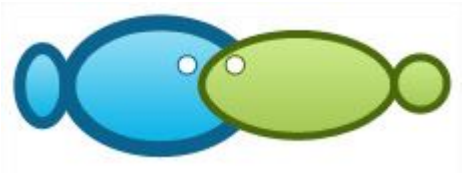

Population dynamics of *Potamocorbula faba* Hinds, 1843 (Bivalvia: Corbulidae) in Permisan Bay, Sidoarjo, Indonesia

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Abstract. *Potamocorbula faba* is a benthic species that can be found scattered in high intertidal zone of Permisan bay, Sidoarjo, Indonesia. Some variables in population dynamics, such as asymptotic length (L_∞), growth coefficient (K), mortality rate (Z, F and M), exploitation rate (E) and recruitment pattern of *P. faba* were estimated from length frequencies analyses by means of FAO-ICLARM Stock Assessment Tools (FISAT). Results showed that growth performance index (φ) was 2.34, asymptotic length (L_∞) was 16.40 mm and growth coefficient (K) was predicted to be 0.81 year^{-1}. Total mortality (Z) for *P. faba* was 2.17 years^{-1}, while fishing mortality (F) was 0.27 year^{-1} and natural mortality (M) was 1.90 year^{-1}. Total mortality rate was quite high due to habitat destruction by pollutant. Reproduction strategy of *P. faba* indicates recruitment occurred every month. Overall during the course of the study, there have been two different peaks, *i.e.* major recruitment commenced in March 2015 (24.32%) and the minor one was in October 2014 (4.16 %).
Key Words: population dynamics, *Potamocorbula faba,* growth, recruitment, mortality.

Introduction. *Potamocorbula faba,* or *Corbula faba* or *Potamocorbula fasciata* (WMSDB 2016; WORMS 2016) is a bivalve species belonging to the family Corbulidae which thrives in high intertidal zone of Permisan Bay, Sidoarjo Indonesia. This benthic organism lives in high intertidal zone (Wahyuni et al 1992). Among various environment factors affecting this clam for spatial distribution and reproduction in the estuary were water salinity and temperature (Carlton et al 1990; Werner & Hinton 2000). Thompson & Parchaso (2012) noted that *Potamocorbula* sp. is high tolerant for low oxygen and eutrophication.

Large populations of Corbulidae Bivalves can be found inhabiting silt, clay, hard-pack clay, sand, gravel, peaty mud and shell hash in the intertidal areas (Hrs-Brenko, 2006; Thompson & Parchaso 2012). *P. faba* is a shallow infauna catagory and its life is very suitable in a soft bottom subtratum (Ambarwati & Trijoko 2011). This small bivalve is a suspension feeder, which pumping water column then filtering by the eulamelibranchia gill. In general, Corbulidae Bivalve is resistant on environmental disturbance (Adami et al 1997; Hrs-Brenko 2006). *P. faba* has high degree of tolerance on extreme environtment, so this species may become the most dominant clam in the estuary (Ambarwati & Trijoko, 2011).

Studies of age and growth of bivalves, especially several species of *Potamocorbula* have been conducted all around the world by Etim et al (1998), and Ryu & Kim (2007), but study on the growth parameters, mortality and recruitment of *P. faba* in Indonesia is still very limited. Knowledge on various parameters of population dynamics is required to manage bivalve resources. One tool that is used to estimate population variables in shellfish is FAO-ICLARM Stock Assessment Tools (FISAT). The programme is relatively simple, as it only requires length-frequency data (Mancera & Mendo 1996; Amin et al 2001; Jagadis & Rajagopal 2007; Panda et al 2011; Chakraborty et al 2014).

This study was conducted to determine basic structure of *P. faba* population*, i.e.,* growth, mortality and recruitment as also to assess factors affecting population dynamics of this clam in the Permisan Bay, Sidoarjo Indonesia.

Material and Method

Study site and sampling method. This study was conducted in intertidal area of Permisan Bay, East Java (Figure 1). *P. faba* was collected once a month and it was done for 8 months, *i.e.,* between September 2014 to April 2015, from substrate depth of 0 to 25 cm. All samples obtained were calculated and measured for their lengths 4 times using Vernier calliper to the nearest 0.1 mm. Individual wet weight of clam was measured using a digital analytical balance GR-200 with accuracy of 0.001 g.

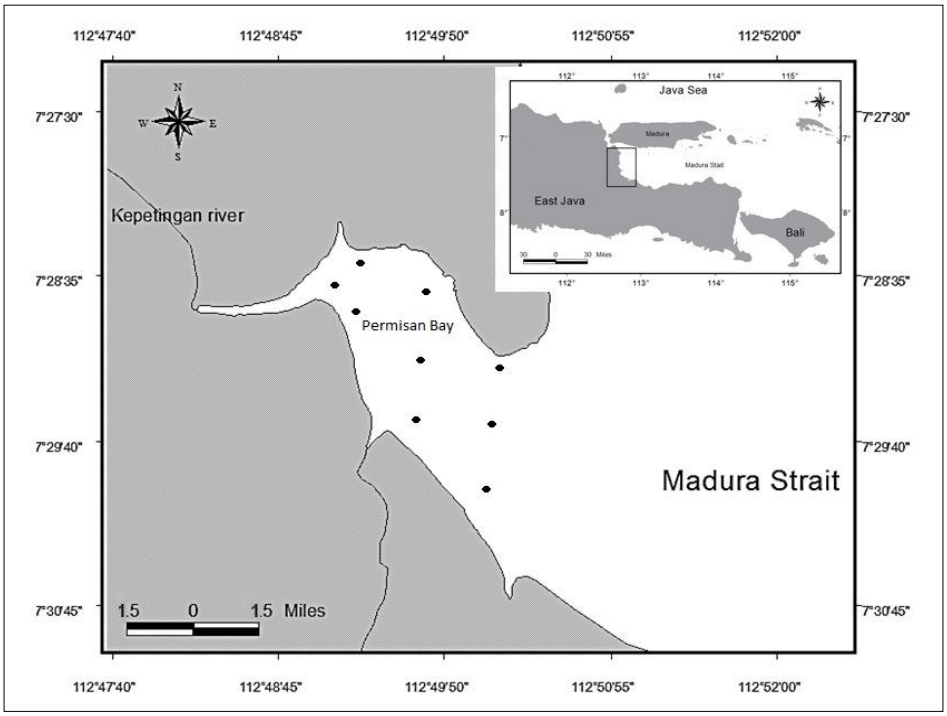

Figure 1. Sampling location of *P. faba* in Permisan Bay, East Java, Indonesia.

Estimates of growth parameters. For data frequency, individual length of 7997 individuals *P. faba* was taken in mm unit and classified into 30 groups of 0.5 mm length interval and the data frequency was analysed using FISAT software (Gayanilo et al 1995). Growth parameters, *i.e.,* asymptotic length (L_∞) and growth coefficient (K) were analysed by means of Von Bertalanffy Growth Function (VBGF) in ELEFAN-1 (Pauly & David 1981). Values of K and L∞ were then used to estimate growth performance index (ϕ) (Pauly & Munro 1984) using the following equation:

$$\phi = 2 \log_{10} L_\infty + \log_{10} K$$

Estimation for the age at birth (t_0) was meant to obtain information complement to the peak of spawning. The value of t_0 was obtained through K and L_∞ values that implemented in equation:

$$\text{Log}_{10}(-to) = -0.3922-0.2752 \log_{10} L_\infty -1.038 \log_{10} K \text{ (Pauly 1980),}$$

where K is growth coefficient, L_∞ is asymptotic length and t_0 (initial condition parameter) is age where length is equal with zero.

VBGF was used to estimate clams age curve in length by using nonlinear estimation procedure (Pauly et al 1992) with the following equation:

$$Lt = L_\infty (1 - e^{-k(t-t_0)})$$

whereas L_t = length in t; L_∞ = asymptotic length; K = growth coefficient; t = age of *P. faba* in t_0 and t_0 = hypothetical age when length is zero. Maximum age (or length age) was estimated using $T_{max} = 3/K$ (Pauly 1980).
Natural longevity is lifespan for a species and achieved by a species in cohort of 99% until all cohort member died of natural death (Sparre & Venema 1998). After being expanded, Von Bertalanffy equation would comprise of equation $t = \log10 (1-L_t/L_\infty)$; and if maximum length (L_{max}) = 0.95 (L_∞) entered into the above equation, it would obtain longest life span with $t_{max} = 2.9957/K + t_0$ (Moses 1990).

Estimates of mortality parameters. Total mortality estimation (Z) was estimated through linear relationship between natural logarithm from the change in amount of clam per time of growth to i^{th} class with age, known as *length converted catch curve* (Pauly 1984) with the formula:

$$\ln (N_t/\Delta_t) = a + bt$$

where: N = number of clam in length class i, Δ_t = time needed for clam to grow in length class to i, t is age (or relative age, calculated with $t_0 = 0$) related to median value of i^{th} class, and b is slope as the value of Z.

Natural death (M) was estimated using empirical relationship equation (Pauly 1980):

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$

where M is natural death, L_∞ is asymptotic length, K is annual growth coefficient of VBGF and T is average temperature for annual habitat (°C). Z and M were further used to estimate death of caught clam (F) with relationship: F = Z-M; where Z is total mortality and M is natural mortality.

Estimates of recruitment parameters. Adding first individual toward clam population (recruitment) from length data frequency was supported by an approach method facilitated by FISAT (Sparre & Venema 1998). Normal distribution of recruitment pattern was determined by NORMSEP (Pauly & Caddy 1985) in FISAT. This program reconstructs recruitment pulse from set of length frequency data after adjusted with Von Bertalanffy Growth Function (VGBF) to determine number of pulse per year and relative strength of each pulse. Recruitment pattern was studied from recruitment curve using final value estimation from L_∞, K and t_0.

Results

Growth. Age group existed within a population showed structure of the population. In overall, based on length data frequency obtained for 8 months using FISAT sub programme ELEFAN, it has obtained that for *P. faba* asymptotic length or infinity length (L_∞) is 16.40 mm with growth coefficient (K) about 0.81 $years^{-1}$ and growth performance index (Φ) 2.34. Analysis for clam distribution during this study has given value for several growth parameters which became the base for von Bertalanffy growth curve of *P. faba* (Figure 2).

The values of K and L_∞ then is used to analyse t_0 by formula $\text{Log}_{10} (-t_o) = -0.3922-0.2752 \log_{10} L_\infty-1.038 \log_{10} K$. Based on previous calculation, the value of t_0 for *P. faba* clam is -0.234 years or 2.80 months. The value of t_0 age was also known as *initial condition parameter* which determines points in time when clam has zero length. Based on these values, von Bertalanffy equation for *P. faba* is as follow:

$$L_t = 16.40 [1-e^{-0.81 (t + 0.234)}]$$

Moreover, *P. faba* lifespan, t_{max}, was about 3.932 $year^{-1}$. Since information about *P. faba* is very limited, infinity value for length and its growth coefficient as the comparison are yet obtained. Values obtained in this study were expected to act as initial information that can be used as base for future comparison.

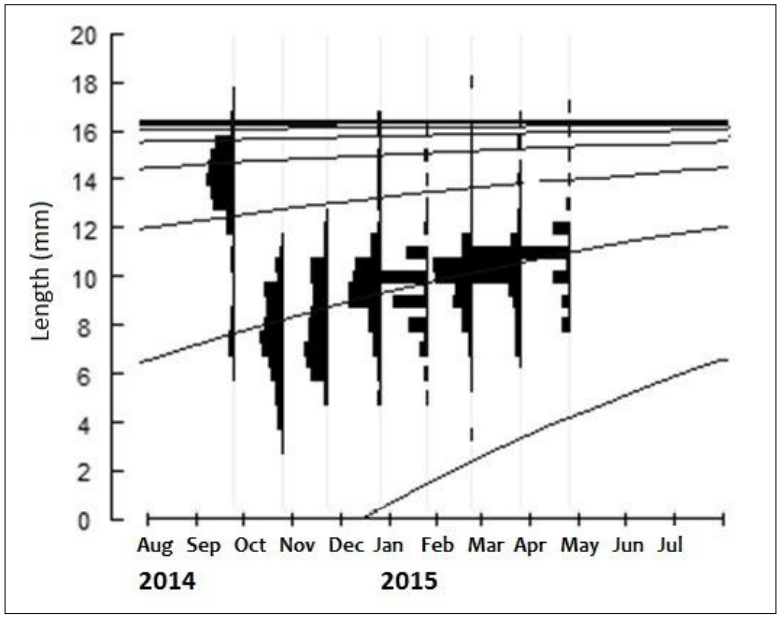

Figure 2. Von Bertalanffy growth curve of *P. faba* in Permisan Bay, East Java analysed by FISAT.

By paying attention toward maximum age, t_0 age, K and L_∞, estimation for growth curve from model being formed are shown in Figure 3.

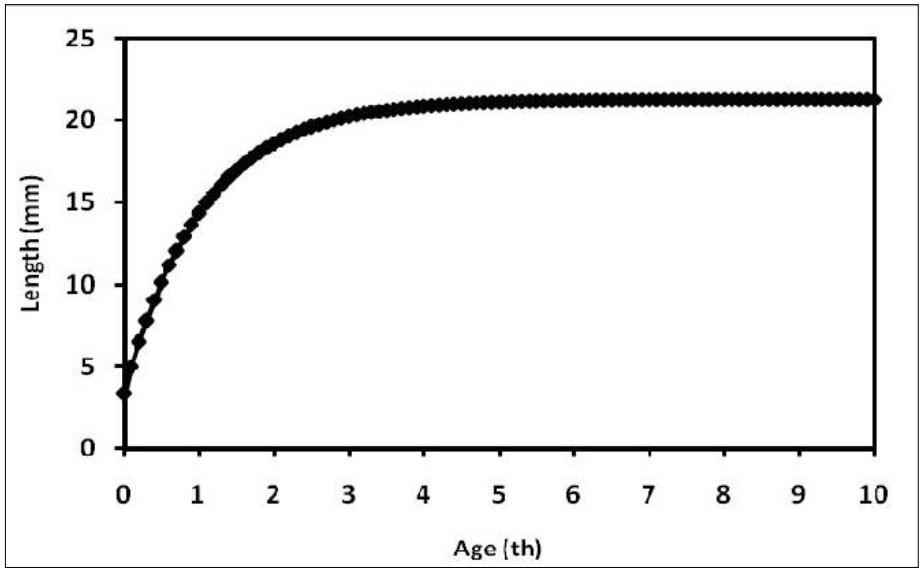

Figure 3. Estimation growth curve for clam *P. faba* from Permisan Bay, East Java.

Mortality. Linear equation to estimate mortality obtained from length converted catch curve (LCCC) of *P. faba* in estuary of Permisan Bay, East Java is Y = 12.613 – 2.167X with r = 0.9816. Clams were categorized into sizable group with interval 0.5 mm. By fitting relative age of samples (dt) against natural logarithm of number of individual per class (ln (N_t/Δ_t)), it resulted in linear equation of LCCC of *P. faba* (Figure 4).

Result showed that total mortality (Z) for *P. faba* in overall is 2.17 $years^{-1}$ including natural mortality (M) about 1.90 $years^{-1}$ and mortality due to catch (F) about 0.27 $years^{-1}$. Mortality value of *P. faba* due to natural causes is higher than catchment, which means that the probability of *P. faba* to die from natural causes such as disease, predation, poor environmental quality is higher than anthropogenic causes.

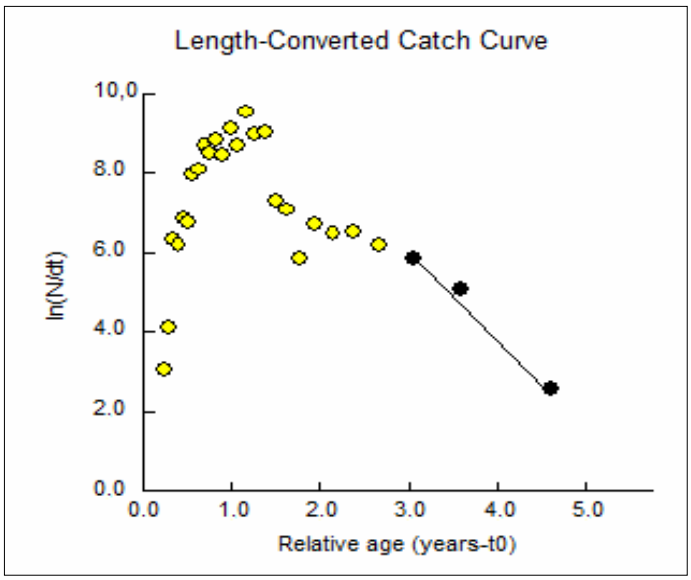

Figure 4. Length converted catch curve (LCCC) of *P. faba*.

Recruitment. FISAT program showed that addition of new individual (recruitment) of *P. faba* has occured each month with varied number. New recruit with high percentage has occured in October 2014 and January 2015. Pattern of recruitment showed that during the study has been the addition of new individuals who also influenced population dynamics in nature. Adding new individuals in a population is a positive cycle for the stability of the population itself. In this study, direct observation revealed that juvenile clam in nature is seldom found, but it existed within the body of clam parent. FISAT produced recruitment percentage and this indicates that in the study site there were new individuals addition every month Although in general, a new individual addition period was restricted to a few months but, this addition is urgent for population sustainability. All this time, pressure toward clams population in Permisan Bay came more from human caught; biotic interaction such as predatory, competition and environmental pressure still possible though for the existed status of this clams population. It is also shown that almost every month there is recruitment. In general, there were two different peaks of pulse. Peak of recruitment in clams occured in October 2014 (4.16%) and March 2015 (24.32%). Processing result for recruitment pattern showed in Figure 5.

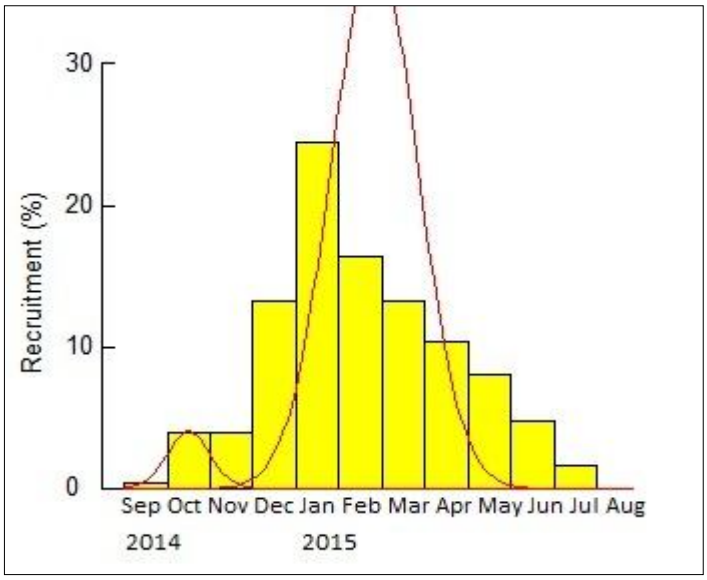

Figure 5. Recruitment percentage for clam *P. faba* in Permisan Bay, East Java.

Discussion. Growth coefficient (K) is important in von Bertalanffy equation, since it could describe growth rate to maximum size and it could be used to compare growth rate from different species or same species from different locations. Infinity length showed how much length could be obtained by an individual. Growth coefficient value (K) is an important factor to find out growth rate toward infinity size. K value is different between distinct species, even from the same species that came from a different location. Growth coefficient value (K) showed how fast a species could attain infinity length (Sparre & Venema 1998) as also to be used in comparing growth rate from different species or the same species from different locations.

Literature and information regarding *P. faba* is highly limited. Compared with other species, *P. faba* is classified as one with a relatively moderate growth rate. Infinity length of *P. faba* is about 16.40 mm in Permisan Bay act as initial information. It was baseline data for support the next study of *P. faba* population. This infinity length was much lower than *P. ustulata ustulata* in west coast of Korea, which was about 30.77 mm (Ryu & Kim 2007). The same occurred with result of Etim et al (1998), infinity length of *Corbula trigona* in Cote d'ivoire was about 21.55 mm.

K value obtained from observation result in Permisan Bay is 0.95 year^{-1}. This value is much higher than that obtained by Etim et al (1998) for *Corbula trigona*, which was about 0.49 year^{-1}. On the other hand, a different K value was found for *Potamocorbula ustulata* in West Coast of Korea with about 0.5472 year^{-1} (Ryu & Kim 2007). This showed that growth rate of *P. faba* is faster than both above mentioned species.

Total mortality consists of mortality rate due to both natural causes (M) and catch/exploitation (F). Total mortality value (Z) for *P. faba* in Permisan Bay is quite high, that is equal to 2.17 year^{-1}. Of that, the highest mortality was due to natural mortality (1.90 year^{-1}). This was proven from the observation on dead clams. Given that this area is in close proximity to residential and industrial areas, natural cause of death in this clam was assumed due to some environmental pressures such as water temperature elevation, waste disposal as also disease and predators. King (1995) stated that many factors in sea environment might cause lower survival within the bivalve population, such as inappropriate condition, lack of food, competition, and mostly was due to predation. According to Welcomme (1985), natural mortality could be also due to predation, diseases, high temperature and low dissolved oxygen in the water. On the other hand, our investigation showed that local people often exploited *P. faba* for consumption as well as for poultry feed ingredients.

Finding young/small size clams indicate that life strategy of *P. faba* made it capable of keeping recruiting in extreme conditions. It is known that *Potamocorbula* sp. has high tolerance to survive in low oxygen condition and high environmental pressure (Thompson & Parchaso 2012). Observing new individuals added every month with varied percentage was also gained during this study. Recruitment was highly related with spawning success and its survival (Chakraborty et al 2014). Recruitment would look apparent from several weeks until several months after spawning, that is after larvae went down to the substrate, commencing their benthic live and become young individual. Thompson & Parchaso (2012) suggest that life span of *Potamocorbula* sp. larvae as plankton is short.

Every month new individuals were detected. There were two recruitment peaks that occurred in October 2014 and March 2015 (Figure 5). The major recruitment peak occurred in March 2015 (24.32%) and minor recruitment peak was in October 2014 (4.16%). Generally, large number of new individual addition has very meaningful toward population sustainability in nature. To date, pressure toward clams' population in Permisan Bay came more from human exploitation, although there was also biotic interaction such as predation, competition and environmental pressure, as such that it is still possible for population to exist, even thrive, in this location. Clams recruitment in tropical area could occur every month, with varied percentage, due to different environmental conditions.

Conclusions. From this study, it could be concluded that population dynamic of *P. faba* is as follows: growth performance index (Φ) is about 2.34, asymptotic length (infinity length) obtained for *P. faba* is 16.40 mm with growth coefficient value (K) is 0.81 per year which indicating moderate growth rate of this species. Total mortality rate (Z) is 2.17 whereas natural mortality (M) is 1.90 and catch mortality (F) is 0.27. Total mortality rate is quite high due to habitat destruction by pollutants. *P. faba* also performed monthly recruitment. In overall, there have been two dissimilar pulses of peaks. The major recruitment peak occurred in March 2015 (24.32%) whilst minor recruitment peak was in October 2014 (4.16%). Moreover, to preserve *P. faba*, the community should prevent further environmental damage.

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