

## Population structure and abundance of *Trochus niloticus* in Tubbataha Reefs Natural Park, Palawan, Philippines with notes on poaching effects

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### Abstract

The topshell *Trochus niloticus* is a highly valuable reef invertebrate that flourishes in the Tubbataha Reefs Natural Park (TRNP), Palawan, Philippines. At present, it is heavily poached inside the park premises, which justifies the present study. The average size of trochus at TRNP was found to be smaller than those harvested from other Pacific Island countries, but the density was very high, ranging from 3,000 to 11,000 ind ha<sup>-1</sup>. An associated species, *Tectus pyramis*, which occurs in very low numbers, are some of the other shells that have been confiscated from the park. The estimated value of sequestered trochus from 2006–2007 was assumed to be very low compared with the overall amount of poached trochus. The declining trend in the size structure of confiscated trochus from 2006–2007 reflects the effects of poaching. If left uncontrolled, this illegal activity is expected to cause considerable decline and eventual extinction of this high-value reef species in TRNP.

### Introduction

*Trochus niloticus*, commonly called topshell or trochus, is one of the most valuable and sought-after reef gastropods because its shell is used in the manufacture of mother-of-pearl buttons (Nash 1988). This species and the less commercially important *Tectus pyramis*, and some other trochids, are naturally distributed in the Indo-West Pacific Ocean including the Philippines (Carpenter and Niem 1998). Its current distribution extends to other tropical islands of the eastern Pacific as a result of numerous successful translocation efforts — between 1927 and the late 1990s — within and outside its natural geographical distribution (Gillett 2002).

Commercial exploitation of *T. niloticus* was observed as early as 1907 (Bour 1987) but early trade statistics are often unavailable. Hahn (2000) reported that the average world harvest of trochus in the 1980s was about 4,000–6,000 t with a wholesale value of USD 4 million and a retail value of about USD 28 million. With the continuous unregulated harvest of trochus, export records from various countries in the Pacific show wide fluctuation, with an overall downward trend (e.g. Etaix-Bonnin and Fao 1997; Gillespie 1997). This declining trend has prompted actions to improve management and continued research on the biology and stock enhancement of trochus (e.g. Hoang et al. 2007; Purcell et al. 2003; Amos and Purcell 2003; Smith et al. 2002; Nash 1988).

Although the Philippines was historically one of the major world trochus exporters, little is known about the current status of its wild populations and information on harvest volume is fragmentary. Before World War II, the harvest in the Philippines was estimated to have reached over 1,000 t yr<sup>-1</sup> but was reduced to less than 300 t annually in 1948 (see Hahn 2000). The estimated annual volume of exported *Trochus* sp. from the Philippines decreased from 200–300 t from 1985–1987 to < 100 t from 1995–2002 (Floren 2003). Because trochus populations were reduced to near extinction (Gapasin et al. 2002), conservation measures were initiated. These measures included: 1) artificial breeding and eventual restocking initiatives of a Japanese private company based in Binduyan, Puerto Princesa City since early 2000; 2) breeding refinement at the Aquaculture Department of the Southeast Asian Fisheries and Development Center (SEAFDEC) in Iloilo (Gallardo 2003); and 3) the passing of national policy declaring trochus a threatened species through Fisheries Administrative Order No. 208, Series of 2001 (BFAR 2006; Floren 2003). Unfortunately, the breeding program at SEAFDEC was short-lived due to budgetary constraints and species prioritization (Gapasin pers. comm.). Also, illegal exploitation remained a major threat to trochus, especially in Tubbataha Reefs Natural Park (TRNP), where large numbers of trochus are found. Given the dearth of information about trochus in the Philippines, this paper presents the current population structure, abundance and the effects of poaching on trochus populations in TRNP.

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## Materials and methods

The study site is TRNP (located at 8°56'00.68"N; 119°48'23.15"E), which was established in 1988 and inscribed in the UNESCO World Heritage List in 1993. The park is an offshore atoll reef area in the middle of the Sulu Sea, about 150 km southeast of Puerto Princesa, the capital city of Palawan, Philippines. It covers an area of 968 km<sup>2</sup> and comprises two atolls and a reef flat. North and South atolls are separated by an 8-km-wide channel. North Atoll is oval shaped, and about 18.5 km long and 5.6 km at its widest portion. South Atoll is triangular shaped, about 9.3 km long and 5.6 km wide. An exposed reef flat at low tide of approximately 200–500 m wide encloses an 8–24 m deep lagoon that has a steep seaward drop-off down to about 70 m (Palaganas et al. 1985). The Jessie Beazly Reef lies 20 km north of North Atoll. It is a small reef flat with a sand bar of about 100 m exposed at low tide. The reef was made part of the park on 23 August 2006 through Presidential Proclamation 1126, expanding the park from 332 km<sup>2</sup> to its present size.

Surveys were conducted between 16 September and 19 October 2006. Seven roughly 1-m-deep sites where trochus abound were established as permanent monitoring sites. Stations 1 to 4 are at North atoll, while the remaining three were established at South atoll. For each site, a 2-m-wide, 150-m-long transect line was laid parallel to the shoreline and was surveyed by snorkelling. *Trochus niloticus* and *Tectus pyramis* found within the transect line were measured for their maximum basal diameter (MBD) using a plastic ruler glued to a slate board. After measuring, the animals were immediately returned to their habitat in an upright position.

Two out of five sacks of trochus that were confiscated in June 2007 were haphazardly selected,

and the shells were measured to establish an MBD to dry weight relationship. In an October 2007 poaching incident in TRNP, MBD of confiscated trochus was again measured using callipers. Information from a local resident who shared his experiences in collecting trochus at TRNP is included in this study.

## Results

### Population structure

The surveys along permanent transects revealed that the average sizes of both species vary among sites. The largest individuals were found at Sites 1, 4 and 5. The MBD of *Trochus niloticus* ranged from 17–130 mm with an average of  $67.0 \pm 14.6$  mm, while that of *Tectus pyramis* only ranged from 23–63 mm with an average of  $46.6 \pm 5.1$  mm (Fig. 1).

*Trochus niloticus* was found in much higher numbers than *Tectus pyramis*, comprising around 98% of the 1,242 individuals sampled (Fig. 2).

Around 55% of the population of *Trochus niloticus* fell below the average size. Those that measured 52–77 mm were dominant, forming almost 51% of the population. Smaller shells with sizes <50 mm comprised 14% of the collected individuals.

### Abundance

The densities of trochus vary among sites with *Trochus niloticus* showing great abundance compared with *Tectus pyramis*. *Trochus niloticus* occurred at densities between 4,000 ind ha<sup>-1</sup> and 11,000 ind ha<sup>-1</sup>, except at Site 5 where it was a little above 3,000 ind ha<sup>-1</sup>. The average density of *Trochus niloticus* was about 6,000 ind ha<sup>-1</sup>. *Tectus pyramis* was rare, having only an average density of 119 ind ha<sup>-1</sup> (Fig. 3).

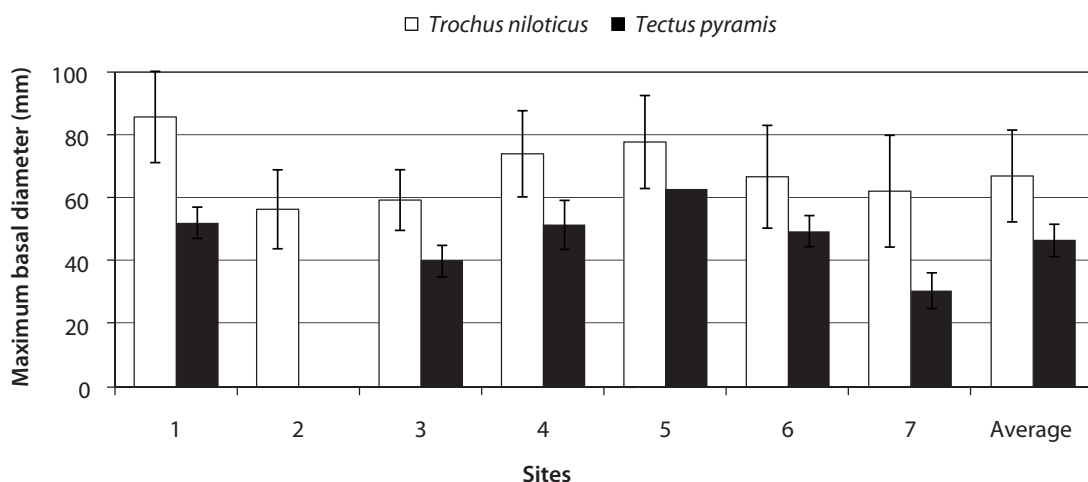
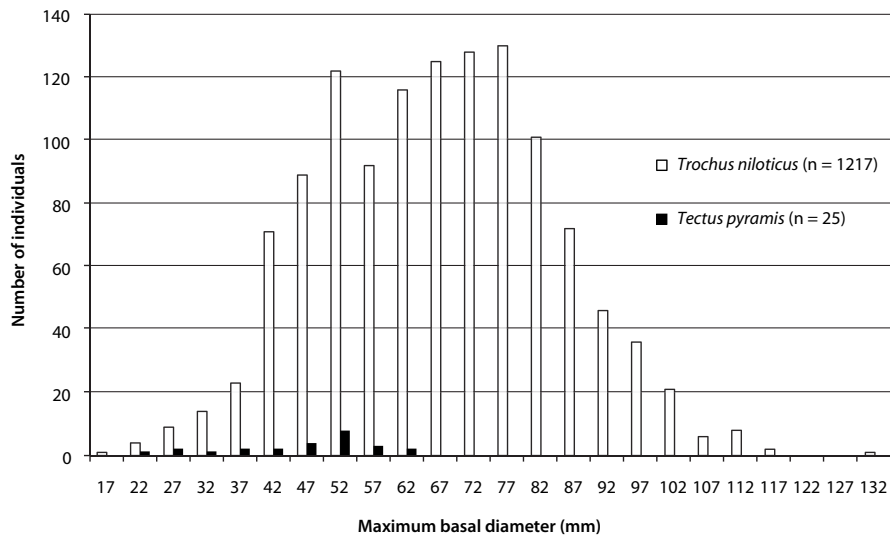
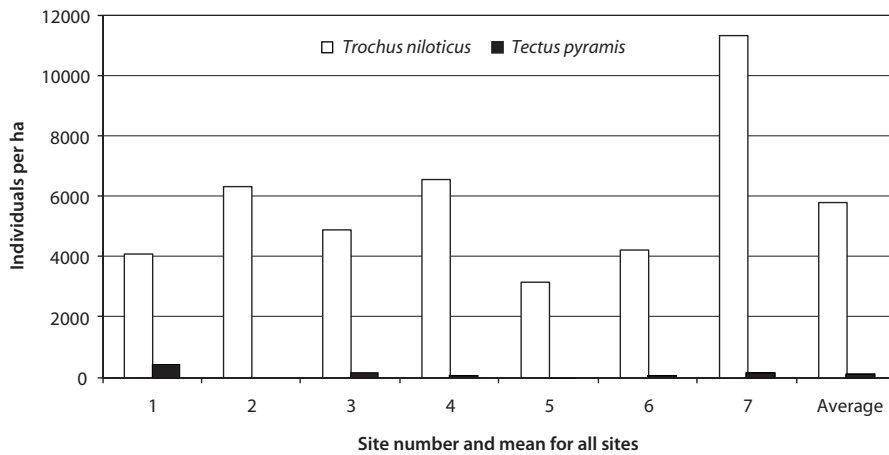


Figure 1. Mean ( $\pm$  standard deviation) maximum basal diameter of *Trochus niloticus* and *Tectus pyramis* per station.



**Figure 2.** Population structure of *Trochus niloticus* and *Tectus pyramis* at Tubbataha Reefs Natural Park (September–October 2006).



**Figure 3.** Density (ind ha<sup>-1</sup>) of *Trochus niloticus* and *Tectus pyramis* in survey sites at Tubbataha Reefs Natural Park in 2006.

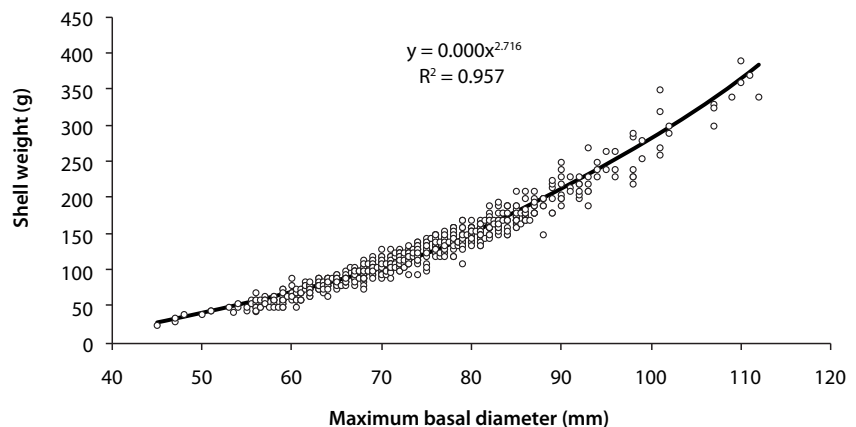
**Mean basal diameter–dry shell weight relationship**

There is a very high positive relationship ( $r^2 = 0.9577$ ) between MBD in *T. niloticus* and its dry shell weight. The weight of dry shell could be estimated using the equation:

$$W = 0.0008X^{2.7763}$$

(W = dry shell weight and X = MBD).

Variability between size and weight tended to increase as the individual got bigger (Fig. 4).



**Figure 4.** Scatter graph of *Trochus niloticus* maximum basal diameter–dry shell weight relationship.

### Notes on poaching

Data obtained from confiscated *T. niloticus* reflect that trochus harvested in June 2007 were larger than those in October 2007 (Fig. 5). In June 2007, the mean size was  $74.1 \pm 10.8$  mm while it was only  $63.8 \pm 7.1$  mm in October 2007 — a 10 mm difference. By comparing maximum sizes, a decrease was even more obvious. The largest individual harvested in June was 15 mm, which was smaller than the largest one collected in October 2007. Assuming specimens to be sexually mature when their shell size is 50–65 mm MBD, around 22.2% and 61.2% of these sizes were among the confiscated shells in June and October 2007, respectively.

From 2002–2007, 59% of 17 apprehended groups of poachers at TRNP were from mainland Palawan. About 24% came from other regions of the Philippines, and the rest were from China, whose target species were not trochus but fishes, marine turtles, dolphins and giant clams. Trochus poachers, mainly from mainland Palawan, began their operation in early 2006. Eight of the 10 apprehended poachers from Palawan in 2006–2007 engaged exclusively in harvesting trochus.

In April 2006, five sacks and 119 individuals of trochus were confiscated, while 81 sacks and 761 individuals were sequestered in 2007, which together weighed more than 3 t. Using the data from June 2007 as the baseline, and a purchase price of PHP 300.00 kg<sup>-1</sup>, the value of the trochus confiscated in those two years represented about PHP 1,000,000 (Table 1), roughly USD 20,000.

### Discussion

#### Population structure and abundance

The mean size of trochus recorded in 2006 at TRNP ( $67.0 \pm 14.6$  mm) was small compared with that measured from Penrhyn, Cook Islands (84.0 mm) (Ponia et al. 1997). Similarly, the mean sizes (74.1 mm and 63.8 mm) of confiscated *T. niloticus* at TRNP are smaller than those harvested in Cook Islands and in Saipan with an average of 86.2 mm (fore-reef slope individuals about 92.1 mm and reef-flat individuals about 76.9 mm; Trianni 2002).

In undisturbed areas, the density of *Trochus niloticus* was generally lower in deeper parts of the reef (Hahn 2000) in contrast with overfished areas (Smith et al. 2002). *Tectus pyramis* on the other hand had higher densities in the subtidal reef slope at TRNP (Dolorosa and Schoppe 2005).

In the present study, surveys were done in intertidal areas where the shells are plentiful, thus a thorough survey of the reef flat is needed to better understand its ecology and the effects of poaching on TRNP's trochus population. More sampling sites at the inundated reef flat are needed to develop a clear picture of its abundance, especially that of juveniles. An area estimate of suitable habitat is paramount in approximating its total population.

Compared with other open access areas in Palawan where density ranges from 0–100 ind ha<sup>-1</sup> (Dolorosa and Matillano 2005; Dolorosa et al. 2007; Gonzales et al. 2005, 2006, 2008), the trochus popu-

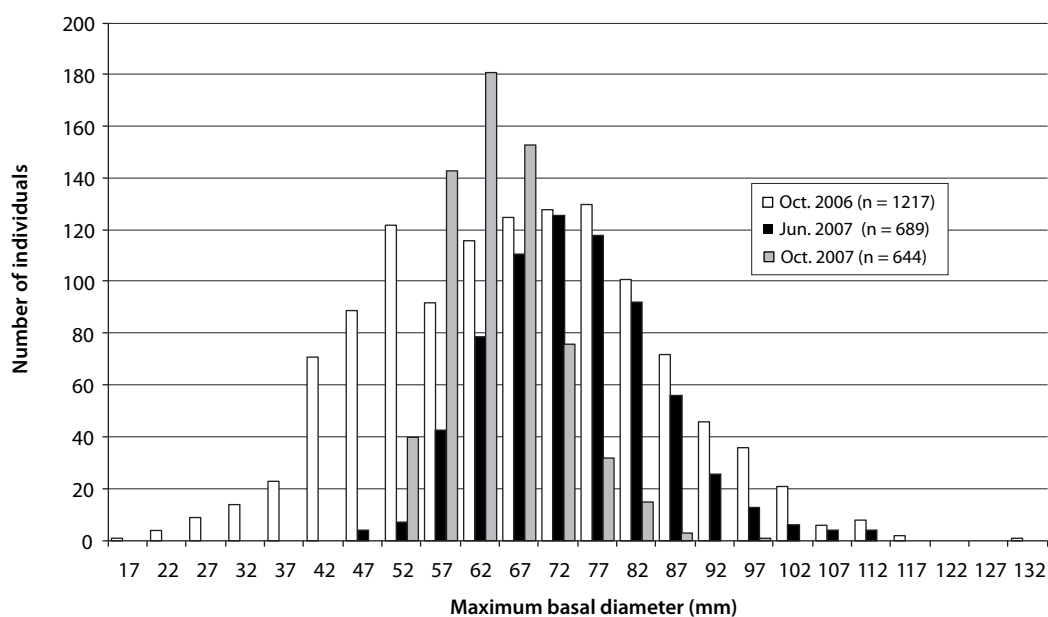


Figure 5. Size structure of confiscated *Trochus niloticus* in June and October 2007 in comparison with those obtained in September–October 2006 baseline sampling.

lation had recovered from overexploitation at Tubataha Reefs after its declaration as a national park in the early 1990s to reach several thousand individuals per hectare. Because it took about a decade or more for trochus to recover at TRNP after closure, and for the introduced trochus in countries such as French Polynesia (Cheneson 1997) and Cook Islands (Ponia et al. 1997) to reach a commercially viable population level, reviving populations in other parts of Palawan and the Philippines appears to be a huge challenge.

With the scarcity of trochus in areas around mainland Palawan and in offshore islands such as the Spratleys, TRNP serves as the only potential seed bank for trochus and many other species. Although the planktonic larval stage of *T. niloticus* is short (3–4 days) and larvae may only settle locally (Nash 1988), settlement may be delayed for about 10 days when appropriate substrate is unavailable (Nash 1993) with the potential to drift outside the park boundaries. In this case, it would be possible for larvae to help replenish depleted reefs on mainland Palawan and other areas within the Sulu Sea. By contrast, if TRNP becomes thoroughly devoid of trochus, recruitment within and outside the park would be more unlikely. Given the scarcity of the species in other areas, the probability that drifting planktonic larvae would settle at TRNP remains low.

### **Mean basal diameter–dry shell weight relationship**

The *T. niloticus* MBD to dry weight relationship is comparable to that measured in Penrhyn, Cook Islands (Ponia et al. 1997), where  $r^2 = 0.979$  and dry shell weight is determined by the equation  $W = 0.00034L^{2.943}$ . It appears that specimens of *T. niloticus* at TRNP have thicker shells than those from Cook Islands. This variation in shell growth may occur in different geographical regions (Lemouellic and Chauvet 2008) and with exposure to specific habitat characteristics (Nash 1985).

### **Notes on poaching**

The low average MBD at Stations 2, 3, 6 and 7, and uneven densities observed especially at South Islet's Stations 5, 6 and 7 are presumed effects of poaching activities that started as early as April 2006. Without harvesting, mean individual sizes and densities could be more uniform given that all stations were in the rocky intertidal zone. Should poaching continue to occur, trochus in TRNP might be overfished again and will suffer the same fate as it has in many other countries (see Smith et al. 2002; Foale and Day 1997; Nash 1985), including the rest of the Philippines. The inclusion of *Tectus pyramis* in the poachers' catches — even though it is of no commercial value for the button industry (Gillespie

1997) — could eventually affect its population. *Tectus pyramis* are rarely noted on the reef flat and comprise only about 17% of all trochid species in an intertidal area at South Islet (Dolorosa and Schoppe 2005) and only about 2.3% (or a range of 0–8.9%) during the present survey.

It seems that larger shells were prioritized by poachers in the early part of 2007, with smaller shells becoming their next target. Harvesting smaller shells is also a common problem in many Pacific Island countries despite government policies (e.g. Trianni 2002; Smith et al. 2002). Such a practice could lead to isolated extinction, as the continuous removal of a large proportion of immature trochus could reduce recruitment and cause the population to collapse (Nash 1985; Foale and Day 1997).

With the use of the dry shell MBD–weight formula, the projected average dry shell weight of *T. niloticus* at TRNP in September–October 2006 was 109.6 g each, or 636 kg ha<sup>-1</sup>, considering the average density at 5,805 ind ha<sup>-1</sup>. Further, it was determined that the two sacks of shells confiscated in June 2007 contained 220 individuals (mean size = 81 mm) and 388 individuals (mean size = 69 mm) and weighed 36 kg and 41 kg, respectively. The shell generally makes up 75–77% of the weight of a live animal (Heslinga 1981), so that each sack could contain about 50 kg of live trochus, manageable enough for each poacher to carry while wading, or during loading and unloading from or into the boat.

When poachers are detected and chased by park rangers, they tend to drop sacks of trochus from their motorized outrigger boat; hence, it is obvious that our estimated value — based on volume of confiscated trochus — is much lower than what has actually been plundered. Given the inadequate surveillance equipment at the ranger station, the number of apprehensions made may only constitute a small fraction of poaching operations. One local resident met by one of the authors claimed that in the summer of 2006, his group of 7–8 poachers was able to undertake 10 poaching operations in one month at Bird Islet (North Atoll). This means that these poachers must have collected trochus near or at Sites 2 and 3. The poacher also claimed that they collected some seabird eggs and were able to gather about 20 sacks of trochus per operation. Each operation of trochus gathering lasted for about three hours per night. Given such information, this group had a catch per unit of effort of around 250 shells ha<sup>-1</sup> or about 200 sacks in all. If each sack weighed 38 kg of dry shells with a purchase price of PHP 300.00 kg<sup>-1</sup>, this group of poachers alone was able to generate more than 2 million pesos in 10 operations. It is of little wonder that despite its remoteness, the park remains a prime poaching destination for both local and foreign nationals. Given the instant high



income, the poachers ignore the distance and risk of apprehension and incarceration. However, it will be difficult to monetize the value of biodiversity in TRNP and in other parts of the country, much less the value of trochus and other organisms that are spared from poachers, and the importance of allowing them to flourish at the park for aesthetic, educational, scientific and other purposes.

Most reefs in the Philippines are now heavily damaged and overfished (Licuanan and Gomez 2000), including some reef areas in Palawan (Anda and Tabangay-Baldera 2004), which harbors few commercially important species (Ablan et al. 2004). If overfishing also occurs at TRNP, Filipinos and the whole world stand to lose an astounding biological wealth, as this reef area is considered one of the most biologically rich. Therefore, the survival of trochus and other species harbored in this World Heritage Site within the Philippines' national territory lies on effective enforcement against poachers — a key to possible habitat conservation and restoration in other parts of the Sulu Sea and the country as a whole. Upgrading surveillance equipment is essential to increasing park rangers' capabilities in detecting illegal fishermen. Conducting day and night patrols around the park is also needed. With the support of relevant national authorities, the Tubbataha Protected Area Management Board needs to put an end to the illegal trade in trochus that is occurring in Palawan Province. Given the ecological and high commercial importance of trochus, the revival of its population in the Philippines must be addressed on a broad scale.

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