Length Based-Spawning Potential Ratio (LB-SPR), on exploited demersal stock (*Priachantus tayenus*) in small scale fisheries, Sunda Strait

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Abstract. The LB SPR approach is needed to predict the ability of stock reproduction as a function of recruitment and stock sustainability. Therefore, we try to apply this technique for demersal exploited stock (*Priachantus tayenus*) in Sunda Strait. The length data were collected in 2013, 2015, 2016, and 2019 by a research team from Labuan landing port. Data analysis consists of length frequency, size at maturity, selectivity, and SPR by using software from barefootecologist.com.au/lbspr. Results have shown asymptotic Length 320.25 mm, length at maturity (Lₘ₅₀) 201.4 mm, von Bertalanffy growth rate 0.136, and ratio M/k 1.56. The SPR of *P. tayenus* range from 6%-36% (average 16%), and it’s relatively under 40% and potentially unsustainable. The length at selectivity 50 percent (SL₅₀) ranges from 154-261.36 mm and length selectivity at 95% (SL₉₅) from 179-348.48 mm. In the 2013-2019 period, SPR was relatively fluctuating and tended to decrease, as indicated by a decrease in the length of the gonad maturity (50% and 95%) of the population. The spawning potential ratio between 6%-36% (average 16%) from 2013-2019 shown an over-exploited stock and potentially high risk to sustainability stock.

Keywords: selectivity; small scale fisheries; spawning ratio; Sunda Strait; maturity

1. Introduction

More than 75% Indonesia fisheries are small-scale fisheries, where it is characteristic by small boat, one-day fishing system. Other characteristics are artisanal activity, low or traditional technology, and limited capacity for fishing data management [1]. Many researchers develop any tactical management to design a good management practice, and then we called data-poor fisheries management.

Hordyk *et al.* [2] found, many scientists developing assessment techniques for data-poor fisheries to manage stock with limited data dynamic information. Therefore, fisheries manager explores life history and dynamic population data such as growth (k), maturity (Lₘ₅₀), length and weight, condition, Spawning Potential Ratio (SPR), mortality (m) to obtain practice ways and conclusion. Spawning Potential Ratio (SPR), recently popular based on length, size structure of catch data to estimate recruitment, potential stock sustainability.
Spawning potential ratio (SPR) is defined as the ratio of the total reproductive production at equilibrium or static status [2]. The equilibrium/static SPRL is the most commonly used for SPR and routinely estimates the in-stock assessment based on length data. In data-poor management, length data are commonly used to estimate SPR because cheapest and simple to collect and record while in the landing process [3]. Representative length data of sample in landing based used to estimate biology parameters such as infinity length ($L_{\infty}$), mortality (M), Bertalanffy growth ($k$), M/k ration, size at maturity ($L_{m50}$). Other parameters related to SPR are selectivity of fishing gear. In practice, easy to collect length data, simple to update the key to success in management, particularly to defining size gear measurement. The dominantly in-mature size caught by fishing gear is the tent to decreasing of stock and potential to vulnerable.

Local studies in Sunda Strait to determine spawning potential ratio (SPR) in tropical water Indonesia require to known sustainability stock and fishing activity of artisanal fisheries. The main target of the fishing process both pelagic and demersal fish, small pelagic fish, and dominant demersal records as targets of fishing. The most popular small demersal fish landed are *Nemipterus* sp., *Priachantus* sp. and *Upeneus* sp.. For this reason, the SPR approach was used to evaluate the proportion of mature or in-mature species relate to selectivity fishing gear regulation. This output also will assist fisheries management in the monitoring of landing size and fishing fleet selectivity.

2. Material and methods

2.1. Research area

This research was conducted in the Sunda Strait, which lies between Sumatera Island and West part of Java Island (see figure 1). Research time was in the second semester in 2019. The data were collected in Labuan landing port for length and weight data, reproduction, gonad maturity, and life history, and population dynamics of *P. tayenus*. And then other data were collected in a fisheries biology laboratory. The data used in this paper was length data in the landing site that recorded each month, and then gonadal development and morphometric.

![Figure 1. Research location in Sunda Strait.](image-url)
2.2. Data analysis
The SPR analysis is based on size and length data of catch, production, and biology reproduction. Population parameter input to SPR estimation is life history parameter such as von Bartallanfyt plot, infinite length ($L_\infty$), Covaria of infinite length ($CVL_\infty$), growth rate ($k$), mortality (natural ($M$) and fishing ($F$)), length maturity at the size at 50%, and 90%, and ratio $M/k$. This process also uses selectivity and (F/M) ratio to the SPR model [3].

The LB-SPR analysis uses the maximum likelihood method [3] to simultaneously to selectivity at length parameter. This approach allows any assumption based on statis/equilibrium status of stock. The first steady-state assume, second parameter population ($M, g$) coastal, third selectivity has an asymptotic form growth allow von Bartalanfy equation, and the fifth is both of sexes, male and female, have the same growth and sex ratio [3]. Model of LB-SPR model the stock in each year is estimated, independently of the status stock previously year.

3. Results and discussion

3.1. Length and growth
The length composition data in 2013, 2015, 2016, and 2019 found the average length data in 2016 and 2013 under 200 mm and 2015 and 2019 above 200 mm. Compare to another area, the length of *P. tayenus* in northern Java (Kendal fishing port recorded), is 105-324 mm [4]. Mortality parameter both of natural mortality ($M$) is about 0.36 and fishing mortality ($F$) about 1.86. The ratio of $M/k$ is 1.56, and the growth rate about 0.23. Its data showed the population growth relatively slow and fishing intensity and fishing rate relatively high in Sunda Strait.

![Figure 2](image)

**Figure 2.** Length distribution frequency of *P. tayenus*, from 2013, 2015, 2016 and 2019.

While on monitoring programs were found six cohorts (2013), five cohorts (2015), two cohorts (2016), and three cohorts in 2019 (see figure 3). The catch in 2013 dominant at length 153 to 177.6 mm; 2015 at length 193.5 to 237.6 mm; 2016 at length 150.7 and at 2019 at length 189.65 to 224.40 mm.

Cohort data in each year used for the von Bertalanffy growth plot by Ford-Walford analysis. The growth rate was found as 0.230 per year, as shown in figure 4. The Pauly equation found the natural mortality as 1.11 per year, and totally the $M/k$ is 5.62 per year.
In northern part of Banten Province, infinitive length of *P. tayenus* is \( L_\infty = 32.34 \text{ cm} \) with growth rate \( (K) = 0.91 \text{ year}^{-1} \) [5]. *P. tayenus* caught in the Gulf of Thailand has an asymptotic length of 300 mm and growth rate coefficient of 1.2 per year [6]. The asymptotic length under than stock in Gulf of Thailand, but growth rate coefficient more slowly. In northern part of South China Sea were record the asymptotic length and growth rate of *P. tayenus* as \( L_\infty = 300 \text{ mm} \) and \( (k) = 0.8 \) per year [7]. Similar research in Beibu Bay found parameters von Bertalanffy growth equation were infinity length as well \( L_\infty = 29.4 \text{ cm} \) and growth rate parameter \( K = 0.65 \) [8].

![Figure 3. Cohort analysis of *P. tayenus* (2013, 2015, 2016, and 2019).](image)

![Figure 4. Von Bertalanffy growth plot of *P. tayenus* (2013, 2015, 2016, and 2019).](image)
3.2. First at maturity
Length of first at maturity for female (Lₘ₅₀) is 201.43 mm, and the majority mature (Lₘ₉₅) at length 243.3 mm (figure 5), and above of northern part of Banten which Lₘ₅₀ was 160.3 mm [5]. In Kendal landing port size at fifty percent maturity of *P. tayenus* is 153 mm [4], and 194 mm in Tegal Landing port [9]. Based on length composition catch, the average production size under than maturity size. Its mean in-mature population dominantly catches mature strategy.

Size at maturity of *Priacanthus hamrur* (Forskall) for females was 191-200 mm respectively in west coast Indian [10]. Different from south of Java Island, Maturity size of *P. tayenus* in Pelabuhanratu was 245.10 mm [11] and 219 mm [12]. There are have a uniqueness of size maturity, wherein northern Java earlier to first at maturity than southern Java. The differences may occur due to differences in environmental, habitat, and fishing intensity.

3.3. Selectivity and maturity
Length and size selectivity of fishing gear is crucial for length fish regulation to management in a tropical country. Swanggi (*P. tayenus*) in Sunda strait caught with multi-gear and multi-size, that potential to decrease stock in the water body.

Fishing gear used by fisherman in Sunda Straits such as danish seine, purse seine, and demersal gill netter. Size at fishing gear used with mesh size 0.5-40 inch (12.7-101.6 mm), potential to increase catch in-mature stock. But since 2016, total catch relatively higher than 100 mm while applying mesh size more than 4 inches by fisherman. Fishing activity in northern java used arad gear with mesh size 1 inch and potential to increase young fish stock [5]. Selectivity and maturity size of *P. tayenus* shown in figure 6.

3.4. Spawning potential ratio (SPR)
The estimate of the spawning potential ratio (SPR) needed to know the stock capacity to recovery. The total SPR in 2013 estimates as 13%, in 2015 as 36%, in 2016 as 6%, and in 2019 as much as 15%. The total average SPR from 2013 to 2019 is 16%, relatively low and under than optimum threshold of SPR is 40% to ensure stock sustain. The profile of SPR in each year show as a figure 7.

3.5. Selectivity, mortality and SPR
The selectivity length at 50% stock range from 154-261 mm and SL₉₅% is 179.72-348.48 mm, where the selectivity at 2019 relatively high. The F/M ratio range from 0.98-15.23 and M/k ratio as much as 1.56. The trend of selectivity, F/M, and SPR model was shown in figure 8.

The total SPR as much as 16% (under than 20%) and total value M/k higher than 1 show that pressure relatively high. Evaluation at Java Sea and found that demersal fish SPR less than 20% and
stock nearly entirely exploited [12]. We have a similar trend of SPR data in the Java Sea and Sunda Strait, particularly on demersal fish.

The F/M ratio in northern South China sea is (0.6/1.4) [6] and F/M ratio in Beibu Bay as well as 2.53/1.19 [8]. Ratio of F/M in Keralla coast India is (2.57/1.13) recorded by [14], and Brunei coast record F/M parameter is (0.03/1.28) [15]. The recommendation to the proxy of optimum effort is F40% to maintain demersal fish life history [16]. It is mean that to increase SPR be should maintain fishing effort under Fmsy particularly for demersal fish and mesh size of fishing gear.

In the context of fisheries governance in poor data availability, SPR is a key indicator in determining management strategies. Based on reproduction and spawning data, the sustainability of stocks can be assessed by the level of sustainability [17]. So that the risk of vulnerability and degradation can be anticipated by regulating fishing techniques. Thus, effectiveness fisheries can be ensured that it will be sustainable for future generations [17].

![Graphs showing selectivity and maturity size of P. tayenus.](image-url)

**Figure 6.** Selectivity and maturity size of *P. tayenus.*
Figure 7. Estimation SPR at 2013, 2015, 2016 and total stock of *P. tayenus*.

Figure 8. Model connectivity of SPR-Selectivity and F/M.

4. Conclusion

*P. tayenus* is a dominant demersal fish caught by Danish seine, purse sein, and gill net with mesh size from 0.5–4 inch and stock dominant in above of 100 mm (or above 3 inches) mesh size in Sunda Strait. Size at maturity at fifty percent mature is 201.43 mm higher than dominant stock caught. It also shown that dominant stock landed is in-mature or young fish. The spawning potential ratio between 6%–36% (average 16%) from 2013–2019 shown an over-exploited stock and potentially high risk to sustainability stock. Therefore, important to design an optimum effort at optimum reproduction to maintain stock sustainability.
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