ASSESSMENT OF SAND LOBSTER (*PANULIRUS HOMARUS*) RESOURCES IN PALABUHANRATU WATERS OF SUKABUMI, WEST JAVA, INDONESIA

Suwartono Tomi

Master's Program in Marine Science, Faculty of Mathematics and Natural Sciences,
University of Indonesia, Indonesia
E-mail: tomeo_37@yahoo.co.id

ABSTRACT

Lobster fisheries resources are popular food commodities with high economic value. Consequently, lobsters are captured globally and have very high selling prices. Palabuhanratu Bay is one of the lobster fisheries centers in West Java, Indonesia. Sand lobster (*Panulirus homarus*), one of the lobster species in Palabuhanratu Bay, has experienced a decrease in the catch. This research aims to (1) examine the sand lobster population based on biological aspect and population dynamics aspect; (2) identify the utilization status and management of sand lobster resources. Population parameter was analyzed using the FISAT II program and Maximum Sustainable Yield (MSY) potential assessment. The results showed that sand lobster carapace length ranged between 30-101 mm with 97.6% carapace length below 8 cm. The growth pattern of sand lobsters was negative allometric. The $L_c < L_r$ value indicated that female sand lobsters have been caught before reaching the mean size at onset of spawning. Asymptotic length (L_∞) of male sand lobsters was smaller than female sand lobsters, while growth coefficient (K) of male sand lobsters was faster than female sand lobsters. The rate of exploitation (E) values for male and female sand lobsters showed above optimum values of 0.59 and 0.61. The sustainable potential and lobster resource utilization level in WPP 573 Waters was 662.93 tons/year and 910 thousand trips with nets as standard fishing gears. Catch fluctuated with a decreasing trend and the rate of exploitation above the optimum value. It indicated that overfishing has occurred.

KEY WORDS

FISAT II, sand lobsters, MSY, *Panulirus homarus*, Palabuhanratu Bay.

The high economic value of lobsters is one of the factors causing continuous lobster fishing with no attention to the resource and environmental conditions. Lack of awareness of fishery practitioners (communities, businesspersons, and fishermen) on the importance of environmentally-friendly fishing practices that can guarantee the sustainability of sea lobster stocks will damage lobster ecosystem and habitat, causing a reduction in the commodity stocks (Wardiatno and Mashar, 2013).

Palabuhanratu Waters is a potential waters with abundant fisheries resources and used as fishing areas for fishermen, one of which is lobster fishing. The high economic value of sand lobsters (*Panulirus homarus*) is one of the factors that encourage Palabuhanratu fishermen to conduct continuous fishing activities without regard to the resources and environmental sustainability. Fishermen are lack of awareness to control fishing as well, for example by regulating the number of catches and lobster fishing effort.

LITERATURE REVIEW

Palabuhanratu community identifies sand lobsters with the name of crayfish. Classification of sand lobsters according to Chan (1998) is:

Phylum: Arthropoda;
Subphylum: Crustacea;
Class: Malacostraca;
Order: Decapoda;

Suborder: Macrura;
 Family: Palinuridae;
 Genus: *Panulirus*;
 Species: *Panulirus Homarus*.

Figure 1 – Dorsal view of lobsters of the genus *Panulirus* (Source: WWF Indonesia, 2015)

In general, the growth rate of lobsters in the family Palinuridae ranges between 0.27-0.54/year. The asymptotic carapace length is quite diverse but generally ranges between 118-164 mm. The values of the growth rate and the asymptotic carapace length are used to determine the maximum lifespan of a lobster population. From some research results, the maximum lifespan of lobsters in the family Palinuridae ranges between 10-14 years (Kadafi et al., 2006). Cobb and Phillips (1980) state that lobsters are found mostly in coastal waters, especially on rocky bottoms or coral reefs, and sometimes on sandy bottoms mixed with aquatic plants. Adult lobsters generally molt and breed during the summer, so that a ban on lobster fishing during this period provides an opportunity for population development (Moosa MK and Aswandy I, 1984).

Population dynamics refers to how populations change in size over time. Population dynamic of lobster resources in waters is characterized by changes in population size both through additions and subtractions (Wijaya, 2007). In the balance of population dynamics, additions to the population can be caused by births, deaths, and migrations of lobster resources. According to Badrudin (2012), the catch per unit effort (CPUE) is a measure of relative abundance as one indicator of lobster resource status, while production levels can act as economic performance indicators. The CPUE trend of fisheries is an important indicator of fishery health.

Table 1 – Advantages and Disadvantages of Lobster Fishing Gears

Name of Fishing Gear	Advantages	Disadvantages
Trap	Able to catch more lobsters than <i>krendet</i> because trap has a bigger chamber than <i>krendet</i>	Need a bigger place when on a boat The cost of making is more expensive than <i>krendet</i> .
Hook with Diving	More selective in terms of the catch.	Able to threaten the health of the catcher when diving
<i>Krendet</i> (hoop net)	The cost of making is cheaper Easy to carry	Fewer caught lobsters than trap Able to damage habitat if left behind or stuck
Trammel Net or Bottom-set Gillnet	Able to catch a fairly large amount of lobsters because the net is long and stretched	Less selective in catching because the net not only catches lobsters but also another biota, such as reef fish, etc.

Source: WWF Indonesia (2015).

Where: W = body weight; L = fork length; a and b = constants.

The length at first capture value or the length at which 50% of a fish at first capture was calculated by the following formula (Sparre & Venema, 1999 in Nuruludin and Sadhotomo, 2013).

$$SL = \frac{1}{1 + \exp^{S_1 - S_2 * L}}$$

Where SL = logistic curve; L = length interval midpoint; S1 and S2 = Constants.

Equation can be rewritten as:

$$\ln\left(\frac{1}{SL} - 1\right) = S_1 - S_2 * L$$

$$L_{50\%} = \frac{S_1}{S_2}$$

The mean size at first gonad maturity (Lm) was calculated using the Spearman-Kärber formula developed by Udupa (1986) as follows:

$$m = x_k + \frac{d}{2} - (d \cdot \sum P_i)$$

Where: m = log size of length groups at first maturity; d = log size increment; k = number of length groups; xk = last log size at which 100% of shrimp are fully mature (Pi = 1). Thus, the length at first maturity was given by antilog equation.

Estimation of growth coefficient (K) and asymptotic length (L ∞) was obtained based on the Ford-Walford method (Sparre and Venema, 1999) by regressing lobster length at age t (Lt) with lobster length at age t+1 (Lt+1) which resulted in growth parameter equation K = -Ln b and L ∞ = a/(1-b). The t0 value or theoretical age of fish was calculated using Pauly's (1983) empirical formula of:

$$\text{Log}(-t_0) = -0.3922 - 0.2752 \log L\infty - 1.038 \log K$$

Estimation of growth parameters (L ∞ and K) used the FISAT (FAO-ICLARM Stock Assessment Tools) II version 1.2.2 program with the ELEFAN I (Electronic Length Frequency Analysis) method.

Von Bertalanffy growth model is as follows:

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

Where: Lt = lobster length at age t; L ∞ = asymptotic length; K = growth coefficient; t = time.

The total mortality rate (Z) was estimated using the Jones & Van Zalinge method, while the natural mortality rate (M) was estimated using Pauly's (1984) empirical formula.

$$\ln M = -0.0152 - 0.279 \ln L\infty + 0.6543 \ln K + 0.463 \ln T$$

Where: M = natural mortality; L ∞ = asymptotic length in the Von Bertalanffy growth equation; K = growth coefficient in the Von Bertalanffy growth equation; T = average water surface temperature (°C).

RESULTS AND DISCUSSION

Previous lobster research in Palabuhanratu Bay obtained a range of carapace length (CL) which was not significantly different from Zairion et al.'s (2017) research. Carapace length of lobsters caught using nets ranged between 28-100 mm.

Table 2 – Lobster production in WPP 573 Waters and Indonesian Waters

Years	Production (tons)		Proportion (%)
	WPP 573	Indonesia	
2005	954	4,538	21.02
2006	759	4,121	18.42
2007	661	4,151	15.92
2008	670	4,631	14.47
2009	630	4,193	15.03
2010	414	4,091	10.12
2011	532	6,731	7.90
2012	673	4,946	13.61
2013	525	4,928	10.65
2014	435	4,244	10.25

Table 3 – Sex ratio of sand lobster (*Panulirus homarus*) every month of observation

Sampling Time	n	Total		Sex Ratio (M:F)
		Male	Female	
October 2017	60	32	28	1:0.88
November 2017	40	13	27	1:2.08
December 2017	60	27	33	1:1.22
January 2018	40	19	21	1:1.11
February 2018	40	15	25	1:1.67
March 2018	37	15	22	1:1.47
April 2018	36	13	23	1:1.77
May 2018	31	18	13	1:0.72
June 2018	51	30	21	1:0.70
July 2018	8	7	1	1:0.14
August 2018	5	4	1	1:0.25
September 2018	14	12	2	1:0.17
Total	422	205	217	1:1.06

Figure 4 – Distribution of carapace length frequency of sand lobsters (*Panulirus homarus*) in Palabuhanratu Bay Waters

The carapace length-weight relationship of male and female lobsters obtained the coefficient of determination (R^2) of 0.73 and 0.76. It means the lobster carapace length influenced 73% of weight for male lobsters and 76% for female lobsters. The analysis results also obtained the growth pattern with the length-weight relationship of $W = 0.0353CL^{2.0612}$ for male lobsters and $W = 0.0348CL^{2.0651}$ for female lobsters. It means male sand lobsters had a faster growth of carapace length than weight compared to female sand lobsters.

The ELEFAN I method in the FISAT II program was used for age group analysis. The analysis results of the age groups of male sand lobsters and female sand lobsters indicated growth with an increase in the cohort line.

The mean length at first capture (L_c) is the length at which 50% of the animals sampled are caught on the selectivity of fishing gear. The mean carapace length at first capture for male and female sand lobsters were 43.56 mm and 52.71 mm respectively. These research

results were not significantly different from Zairion et al.'s (2017) research in which the mean carapace length at first capture (L_c) of male lobsters was 50.45 mm and female lobsters was 59.87 mm. The size of the lobster catches results indicated high activity intensity condition in fishing activities and the high rate of exploitation.

Figure 4 – The carapace length-weight relationship of sand lobsters in Palabuhanratu Bay:
(1) males and (2) females

This research found that the mean carapace length of female lobsters at onset of spawning was 72.75 mm. The mean size at onset of spawning (L_r) in Palabuhanratu Bay in 2016 was 81 mm with a range between 80-82 mm (Zairion et al., 2017). In addition, Junaidi et al. (2010) stated that the value (L_r) on carapace length was 77.44 mm.

The Von Bartalanffy growth equation of male and female sand lobsters resulted in $L_t = 104,40(1 - e^{-0,33(t+0,3565)})$ and $L_t = 108,90(1 - e^{-0,31(t+0,3760)})$. Male sand lobsters are estimated to live up to 8.73 years and female lobsters up to 9.30 years. The rate of exploitation (E) values for male and female sand lobsters showed above optimum values of 0.59 and 0.61. Based on these values, it is estimated that overfishing has occurred on the sand lobster population in Palabuhanratu Bay.

Figure 7 generates a CPUE linear equation = $1.4565 - 0.0008E$ with the constant (a) of 1.4565. It means that when there is no effort, the available potential in nature is 1.4565 tons/effort.

The calculation results of the Schaefer model equation showed that $C = 1325.87E - 0.7282E^2$. Potential estimation can be continued because the slope value was negative in which the value was a condition for determining MSY and FMSY. Based on the MSY value, the total allowable catch (TAC) for lobsters in WPP 573 was 530.34 tons/year.

Figure 5 – Distribution of carapace length frequency with the curve plot of von Bertalanffy's growth of sand lobsters (*Panulirus homarus*) in Palabuhanratu Bay Waters; (1) males and (2) females

Figure 6 – Graph of total mortality (Z), natural mortality (M), capture mortality (F), and rate of exploitation (E) of sand lobsters (*Panulirus homarus*) in Palabuhanratu Bay Waters based on the length-converted catch curve method: (a) males and (b) females

Table 4 – Production and Effort from Nets and Traps

Year	Effort		Production (Ton)	
	Nets	Traps	Nets	Traps
2005	670	320	763	191
2006	714	345	592	167
2007	740	369	502	159
2008	801	283	536	134
2009	778	260	504	126
2010	698	218	331	83
2011	581	206	399	133
2012	496	232	538	135
2013	538	255	424	101
2014	671	230	333	102

Table 5 – FPI Calculation for Traps and Nets as Standard Fishing Gears

Year	CPUE (C/E)		CPUE Standardization		FPI
	Nets	Traps	Nets	Traps	
2005	1.1391	0.5963	1	0.5234	1.5234
2006	0.8292	0.4840	1	0.5837	1.5837
2007	0.6789	0.4299	1	0.6333	1.6333
2008	0.6692	0.4735	1	0.7076	1.7076
2009	0.6478	0.4846	1	0.7481	1.7481
2010	0.4744	0.3800	1	0.8010	1.8010
2011	0.6867	0.6456	1	0.9401	1.9401
2012	1.0855	0.5802	1	0.5345	1.5345
2013	0.7890	0.3943	1	0.4997	1.4997
2014	0.4966	0.4426	1	0.8912	1.8912

Table 6 – Catch and fishing effort of sand lobsters (*Panulirus homarus*) in WPP 573

Year	C (Production)	Standard Effort	Standard CPUE
2005	954	838	1.1391
2006	759	915	0.8295
2007	661	974	0.6786
2008	670	1001	0.6692
2009	630	972	0.6481
2010	414	873	0.4742
2011	532	775	0.6865
2012	673	620	1.0855
2013	525	665	0.7895
2014	435	876	0.4966

Figure 7 – Graph of the Standard Effort and Standard CPUE Relationship

Figure 8 – MSY curve of sand lobsters (*Panulirus homarus*) in WPP 573 Waters

CONCLUSION

Distribution of carapace length frequency of sand lobster (*Panulirus homarus*) in Palabuhanratu Waters ranged between 30-101 mm with 97.6% carapace length below 8 cm. The growth pattern of male and female sand lobsters was negative allometric. Many female sand lobsters have been caught before reaching the mean size at onset of spawning. The rate of exploitation of sand lobsters was above the optimum value of lobster fishing. The status of lobster resources utilization in Palabuhanratu waters showed a decreasing utilization trend which indicated overfishing.

REFERENCES

1. Chan, T.Y. 1998. Lobster. In: Carpenter KE, Niem VH (eds.) FAO Species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 2. Cephalopods, Crustaceans, Holothurians and Sharks. Rome: FAO. pp. 687-1396.
2. Cobb, J. S., and Phillips, B. F. (1983). Behavior and distribution of larval and early juvenile *Homarus americanus*. Can. J. Fish. Aquat. Sci. 40: 2184-2188.
3. Effendie, M. I. 2002. Biologi Perikanan. Yogyakarta: Yayasan Pustaka Nusantara.
4. Kadafi, M., Widaningroem, R., & Soeparno. 2006. Aspek biologi and potensi lestari lobster (*Panulirus* spp.) di perairan pantai Kecamatan Ayah, Kabupaten Kebumen. Jurnal Perikanan. 8(1): 108-117.
5. Moosa, M. K., & Aswandy, I. 1984. Udang karang (*Panulirus* spp.) dari perikanan Indonesia. LONLIPI. Jakarta.
6. Pauly, D. 1984. Fish Population dynamics in tropical waters: a manual for use with programmable calculators. Manila: ICLARM.
7. Sparre, P., & Venema, S. C. 1999. Introduksi Pengkajian Stok Ikan Tropis Buku e-manual (Translated Edition). In cooperation between FAO UN and Center of Fisheries Research and Development, Badan Penelitian and Pengembangan Pertanian, Jakarta, Indonesia.
8. Zairion, Islamiati, N., Wardiatno, Y., Mashar, A., Wahyudin, R. A., & Hakim, A. A. 2017. Dinamika Populasi Lobster Pasir (*Panulirus homarus*), di Perairan Palabuhanratu, Jawa Barat. Jurnal Penelitian Perikanan Indonesia. 23(3): 215-226.