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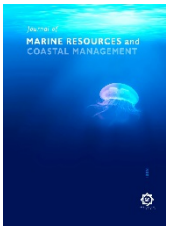

Stingray (*Neotrygon orientalis*) population structure based on catch data in Nusantara Fishery Port (Pelabuhan Perikanan Nusantara/PPN) Brondong, Lamongan

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ABSTRACT

Stingray is a type of fish included in the Elasmobranchii class that has high economic potential. This study aims to determine the sex ratio, growth rate, length-weight relationship, condition factor, mortality and exploitation rate of stingray (*Neotrygon orientalis*) in PPN Brondong, Lamongan. Samples *N. orientalis* collected every week starting from October 1, 2019 until January 2021 and weighed in total body weight (gram) and measured in total body length (cm) then sex was identified based on macroscopic characteristics of gonads. The results showed that the sex ratio of *N. orientalis* was 1.4 : 1. Length growth value (*K*) of male and female *N. orientalis* are 0.0285 and 0.0233, respectively, which show a slow growth time to reach the asymptotic length ($K \leq 0.5$). Based on the analysis of the relationship between length and weight, the results show that *b* value are 1.9394 and 2.2023 in male and female *N. orientalis*, respectively, which means length growth rate faster than weight growth ($b < 3$, negative allometric). *N. orientalis* are included in the category of flat (thin) fish with condition factor values ranging from 0.2462-3.9227. The total, natural, and fishing mortality rate were 0.395, 0.177, and 0.218, respectively. The exploitation rate is 0.551 where the value has exceeded the optimum value 0.5, which means that *N. orientalis* landed at the PPN Brondong, Lamongan has indicated overfishing caused by excessive fishing activity.

Keywords: *Neotrygon orientalis,* growth rate, length-weight relationship, condition factor, mortality rate, exploitation rate.

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INTRODUCTION

Indonesia is an archipelagic country that has potential marine resources. One of province which has a big influence in fishery production is East Java Province. There are three big Fish Auction Site (*Tempat Pelelangan Ikan*, TPI) in East Java Province, namely TPI Brondong (Lamongan Regency), TPI Muncar (Banyuwangi Regency), and TPI Perigi (Trenggalek Regency) [1-3]. TPI is one of the supporting facilities provided by "Perum Perikanan Indonesia" under the Fishery Port which is a public facility to carry out the first fish marketing activities since getting off the ship.

Nusantara Fishery Port (*Pelabuhan Perikanan Nusantara*, PPN) Brondong is one of the Minapolitan area in East Java Province based on the Decree of the Minister of Marine Affairs and Fisheries Number 32/MEN/2010 [4]. PPN Brondong has role in business development capture fisheries, namely as one center of marine fishery activities, especially in the Lamongan Regency Area [5].

Fish is landed on the TPI Brondong dominated demersal fish species such as Kurisi (*Nemimterus hexodon*), big eyes (*Priacanthus tayanus*), Balak/Beloso (*Saurida tumbil*), and other [5]. One of the by-catch of fishers is stingray (*Neotrygon orientalis*). Stingray is one of the types of fish included in Elasmobramchii class. This fish is known as Batoid fish is a group of fish cartilaginous and has a tail like the whip [6]. In general, Stingrays have a flat, flattened body shape widened so that it resembles a plate, coupled with the wide fin like a wing that blends in with a part front of the head as shown in Figure-1.

Figure-1. *Neotrygon orientalis*

Neotrygon orientalis is stingrays found in the PPN Brondong. This types of stingrays can reach 50-150 kg per trip. This species is important to be analyzed further considering it has high economic potential. Therefore, this study aims to determine the sex ratio, growth, weight-length relationship, condition factors, mortality and utilization rate of *Neotrygon orientalis* at PPN Brondong.

METHODS

Study Site and Sample Collection

This research was carried out at the PPN Brondong, Lamongan (Figure-2). Samples of *N. orientalis* were collected every week starting from October 1, 2019 until January 2021. Samples collected were weighed in total body weight (gram) and measured in total body

length (cm). Each samples was dissected and sex was identified based on macroscopic characteristics of gonads.

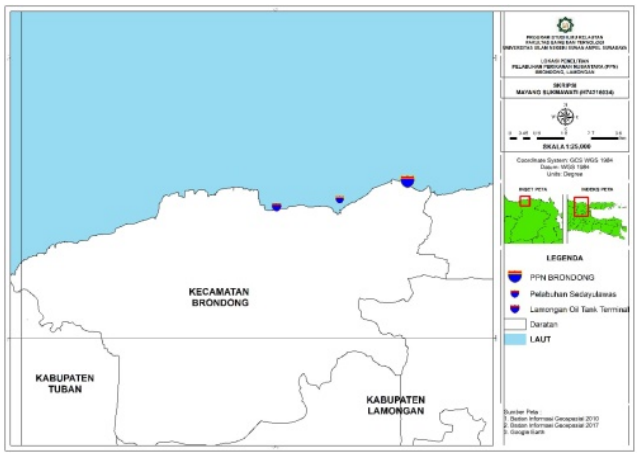

Figure-2. Map of Research Location

Data Analysis

Sex ratio is the ratio between males and females stingray calculated using Equation (1) [7].

$$R = \frac{J}{T} \times 100\% \quad (1)$$

where R is sex ratio (%), J is number of females/males (ind), and T is total number of stingray (ind).

Stingray growth (*Neotrygon orientalis*) analyzed using a model Von Bertalanffy [8], as shown in Equation (2) and (3).

$$(\blacktriangle L/\blacktriangle t) = (L2\text{-}L1)/(t) \quad (2)$$
$$Lt = (L2+L1) \quad (3)$$

where ▲L/▲t is growth relatively, ▲L is fish length, ▲t is time difference, and Lt is the mode average length.

By plotting the values of Lt and (▲L/▲t) so that it is obtained linear equation as shown in Equation (4).

$$Y = a + bx \quad (4)$$

The value of the infinity length (L∞) and growth coefficient (K) shown in Equation (5) and (6), respectively. Then it analyzed using the Von Bertalanffy equation with Gulland and Holt Plot approach [8], as shown in Equation (7).

$$K = -b \quad (5)$$
$$L\infty = -a/b \quad (6)$$
$$Lt = L\infty\ (1 - exp^{-k(t-t_0)}) \quad (7)$$

Determination for the value of t_0 according to [9] using Pauly's empirical formulas by using multiple regression relationship between the current theoretical lifespan fish length zero (t_0) with infinity length (L∞) and K, as shown in Equation (8).

$$Log - t_0 = -0{,}3952 - 0{,}2752\ Log\ L\infty - 1{,}038\ Log\ K \quad (8)$$

Relationship of length and weight calculated using Equation (9) [10].

$$W = aL^b \quad (9)$$

where W is fish weight (kg), L is total length of fish (mm), a and b are constants.

Condition factor (CF) calculated based on length and fish weight using Equation (10) [10].

$$CF = \frac{W}{aL^b} \quad (10)$$

Total mortality rate (Z) suspected by using the Beverton and Holt model packaged in the FISAT program II. Natural mortality rate (M) suspected by using Pauly's empirical formula as shown in Equation (11) [8].

$$\text{Log}(M) = -0.0066 - 0.279 \times \text{Log}(L\infty) + 0.6543 \times \text{Log}(K) + 0.4634 \times \text{Log}(T) \quad (11)$$

where M is natural mortality, L∞ is asymptotic length on the growth of Von Bertalanffy equation, K is coefficient growth on the equation growth of Von Bertalanffy, and T is average temperature water level (°C).

Fishing mortality rate (F) and exploitation rate (E) coefficient calculated using the Equation (12) and (13), respectively.

$$F = Z - M \quad (12)$$
$$E = F/Z \quad (13)$$

where Z is total mortality rate and M is natural mortality rate.

Optimum fishing mortality (F_{opt}) and optimum exploitation (E_{opt}) according to Gulland estimated using Equation (14) and (15), respectively [8]. If the value of E is more than 0.5 then it is an indication of overfishing conditions.

$$F_{opt} = M \quad (14)$$
$$E_{opt} = 0.5 \quad (15)$$

RESULTS AND DISCUSSIONS

Sex Ratio

Total of 614 stingray samples were analyzed during the study period (Table-1). The sex ratio for *N. orientalis* was given as males : females as 58.48% : 41.52% or 1.4 : 1.

Growth Rate

Class of frequency distribution of female *N. orientalis* total length shown in Table-2. The results of the analysis of frequency distribution of female *N. orientalis* total length scores intercept a= 2.0784 and interslope b= -0.0233 follows the equation y = -0.0233x + 2.0784 (Figure-3). Based on this equation, the Von Bertallanfy growth model for the length of the female *N. orientalis* Lt : 89.20 (1- exp $^{-0.0233(t-5.831)}$) was obtained (Figure-4).

Table-1. *N. orientalis* sex ratio

Sampling	Male	Female	Total	Male (%)	Female (%)
#1	70	68	138	50.72	49.28
#2	44	26	70	62.86	37.14
#3	55	50	105	52.38	47.62
#4	41	20	61	67.21	32.79
#5	38	38	76	50.00	50.00
#6	16	7	23	69.57	30.43
#7	54	29	83	65.06	34.94
#8	29	29	58	50.00	50.00
Total	347	267	614	58.48	41.52

Table-2. Length class interval for female *N.orientalis* based on October - November 2019 sampling results

No	▲t	L1 (cm)	L2 (cm)	▲L	Lt (cm)	(▲L/▲t)
1	7	17.8	27.9	10.1	22.85	1.44
2	7	27.9	35.7	7.8	31.80	1.11
3	7	35.7	47.8	12.1	41.75	1.73
4	7	47.8	53.4	5.6	50.60	0.80
5	7	53.4	56.4	3.0	54.90	0.43
6	7	56.4	64.9	8.5	60.65	1.21
7	7	64.9	66.2	1.3	65.55	0.19

The growth of female *N. orientalis* based on total length has a value of K= 0.0233 which means that it has a slow growth time ($K \leqslant 0.5$). Female *N. orientalis* have an increased growth rate of 1.5 cm/week with the required time of 56 weeks or 392 days to reach maximum length.

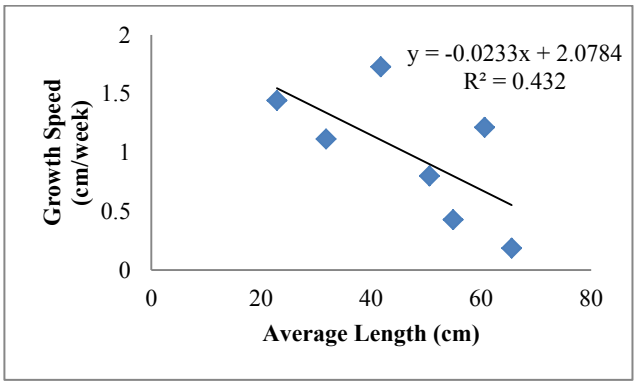

Figure-3. Equation of length for female *N. orientalis* based on October to November 2019 sampling results

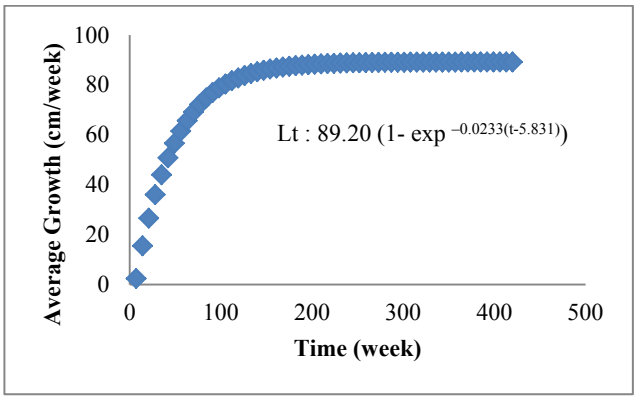

Figure-4. Length growth curve for female *N. orientalis* based on October to November 2019 sampling results

Class of frequency distribution of male *N. orientalis* total length shown in Table-3. The results of the analysis of frequency distribution of male *N. orientalis* total length scores intercept a= 2.3323 and interslope b= 0.0285 follows the equation y = -0.0285x + 2.3323 (Figure-5). Based on this equation, the Von Bertallanfy growth model for the length of the male *N. orientalis* Lt : 81.83 (1- exp $^{-0.0285(t-4.8444)}$) was obtained (Figure-6). The growth coefficient (K) has a value of 0.0285, which means it takes a long time to reach its asymptotic length. Male *N. orientalis* have an increased growth rate of 1.2 cm/week with the time needed of 60 weeks or 420 days to reach maximum length.

Table-3. Length class interval for male *N.orientalis* based on October - November 2019 sampling results

No	▲t	L1 (cm)	L2 (cm)	▲L	Lt (cm)	(▲L/▲t)
1	7	16.8	28.6	11.8	22.70	1.69
2	7	28.6	36.7	8.1	32.65	1.16
3	7	36.7	46.7	10.0	41.70	1.43
4	7	46.7	54.7	8.0	50.70	1.14
5	7	54.7	57.6	2.9	56.15	0.41
6	7	57.6	62.5	4.9	60.05	0.70
7	7	62.5	65.6	3.1	64.05	0.44

The length growth of male and female *N. orientalis* has a K value of 0.0285 and 0.0233, respectively, which means both has a slow growth time ($K \leqslant 0.5$). The difference in K value can be influenced by environmental conditions, especially temperature and food availability. Fish can continue to grow even in conditions of unfavorable environmental factors [11].

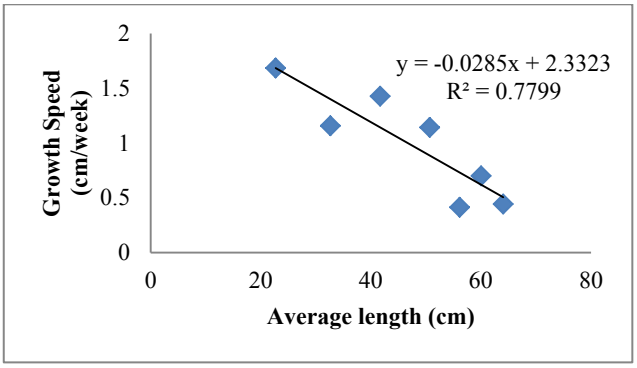

Figure-5. Length growth curve for male *N. orientalis* based on October to November 2019 sampling results

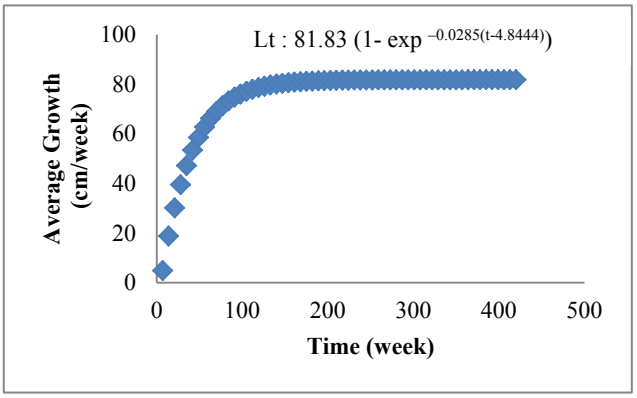

Figure-6. Length growth curve for male *N. orientalis* based on October to November 2019 sampling results

Length-Weight Relationship

The results of data analysis of the length and weight of male *N. orientalis* landed at PPN Brondong show the equation $y = 1.9394x - 1.4882$ with a determination value (R^2) = 0.5477 (Figure-7). The value of $b = 1.9394$ means that the *N. orientalis* is negative allometric (b < 3).

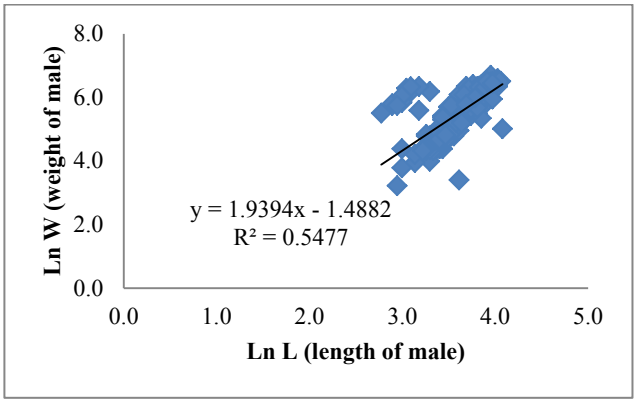

Figure-7. Length-weight relationship of male *N. orientalis*

Furthermore, length and weight relationship analysis of female *N. orientalis* landed at PPN Brondong show the equation $y = 2.2023x - 2.4162$ with a determination value (R^2) = 0.59 (Figure-8). It is show that they have faster growth in length compared to their weight [10], with a value of $b = 2.2023$ (negative allometric). The difference in *b* value between males and females is because the difference in the number and size variation of fish observed and differences in stock in the same species.

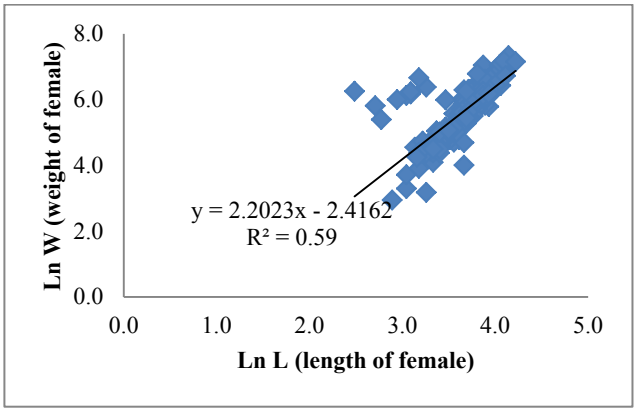

Figure-8. Length-weight relationship of female *N. orientalis*

Condition Factors

The condition factors in *N. orintealis* during research on males and females in Java Sea waters can be seen in the Table-4. The results of the analysis of the calculation of the condition factor in the Neotrygon orientalis stingray ranged from 0.2462-3.9227, where the value of the condition factor was included in the flat (thin) fish condition. The value of the condition factor 1-3 show that the condition of the fish is flat (thin), but if the value of the condition factor is 3-4 then the condition of the fish is slightly flattened (fat) [12].

Table-4. Condition Factors of *N. orientalis*

Length interval (cm)	Weight class interval (gram)	Average			CF
		Length (cm)	Weight (gram)	Range	
12-17	19-171	14.75	112.58	0.0500-0.4425	0.2462
17-22	171-323	20.15	247.77	0.4425-0.8256	0.6340
22-27	323-475	25.68	400.59	0.8256-1.2024	1.0140
27-32	475-627	30.03	542.14	1.2024-1.5745	1.3885
32-37	627-779	35.00	689.48	1.5745-1.9427	1.7586
37-42	779-931	39.97	849.40	1.9427-2.3079	2.1253
42-47	931-1083	44.82	992.67	2.3079-2.6704	2.4892
47-52	1083-1235	49.92	1166.00	2.6704-3.0307	2.8506
52-57	1235-1387	54.57	1284.25	3.0307-3.3889	3.2098
57-62	1387-1539	59.25	1535.00	3.3889-3.7453	3.5671
62-67	1539-1691	66.00	-	3.7453-4.1001	3.9227

Mortality and Exploitation Rate

The mortality rate for *N. orientalis* uses the Beverton and Holt equation based on length data and sea surface temperature of 29.39ºC (data from imagery Aqua MODIS Level 3) shown in Table-5. Based on the data analysis result in Table-5, it shows that the mortality of *N. orientalis* is more dominated by fishing mortality. According to [13] increasing fishing mortality and decreasing natural mortality indicate a condition in "Growth Overfishing", namely the small number of old fish because young fish do not have time to grow due to being caught. Meanwhile, according to [14] natural mortality is influenced by predators, disease, age and environmental factors that affect natural mortality i.e. the average temperature of the waters, in addition to the maximum length and growth rate.

Table-5. Mortality and exploitation rate of *N. orientalis* in October and November 2019

Parameter	Value
Natural mortality (M)	0.177
Fishing mortality (F)	0.218
Total mortality (Z)	0.395
Exploitation (E)	0.551

The exploitation rate of *N. orientalis* obtained was 0.551 which was caused by high fishing mortality. The exploitation rate is more than 0.5 indicate of overfished conditions.

CONCLUSIONS

The sex ratio of *N. orientalis* was 1.4:1, which indicates that the male and female catches are in a balanced condition. The *N. orientalis* which landed at the PPN Brondong has a negative allometric growth pattern ($b < 3$) where length growth is faster than weight growth. The *N. orientalis* condition factor value ranging from 0.2462-3.9227, where included in the condition of the flat (thin) fish. The exploitation rate of *N. orientalis* was 0.551 thus indicated that exploitation status in Java waters was overfishing.

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