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Fisheries biology and population dynamics: Key attributes for scyphozoan fisheries resources management in Saleh Bay, Indonesia

[1]Evron Asrial, [2]Hamid, [3]Muhammad Marzuki, [4]Erwin Rosadi, [5]Ruly I. Khasanah, [6]Gatut Bintoro, [2]Naning D. Sulystyaningsih, [1]Rusmin Nuryadin

[1] Department of Fisheries Resources Utilization, Faculty of Fishery, University of 45 Mataram, Mataram, West Nusa Tenggara, Indonesia; [2] Department of Aquaculture, Faculty of Fishery, University of 45 Mataram, Mataram, West Nusa Tenggara, Indonesia; [3] Department of Aquaculture, Faculty of Agriculture, Mataram University, Mataram, West Nusa Tenggara, Indonesia; [4] Department of Capture Fisheries, Faculty of Fishery and Marine, Lambung Mangkurat University, Banjarbaru, South Celebes, Indonesia; [5] Marine Science Program, Faculty of Science and Technology, State Islamic University of Sunan Ampel, Surabaya, East Java, Indonesia; [6] Department of Fisheries Resources Utilization and Marine, Faculty of Fishery and Marine Science, Brawijaya University, Malang, East Java, Indonesia. Corresponding author: E. Asrial, evronasrial81@gmail.com

Abstract. The main benefit of edible jellyfish/scyphozoan (*Crambione mastigophora*) fisheries in the Saleh Bay is to increase the fishers' income. The scyphozoans blooming take place during September-December, almost every year. The current research aimed to identify and describe the fisheries biology and population dynamics of scyphozoans. The samples were collected during October 2017-March 2018. Data collection method was survey-dependent through the sampling technique. For data processing, multiple applications were used. The scyphozoans fisheries' status was estimated using the comparative method, between the data processing results and the standard values from previous studies. Production (i.e. fishing) of medusivorous fishes may result in increased scyphozoans blooms. The umbrella's diameter of 1 year old scyphozoans reached 18.15 cm. The scyphozoans natural mortality rate was very high, whereas scyphozoan spawning did not take place every month. The peak of scyphozoan recruitment took place in September and October. The study revealed that the status of biomass trend was decreasing gradually. Jellyfish exploitation status was overexploited and the utilization status showed excessive exploitation. Referring to all statuses that rely on the harvest management and the stock security, it is recommended that decision-makers should conduct regular assessments for the scyphozoan fisheries in order to sustain such fishing resources.
Key Words: blooming, excessive exploitation, jellyfish, medusivorous.

Introduction. Indonesia is one of the important countries to meet the supply and demand of the world's jellyfish, especially for China. The coastal waters of Indonesia are considered a potential habitat for the edible jellyfish resources (scyphozoans) as one of the fisheries export commodities. In 2012, Indonesia was the 3rd largest jellyfish supplier to China (3,000 tons) among 14 countries that were the leading jellyfish suppliers (López-Martínez & Álvarez-Tello 2013).

Scyphozoans from Indonesia are exported in the form of processed products "Flower type" and "Prigi type" (Asrial et al 2017). Flower type is a method of processing a part of a jellyfish umbrella into a salted jellyfish product that takes 11 days, while the Prigi type takes 5 days to process the jelly-mouth portion of the jellyfish into a salted jellyfish product. Prigi type was first introduced by Indonesian jellyfish processors from the Prigi Bay (East Java Province).

One of the important jellyfish fisheries centers in Indonesia is Saleh Bay, which is located in Nusa Tenggara Barat Province (NTB), Indonesia. Jellyfish (*Crambione* *mastigophora*) were captured (Figure 1 and 2) and processed into jellyfish products (salted mouth-arm) (Figure 3) using the Prigi-type method in Saleh Bay (Figure 4).

Figure 1. Saleh Bay's *Crambione mastigophora* or gullung (original).

Figure 2. Fishers and boat to catch scyphozoan in Saleh Bay (original).

Figure 3. Oral-arm of scyphozoan (original).

Figure 4. Activities of cleaning (A), transferring (B) and salting (C) oral-arm of *Crambone mastigophora* in Saleh Bay (original).

Since 2003, fishers discovered the commercial value of *C. mastigophora* (Maas 1903) from the Scyphozoa class, called "Scyphozoan" (Perissinotto et al 2013; Asrial et al 2015a) or gullung (local term) (Asrial et al 2019; Asrial et al 2021). Scyphozoan fisheries activities have begun since 2006 (Asrial et al 2017) when repetitive scyphozoan blooms occurred in the rainy season during September-January (Asrial et al 2015a). Strobilation likely occurs during times of low rainfall, with medusae maturing during the rainy season (September-December). Human activities may also influence scyphozoan population in Saleh Bay. Aquaculture production results in excess food and nutrients, resulting in eutrophication, and the removal of medusivorous fish may reduce predation on scyphozoans. Another problem is the security of scyphozoan stock (Asrial et al 2017).

In 2014 in the Saleh Bay waters, the sustainable potential of scyphozoan (U_{MSY}) was 33,261 tons year^{-1}, the sustainable fishing (f_{MSY}) was 3,917 units of fishing gears year^{-1}, and the sustainable fish catch (Y_{MSY}) was of 8.49 tons gear^{-1} year^{-1} (Asrial et al 2015b). In 2015, scyphozoan production in Saleh Bay was 33,545.10 tons year^{-1} (DMAF NTB 2016). When compared with the production of 2013 and 2014, it increased by 2,727.23 tons (8.85%) and 2,215.50 tons (7.07%), respectively.

To ensure the sustainability of scyphozoan fisheries management at provincial and national levels, a more sustainable and responsible approach should be developed for the scyphozoan fisheries. Researches on the fisheries status of scyphozoans in Indonesia are almost nonexistent. Therefore, this research is very important to be conducted to achieve sustainable and responsible management for the scyphozoan fisheries in Indonesia.

The study is a part of the biological dimension of the scyphozoan population, which is focused on two aspects; namely, fisheries biology and fish population dynamics. The results are essential to assess the sustainability of scyphozoan fisheries resources management in Saleh Bay. This research aimed to: (1) identify and describe the growth parameters and the population dynamics parameters of scyphozoan resources and (2) assess the status of existence and utilization of scyphozoans resources and population.

Material and Method

Description of the study sites. The study was conducted in the coastal waters of Saleh Bay in Sumbawa Island (NTB Province) (Figure 5) and in several Fishers centers around Saleh Bay. The data collection period was from 1 October 2017 to 31 March 2018.

During the survey, from the 1st of October to the 30th of December 2017, a total of 261 samples of scyphozoans were measured. The samples were obtained from local fishers who captured scyphozoans in Saleh Bay. The main equipment used to capture scyphozoan samples consisted of: scoop net, light, wooden boat and plastic basket, while the equipment used to identify the scyphozoans consisted of digital scales, ruler, digital caliper, and stationery. All types of tools used were one unit each.

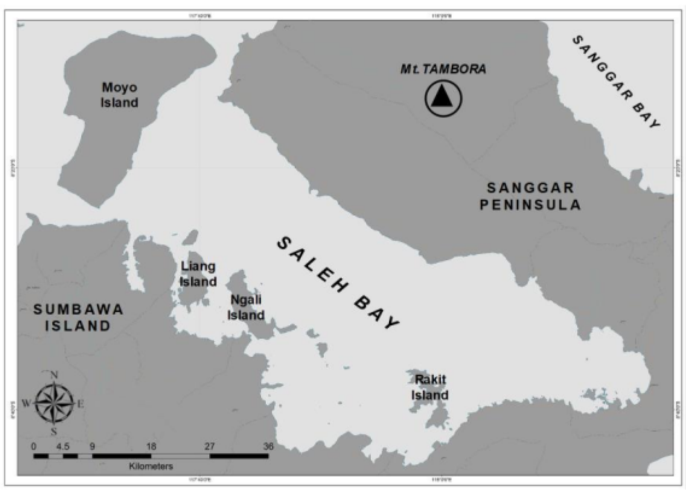

Figure 5. Map of Saleh Bay in Sumbawa Island, Indonesia.

Data compilation method. The study area was investigated nine times for data collection, for the examination of the blooming phenomenon, and the fisheries activities of scyphozoans. The types of data collected consisted of cross-section data (primary data) and second-hand data (secondary data).

The method of data collection was survey-dependent, where the researchers were dependent on the samples obtained by fishers. Biological data collection of scyphozoans using sampling techniques was evaluated against the scyphozoans captured by fishers. Other dimensional data were obtained via interviewing and documentation techniques, which were mostly considered as secondary data.

Data collection was conducted during the period October 2017-March 2018 (6 months). The measurements of scyphozoans were performed twice a month i.e. at the middle and end of each month. The time series data consisted of scyphozoan production volume and the number of fishing gear (scoop net) used by fishers to catch scyphozoan.

Data analysis

Growth coefficient (K) and length asymptotic length (L∞). The growth parameters (K and L∞) were analyzed by the method ELEFAN I by scanning the K-values with FiSAT II. The growth parameter was estimated using the growth formula of Von Bertalanffy (Sparre & Venema 1998) as follows: $Lt = L\infty\,(1 - e^{-k(t-t0)})$, where: Lt = fish length at age t (mm), L∞ = asymptotic length of fish (mm), K = coefficient of growth rate, t0 = fish theoretical age at length 0 (year), and t = age of fish (year).

The K and L∞ were determined using the methods of Ford (1933) and Walford (1946), by plotting L (t + Δt) and L (t) with the following equation: $L\,(t + \Delta t) = a + bL(t)$. The linear regression equation results from both relations:

$$Y = a + bX$$

Where:
$a = L\infty\,(1 - b)$
$b = exp\,(-K.\Delta t)$
After that, the following formula was obtained:

$$L\infty = a/(1 - b)$$
$$K = \ln b\,(-1/\Delta t)$$

Then the equation of Pauly (1980) was used, as follows:

$$log\,(-t_0) = -0.3922 - 0.2752\,(log\,L\infty) - 1038\,(log\,K)$$

Where:
L - asymptotic length of fish (mm);
t_0 - fish theoretical age at length = zero (year);
K - coefficient of growth rate.

Mortality and rate of mortality. Mortality is measured from natural mortality (M), fishing mortality (F) and total mortality (Z). To determine M and the exploitation rate, the empirical formula of Pauly (1984) was used, which shows the annual temperature effect:

$$ln\,M = 0.8\,x\,exp\,(-0.152 - 0.279\,ln\,L\infty + 0.6534\,ln\,K + 0.4634\,ln\,T)$$

Where:
L - asymptotic length of fish (mm);
K - growth rate coefficient;
T - average temperature of waters (ºC).

Total mortality (Z) was estimated by the Beverton & Holt (1956) equation:

$$Z = K(L\infty - L)/(L - L'),$$

Where:
Z - total mortality ($year^{-1}$);
K - growth rate coefficient;
L∞ - scyphozoan asymptotic length (mm);
L - average length of the definitely caught fish (mm);
L' - minimum size of length class of the definitely caught fish (mm).
By using the formula Z = F + M, the fishing mortality value can be calculated through the equation: F= Z-M (Gulland 1969).

Maximum sustainable yield (Y_{MSY}, f_{MSY}, U_{MSY}). The maximum sustainable yield (MSY) is a sustainable catch obtained by substituting the optimum capture effort value into the equation: $Y_{MSY} = -a^2/4b$ and $f_{MSY} = -2b/a$, where: Y_{MSY} = the maximum sustainable catch (tons), f_{MSY} = the maximum sustainable scoop net (units), a=intercept, and b=constant of the catching device.

The catch per unit of effort optimum ($CpUE_{opt}$) is used to describe the changes in the scyphozoan biomass. The unit for CpUE is the number of scoop net used per year, calculated by dividing the value of the optimum catch (C_{opt}) or MSY (previously obtained) with the optimum effort value (f_{opt}). $CpUE_{opt}$ values can be obtained by: $CpUE_{opt} = U_{MSY} = ½\, x\, a = a/2$.

The stock potential of scyphozoan resources in the waters of Saleh Bay is also predicted using the model described in Garcia et al (1989). The model has been widely applied by fisheries management institutions in the world with the aim of sustainability of fish resources. The MSY was calculated using the formula that was developed by Garcia et al (1989): $MSY = (B_{ave}M^2)/(2M - F)$, where: MSY = sustainable potential (tons $year^{-1}$) and B_{ave} = average of biomass (tons $year^{-1}$), M = natural mortality rate ($year^{-1}$), and F = rate of fishing mortality ($year^{-1}$).

Status of exploitation and utilization. The natural mortality (M) is stated to be "high" if its value is 1.5 $year^{-1}$ or more, and the optimum fishing mortality rate (F_{opt}) occurs when the fishing mortality rate is equal to the natural mortality rate (Pauly 1984). The fishing mortality rate was determined by the formula: $F = Z - M$ (F_{opt}=M) (Gulland 1969). The overexploitation in fish resources occurs when F is greater than M (Gulland 1969).

The rate of exploitation (E) can be estimated based on the mortality rate (fishing mortality, total mortality). According to Pauly (1980), E is generated by comparing mortality rates through the equation: $E = F/Z$ (E_{opt} =0.5). The authors divided the status of exploitation rate into five categories, namely: (a) No exploitation (E=0.00), (b) Low exploitation (0.00=<E<0.50), (c) Optimal exploitation (E=0.50), (d) High exploitation (0.50=<E<1.00) and (e) Stop exploitation (E=1.00).

The rate of scyphozoan utilization (U) was also evaluated using a mortality approach, with the equation: $U = F/M$. The terms corresponding to the utilization status are: (a) No exploitation (U=0), (b) Low exploitation (0<U<1.0), (c) Optimum exploitation (U=1.0), (d) Excessive exploitation (U>1.0), and (e) Stop exploitation (U=∞).

The utilization rate of scyphozoans (U) was calculated based on the production volume (last year) divided by the sustainable production volume, with the formula: $U = (Y_t / Y_{MSY})\, x\, 100\%$. The utilization status of scyphozoan resources was estimated by Dwiponggo (1987), as follows: (a) U=production decreases drastically (Depleted=D), (b) U=>100% MSY (Overfishing=OF), (e) U=>75-100% MSY (Fully exploited=FE) (d) U=> 50-75% (Moderately exploited=ME), (e) U=>25-50% (Lightly exploited=LE), and (f) U=0-25% (Unexploited=UE).

The status of biomass trend (CpUE) of scyphozoan resources was estimated based on the standard values published by Charles (2001). The standard values categorized the biomass trend into three criteria: (a) sharp decline, (b) gradual decreasing, and (c) no decrease.

Results and Discussion

Scyphozoan resources and production. The scyphozoan bloom in the waters of Saleh Bay commonly occurs during the period from September to December and recurs almost every year. Fishers catch scyphozoan every night from October to December using scoop nets. To attract the scyphozoan closer to the fishing vessels, fishers use lights that are turned on using a generator set as a source of electricity. Zooplankton (including scyphozoans) is known to respond to light as they have positive phototactic behavior (Martynova & Gordeeva 2010).

The utilization of scyphozoans has begun in the year of 2006 along with the arrival of buyers from Surabaya (East Java). As well, the registration of scyphozoan production as statistical data has commenced since 2010. Production during the 2010-2015 period ranged from 30,519.14 to 34,566.79 tons $year^{-1}$ with an effort of 0.14-0.27 tons/unit of fishing gear (Table 1). The gradual decrease of the CPUE lasted in the period 2010-2014, and the most severe occurred in 2013-2014 which was -38.92% (Asrial 2015).

Table 1

Production of scyphozoan from Saleh Bay, 2009-2015

Year	*Production (tons year^{-1})*	*Effort (units year^{-1})*	*CPUE (tons/unit/year)*
2009	86,105.00	25,597.00	3.364
2010	111,885.00	30,199.00	3.705
2011	140,170.00	34,921.00	4.014
2012	132,765.00	32,897.00	4.036
2013	142,187.00	38,810.00	3.664
2014	227,084.00	28,120.00	8.076
2015	212,036.00	35,444.00	5.982

Jellyfish bloom occurs in special conditions, such as a low density of medusa predators (medusivorous) populations. The species of medusivorous that live in the Saleh Bay waters are fishes group of grouper, snapper and rabbit fish (Asrial et al 2015a). The binomial or scientific names of medusivores are: *Lutjanus malabaricus*, *Cephalopholis sonnerati*, *Variola louti*, *Cromileptes altivelis* and *Siganus canaliculatus*.

Growth coefficient. The number of scyphozoan samples was 261 ind with a mean diameter of 19.28 cm ind^{-1} and an average body weight of 824.79 g ind^{-1}. The lightest weight was 230 g ind^{-1} (in October 14, 2017), and the heaviest weight was 1,820 g ind^{-1} (captured in December 13, 2017). The average monthly body weight of the scyphozoan samples ranged from 447.5 to 1,295.4 g ind^{-1}, and the average umbrella diameter ranged between 15.91 and 23.38 cm ind^{-1} month^{-1} (Table 2, Table 3). Overall, the average diameters of the scyphozoan umbrella captured each month were: (a) October: diameter=16.81 cm ind^{-1}, (b) November: diameter=19.91 cm ind^{-1} and (c) December: diameter=22.63 cm ind^{-1}.

Table 2

Sampling data of scyphozoans in Saleh Bay on 2017, based on the sampling date

Size	*Sampling date*					
	D (cm)	*W (g)*	*D (cm)*	*W (g)*	*D (cm)*	*W (g)*
	14.Oct.2017 (n=64)		29.Oct.2017 (n=46)		*14.Nov.2017 (n=52)*	
Maximum	20.5	930.0	24.5	1,260.0	24.5	1,400.0
Minimum	12.0	200.0	13.0	290.0	14.5	360.0
Average	15.9	447.5	18.1	655.4	19.6	761.9
	30.Nov.2017 (n=34)		13.Dec.2017 (n=26)		30.Dec.2017 (n=39)	
Maximum	25.0	1,820.0	26.0	1,820.0	27.0	1,600.0
Minimum	16.5	840.0	18.5	740.0	21.0	1,030.0
Average	20.4	1,063.5	21.7	1,160.8	23.3	1,295.4

Table 3

Scyphozoan growth patterns in Saleh Bay

Sampling time	*D<17 cm (%)*	*Growth pattern*		
		b value	*Status*	*Model*
October 14th, 2017	64.06	2.72	MA	ln W = -1.46+2.72 ln D
October 29th, 2017	31.30	2.35	MA	ln W = -0.36+2.35 ln D
November 14th, 2017	17.31	2.26	MA	ln W = -0.13+2.26 ln D
November 30th, 2017	2.86	0.70	MA	ln W = 4.84+2.86 ln D
December 13th, 2017	0.00	2.15	MA	ln W = 0.43+2.15 ln D
December 30th, 2017	0.00	1.58	MA	ln W = 2.21+1.58 ln D

D - diameter of umbrella; b - D variable; MA - minor allometric.

The growth coefficient (K) obtained was 3.00 $year^{-1}$ and the infinity diameter ($D\infty$) value was of 28.88 cm, while the value of t_0 (theoretical age at scyphozoan diameter 0) based on the empirical equation (Pauly 1984) was 0.03 years (Figure 6).

The scyphozoan growth curve was implemented using the Von Bertalanffy growth function (VBGF). The resulting scyphozoan growth equation is $D_t = D\infty \{1\text{-}exp^{-1.1(t + 0.9)}\}$ (Figure 7). It showed that when the age of scyphozoan was 1.0 year, the theoretical diameter of scyphozoan reached 19.58 cm. The asymptotic diameter of scyphozoan reached 28.88 cm was thought to occur at the age of 7.9 years. The scyphozoan growth rate had decelerated since reaching the age of 1.6 years and so on.

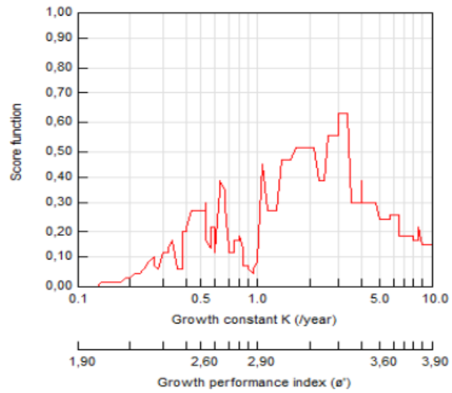

Figure 6. The value curve of K and $D\infty$.

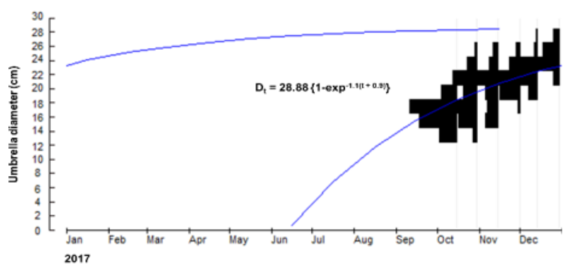

Figure 7. Curve of scyphozoan growth with age plot and theoretical diameter.

Based on the observed samples, the estimated size of the maximum umbrella diameter (D_{max}) of the scyphozoan is reached to 27.50 cm. While the maximum predicted diameter of scyphozoan was 28.56 cm at a 95% confidence interval of 26.36-30.76 cm (Figure 8).

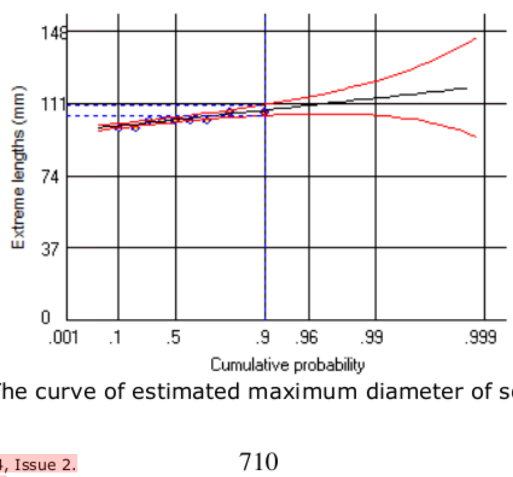

Figure 8. The curve of estimated maximum diameter of scyphozoan.

Cohort (based on diameter and weight distribution). The age composition (cohort) was analyzed using NORMSEP progression analysis model (Figure 9). Overall, there were two types of scyphozoan cohort sampling. During the 1st, 4th, 5th, and 6th sampling activity, only one cohort was found. While on the 2nd and the 3rd sampling, two cohorts were found (Figure 10).

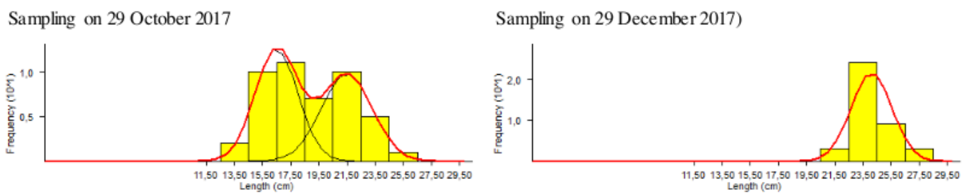

Figure 9. Saleh Bay's scyphozoan monthly cohort analysis.

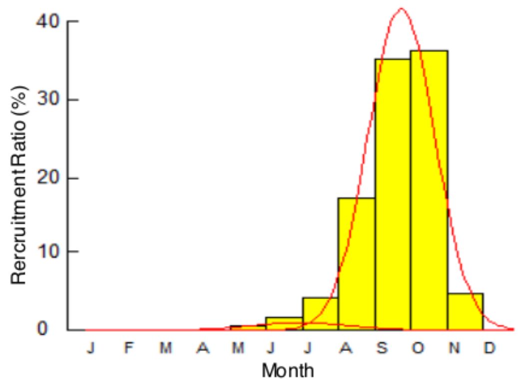

Figure 10. Annual pattern of scyphozoan recruitment in Saleh Bay.

Due to the lack of the scyphozoan samples, the first sampling had only one group of sizes. It consisted of 64 individuals of scyphozoans, with a diameter of 16.69±1.96 cm. The second sampling was represented by two cohorts consisting of (a) the first cohort of 24 individuals with a mean diameter (MD) of 16.48±1.5 cm and (b) the second cohort of 22 individuals with a MD of 21.48±1.8 cm. The first group of scyphozoans samples from the second sampling was similar to the scyphozoans of the first sampling. The third sampling was also composed of two cohorts: (a) the first cohort of 30 individuals with a MD=19.54±3.34 cm, and (b) the second cohort of 22 individuals with a MD=21.50±0.22 cm. The cohort in the third sampling is a part of the second sampling population, which had grown and increased in the average of umbrella diameter as age increased. The fourth sampling composed of one cohort of 34 individuals of scyphozoan with a MD=21.32±1.8 cm. The fifth sampling constituted of one cohort of 26 individuals with a MD=22.35±2.0 cm. The sixth sampling obtained one cohort of 39 individuals with MD=24.12 cm and SD=1.4.

Mortality and the rate of mortality. The rate of the total mortality (Z) for the scyphozoans was 8.21 $year^{-1}$, whereas the rate of the natural mortality (M) at the mean annual water temperature of 30ºC was 3.83 $year^{-1}$, and the fishing mortality rate (F)= 4.38 $year^{-1}$. The exploitation rate (E) reached 0.53 $year^{-1}$ (Figure 11) and the utilization rate (U) reached 1.14 showing an excessive exploitation status. All of these mortality parameters values express an unfavorable mortality status for the scyphozoan population in the Saleh Bay conditions.

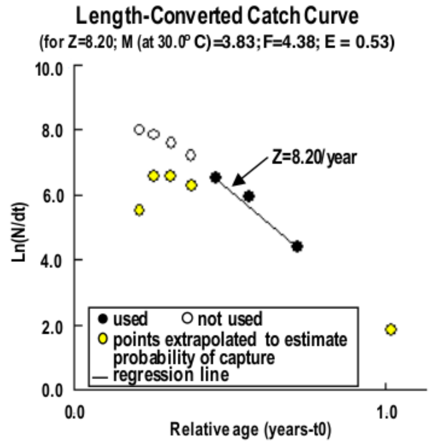

Figure 11. Length-converted catch curve.

The scyphozoan natural mortality rate (M) at the study site was more than 1.5 $year^{-1}$, which, according to the provisions of Pauly (1984), is elevated. The value of fishing mortality rate (F) indicated that the status was overexploited because it had exceeded the optimal capture (F>M → 4.38>3.83). Hence, the utilization status revealed excessive exploitation. Gulland (1969) stated that the fishing rate is optimal when the value is equal to the rate of natural mortality (F_{opt}=M). Similarly, the value of exploitation indicated that the scyphozoan exploitation had exceeded the limits of optimum exploitation (E=0.53>0.50). The exploitation of fish resources reaches the optimum level (E_{opt}) if the value is 0.5 $year^{-1}$ (Gulland 1969).

Scyphozoan diameter at first capture. The fish length at first capture (L_C) by the fishing gear is often also called $L_{50\%}$. It means that the length at which 50% of fish get caught in the net and 50% pass through (Sparre & Venema 1998). In the present study, the diameter of scyphozoan was equivalent to the fish length concept, so it is called scyphozoan diameter first capture (D_C). As well, the results analysis showed that the D_C size in the study sites was 17.8 cm (Figure 12).

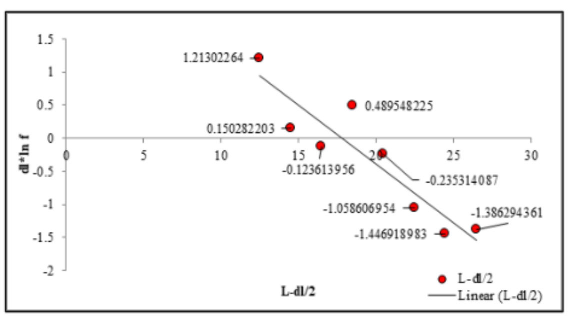

Figure 12. Curve of scyphozoan D_C values.

Therefore, this information would be very important as a reference in the management of scyphozoan resources in Saleh Bay. Uncontrolled fishing activities can lead to a change in the relative abundance of species, negatively affecting the waters fertility and the fish age at first maturity (Allan et al 2005). In addition, it could decline the average age and the length of fish (Hutchings 2004). Walters & Martell (2004) pointed out that fishing activities should be selective on the fish size, in order to avoid overfishing in both recruitment and growth phases.

New individual addition (recruitment). Recruitment in the population is the addition of new individuals to the stock of fisheries (Effendie 2002). The recruitment pattern of scyphozoans in Saleh Bay did not occur throughout the year, especially in the period from January to May. The peak of scyphozoan recruitment took place in September (35.03%) and October (36.15%) (Figure 10).

Based on the recruitment pattern (Figure 10), it was found that the scyphozoans did not breed every month. The peak of the spawning season was expected during June-July. These predictions were confirmed by a relatively abundant and exploited scyphozoan population in the next three months (October-December).

MSY based of surplus production model. The surplus production model used is the Gordon-Schaefer model (Gordon 1954; Schaefer 1957a,b; Schaefer 1959), which can be used to evaluate the scyphozoan fisheries in Saleh Bay. It could estimate the maximum sustainable yield (Y_{MSY}, f_{MSY} and U_{MSY}). Scyphozoans production data processing (by the regression method) for the period from 2009 to 2015 is shown in Table 1.

The values of MSY obtained were: (a) Y_{MSY}=51,477.05 tons year^{-1}, (b) f_{MSY}=124,752 units year^{-1} and (c) U_{MSY}=0.41 tons unit^{-1} year^{-1}. While the statistical model was as follows: $U = 0.8253 - 0.000003\,f$.

If Y_{MSY} above is compared with scyphozoan production in 2015, then the utilization rate has exceeded half of the sustainable stock (65.17%). Thus, the stock of scyphozoan is still in safe condition due to its utilization status as "Moderately exploited" (between 50 and 75%). This was in accordance with Asrial et al (2015b) who reported that the status of scyphozoan utilization in 2013 was "Moderately exploited". Hence, the utilization of scyphozoan resources in Saleh Bay between 2013 and 2015 has the same status.

MSY based mortality. MSY can be estimated on the basis of the equation of Garcia et al (1989). The regression equation of scyphozoan resources in Saleh Bay area is $MSY = 0.2563\,Biomass - 5.2615$ (Figure 13). The current results showed that the MSY=25.63% for the scyphozoan biomass. With regard to the mean of scyphozoan biomass during the period from 2010 to 2015 (64,198.34 tons year^{-1}), then MSY estimation was 16,448.77 tons year^{-1}. By 2015, scyphozoan production from Saleh Bay was 33,545.10 tons. The utilization rate reached 49.03%. This means that the status of utilization of scyphozoan resources in Saleh Bay is "Low exploitation" (between 25.0 and 50%).

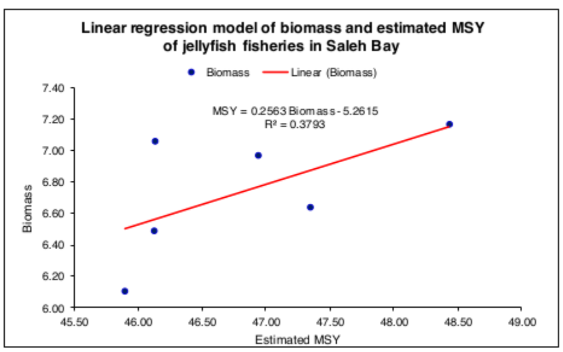

Figure 13. The linear regression model of biomass and estimate MSY.

Discussion. In the present study, the individual growth pattern parameter of scyphozoan (b=0.70-2.72) was hypo-allometric. This finding is supported by the pattern of the allometric equations, showing the strong relationship between the umbrella diameter and the body weight of scyphozoans. This was in agreement with the results of Effendie (2002) who mentioned that the growth rate of the diameter of scyphozoan is hypo-allometric, as it grows faster than it gains weight.

The results of the LWR analysis use the data in Table 1, with r=87.05%, R^2=75.77%, adj. R^2=70.93% and SE=18.49%. The value of R^2 means: (a) the fishing gear has a strong influence of the CPUE value (R^2 between 60 and 80%), and (b) the model can be used for forecasting (R^2>60%) (Mulyono 2001). The high value of adjusted R^2 (>50%) indicates that samples are representative for the population.

Scyphozoan that could be processed should have an umbrella diameter of more than 18.0 cm ind^{-1}. That feasible size occurs in Saleh Bay scyphozoans at the age of one year, where they reach a D of 18.15 cm ind^{-1}. The prediction of fish growth up to their exploitable size is very important in order to prevent overfishing (Hilborn 1996).

Based on the sampling data in October-December 2017, the percentage of scyphozoans whose processing was not feasible (D<18.0 cm ind^{-1}) was as much as 34.87%, of which 29.50% was caught in October 2017 (D between 12.0 and 17.5 cm ind^{-1}, $D_{average}$=15.26 cm ind^{-1}) and 5.76% was captured in November 2017 (D between 14.5 and 17.0 cm ind^{-1}, $D_{average}$=15.86 cm ind^{-1}), while in December 2017 the smallest diameter size of scyphozoan's umbrella was 18.50 cm ind^{-1}.

Regarding the method used, possible sources of errors are to measure the jellyfish samples only at a certain point in time (e.g., one month) or at one sampling site, during the fishing season of scyphozoan. The concern is that jellyfish do not rise to the water surface to be caught, during the capture season.

The scyphozoans captured in October 2017, at the age of 10 months, were probably originating from the recruitment occurred during December 2016 (captured). Also, the scyphozoans caught in November 2017, were probably originating from the recruitments occurred in November 2016 (those caught at the age of 11.85 months) and in December 2016 (those caught at the age of 11.0 months). The scyphozoans captured in December 2017 at the age of 15.0 months, 13.85 months and 12.47 months, they were predicted to be originated from the recruitments occurred in October, November and December 2016, respectively).

Recruitment occurring during June-September was strongly suspected to endure the natural mortality in the phase of juveniles and/or before reaching adulthood. It was assumed that the mortality occurred during the dry season on the Sumbawa Island in the period of April-September. Moreover, the high natural mortality was revealed by the value of M, that was 3.83 $year^{-1}$. According to Pauly (1984), if the value of M reaches 1.5 $year^{-1}$, then the M status is in the high category.

Mortality greatly affects the scyphozoans' stock and biomass safety in the waters of Saleh Bay. This is in line and similar to Gordon & Schaefer's (1959) stock estimation model which is based on a biological approach.

The M/K value in the red jellyfish from the present study was 1.46. This value was very normal because it ranged from 1.0 to 2.0 (Beverton & Holt 1956; Pauly 1998). However, this is still lower (less than half) compared to 3.03, the value obtained by Palomares & Pauly (2009).

It was found that the MSY of the scyphozoans and the safe yield for a sustainable utilization cannot reach more than 72,023.41 tons $year^{-1}$. When the production of scyphozoans in 2015 was compared with the MSY, it revealed that the utilization rate had not reached half of the stock (46.58%). Thus, the stock of scyphozoans is still in a safe condition, due to its utilization status as "low exploitation" (between 25 and 50%). The utilization status was better when compared to 2013, with a "Fully Exploited" status, according to Asrial et al (2017). The status of scyphozoan biomass trend in Saleh Bay was "no decrease", following the standard status from Charles (2001). Accordingly, the parties have taken the appropriate actions to achieve and secure a safe scyphozoan stock.

MSY is widely used as a basis for developing and implementing modern fisheries management models. MSY constitutes half (50%) of fish biomass that can be caught from the total fish biomass available in one waters area. Thus, the 50% of fish stock left in the waters can reproduce productive processes indefinitely. With the addition of new members to the population (recruitment), the existence of one type of fish will remain sustainable and fisheries activities will be sustainable. The use of MSY for fisheries activities, including jellyfish fisheries, is still very effective, while the weakness of the MSY concept is not being able to estimate the spawning potential ratio (SPR) of the parent in a population of a species of fish that is still alive and breeding in certain waters.

Conclusions. Parameters of fisheries biology and fish population dynamics are the most important part of the biological dimension to detect and determine the causes of the population change. Hence, they are effectively applied to assess the status of scyphozoan resources and population. Therefore, the government can use these parameters to predict the stock, utilization rate and exploitation rate of jellyfish. The aim of this study was to create sustainable and responsible jellyfish fisheries management. It is expected that bureaucrats and technocrats can use these attributes to predict the sustainable potential/MSY (Y, f & U), utilization rates and the level of exploitation of jellyfish regularly, every year.

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Authors:
Evron Asrial, University of 45 Mataram, Department of Fisheries Resources Utilization, Faculty of Fishery, Jl. Imam Bonjol 45, Mataram 83239, West Nusa Tenggara, Indonesia, e-mail: evronasrial81@gmail.com
Hamid, University of Mataram 45, Department of Aquaculture, Faculty of Fishery, Jl. Imam Bonjol 45, Mataram 83239, West Nusa Tenggara, Indonesia, e-mail: hamid.salwi@gmail.com
Muhammad Marzuki, Mataram University, Faculty of Agriculture, Department of Aquaculture, Jl. Majapahit 62, 83115 Mataram, West Nusa Tenggara, Indonesia, e-mail: marzuki_rina@yahoo.co.id
Erwin Rosadi, Lambung Mangkurat University, Faculty of Fishery and Marine, Department of Capture Fisheries, Jl. Ahmad Yani Km 36th, 70714 Banjarbaru, South Celebes, Indonesia, e-mail: erwin.rosadi@ulm.ac.id
Ruly Isfatul Khasanah, State Islamic University of Sunan Ampel, Faculty of Science and Technology, Marine Science Program, Jl. Ahmad Yani 117, 60237 Surabaya, East Java, Indonesia, e-mail: ulick.isfatul@gmail.com
Gatut Bintoro, Brawijaya University, Faculty of Fishery and Marine Science, Department of Fisheries Resources Utilization and Marine, Jl. Veteran, 65145 Malang, East Java, Indonesia, e-mail: gatutbintoro@yahoo.com
Naning Dwi Sulystyaningsih, Mataram 45 University, Faculty of Fishery, Department of Aquaculture, Jl. Imam Bonjol 45, 83239 Mataram, West Nusa Tenggara, Indonesia, e-mail: nonaning11@gmail.com
Rusmin Nuryadin, University of 45 Mataram, Faculty of Fishery, Department of Fisheries Resources Utilization, Jl. Imam Bonjol 45, 83239 Mataram, West Nusa Tenggara, Indonesia, e-mail: rusmnnuryadin87@gmail.com

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