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Original Paper

THE GROWTH ANALYSIS OF *Stichopus vastus* (Echinodermata: Stichopodidae) IN KARIMUNJAWA WATERS

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ABSTRACT

Stichopus vastus is one of sea cucumber resources utilize which has commercial economic value, locally known as "gametes". Because this species is continuously exploited, while the nature of life has not been known, one of them especially its growth. Aspect of growth is an important parameter which is used as a basis for evaluating these resources, hence this resource is well managed and can be utilized in a sustainable manner. The study aims to: (1) estimates the growth characteristics mortality rate, recruitment and potential use of sea cucumber of S. vastus in Karimunjawa. The study is expected to give beneficial to the species of sea cucumber resource management strategy at Karimunjawa waters, Jepara. The analysis of the growth parameters of S. vastus obtained values of growth coeficient (K) of 0.55 year-1 and length infinity L ∞ value of 315.80 mm. Therefore the obtained values of K tend to be close to zero value, it indicates the nature of growth tends to slow and with a relatively long life. Life span of S. vastus is 5.41 years, which can achieve body lengths of 283.06 to 296.91 mm, and the monthly growth rate ranged from 9.0 to 12.37 mm. The results of the analysis of mortality showed that S. vastus has value of total mortality (Z) of 0.98, natural mortality (M) of 0.298, and catch mortality (F) of 0.682, with the rate of exploitation (E) of 0.6963. This suggests that the rate of exploitation is above the threshold standard set by the Government of 0.5 (BRKP, 2004). The analysis of the S. vastus the recruitment showed that the higest percentage recruit occurred in May-June is 17.16 - 18.33%. This is presumably due to a population increase of the spawning process in those months, although the value of the addition is not very significant. It is suggested the need for regulations regarding: (a) the catchment season which is based on the tendency of the reproductive patterns of S. vastus, in Karimujawa, (b) restrictions on the size of the catch, (c) catch quotas, (d) the methods that are environmentally friendly catch, (e) permits the ship / boat used to catch sea cucumbers business. To support the success of regulation, it is necessary to strengthen community institutions through the management of sea cucumber resource-based society, with the Co-management approach.

Key words: Stichopus vastus ; growth ; mortality ; recruitment ; potential utilization.

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INTRODUCTION

Ecologically, Karimunjawa waters are dominant coral reef ecosystems and their associates. As coral reefs and their associations, the aquatic ecosystem of Karimunjawa have a very important ecological function, which can provide food and habitat for a variety of marine resources, and are vital ecosystems that provide the functions and roles in stability of the ecosystem. Condition of the ecosystem is possible for sea cucumber resources to be able to grow and thrive in their habitats.

Sea cucumber is a member of the phylum Echinodermata, Holothuroidea class significance of benthic communities, many are found in shallow water coral reef environments near shore waters to the deepest part (Atafua *et al.*, 2008), has relative slow movement (sluggish) (Friedman *et al.*, 2008; Brusca and

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Brusca, 2003; and Chenoweth and McGowan, 2009). One type of sea cucumber which is dominant in Karimunjawa waters is Stichopus vastus. This species is known locally as sea cucumbers gametes and this type is used by many local people as high valuable organism which is quite expensive commercial medium category.

Sea cucumber S. vastus is widely used as an export commodity, which is taken from nature, and regardless of it's sustainability. On the other hand, the knowledge of various aspects of growth are also not yet known, this aspect of growth is one indicator that is used as the basis for management. Considering the importance of these resources for the community, on the other hand, concerns over the sustainability of the resource population, the growth aspects of this species needs to be studied and analyzed further so it can be beneficial to develop plans for management strategies.

Materials And Methods

Given the limited sample taken, then the data collection was done by freely transect, at the study site. The sea cucumber *S. vastus* samples taken 40 individuals for many sampling, because for limited samples number, at least minimal individuals taken is 30 individuals per sampling (Saputra, 2009). Reasons for the selection of species used with the following judgment, (a) the sample used is a commercial sample belonging to the type of behavior in the market, (b) species of sea cucumber that are found by a fisherman, (c) the number of eligible required ,ie at least 30 individuals per species sampled at each sampling.

Samples obtained from the sampling was then preserved using $MgCl_2$ to achieve a state of relaxation, then the samples were measured their body length without visceral (body Wall) using the tool bar (mm) and recorded.

Estimation of growth parameters related to age, through the growth model approach Von Bartalanfy in total length, with the following formula :

$$Lt = L\infty\,(1 - e\text{-}K\,(t\text{-}t_0))$$

Based on length frequency data from each of the measurement, the results obtained at each sampling time will show the minimum and the maximum score. Then the data is incorporated into the program called sub program FiSAT, ELEFAN II (Electronic Lengths Frequency Analysis) to obtain the hypothetical age at length zero (t_0), used empirical formula Pauly (1980), by inserting the value of K and L ∞ in the equation as follows:

$$\text{Log } 10\,(-\,t_0) = -\,0.3952 - 0.2752 \log 10\, L\infty - 1.038 \log 10\, K$$

Where, K = growth coefficient
L ∞ = length asymtot
t_0 = age when length equals zero.

To get a natural life span were obtained from the translation Von Bartalanfy equation:

$$t = \log 10\,(1 - Lt / L\infty) / K - t_0$$

If the initial allegations length infinity (L ∞), obtained from the formula Pauly (1980), the equation L ∞ = L max / 0.95 is known, then the value will be different between the size of the organisms that lived long and short. For the short-lived fish will be smaller than L ∞ = L max / 0.95, and vice versa. To obtain the longest life of sea cucumbers (life span) is L max = 2.9957 / K + t.

Used approach to estimating total mortality Length Converted Cath Curve (LCCC), which is a linear relationship between the natural log (ln) of the change in the number of individuals to grow cucumbers in a time-i with age. The formulas used are as follows:

$$\ln (Ni / \Delta ti) = a + b\, ti$$

Where: N = number of individuals of sea cucumbers in the ith length class
t = age of relative, with t_0-0
b = angle / slope which is a form of value

Based on mortality estimates obtained with the LCCC approach the value of Z which is a negative value of the slope (b) based on the equation above. Having obtained the value of Z we then calculated the value of the alleged natural mortality (M) by using the formula Pauly (1984) as follows:

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Log M = -0.0066 - 0.279 log L ∞ + 0.6543 log K + 0.4634 log T

The value M is used to estimate the value of F (fishing mortality) by Z (total mortality), M (natural mortality) and to estimate the exploitation rate (E) is to see the results of F / Z, with values that do not exceed the value of 0.5 (BRKP, 2004). If the value is greater than 0.5, then the value of resources in conditions that are worrisome. Based on the trace length frequency data entered into the program is tailored to the equation FiSAT Von Bartalanfy then obtained monthly proportion of the population of new individuals additions.

RESULTS AND DISCUSSION

Result

Growth Esimation

During the period of July 2010 - May 2011, 240 individuals of *S. vastus* has been obtained. The obtained samples were subsequently measured their body length taken at each sampling time (**Table 1**).

Table 1. The length size distribution of S. vastus during the research study.

Sampling time	No. of sample (N)	Min-max Interval (mm)	Average ± SD (NORMSEP)
2010, July	40	231 – 270	250.50 ± 9.47
2010, September	40	178 – 289	275.00 ± 8.66
2010, November	40	225 – 291	252.50 ± 14.8
2011, January	40	221 – 300	270.50 ± 15.80
2011, March	40	225 – 285	251.00 ± 12.807
2011 May	40	225 – 300	275.75 ± 17.52

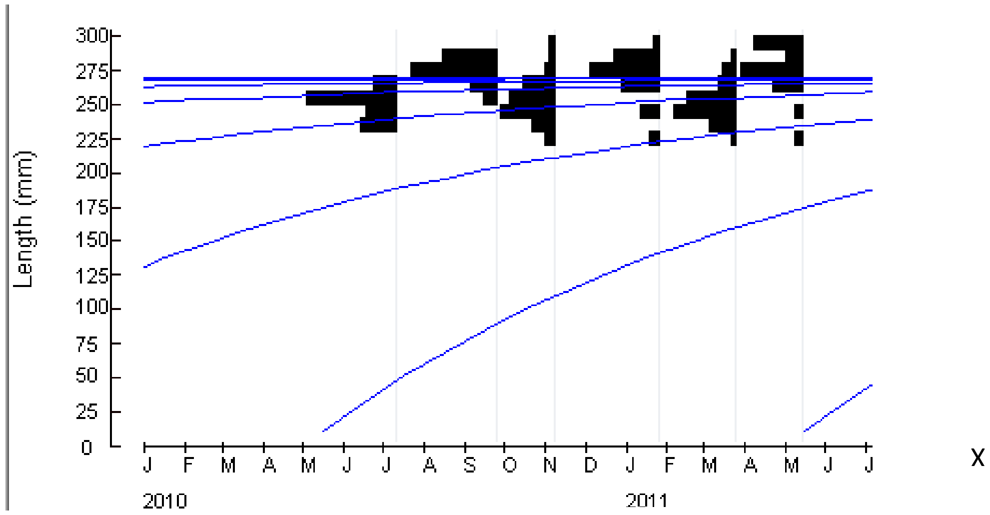
The analysis of the data length (mm) frequency distribution can be determined by the scale length of 10 mm class interval. Furthermore, the data were analyzed using the method through the auxiliary Bhatacharya (FiSAT software), so that it reveals the condition of the distribution of population (cohort) based on the length of each species at each sampling time. The results of the analysis of the distribution of the cohort are shown in **Table 2.** The analysis of monthly distribution of cohort shows that there is one cohort in each month, and *Stichopus vastus*, has three groups of cohorts, i.e: Cohort A with mode shift from July 2010 amounted to 250.50 ±9.47 mm to 275.00 ± 8.66 mm in September 2010, with average growth of 12.25 mm month-^{1} Cohort B of 252.50 ±14.79 mm in the month of November 2010 to 270. 50 ± 15.81 mm in the month of January 2011, with average growth of 9.00 mm month-1. Cohort C of 251.00 ± 12.81 m in the month of March 2011 to 275.75 ± 17.52 mm in the month of May 2011, with average growth of 12.36 mm month-1.

Table 2. Distribution of monthly growth rate of S. vastus during the research study

Cohort	Averages (mm) ± SD	The shift mode (month)	The growth rate month-1 (mm)
A	250.50 ± 9.47 – 275.00 ± 8.66	July – September	12.25
B	252.50 ±14.8– 270.50 ± 15.80	November - January	9.00
C	251.00±12.807–275.75± 17.52	March – May	12.37

To obtain the value of the coefficient of growth in length infinity (L ∞) and growth coefficient (K) measured the length of the data used in time series, using the Von Bartalanfy equation Lt = 12.75 [1 - e -0.31 (t-0, 2421)]. Length infinity (L ∞) is a factor that shows how much the size that can be achieved by an individual to perform the growth of sea cucumbers, and K is a factor used to determine the rate of growth of an individual sea cucumber to reach a length of infinity (Sparre and Venema, 1992).

Based on the analysis through FiSAT program, sub program ELEFAN II (Gayanillo, *et al.*, 1994), it obtained values of growth coefficient (K) and length infinity (L ∞) for the species S. vastus, the L ∞ = 315.8 mm and K = 0.55 year-1. To obtain a Von Bartalanfy Growth Curve (VBGC), which was formed from the length distribution data for the study of sea cucumbers, are shown in the growth curve in **Fig. 1.** For the longest expected life span takes the value of t_0 of sea cucumbers in which the age at length zero, which is based on the empirical formula of Pauly (1980), the log - t_o = - 0.3952 - 0.2752 log L ∞ - 1.038 log K.



Month (January 2011 –July 2011)

Fig. 1. Length-frequency distribution output from FiSAT with superimposed growth curve for S. vastus from Karimunjawa waters, . L∞ = 315.8 mm (total length), K = 0.55 year-1

The analysis of the translation Von Bartalanfy equation obtained values of life span (longevity) of sea cucumbers. Those values obtained from the equation t = log10 (1 - Lt / L ∞) of K + to, and if the maximum length (L max) = 0.95 (L∞), the value obtained is inserted into the equation above, the obtained age of the longest sea cucumbers (t max). Value of the longest life (life span), which is tmaks = 2.9957 / K + to. If L∞, K, and t0 is known, then tmaks known.

Analytical results obtained value of t_0 = 0.98 , t max = 5.44 years, and L max = 300 mm. The results of the analysis, provide information that for *S. vastus* in length beginning atbirth t_0 = 0.98 mm and the maximum age tmax: = 5.44 years and a maximum length Lmax = 300 mm, The analysis showed that the life span for *S.vastus* is 5.44 years, with a body length is around 283.06 to 296.91 mm. (**Table 3**).

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Table 3. The analysis estimates the growth parameters *S. vastus*

Year	Lt (length at the t- age)
1	20.42
2	145.38
3	217.47
4	259.06
5	283.06
6	296.91

By using the longest age data (t max), the age to, K, and L∞ then the model can then be alleged that form on the growth curve as in **Fig. 2.**

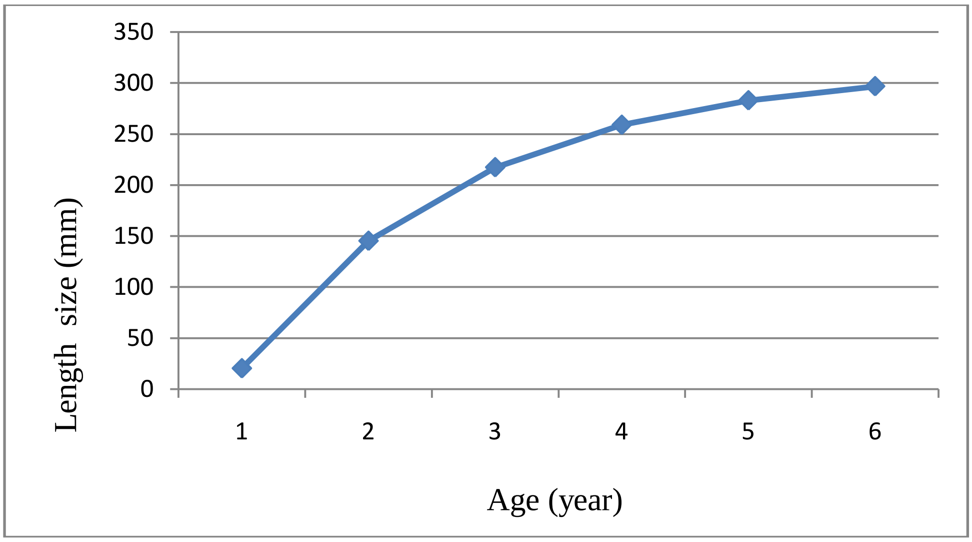

Fig. 2. The growth curve of the sea cucumber *S. vastus.*

Mortality

Mortality parameters estimate use Length Converted Catch Curva (LCCC) will result in the equation Y = 7.564-0.997 X with the value obtained for r = 0.817. The analysis showed that the value of total mortality (Z) obtained from the negative slope (b), namely 0.997 value estimate total mortality (Z), is used to estimate natural mortality (M), fishing mortality (F), and the rate of exploitation (E), as shown in **Table 4** below.

Table 4. Mortality Analysis of *S. vastus.*

Total Mortality (Z)	Natural Mortality (M)	Catch Mortality (F)	Exploitation Rate (E)
0.98	0.297	0.682	0.696

Analysis results provide information that *S. vastus* obtained value of total mortality Z = 0.98, natural mortality M = 0.298, catch mortality F = 0.682 and exploitation rate E = 0.696. More information can be found on Length Converted Catch Curve (LCCC) of the

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S. vastus species from Karimunjawa waters were observed (**Fig. 3**).

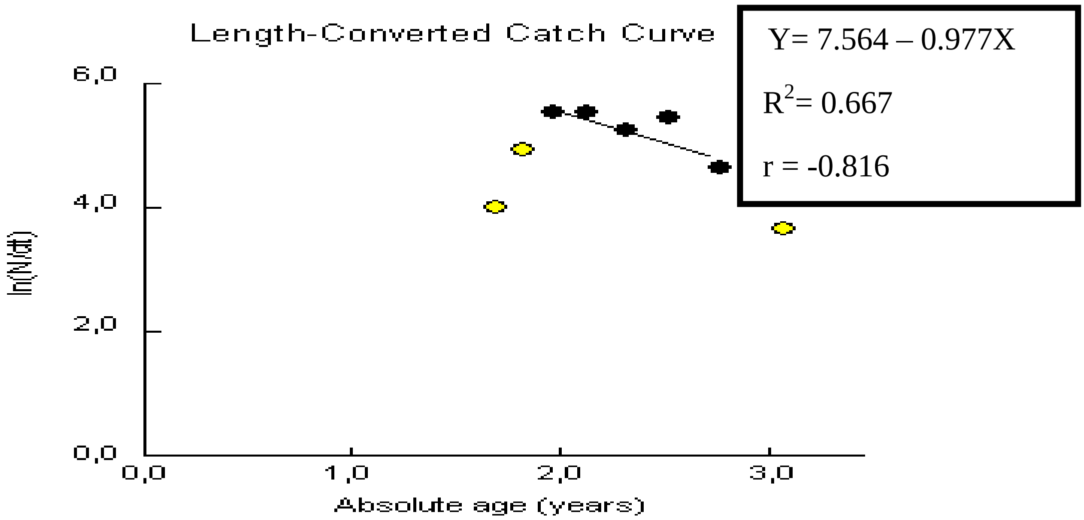

Fig. 3. Length-converted catch curve (LCCC) for S. vastus from the Karimunjawa waters.

Recruitment.

By using the length frequency data, and then analyzed using a software program ELEFAN II Pattern recruitment, the FiSAT sub program package (Gayanillo, *et al.*, 1994). The analysis of monthly recruitment (%) can be seen in **Fig. 4.**

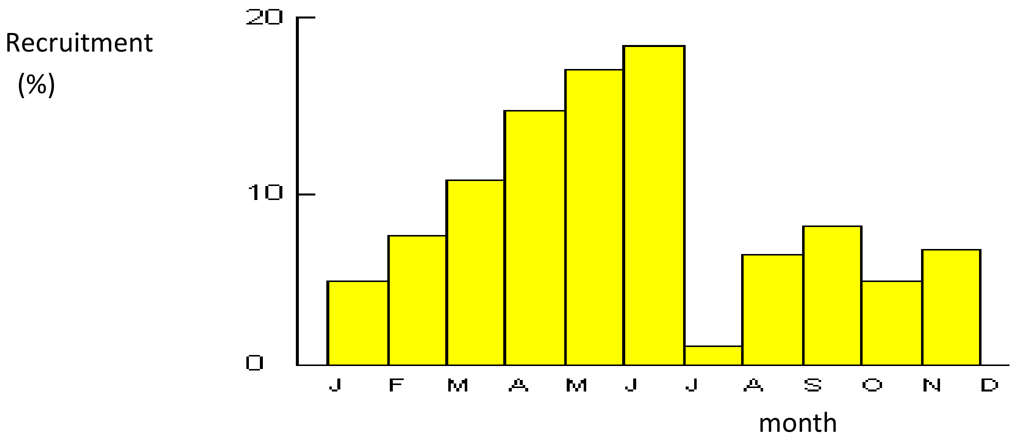

Fig. 4. Rrecruitment (%) monthly S. vastu.

Analytical results obtained showed that every month the addition of an individual to population, except December where the addition of new individuals is zero. The highest recruitment value for S. vastus occurred in May 2011 and June 2010 respectively by 17.16% and 18.33%.

Discussion

The results of the analysis of the growth of *S. vastus* revealed that the growth coefficient K approach the value 0 (zero), which belongs to the nature of slow growth, life span, and to achieve the maximum length require a relatively long period. This is shown from the analysis of the growth coefficient K of 0.55 year-1, the L∞ is achieved by 315.80 mm. K and L ∞ value obtained does not vary much with the results of several previous investigators (**Table 5**). Growth curve of **Fig.1** and **Table 2** shows that for the range of *S. vastus* life is 5.44 years with a body length is achieved at 283.06 to 296,91 mm.

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Table 5. Comparison of S. vastus Von Bartalanfy Growth in Karimunjawa waters and the location of the Gulf waters of Southern California, Mexico.

Jenis	L ∞ (mm)	K (year-1)	Site	Reference
S. japonicus	367.00	0.33	Southern Gulf of California, Mexico	Hamano, *et al.*, (1989)
S. chloronatus	342.00	0.45	Southern Gulf of California, Mexico	Conand (1990)
S. vastus	315.80	0.55	Karimunjawa	In this research study

The results Chavez, *et al.*, (2011) to Parastichopus parvimensis in California waters, values obtained by 5-year life span, which is lower than the results of research on this species. However, CITES (2002), in an average life span of sea cucumber S. japonicus 5-10 years old with most of the first species to reproduce at the age of 2-6 years. Further it is said that the speed of the growth rate of *Stichopus japonicus* per month for an average of 4-20 mm, whereas in this study found increasing the length or growth rate per month is 18.00 to 24.75 mm, the results of this study was also supported by the opinions of Purcell (2009), that the life span of sea cucumber generally 5-10 years. Thus, the rate of growth in length per month in this study are not much different attempts to discuss the research in other areas.

Recruitment is the inclusion of a group of individuals of a species population into stocks which occur naturally through the process of breeding stock and have reached a certain size. Based on this, so in this study indicate that the observed species new additions have occurred in every month with varying amounts, and there tends to be increased especially in the month of May 2011, and June respectively by 17.16% and 18.33 %., although not sharp. Rise and fall of the percentage of recruits in each month low quality can be caused by the dynamics of gonad maturation that occurred in previous months are relatively low. The low quality of gonad maturity as much distance between individuals, or individuals who are low-density conditions, the effects of global warming, and the occurrence of predation on sea cucumber juvenil before adult hood. As is known spawning and fertilization success is directly dependent on population density (Levitan and Sewell, 1998). Other reasons, such as sea cucumbers are not taking the time to see spawning season and size of sea cucumbers.

The analysis showed that the mortality due to capture (F) and catch rate (E) of each species at 0.862 and 0.696. The analysis shows that the condition of sea cucumber S. vastus observed in conditions that are worrisome because value and the ratio of the catch (E) has been more than 0.5 and a maximum value of the total population or the rate of exploitation has been exceeding the threshold recommended by the government, which is 0.5 of the population (BRKP, 2004). This indicates that the pressure of exploitation of S. vastus in Karimunjawa waters are relatively very high. If this is not managed since from now feared this sea cucumber species will become extinct in the future. Increase in the rate of exploitation led to the disruption of equilibrium in which the total mortality rate equal to natural mortality,

Sustainable exploitation can be achieved when the production conditions of the annual stock mortality due balance between the number of catches (F) and natural mortality (M), here in after referred to as total mortality (Z). At the same time catch mortality by natural mortality (F = M) or at the level of exploitation of 50%, then E = F/Z = 0.5, which occurred on the stock after the arrest, as shown by Marine and Fisheries Research Institute (2004).

CONCLUSIONS

The results can be conclude as follows :

1. Estimation of the S. vastus growth parameters
   The .S. vastus K values of obtained tend to be close to zero value, it is indicated that the growth properties of the observed species tend to be slow and with a relatively long life (5.44 year).

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2. Mortality
   The results of the S. vastus mortality analysis suggests that the rate of exploitation is above the threshold standard set by the Government of Indonesia.
3. Recruitment
   The analysis of the S. vastus recruitment from Karimunjawa waters shows that the percentage of new individual additions (recruitment): the highest population of *S.pus vastus* occurred in May-June, this is presumably due to a population increase of the spawning process in those months, although the value of the addition is not very significant.

Suggestion

Based on research results obtained during the time period July 2010 - May 2011, the following suggestions are forwaded:

1. Based on the research results, in order to avoid a sharp decline in population and even scarcity, it is suggested to have regulations regarding: (a) the catchment, which is based on the tendency of the reproductive patterns of sea cucumber S. vastus from Karimujawa waters, (b) restrictions on the size of the catch, (c) catch quotas for individual per year, (d) innovation of technology for method of catch-friendly environment, namely: the tools and equipment used for diving which do not damage the health and ecosystems, and (e) permits the ship / boat used for sea cucumber fishing effort.
2. To support the success of stock management, it is required to have strengthening community institutions, through the management of sea cucumber resource-based society, with the Co-management approach.

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