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Growth, Recruitment and Exploitation Rate of Goldband Goatfish (*Upeneus moluccensis*) in Bualan, Kumalarang, Zamboanga del Sur

Edeliza Y. Bangalisan, Jenny M. Villarin, Detchel P. Canoy and Floriefe G. Torino

College of Fisheries, Mindanao State University Buug, Datu Panas, Buug, Zamboanga Sibugay, Philippines
Email: floriefe.torino@msubuug.edu.ph

ABSTRACT

The growth parameters, mortality, exploitation and recruitment pattern of goldband *Upeneus moluccensis* in Dumanquilas Bay were determined from August 2019 to July 2020. A total of 840 samples caught by fish corral were collected from the fish port of Bualan, Kumalarang, Zamboanga del Sur. Growth was estimated using the ELEFAN 1 and the estimated parameters were $L\infty = 18.8$ cm and $K = 0.76$ yr^{-1}. Total natural and instantaneous rate of mortality values were $Z = 4.58$ yr^{-1}, $M = 1.74$ yr^{-1}, $F = 2.84$ yr^{-1} and the exploitation rate value of E was 0.62 yr^{-1}. The recruitment pattern of goldband Upeneus moluccensis suggests that this specie spawns all year round. Based on the results, goldband *Upeneus moluccensis* caught by fish corral in Dumanquilas Bay, from August 2019 to July 2020 was overexploited and that fishery resource management must be promulgated and implemented to address the depleting fishery resource.

Keywords : asymptotic length, growth rate, total mortality, natural mortality, fishing mortality, exploitation rate

1. INTRODUCTION

Goatfishes are the perciform fish of the family Mullidae are widely distributed throughout the pacific and Indo-pacific regions. The Perciformes are the largest and most diverse group of modern bony fishes, comprising 40% of bony fishes. According to Kumaran and Randall (1984) goatfishes are important component of demersal fish assemblages and artisanal fisheries that are established around coral reefs in shallow water of the Red sea. Goatfish species are an important fishery in many areas of the world and some species are economically important.

The habitats are still insufficiently known which require continued effort to sample, describe and register all species and due to increasing signs of human-induced local and global impacts (Cohen et al, 1997, Gommes et al, 1998, and Phillippart, 2007), there is also a pressing need to study further coastal organisms to understand their ecological role and function and to evaluate their potential use as indicators and/ or key species for coastal ecosystem monitoring and management.

According to Nicholls (2002) the measuring of such responses can be based on occurrence and distribution patterns, local abundance, weight, size, behavior or physiology. Indicators should be relatively abundant and widespread, easy to sample and tolerant to a wide variety of environment conditions. They cause a gradual loss of species on local, regional and global levels. Additionally, the introduction of species into new ecosystems destroy natural balance.

The goldband goatfish (*Upeneus moluccensis*) is a Lessepsian migrant species which penetrates into the Mediterranean Sea through the Suez Canal (Golani and Ben-Tuvia, 1995). It is a subtropical species distributed along the western Indian ocean from the Red sea to Southern Oman (Ben-Tuvia and Golani, 1989). The Goldband goatfish in other regions of the Mediterranean were studied satisfactorily by many researchers in recent years. Most of the available information on the distribution of the species, except for a few studies (Golani and Tocu, 1995; Taskavak and Bilecenoglu, 2001) provided some information on the feeding habits of the species. There are only a very few attempts of recent studies that deal with Lessepsian migration (Brachie et al, 2013; Frickie, 2012), classification (Randall, 2004; Sonin et Al, 2013), distribution and abundance (Sartian et Al, 2014).

The Philippines, with an island-dwelling population of more than 93 million and more than 7,101 islands, is a major fishing nation and the world's second largest archipelagic state with over 2.2 million km^2 of highly productive seas. Municipal marine cap-

ture fisheries operate in coastal waters within 15 km from the coastline, using vessels up to 3GT or without the use of vessels (www.fao.org). The Philippine fishery production declined between 2010 and 2017. As a result, since 2010, the contribution of fishery to agriculture growth has been negative (Dy, 2018). In 2018, the total volume of fisheries production was estimated at 4.35 million metric tons, which was 0.92 percent higher than its previous year's level of 4.31 million metric tons.

Despite the social economic importance, however many problems beset Philippine marine fisheries. These include declining catch rates that are symptomatic of overharvesting, degradation of critical coastal habitats, intense conflicts among resource users, poverty among artisanal fishers and increasing food deficiencies with dire implications for economic and social stability in rural, coastal areas of the country (Luna et al, 2004).

Kumalarang is one of the coastal municipalities of Dumanquilas Bay. It has a total land area of 151.49 km^2 or 58.49 square miles. The Dumanquilas Bay covers a total area of 29, 662.98 hectares of which 25, 948 hectares is the protected area, and 3, 714.984 hectares in the buffer zone. The Goldband *Upeneus moluccensis*, an economically important species, is commonly found in Dumanquilas Bay. However, there has been no study conducted yet to assess the population dynamics of this species in the area, thus, this study would like to determine the growth, mortality rate, exploitation rate and recruitment pattern of Goldband goatfish *Upeneus moluccensis* caught by fish corral (Bunsod) in Bualan, Kumalarang Zamboanga Del Sur.

2. METHODOLOGY

2.1 Location of the Study

There was only one sampling station in this study, at the fishing port of Bualan, Kumalarang, Zamboanga Del Sur (Fig. 1). The municipality land area of 151.49 km^2 or 58.49 square miles which constitutes 3.37% of Kumalarang, Zamboanga Del Sur total area, is a 4th class Municipality in the Province of Zamboanga Del Sur, Philippines. According to the 2015 census it has a population of 28, 469 people. The Municipality is composed of politically subdivided 18 barangays. It is bounded by Lapuyan on the east, on the south by Dumanquillas Bay, and Buug on the west, which is already part of the Zamboanga Sibugay province. It can reach through modes of land transportation are van, buses, and motorcycles. The Municipality of Kumalarang in coastal communities' people is relying on marine environment and farmland when it comes to source of food and livelihood.

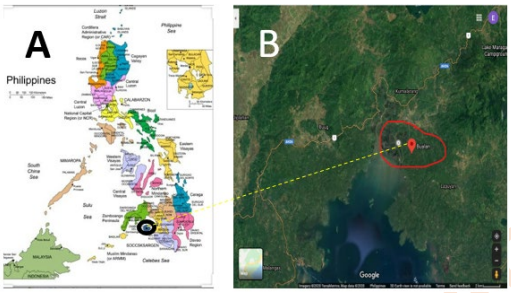

Fig. 1. Map showing the sampling area in Bualan, Kumalarang Zamboanga Del Sur A.) Map of the Philippines; B.) Map where the sampling sites (https://www.maps.google.com.ph)

The Test Organism

According to Bleeker (1855) *Upeneus moluccensis* (Fig. 2) has an elongated body which has a sub-cylindrical anterior portion which becomes compressed towards the tail with two dorsal fins which are well separated with the second dorsal fin directly above the anal fin.

The caudal fin is deeply forked. The chin bears a pair of barbels which do not extend past the margin of the preopercular. The upper and lower jaws, the palatine or palate and the vomer are covered in brush-like villiform teeth. The back is pinkish-red in color contrasting with the white belly, from which it is separated by single longitudinal yellow stripe which runs from the operculum to the caudal fin peduncle. The dorsal fins are yellow in color with a parallel red bar while the pectoral fin is a similar color but lacks markings and the pelvic fin peduncle. The upper lobe of caudal fin is whitish and has 5 or 6 black diagonal bars while the lower lobe is unmarked except for the bind margin which is black as the second bar of the upper lobe extend along it.

They can grow to 25 cm but are more usually 10-15 cm. The goatfish are perciform fish of the Mullidae. The family is also sometimes referred to as the red mullets, but other than red mullet and the striped red mullet or surmullet as called in different countries (Rafinesque, 1815). In the Philippines, the local name for goldband goatfish is called salmonete or timbungan.

Fig. 2. The goldband goatfish (*Upeneus moluccensis*)

Fishing Gear

The fishing gear used by the fisher folk in Bualan, Kumalarang Zamboanga Del Sur is called fish corral (bunsod). It is enclosed made up of closely-woven bamboo screens, nylon screens or nets or other materials attached to poles staked at the bottom up to the surface the river or other shallow bodies of water for the purpose of growing and or culturing of fish to various sizes in fresh, brackish and marine waters. Fish corral is stationary and is constructed in

areas known to be rich fishing grounds. Collecting the captured fish is done daily or every two to three days. It is usually done early in the morning. Collect the trapped fish by scooping them with hand nets (Fig. 3).

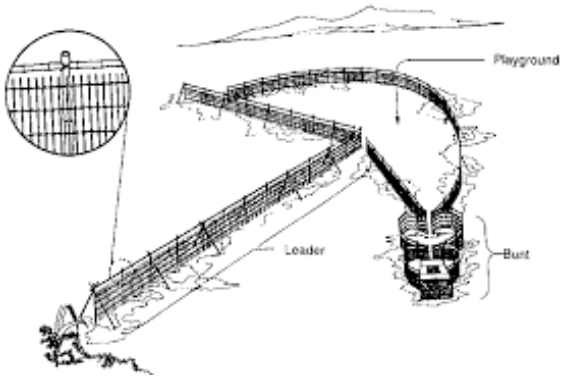

Fig. 3. Fish Corral (Bunsod)

2.2 Sampling Method

Seventy (70) samples of goldband goatfish (*Upeneus moluccensis*) were collected monthly from August 2019 to July 2020. Each sample were measured using a ruler and digital weighing scale to determine the length and the weight, and then photographed for documentation.

Growth parameters estimation

Growth

The goldband goatfish growth parameters L∞ and K of the Von Bertalanffy equation for growth in length were estimated using the ELEFAN I available in the FAO-ICLARM Stock Assessment Tools (FiSAT) software (Gayanilo, et al., 1994). The method restructures the length-frequency data and the growth curve which have the best fit to the peaks is identified. The input data used were the length-frequency data of Goldband goatfish caught by fish corral in Kumalarang Zamboanga Del Sur from August 2019 to August 2020.

The ELEFAN I (Electronic Length Frequency Analysis) program was developed by Pauly and David (1981). The idea behind the method is to split a composite distribution into peaks and troughs, and to find the best growth curve passing through the maximum number of peaks and avoiding troughs as far as possible. Goodness of fit is assessed by the ratio of ESP/ASP, where ESP (Explained Sum of Peaks) is the number of peaks accumulated by a growth curve while ASP

(Available Sum of Peaks) is the highest number of peaks that the best growth curve can accumulate for a given value of length-frequency data.

Mortality

Total mortality (Z)

The annual instantaneous rate of total mortality (Z) was derived from the length converted catch-curve analysis utilizing the ELEFAN II routine (Gayanilo, et al., 1994). Pooled length frequency samples were converted into relative age frequency distributions by means of the inverse of the von Bertalanffy function for the species. The natural logarithm of the number of fish in each group divided by the change in relative age was plotted against the relative age. The annual instantaneous rate of total mortality was estimated from the slope of the best fit line through the descending data points using least-squares linear regression. Initial ascending points representing fish not fully recruited to the fishery or too small to be vulnerable to the gear were excluded from the regression.

Natural mortality (M)

Estimates of annual natural mortality rate (M) was obtained using the empirical formula derived by Pauly (1984):

$\log M = -0.0066 - 0.279 \log L\infty + 0.6453 \log K + 0.4634 \log T$

Where:

K and L∞ are derived from the von Bertalanffy growth function

T is the annual mean temperature of 290C

Fishing mortality (F)

The annual estimates of fishing mortality (F) were calculated by subtracting the natural mortality (M) from the total mortality Z ($F = Z - M$).

Exploitation rate estimation

The estimate of present values of the instantaneous fishing mortality coefficient, (Fpresent), was obtained by the subtraction of M from Z. The exploitation rate (E) was then computed from the equation: $E = F/Z$ (King, 1995).

Recruitment pattern

The ELEFAN software package also provides a description of the recruitment pattern using the final growth parameters obtained. The recruitment pattern was obtained by projecting a set of length-frequency data backward onto a one-year time axis (Ingles and Pauly, 1981).

3. Results and Discussion

Growth

The estimated von Bertalanffy growth parameters for the Goldband goatfish were as follows: L∞ 18.8 cm, K = 0.76 y^{-1}, total, natural, and fishing instantaneous rate of mortality values were Z= 4.58 y^{-1}, M= 1.74 y^{-1}, at 29℃, F= 2.84 y^{-1} and the exploitation rate value of E was 0.62 y^{-1} (Fig. 4).

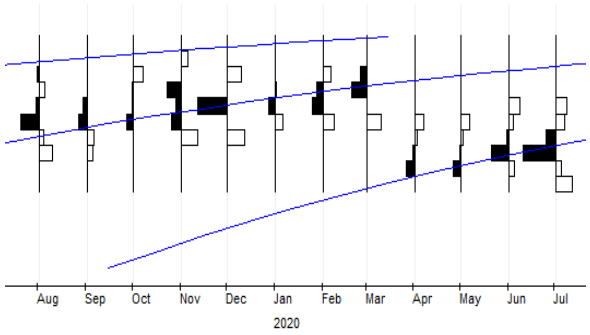

Fig. 4. Restructured length- frequency data (ELEFAN 1) and superimposed growth curve growth curve of *Upeneus moluccensis* using a class interval of 1 cm. Estimated values are L∞ = 18.8 cm, K = 0.76y^{-1} with Starting Sample = 9 cm and Starting Length = 6.95 cm.

The length-frequency data and superimposed growth curve for *Upeneus moluccensis* showed that peaks being hit by the growth curve from the month of August, September, October, November, December, January, February 2020 and March 2020 were samples of bigger sizes. Peaks from April 2020 and May 2020 hit by the growth curve were samples by smaller length groups. Significant variability in recruitment from year to year at any site means that certain year groups should have the potential to dominate population and community numbers, and to play a disproportionately large role in the competition for resources.

Factors potentially affecting community must act against this background of variability of recruitment, and their influence on the community as a whole may be moderated or even negated in years of heavy recruitment.

Adding first individual toward *Upeneus moluccensis* population (recruitment) from length data frequency was supported by an approach method facilitated by FISAT (Spare and Venema 1998). Normal distribution of recruitment pattern was determined by NORMSEP (Pauly and Caddy 1985) in FISAT. This program reconstructs pulse from set of length frequency data after adjusted with Von Bertalanffy Growth Function (VGBF) to determine number of pulse recruitment curve using value estimation from $L\infty$, K and T_o.

The growth curves fitted by ELEFAN 1 estimated different values of asymptotic length $L\infty$ and growth coefficient K for the length-frequency data of *Upeneus moluccensis* with a 1 cm class interval. The best estimated value obtained for the parameter $L\infty$ was 18.8 cm and for K was 0.76 fr[illegible]020. Given the above estimates, the peaks in [illegible]ata were more clearly outlined and this enabled a good fit for the growth curves to be obtained. The parameters obtained were later utilized as an input data for the subsequent estimation of the mortality and exploitation rate and for the derivation of recruitment pattern.

Since information about *Upeneus moluccensis* is not limited, infinity value for length and its growth coefficient as the comparison are yet obtained. Value obtained in this study were expected to act as initial information that can be used as base for future comparison.

The *Upeneus moluccensis* is commercially important for the Mediterranean fisheries in Libya. The results of the growth rate in the first year of the goldband goatfish caught in Elkhoms coast of Libya reported in the present study are in agreement with those reported by Kaya et al (1999) in south Aegean coasts of Turkey, Ismen (2005) in Iskenderun Bay, the Eastern Mediterranean and Ozvarol et al (2010) in the gulf of Antalya (Turkey). It was found that the first annulus is formed at a length of 11.2 cm; 11 cm and 11 cm respectively. However, Torcu (1995) in Iskenderun Bay, stated that the first annulus of this fish species was formed at 8.2 cm. The mean annual growth rate in the present study for 1-5-years old ranged between 1.2 - 3.4cm and 1.4 - 3.2cm for females and males respectively (Tables 1&2). Growth was rapid in both sexes for the first year and declined gradually over subsequent years. Torcu (1995) reported that the mean annual growth rate for 1-5 years old of the same fish was about 1.9 cm, 1.7 cm, 1.3 cm and 1.4 cm, respectively. Meanwhile Kaya et al. (1999) stated that this mean annual growth rate for 1-6-years old fish was about 1.9 cm, 1.7 cm, 1.3 cm and 1.4 cm, for females and males respectively.

The growth performances of the goldband goat fish sampled from the different regions in the north and eastern Mediterranean. The values of these parameters are $L\infty$= 24.3 k = 0.228 y^{-1} to = 1.532 y^{-1} for the Gulf of Suez Red Sea (El-drawany, 1995) and $L\infty$= 25.2 k = 0.197 y^{-1} t_0 = -1.002 for Iskenderun Bay, the north-eastern Mediterranean (Ismen, 2005). Goncalves et al (2003) reported that the estimated von Bertalanffy growth parameters may vary according region, and year. Recently, Cicek and Avsar (2011) decided that, the major driving force in population fluctuation is recruitment variability year by year.

Mortality and Exploitation

The annual instantaneous rate of total mortality (Z) derived from the length converted catch curves was 4.58 y^{-1} (Fig. 5). Annual instantaneous rate of natural mortality (M) was estimated 1.74 y^{-1} after using the empirical formula derived by Pauly (1984). The annual instantaneous rate of fishing mortality (F) was estimated 2.84 y^{-1}. The estimated exploitation rate (E) was 0.62 y^{-1}. The correlation coefficient r^2 value of 0.98 obtained in the length converted catch curve analysis suggests strong relationship between points selected in the catch curve.

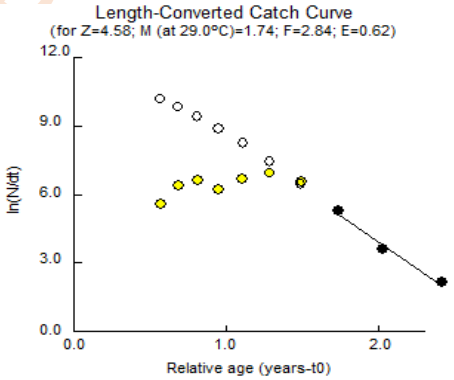

Fig. 5. Catch curve analysis showing mortality estimates of *Upeneus moluccensis* caught by fish corral in Dumanquilas Bay from August 2019 to July 2020.

The selection curve for *Upeneus moluccensis* is shown in Fig. 6. As illustrated, there is an ascending curve which shows that the mean length of capture at L_{25} was 10.20 cm at L_{50}, was 11.04 and finally at L_{75}, the length of capture was estimated at 11.86 cm.

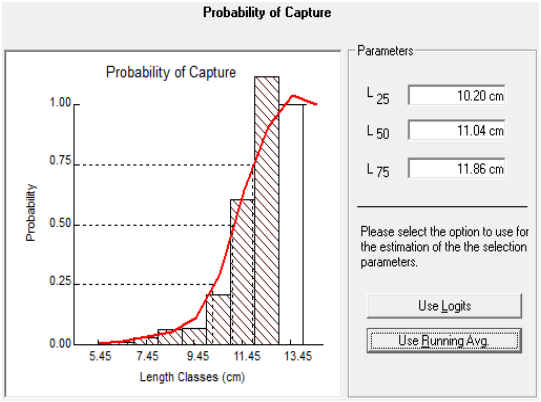

Fig. 6. Selectivity catch curve showing probability captures of *Upeneus moluccensis*

In Dumanquillas Bay in Mindanao, this species was reported to have a total mortality of 4.58 y^{-1}, natural mortality of 1.74 y^{-1} and a fishing mortality of 2.84 y^{-1}.

The instantaneous rate of total mortality Z was estimated using the length converted catch curve method mentioned by Pauly (1983). Natural mortality rate M was estimated by empirical equation of Pauly (1980) expressed below using a mean surface temperature T of 29°C, where M is the natural mortality, L∞ is asymptotic length., T is the mean surface temperature and k refers to the growth rate coefficient of the VGBF.

Fishing mortality F was calculated using the relationship (Gulland, 1971) F=Z-M

Where Z is the mortality rate, F the fishing mortality rate and M is the natural mortality rate. Limiting fishing mortality Flimit and the optimum fishing mortality Fopt which form the precautionary target were calculated as Fopt- 0.4*M (Pauly, 1983) and Flimit = 2/3* M (Patterson, 1969). The recruitment pattern was computed following the method described in the FiSAT routine (Gayanilo et.al, 2005). The relative yield- per- recruit Y/R and relative biomass per recruit B/R were estimated using Beverton and Holt model (1964) as modified by Pauly and Soriano (1986). The computed exploitation rate was compared with the expected values of Emax (Sparre and Venema 1992; Gayanilo and Pauly, 1997) as reference points.

The exploitation rate E = F/Z and the current exploitation rate was found to be (E 0.620), this value refers to an overexploitation on the stock of *Upeneus moluccensis* from the Dumanquilas Bay, where Gulland (1971) reported that the optimum exploitation.

Recruitment

The recruitment pattern of new stocks of *Upeneus moluccensis* in Dumanquilas Bay is whole year round (Fig. 7). FiSAT program showed that addition of new individuals (recruitment) of *Upeneus moluccensis* has occurred each month with varied number. New recruit with high percentage has occurred in November 2019 to July 2020.

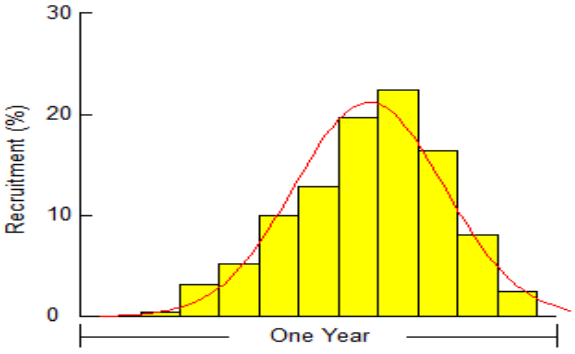

Fig. 7. Recruitment pattern of *Upeneus moluccensis* from Dumanquilas Bay.

In Dumanquilas Bay came more from human caught, biotic interaction such as predatory, competition and environmental pressure possible thought for the existed status of *Upeneus moluccensis* population.

4. Conclusion

The best growth parameters of *Upeneus moluccensis* were L∞ 18.8 cm and k = 0.76 y^{-1}. The annual instantaneous rate of total mortality (Z) derived from the length converted catch curve was 4.58 y^{-1}. The annual instantaneous rate of fishing mortality (F) was estimated at 2.84 y^{-1}. The higher value of total mortality (Z) obtained was indicative of the greater fishing mortality as affected by fishing pressure exerted to the individuals of *Upeneus moluccensis* mostly caught by fish corral were samples belonging to the smaller length groups. The estimated exploitation rate (E) of 0.62 y^{-1} was a result of the high levels of annual instantaneous rate of both fishing and mortality. The recruitment pattern for *Upeneus moluccensis* in Dumanquilas Bay showed that there was only one pulse of annual recruitment. This show that the recruitment of *Upeneus moluccensis* is a new stock all year round. Age structure is incorporated in terms of age- specific schedules of mortality, growth and sexual maturity. Age specific fishing mortality rates reflect the effects of a fishery selection or exploitation pattern, in which the vulnerability of a cohort changes as it ages or this could reflect changing patterns in availability to the fishery or vulnerability to the gear. The exploitation pattern are approximations that assume that below the age at first capture, fishing mortality = 0, but at or above the age first capture, the cohort is fully vulnerable to the same rate of fishing mortality. The estimated exploitation rate E 0.62 y^{-1} exceeded the Eoptimum = 0.5. Moreover. The fishing mortality (F) of 2.84 y^{-1} was higher than both the target (Foptimum = 0.55 y^{-1}) and limit (Flimit = 0.75 y^{-1} above) biological reference points. This study revealed that *Upeneus moluccensis* in Dumanquilas Bay are highly exploited. Thus, fishery resource management involvement and plan of action for this species must be promulgated and carry out to aware this kind of overfishing.

5. RECOMMENDATIONS

The recommended management strategies to help the fishery resource management to recruit the new stock of *Upeneus moluccensis* in Dumanquilas Bay are: 1) Reduce fishing effort in the Bay. Fishing effort can be reduced by regulating the type of fishing gear to be used by fishermen in Dumanquilas Bay; 2) The use of non-selective and destructive fishing gears must be banned; 3) Enforce fishery laws effectively. It was observed that filter nets with fine mesh sizes be a backbone in doing fisheries management. The mobilizing agents for their approach will be a composite team coming from the LGU's, NGO's, PNP's, fishery warden and fishermen. The NGO's can actively participate in fishery law enforcement through their community development workers who will be trained and implement community based coastal resource management; 4) Strengthen the community organization. The organization in a community is the basic foundation for implementing coastal resources management. Through proper education, the fisherfolk will become more conscientious resource managers aside from being a trifling resource user; 5) Establishment of fish sanctuaries and marine reserves. Fish sanctuaries and marine reserves have to be established to effectively maintain the breeding and nursery areas for many crustaceans and

finfish species in Dumanquilas Bay; 6) Establishment of more artificial reefs. The establishment of artificial reef in Dumanquilas Bay highly encouraged to help depleting fishery. The LGUs, NGOs, and the fishermen must form a collaborative effort in establishing artificial reefs to be placed in suitable areas of the Bay; and 7) Studies recommended for *Upeneus moluccensis* in Dumanquilas Bay must include determination of sex ratio between male and female, gonadosomatic indices, fecundity, food and feeding habits of *Upeneus moluccensis*.

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