Use of Population Parameters in Examining Changes in the Status of the Short-Necked Clam *Paphia undulata* Born, 1778 (Mollusca, Pelecypoda: Veneridae) in Coastal Waters of Southern Negros Occidental*

Annabelle del Norte-Campos* and Karen A. Villarta
Marine Biology Lab, College of Arts & Sciences
University of the Philippines Visayas, Miagao, Iloilo
*Correspondng Author: Email: upvmarbio@yahoo.com

ABSTRACT

Growth, recruitment, mortality and exploitation rate of the short-necked clam *Paphia undulata* (Born, 1778) were studied in southern Negros Occidental waters between August 2007 and July 2008 from length-frequency data derived from catches of divers, to be able to compare with earlier data derived and analyzed 13 years ago by Agasen et al. (1998). Both sets of data were analyzed using the FiSAT software (Gayanilo & Pauly, 1997). The asymptotic shell length ($S\infty$ = 79 mm) derived from the present data proved to be smaller compared to the earlier data ($SL\infty$ = 81.5 mm) due to the lack of bigger sizes in the present samples. The growth constant (K = 1.0 yr^{-1}) was however comparable indicating it to be a more species-characteristic parameter. Two recruitment pulses for each study were derived and were found to be correlated with the spawning pattern in the species. The value of natural mortality (M = 1.57 yr^{-1}) derived from bivalve literature, is deemed more appropriate compared to the earlier estimate (M = 2.89 yr^{-1}) based on Pauly's (1980) empirical equation developed for fish. Total mortality (Z) values for both studies were comparable, but a higher level of fishing mortality (F = 4.61 yr^{-1}) was estimated for the present data set, thus resulting likewise in a higher exploitation rate (E = 0.75). These, together with fishery information from an accompanying paper (Villarta & del Norte-Campos, 2010), not only validate the earlier findings of overexploitation due to lack of management, but reveal a worsening condition of the stock, most likely as a result of growth overfishing. Overexploitation can only be mitigated by imposing stringent restrictions in terms of the minimum size for exploitation (45 mm shell length) and closed seasons during the spawning peak (August-November).

Keywords: Paphia undulata, population parameters, Negros Occidental

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INTRODUCTION

The short-necked clam *Paphia undulata* (Born, 1778) (Figure 1), locally known in western Visayas as "nylon shell", is a popular shellfish resource harvested mainly for food. Aside from Negros Occidental (Agasen et al. 1998), it is likewise found in Bolinao, Pangasinan, where it is locally called "kabloy", and in Sorsogon Bay in Bicol Region, where it is called "badoy" (Soliman et al., 1999). It is reputed to have a "boom and bust" fishery (Pastor & Juinio-Meñez 2003), just like its related species *P. textile* off Bantayan Island, Cebu (Dacles 1998). Agasen et al. (1998) in their study thirteen years ago reported the species to be overexploited in coastal waters of Negros Occidental. The suitability of size-based, single-species assessment for bivalves has already been demonstrated in a number of papers in the country, such as those on scallops (del Norte, 1988; Gabral-Llana 1988; Soliman & Dioneda 2004; del Norte-Campos & Villarta, 2008) or even clams (del Norte-Campos 2004).

Due to the commercial importance of the *P. undulata*, as well as its polyculture potential, there is a need to re-assess its status considering that there are still no known management policies governing its exploitation. Comparing the status of the stocks at different times is important as it provides insights on the impact of unregulated exploitation on the resource. The objectives of this study were to (a) examine the population biology of the species, by estimating the parameters of its growth, recruitment, mortality, and exploitation rate, and (b) compare the results with the those of a study on the same species in the same fishing ground conducted thirteen years ago (Agasen et al., 1998). The results are then used in the context of other information from parallel investigations on the fishery (Villarta & del Norte-Campos, 2010) and reproductive biology (Nabuab et al., 2010) as the scientific basis for the formulation of management guidelines for the rational exploitation of short-necked clam stocks in coastal waters of Negros Occidental, Central Philippines.

Figure 1. **The short-necked clam *Paphia undulata* Born, 1778 (Mollusca, Pelecypoda: Veneridae)**

MATERIALS AND METHODS

The study was conducted in the waters of Hinigaran, Binalbagan, and Himamaylan, Negros Occidental, central west Visayas (Figure 2). Length-frequency data from catches of compressor divers covering the period August 2007 to July 2008 were analyzed. Shell lengths (SL) (i.e. shell anterior to posterior) of clams were measured to the nearest 0.05 mm using a Vernier caliper. SL's were grouped in size classes of 5 mm and analyzed using the FiSAT software (Gayanilo & Pauly, 1997). The growth parameters, asymptotic shell length (SL_∞ in mm) and growth coefficient (K, yr^{-1}) were derived using the ELEFAN I routine. The growth function (ϕ') of Pauly & Munro (1984) was computed using the following formula:

$$\phi' = \log K + 2\log L_\infty \qquad (1)$$

Recruitment, and total mortality (Z, yr^{-1}), were derived with the use of the ELEFAN II routine. The estimate of natural mortality (M) was derived by averaging M/K values from bivalve literature and multiplying it with the K value derived from this study. Fishing mortality (F, yr^{-1}) was computed by subtracting M from Z, total mortality being equivalent to:

$$Z = F + M \qquad (2)$$

Exploitation rate was then computed with the formula:

$$E = F/Z \qquad (3)$$

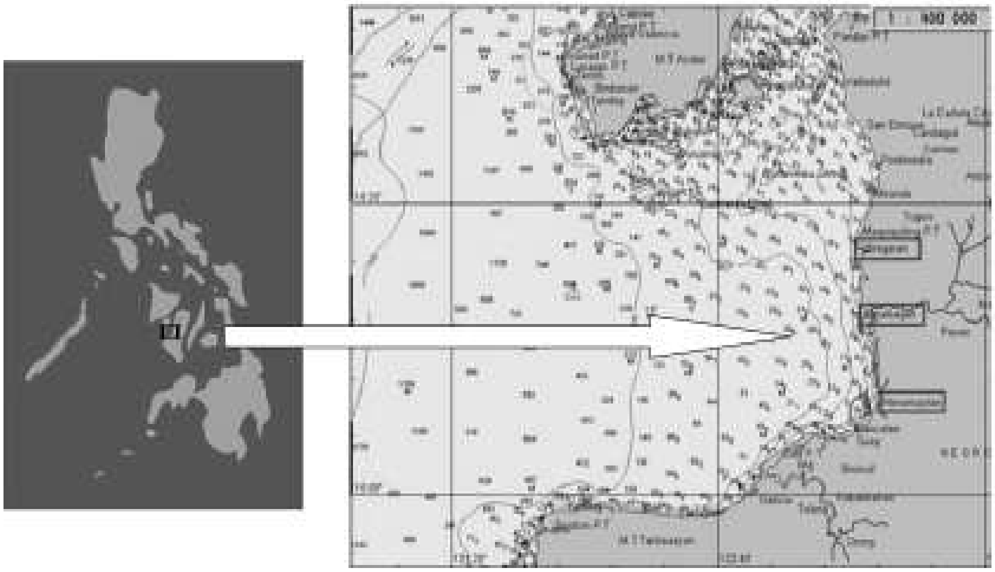

Figure 2. Location of the study area in southern Negros Occidental

RESULTS AND DISCUSSION

Population parameters (growth, recruitment, mortality) are useful bases in comparing the status of exploited resources as they provide valuable information on how exploitation affects the population (Pauly 1984).

The SL∞ of 79 mm (Figure 3) derived from this study is smaller than the 81.5 mm) obtained by Agasen et al. (1998), which can be attributed to the smaller sizes of the present data (Figure 4). A t-test performed on random samples taken from the original data sets to compare mean sizes of clams from current (SL = 44.8 mm) and previous (SL = 55.9 mm) studies showed that the difference in sizes (i.e. a reduction of almost 24%) is significant ($t = 6.38$, $df = 39$, $p<0.001$). Therefore, whereas clams > 75 mm SL were still caught in 1996-97 during the study of Agasen et al. (1998), sizes from

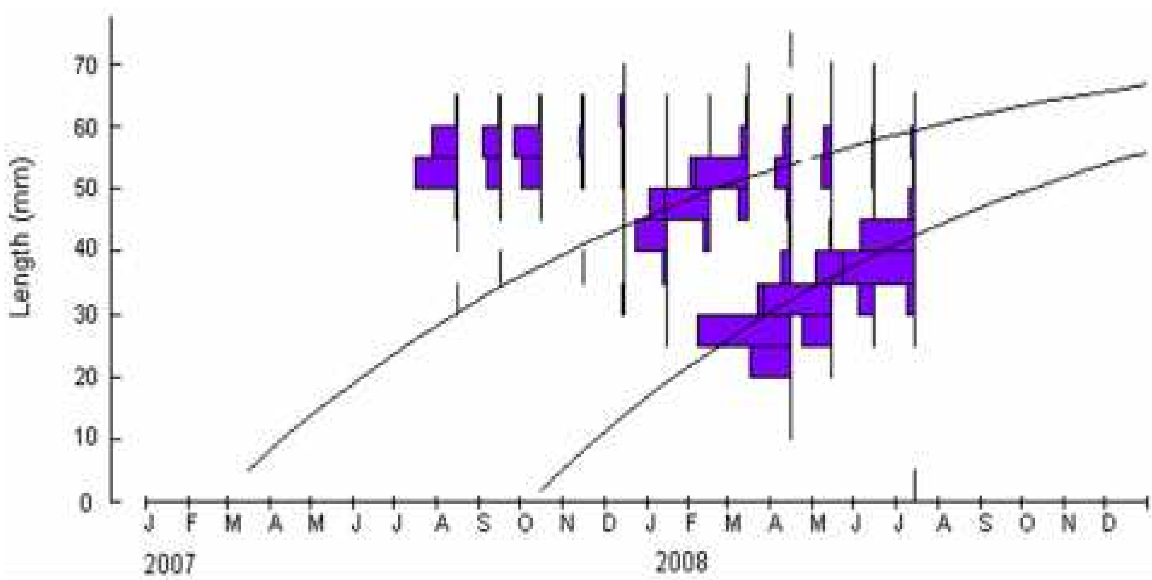

Figure 3. von Bertalanffy growth curve of the short-necked clam *Paphia undulata* derived using ELEFAN I in the FiSAT software (SL_∞ = 79 mm, K = 1.0 yr^{-1}, Rn = 0.561)

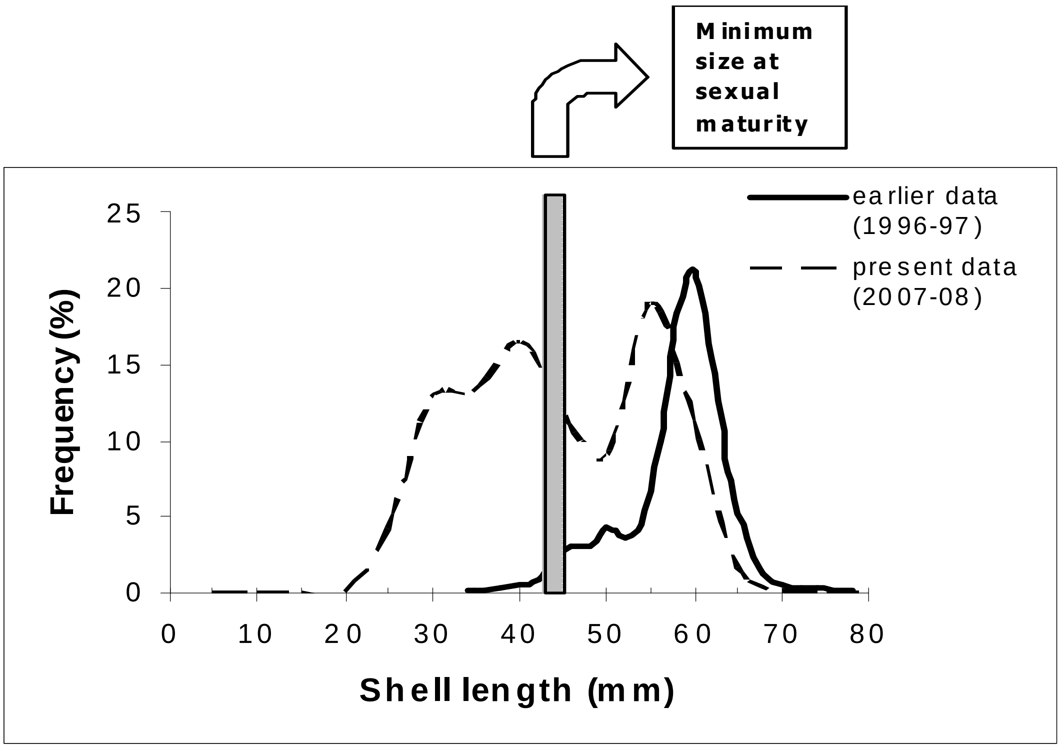

Figure 4. Comparison of sizes (shell length in mm) of the short necked clam *Paphia undulata* caught 13 years ago based on Agasen et al. (1998) and current sizes in southern Negros Occidental with the range of sizes at sexual maturity for males (42.3 mm) and females (44.8 mm) superimposed.

current catches did not exceed 65 mm (Villarta & del Norte-Campos, 2010). The value of K in the present study (1.0 yr^{-1}) differed only slightly from the estimate of Agasen et al. (1998) (1.2 yr^{-1}), thereby resulting in close estimates of ϕ' (3.791 and 3.901, respectively). This shows that the difference in SL_∞ values stems from the difference in maximum sizes in the two sets of samples, and that the growth function (ϕ') can truly be used to characterize not only similar species (Pauly & Munro 1984), but also related species as in the case of scallops (Del Norte 1988). Nabuab et al. (2010) reported that the minimum size at sexual maturity is 42.6 mm for males and 44. 8 mm for females. Thus, in addition to being smaller clams, the bulk of current catches are also immature (SL< 45mm) (Figure 4) indicating that growth and perhaps even recruitment overfishing (Gulland 1971) set in sometime during the past 13 years.

Two recruitment pulses were derived (Figure 5) just as in Agasen et al. (1998). Whereas reproduction was not examined in the earlier study, these pulses indicate spawning peaks which were observed between August to November (Nabuab et al., 2010). These pulses not only coincide with the spawning peak, but are also related to the monsoons. Spawning and subsequent recruitment are believed to be timed during a "survival window" during the monsoons. This pattern is similar to those observed in many tropical species (Pauly & Navaluna, 1983), including many bivalve species in the Philippines like scallops (del Norte 1988; Gabral-Llana 1988) and ark shells (Ledesma-Fernandez & del Norte-Campos 2004).

Bivalve literature data used in computing natural mortality (M) are shown in Table 1. Based on these, M was estimated to be 1.57 yr^{-1}. This estimate is deemed more proper than the estimate of Agasen et al. (1998) (2.89 yr^{-1}) which was based on Pauly's (1980) empirical equation. The latter was based purely on information from fish, and may thus be inappropriate for invertebrates, including bivalves. Natural mortality, just like K, are species- or taxon-specific parameters reflecting the niche of the species and/or the taxon in

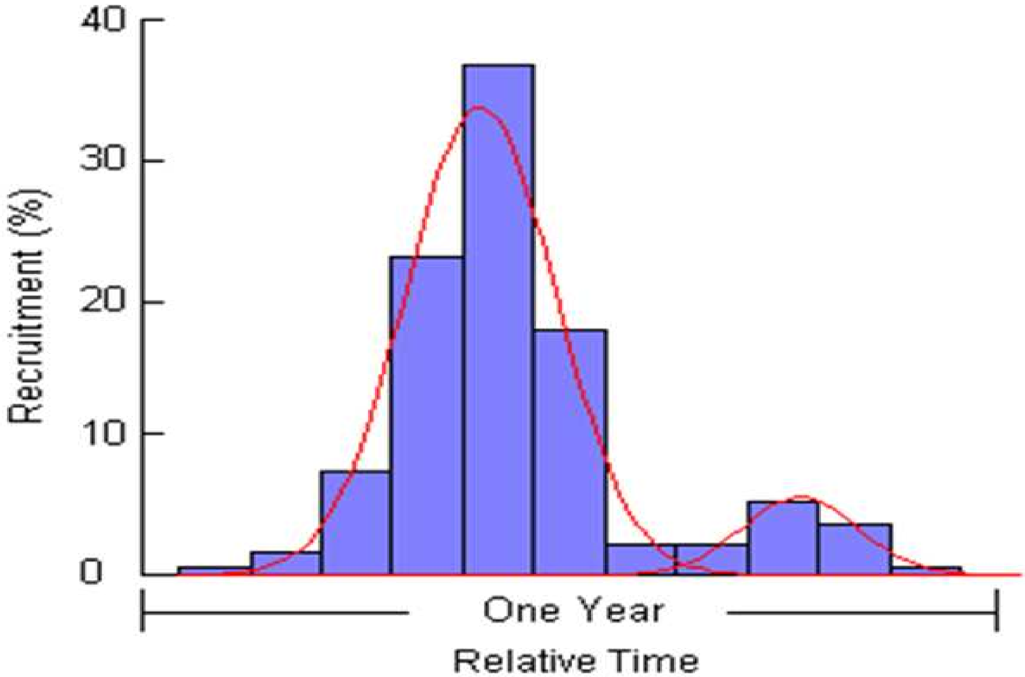

Figure 5. Recruitment pattern of *Paphia undulata* showing two recruitment pulses

question. As such, their values do not deviate widely among related species and/or within taxonomic groups. Averaged M/K values taken from bivalve literature are therefore biologically suitable to use as basis for computing M for the species in the present study.

Mortality and exploitation estimates are shown in Table 2. From these, comparable values of total mortality, Z (6.18 vs. 6.22 yr^{-1}) were derived but a higher fishing mortality (F = 4.61 yr^{-1}) was computed, thereby resulting also in a higher value of exploitation rate (E = 0.75). These results not only confirm the previous finding that the Negros stock is overfished (Agasen et al., 1998), but even further emphasize that the situation has become far more serious at the present. Details of overfishing are presented in another paper (Villarta & del Norte-Campos, 2010). The present results therefore further highlight the urgent need to manage this resource. This problem can only be mitigated by imposing strict management guidelines that should include (1) fishing only sizes that are sexually mature, i.e. >45 mm (Pongthana 1990; Nabuab et al., 2010), and (2) imposing closed seasons during the spawning season (August-November). These guidelines, albeit unpopular due to their initial short-term impact on fisher livelihoods, can restore the stock to a sustainable status if properly implemented, thereby assuring a more stable income for the fishers.

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Table 1. Natural mortality (M, yr^{-1}) and growth coefficient (K, yr^{-1}) literature estimates for different bivalve species used to compute the M value for the short-necked clam, *Paphia undulata* in the present study.

Species	Common Name (FAO, 1998)	M (yr^{-1})	K (yr^{-1})	M/K	Literature
Amusium pleuronectes	Asian Moon Scallop	1.29	0.92	1.4	del Norte (1988)
A. pleuronectes	“	1.3	0.94	1.38	Gabral-Llana (1998)
A. pleuronectes	“	1.49	0.90	1.66	del Norte-Campos & Villarta (2008)
Tridacna maxima	Elongate Giant Clam	0.21	0.074	2.84	Munro & Heslinga (1982)
T. maxima	“	0.15	0.132	1.14	McKoy (1980)
Tapes philippinarum	Japanese Carpet Shell	0.2005	0.9125	0.22	Yap (1977)
Chlamys funebris	-	0.506*	0.457	1.11	Soliman & Dioneda (2004)
C. senatoria nobilis	Senatorial Scallop	0.506*	0.457	1.11	“
Decatopecten striatus	-	0.525*	0.507	1.04	“
Gari elongata	Elongate Sunset Clam	2.95	1.0	2.95	del Norte-Campos (2004)
Paphia undulata	Short-necked Clam	2.89	1.2	2.41	Agasen et al. (1998)
				1.57 Mean M/K	
Paphia undulata	Short-necked Clam	**1.57**	1.0		This study

**given values obtained from different methods were averaged*

Table 2. Mortality and exploitation rate estimates for the southern Negros Occidental stocks of the short-necked clam *Paphia undulata*, derived from the present study and those from Agasen et al. (1998).

Total mortality (Z, yr^{-1})	Fishing Mortality (F, yr^{-1})	Natural Mortality (M, yr^{-1})	Exploitation Rate (E)	Source
6.18	4.61	1.57*	0.75	This study
6.22	3.33	2.89**	0.54	Agasen et al. (1998)

derived from averaged **bivalve literature*
*** inappropriately derived from **fish** stocks (Pauly, 1980)*

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