristics, i) length cannot be used as an indicator of age, and ii) strong recruitments cause drastic increase of biomass and iii) recruitment strength is hard, if possible, to predict (note that armorhead in the pelagic stage distributes widely in the northeastern Pacific and hence targeted investigations are impractical, though juveniles are occasionally caught/observed by investigations for different purposes; see Murakami et al. 2016 and paragraph 17 in Small Scientific Committee on Bottom Fish 2019).

Because armorhead settles to seamounts in "fat" (i.e. deep body relative to length) form and then changes its body to "lean" form after experienced a spawning season (i.e. winter), the fatness (Fatness Index, FI = body depth/body length) can be an indicator of recruits (Somerton & Kikkawa 1992). Nishida et al. (2016) used FI and CPUE trends to detect strength and season of recruitment. The recruitment of this stock is highly episodic, and as a result, the annual catch also fluctuates year-to-year. Yonezaki et al. (2017) examined the relationship between recruitments and marine environments using particle tracking simulations but did not obtained a clear correlation.

Stock and biomass

Stock assessment means "the use of various statistical and mathematical calculations to make quantitative predictions about the reactions of fish populations to alternative management choices" (Hilborn & Walters 2013). Unfortunately, no successful stock assessments meeting this definition has been conducted for armorhead. Yonezaki et al. (2012) applied an observation-error non-equilibrium surplus production model analysis using the software ASPIC and MS-Excel, with standardized CPUE by generalized linear models as an input data. None of their models fitted well to the data, unsurprisingly given the large process error in the recruitment and the discordance between the model assumptions and armorhead life history.

Other approaches attempted to estimate the recruit biomass or the standing biomass. Kiyota et al. (2013, 2014) applied de Lury method (depletion model) to Japanese and Korean fisheries data. This method was suggested to be "one of the practical methods for the preliminary stock assessment for NPA under the current stage" by the participants of SSC NPA02 (paragraph 12 in Small Scientific Committee on North Pacific Armorhead 2017). In this method, annual recruitment in each seamount is estimated using the shape of CPUE-cumulative catch plot during a fishing season (Fig. 1). This approach successfully estimated the amount of annual recruitments, although some issues (target shift, model assumptions) were noted (Kiyota et al. 2014). This method could also be affected by the uncertainty of fishery data contained in the recent Japanese trawl data.

Korean scientists (Park et al. 2014) applied a biomass-based length cohort analysis to armorhead, using catch and length-composition data from Korean and Japanese vessels. However, it was pointed out that "the method used would not be suitable for armorhead" (Scientific Working Group of the Preparatory Conference of the North Pacific Fisheries Commission 2014).

Another possible approach to estimate biomass is an acoustic survey. Japan submitted the results of acoustic surveys to NPFC (Matsuura et al. 2017). We do not discuss it in detail, because it will be discussed under a different agenda item in this SSC.

Okuda et al. (2014) discussed the difficulties in applying various stock assessment methods to armorhead. We reproduced the table of this document (Table 1) to avoid wasting time by a similar discussion.

Splendid Alfonsino

Biology and life history

Splendid alfonsino *Beryx splendens* (hereafter "alfonsino") distributes circumglobally and is exploited in many areas (Shotton 2006). As a result, there are many studies on the life history and recruitment of this species (reviewed by Shotton 2006). However, the number of studies on the Emperor Seamounts population is still limited. Estimation of the growth curves was conducted by Yanagimoto (2004; the equation cited in Yanagimoto & Nishimura 2007) using small individuals only and later by Takahashi (2018; the equation cited in Sawada & Yonezaki 2019) using a wider size range of individuals collected through NPFC scientific observer program.

See Sawada et al. (2018) for other biological aspects of alfonsino.

Stock and biomass

In 2008, Japan applied an observation-error non-equilibrium surplus production model analysis to splendid alfonsino in the Emperor seamounts (Fisheries Agency of Japan 2008, Nishimura & Yatsu 2008) using the software ASPIC and MS-Excel, with nominal and adjusted (see below) CPUE as an input data. As a result, they estimated that 10-year (1996-2006) average of fishing mortality is 20-28 % higher than the MSY level. However, Sawada et al. (2018) noted several issues that undermine the reliability of their analysis: i) although their "adjusted CPUE" (the fishing effort was corrected by the ratio of log-transformed catch of alfonsino and that of armorhead) was intended to correct target shift between armorhead and alfonsino, Sawada et al. (2017) suggested that the correction was not sufficient using directed CPUE method (Biseau 1998), ii) CPUE may be hyperstable due to fish aggregation, iii) the possible change of selectivity by trawlers toward smaller size (Sawada et al. 2018) and iv) unreasonably high estimates of intrinsic population growth rate (0.9-1.6 per year) in compared with the rate estimated for Chilean population (0.12 per year, Wiff et al. 2012).

As another approach to assess the status of the alfonsino stock and fisheries, yield-per-recruit (YPR) analysis was conducted by Takahashi (2018) and Sawada & Yonezaki (2019), and both studies suggested growth overfishing before the implementation of mesh size regulation in 2019.

Acknowledgements

We thank Dr Takehiro Okuda for helpful comments, and Dr Seok-Gwan Choi for providing a meeting document. This research was conducted as a part the project on the evaluation of status of fishery resources by the Fisheries Agency of Japan.

References

Biseau, A. 1998. Definition of a directed fishing effort in a mixed-species trawl fishery, and its impact on stock assessments. Aquat. Living Resour. 11(3): 119–136.

Fisheries Agency of Japan. 2008. Information describing splendid alfonsin (*Beryx splendens*) fisheries relating to the North Western Pacific Regional Fishery Management Organisation, 22 pp.

Hilborn, R., and Walters, C.J. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Springer Science & Business Media.

Kiyota, M., Okuda, T., and Yonezaki, S. 2013. Stock status of the North Pacific armorhead (*Pseudopentaceros wheeleri*) and management proposal. SWG11/WP4/J, 11 pp.

Kiyota, M., Okuda, T., and Yonezaki, S. 2014. Depletion model analysis on recent recruitment and exploitation levels of North Pacific armorhead in the Southern Emperor-Northern Hawaiian Ridge seamounts. SWG12/WP3/J, 11 pp.

Kiyota, M., Nishida, K., Murakami, C., and Yonezaki, S. 2016. History, biology, and conservation of Pacific endemics 2. The North Pacific armorhead, *Pentaceros wheeleri* (Hardy, 1983) (Perciformes, Pentacerotidae). Paci. Sci. 70(1): 1–20. [= NPFC01-2016-SSC-NPA01-Inf01a]

Matsuura, T., Sawada, K., Nishida, K., Yonezaki, S., and Kiyota, M. 2017. Report of the scientific survey in the Southern Emperor Seamounts (southern ES) area in 2016: Results of the acoustic data analysis. NPFC-2017-SSC NPA02-WP05, 8 pp.

Murakami, C., Yonezaki, S., Suyama, S., Nakagami, M., Okuda, T., and Kiyota, M. 2016. Early epipelagic life-history characteristics of the North Pacific armorhead *Pentaceros wheeleri*. Fish. Sci. 82(5): 709–718. [= NPFC-2017-SSC NPA02-IP01]

Nishida, K., Kiyota, M., Yonezaki, S., and Okuda, T. 2016. Estimation of recruitment period of North Pacific armorhead, Pentaceros wheeleri based on CPUE and fatness index. NPFC01-2016-SSC-NPA01-WP02, 10 pp.

Nishimura, A., and Yatsu, A. 2008. Application of surplus-production models to splendid alfonsino stock in the Southern Emperor and Northern Hawaiian Ridge (SE-NHR). NWPBT/SWG-05, 11 pp.

Okuda, T., Kiyota, M., and Yonezaki, S. 2014. Issues of applying major stock assessment methods for North Pacific armorhead. SSWG-NPA1/WP2/J, 4 pp.

Park, H., Yeon, I., and Choi, S-G. 2014. Biomass-based length cohort analysis for estimation biomass of armorhead, *Pseudopentaceros sheeleri*. SWG12/WP11/K, 3 pp.

Sawada, K., Nishida, K., Yonezaki, S., and Kiyota, M. 2017. Application of the directed CPUE method to the multispecies bottom fisheries in the Emperor Seamounts region, for the monitoring of stock status and fishing activity. NPFC-2017-SSC-NPA02-WP02 (Rev. 1), 14 pp.

Sawada, K., Nishida, K., Yonezaki, S., and Kiyota, M. 2018. Review of biology and fisheries of splendid alfonsino *Beryx splendens*, especially in the Emperor seamounts area. NPFC-2018-SSC BF01-WP03, 26 pp.

Scientific Working Group of the Preparatory Conference of the North Pacific Fisheries Commission. 2014. Record of the 12th Scientific Working Group of the Preparatory Conference of the North Pacific Fisheries Commission. 6 pp.

Shotton, R. 2016. Global review of alfonsino (*Beryx* spp.), their fisheries, biology and management. FAO Fisheries and Aquaculture Circular 1084: 1–165.

Small Scientific Committee on Bottom Fish. 2019. 2nd Meeting Report. NPFC-2019-SSC BF02-Final Report. 68 pp.

Small Scientific Committee on North Pacific Armorhead. 2017. 2nd Meeting Report. NPFC-2017-SSC NPA02-Final Report. 45 pp.

Somerton, D.A., and Kikkawa, B.S. 1992. Population dynamics of pelagic armorhead *Pseudopentaceros wheeleri* on Southeast Hancock Seamount. Fish. Bull. 90(4): 756–769.

Takahashi, Y. 2018. A study on age, growth and harvest strategy of the alfonsino *Beryx splendens* in the Emperor seamounts water. Master Thesis, Tokyo Univ. Mar. Sci. Tech., 74 pp. (in Japanese with English tables and figures)

Wiff, R., Quiroz, J.C., Flores, A., and Gálvez, P. 2012. An overview of the alfonsino (*Beryx splendens*) fishery in Chile. Division de Investigacion Pesquera. Instituto de Fomento Pesquero (IFOP), Valparaiso, Chile. MS presented at the FAO International Workshop on Assessment and

Management of Alfonsino Fisheries, January 10–12, 2012 FAO, Rome, Italy. 25 pp.
Yanagimoto, T. 2004. Groundfish fisheries and the biological properties of alfonsino, *Beryx splendens* Lowe in the Emperor Seamounts. Fish. Biol. Oceanogr. Kuroshio, 5: 99-109. (in Japanese)
Yanagimoto, T., and Nishimura, A. 2007. Review of the biological information of alfonsin *Beryx splendens*. SG1/J-2B, 5 pp.
Yonezaki, S., Masujima, M., Okazaki, M., Miyamoto, M., Kiyota, M., and Okunishi, T. 2016. Relationship between the recruitment of North Pacific armorhead and marine environment: Results from particle tracking experiments for estimating the movement route and surrounding environment of the larvae. NPFC-2017-SSC NPA02-WP01, 9 pp.
Yonezaki, S., Okuda, T., and Kiyota, M. 2012. Application of the non-equilibrium surplus production models to North Pacific armorhead in the Southern Emperor and Northern Hawaiian Ridge (SE-NHR) seamounts. The Stock Assessment Workshop for North Pacific Armorhead, Doc-2-Rev2.

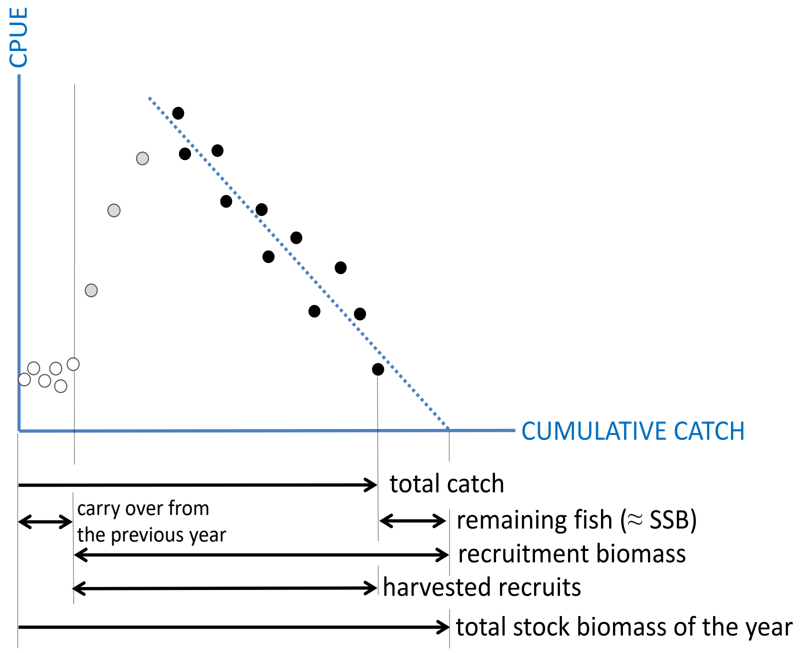

Fig. 1. Concept of the depletion model (de Lury method) applied to armorhead. Reproduced from Kiyota et al. (2014).

Table 1. Issues of applying major stock assessment methods for North Pacific armorhead. Modified (slightly) from Okuda et al. (2014).

	Stock assessment method	**Scheme**	**Required information and data**	**Problems in applying for armorhead (Cause of difficulties in conducting stock assessment or limitation of stock assessment methods' own)**
Population dynamics models	Surplus production model (Biomass dynamics model)	This model describes the dynamic of stock biomass by using logistic equation, which assume that stock biomass is changed by combining surplus production (recruitment, growth, and natural mortality) and fishing mortality.	Catch and fishing effort	1) Initial catch has possibly large uncertainty 2) Nominal CPUE does not exactly reflect stock biomass (e.g., multiple target species, multi-fleet fishery) 3) Constrained assumption; intrinsic population growth rate is fixed and stock biomass is determined only by fishing intensity 4) The model cannot consider time-lag effects 5) Armorhead is assumed to reproduce after fishing season
	Delay-difference model	This model allows time lag (delay) of relationship between spawning stock and recruitment by expanding the surplus production model, which incorporates simple age structure considering recruitment, growth, fishing mortality, and natural mortality.	Catch, CPUE, recruitment amount (or stock recruitment relationships), growth rate and survival rate (or body size data at each age), fishing efficiency (q), virgin stock and recruitment amount [depending on the model]	1) Considering time-lag is not sufficient because of unclarity of stock recruitment relationships caused by large fluctuation of recruitment 2) The estimated results are largely influenced by the informative parameters: large uncertainty of natural mortality and growth (recently not surveyed), and large uncertainty of virgin stock amount which is used for estimating the parameter in Beverton-Holt recruitment equation
	Age-structured model	This model describes loss of a cohort caused by natural mortality, fishing mortality, and fishing induced mortality for a closed population with no immigration and emigration.	Catch of each cohort, natural mortality rate, age length key for age classification of catch, size selectivity of fishing gear	1) Catch is not classified age structure based on body size because armorhead stop growing after settlement on seamounts 2) Migration in of armorhead in benthic stage is un-known

	Stock assessment method	**Scheme**	**Required information and data**	**Problems in applying for armorhead (Cause of difficulties in conducting stock assessment or limitation of stock assessment methods' own)**
	Size-based model	This model represents the transition of groups by body size, which is caused by recruitment, growth, natural mortality, and fishing mortality for a closed population.	Catch of each group by body size, growth rate, natural mortality, mature size	1) It is difficult to classify catch composition into size class (e.g., body length and weight) because armorhead stop growing after settlement on seamounts 2) Migration of armorhead in benthic stage is unknown
Other assessment methods	Depletion model	This model estimates stock amount based on a decreasing trend of CPUE for a closed stock.	Time series of catch, fishing effort (or CPUE)	1) Ignoring natural mortality 2) Migration of armorhead is un-known 3) Retrospective method which cannot use for future forecast
	Y/R analysis	This model estimate catch amount per recruitment and FMAX or F0.1 as a management guidepost.	Catch weight of each cohort (age-weight relationship after recruitment), natural mortality, fishing efficiency, selectivity of fishing gear	Large uncertainty of natural mortality (recently not surveyed)
	SPR analysis	This model applies Y/R analysis for spawning stock and estimate spawning stock per recruitment and %SPR as management guidepost.	Catch weight of each cohort, recruitment, natural mortality, fishing efficiency, mature rate, selectivity of fishing gear	Large uncertainty of natural mortality (recently not surveyed)