Effect of lunar phases in the size distribution of *Holothuria scabra* on intertidal areas in Sarangani Bay, Philippines

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Abstract

There have been few studies conducted on sea cucumbers, specifically *Holothuria scabra,* in Sarangani Bay, Philippines; and thus, there is little information to guide conservation and management efforts of these organisms in this area. A survey on the size distribution of *H. scabra* was carried out in three shallow intertidal areas by using the belt transect method during two lunar phases – full moon and new moon – for four months to evaluate this species' intertidal population. The result shows a unimodal distribution of *H. scabra*, with specimens found during the new moon phase to be significantly larger than those found during the full moon phase. The sex ratio was estimated to be 1:1, consistent with most holothuroid studies, and not affected by the lunar phase. Population densities ranged from 0.17 individuals per square metre (ind. m^{-2}) during full moon periods, to 0.34 ind. m^{-2} during new moon periods at three stations. The calculated allometric coefficient of 1.84 indicates that *H. scabra* are leaner for a given length in these areas than in other areas. The results also suggest that lunar phases have an effect on the size distribution of *H. scabra,* which probably explains the larger individuals collected by intertidal gleaners during new moon periods.

Introduction

Overexploitation and habitat loss are the two main reasons for the population decline of sea cucumbers in the Philippines. These threats, coupled with the increasing demand by the sea cucumber trade, destabilize sea cucumber populations in the country. *Holothuria scabra,* a high-valued species, is actively harvested and exploited, leading to severe fishing pressure and serious depletion of natural populations (Akamine 2005). Although it is considered a commercially valuable species in the Philippines (Akamine 2001), management measures specific to sea cucumber conservation are still lacking in the country (Bruckner et al. 2003).

In Sarangani Bay, few studies have been conducted on sea cucumbers, which makes it difficult to establish conservation and management measures based on scientifically sound assessments. Previous work on sea cucumbers, specifically *H. scabra,* have failed to provide metrics about the size distribution of the local population or contribute to the very little information about this economically important species. Because it is a local delicacy, this species is also collected by intertidal gleaners during low tides, especially during a new moon when larger sized individuals can be collected. Unfortunately, anecdotal evidence suggests that there is a reduction in the size of *H. scabra* gleaned in the intertidal areas of the bay. A rapid survey was, therefore, conducted to evaluate the size distribution, sex ratio and density of *H. scabra* on selected intertidal areas in Sarangani Bay during two different lunar phases: full moon and new moon.

Materials and methods

Sarangani Bay is located in the southeast of Mindanao, Philippines between 5°33′25′′,and 6°6′15′′N and between 124°22′45′′ and 125°19′45′′E (Fig. 1). Three stations were selected in Sarangani Bay for the study. The stations were chosen based on reports of high abundance of sea cucumbers and the presence of intertidal gleaners. The first site is in Sitio Linao, Barangay Tinoto, Maasim, where the nearby Tausug community harvests sea cucumbers for subsistence; the second site is in Sitio S'nlang, Barangay Tinoto, Maasim, where harvesting is minimal; and the third site is in Sitio Macatimobol, Barangay Taluya, Glan, where sea cucumbers were harvested unsustainably.

In every station, six belt transects (50-m long and 4-m wide) were established perpendicular to the shore at 10-m intervals. Investigators surveyed these transects at the lowest ebb tide during the full moon and new moon phases. In total, sampling took place over 24 nights between October 2014 and January 2015. Three investigators collected all *H. scabra* found within the 200 m^2 transects. Sea cucumbers were put back into water to

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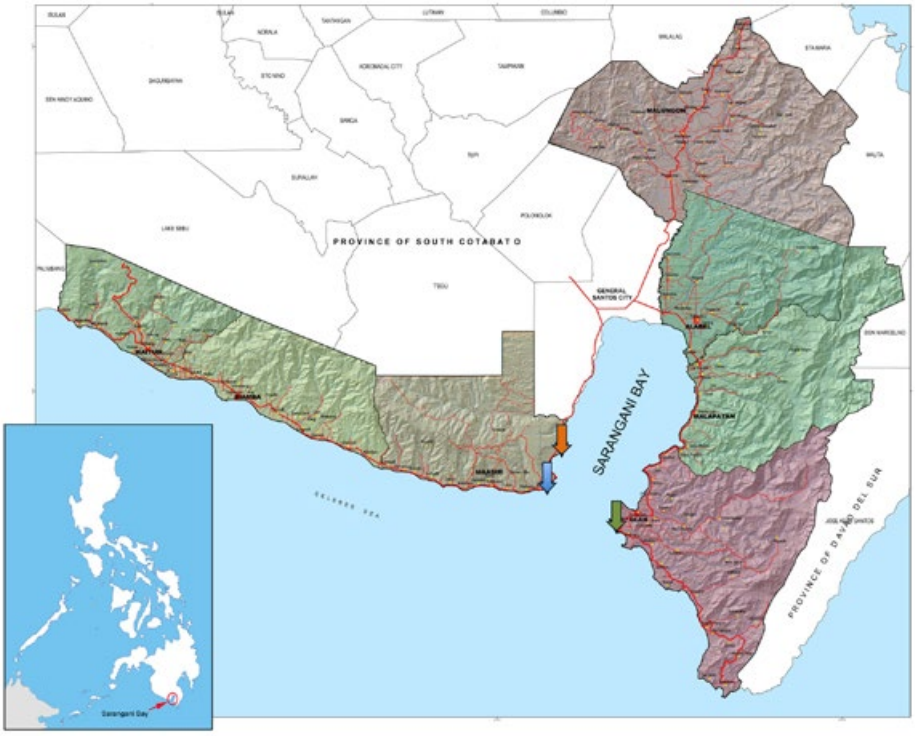

Figure 1. Location of Sarangani Bay and the three survey stations, indicated by downward arrows (orange = Sitio Linao; blue = Sitio S'nalang; and green = Sitio Macatimbol). Source: Provincial Planning and Development Office of Sarangani.

relax for five minutes. Then, total length – from mouth to anus – was measured to the nearest 0.5 cm with a tape measure. This operation was done quickly so that the sea cucumbers would not eviscerate. All of the measurements were recorded on pre-printed datasheets.

Sex identification

In total, 127 individuals measuring >16 cm in length, considered mature (Purcell et al. 2012), were taken from each transect for sex identification based on gonad color. This was done by squeezing the body to trigger the expulsion of the gonads (Al-Rashdi et al. 2007).

Results

The distribution of *Holothuria scabra* was found to be unimodal, with significantly larger sizes found during new moon phases (ANOVA, p = 0.01). About 67% of specimens collected during a new moon phase were >15 cm in size, 51% of which were found in Sitio Linao where the highest concentration of large specimens was recorded (see Figs. 2, 3, 4 and 5).

Of the 127 mature individuals, 18 were indeterminate in gender, 60 were males, and 49 were females. Female specimens were, on average, larger

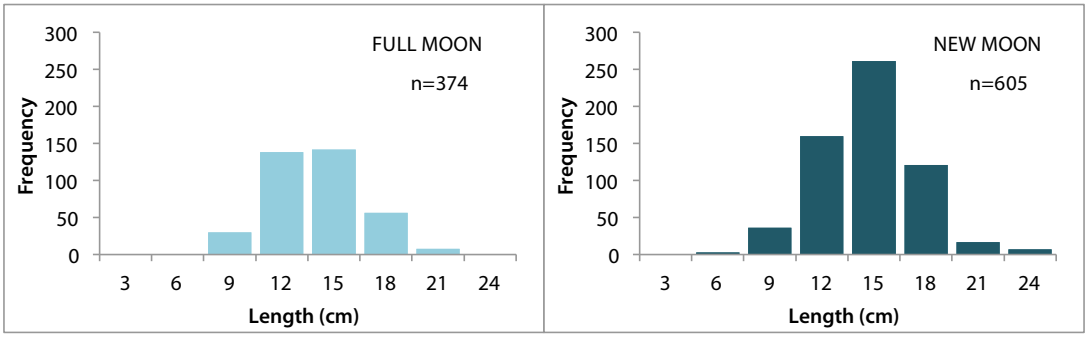

Figure 2. Combined length-frequency distribution of *Holothuria scabra* in Sarangani Province from October 2015 to January 2016 during full and new moon phases.

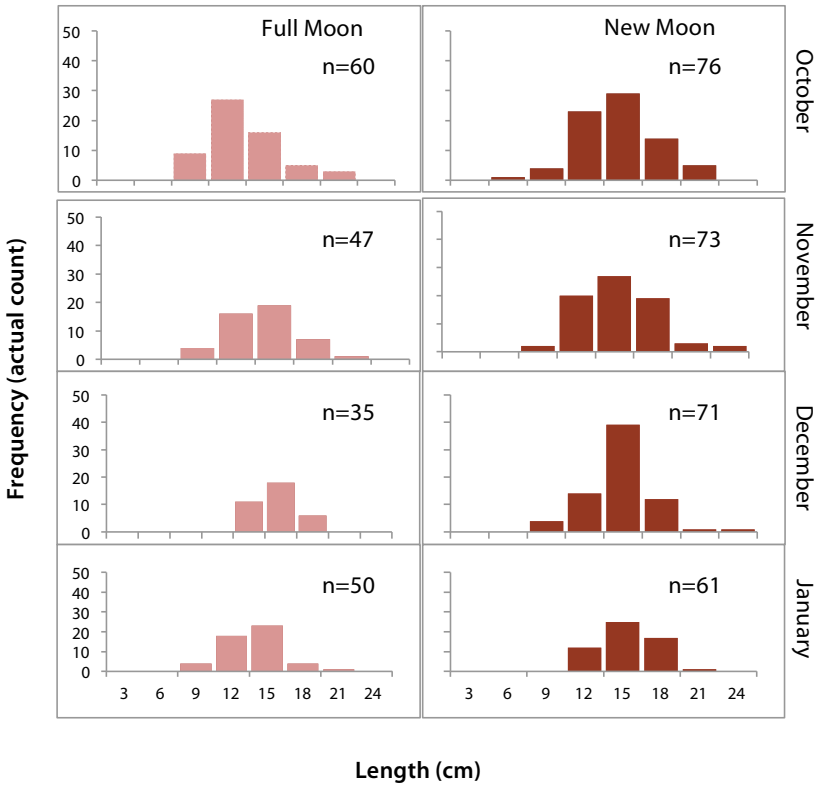

Figure 3. Length-frequency distribution of *Holothuria scabra* in Sitio Linao from October 2014 to January 2015 during full and new moon phases.

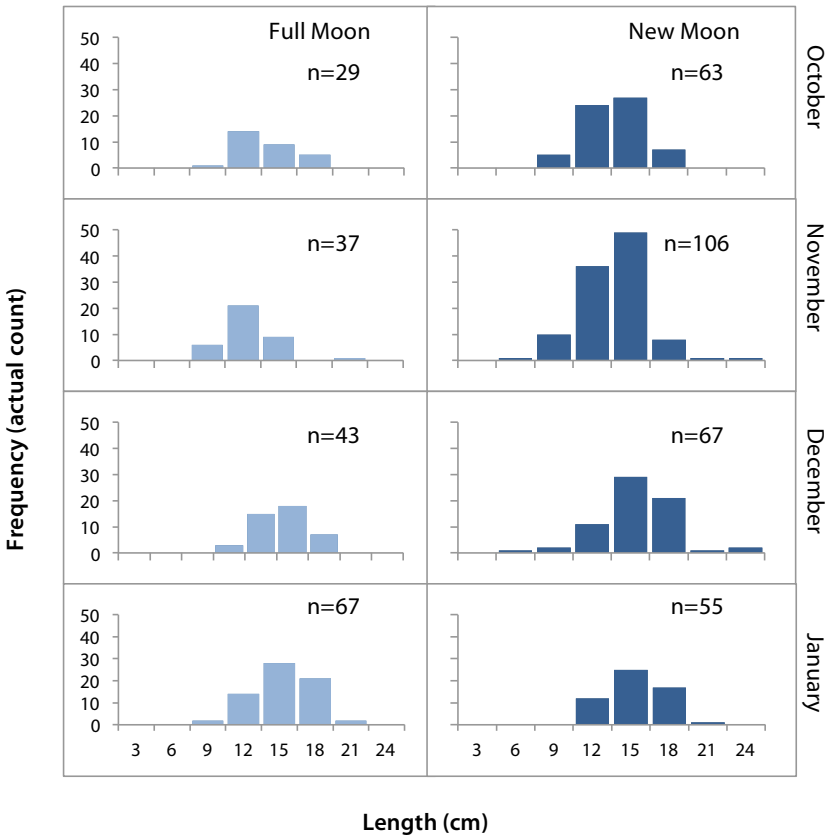

Figure 4. Length-frequency distribution of *Holothuria scabra* in Sitio S'nalang from October 2014 to January 2015 during full and new moon phases.

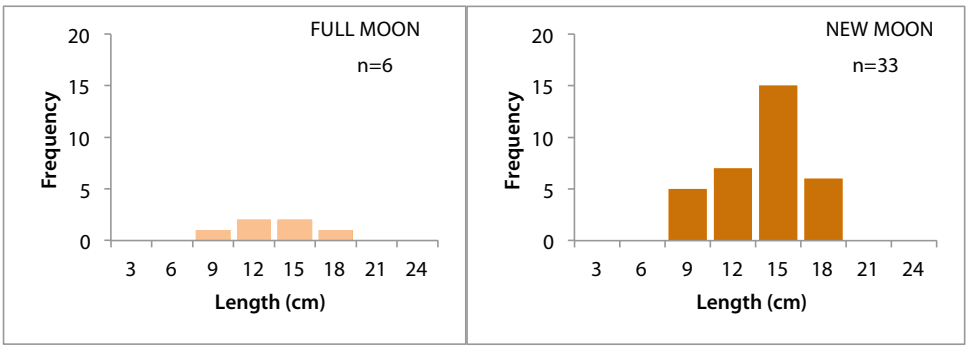

Figure 5. Length-frequency distribution of *Holothuria scabra* in Sitio Macatimbol from October 2014 to January 2015 during full and new moon phases.

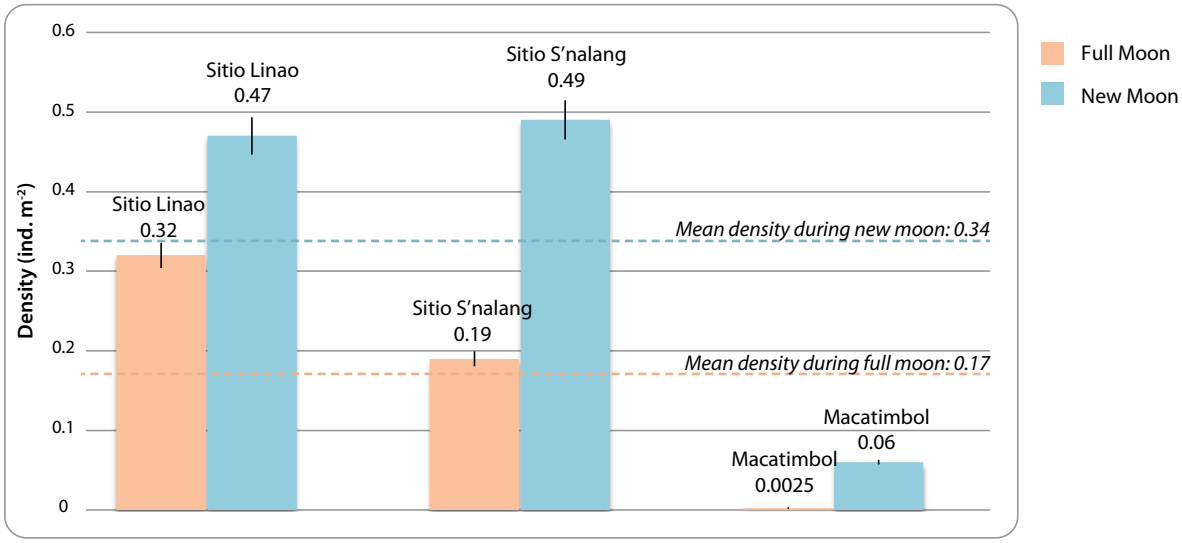

Figure 6. Density of *Holothuria scabra* in the three stations studied in Sarangani Bay from October 2014–January 2015 during full and new moon phases.

(18.10 cm ± 2.030) than males (17.25 cm ± 1.074). Among the specimens for which gender could be assessed, the female–male ratio was 50%–50% during a full moon phase, and 43.2–56.8% during a new moon phase. This is equivalent to an overall sex ratio of 1:1 for both full and new moon phases, as a Chi-square analysis with Yates' correction indicated the change in sex distribution between moon phases was not significant (Chi square = 0.162, p = 0.69).

The density of *H. scabra* was higher during new moon phases (mean: 0.34 ind. m^{-2}) than during full moon phases (mean = 0.17 ind. m^{-2}) all throughout the duration of the study (Fig. 6).

The calculated allometric coefficient (1.84) suggests that *H. scabra* individuals in these areas are leaner for a given length, when compared to other areas.

Discussion

We found that the size distribution of *Holothuria scabra* in all three stations was unimodal, which conforms to the results obtained from most other *H. scabra* population structure studies, such as those done in Dar es Salam (Kithakeni and Ndaro 2002), Gulf of Mannar, Palk Bay (Baskar 1994), Kitoni in Tanzania (Mmbaga 2013), and Al Eigah, Mahout Bay, Oman (Al-Rashdi et al. 2007). Significantly larger individuals were collected during a new moon than during a full moon, which supports the claim of intertidal gleaners in Sarangani Bay that collection is ideal during a new moon because of the abundance of larger sizes.

Lunar phases affected the distribution of individuals possibly due to the drastic changes in tides

for both moon phases. In the study by Mercier et al. (2000), *H. scabra* was shown experimentally to aggregate in pairs, trios, or slightly larger groups before a full moon. The groups formed were larger before a new moon than before a full moon. The behaviour was observed prior to spawning in response to the lunar cycle. This study identified the sex of individuals through their gonads but did not measure the gonad index, which may fail to support the idea of reproductive-related behaviour during the aggregation of *H. scabra* observed during a new moon in this study. However, most specimens found during a new moon were in the 15–18 cm size class, which suggests that most were mature according to Kithakeni and Ndaro (2002), who give a size of 16.8 cm for first maturity. This is supported by this study because the most prevalent color of male gonads was creamy yellow, indicating stage IV of maturation; female gonads were dark orange to orange, also indicating stage IV, or even stage V (spawning) of maturation (Rasolofonirina et al. 2005). In the Philippines, the maturation of *H. scabra* gonads occurs from October to April, which excludes the main spawning events of May to June (Ong Che and Gomez 1985).

The *H. scabra* sex ratio of 1:1 for individuals collected during this study during full and new moon phases is in line with most species of holothuroids (Conand 1989; Hasan 2005; Uthicke 1997). This balanced ratio is important for ensuring the sustenance of local *H. scabra* stocks (Guzman and Guevarra 2002).

The Sitio Linao station had relatively high densities of *H. scabra* during both lunar phases. This is likely due to the area being a bay that is protected from strong waves. This habitat is favourable for *H. scabra* (Conand 1989) because it supports good settlement of detrital particles (Mercier et al. 1999), which are a food source for sea cucumbers. Furthermore, Sitio Linao has a high percentage of organic matter in its sediments at 1.42%, which could also explain the higher density of *H. scabra* because organic matter content is positively correlated with *H. scabra* density (Mmbaga 2013). The study by MacTavish et al. (2012) demonstrated the ability of sea cucumbers to ameliorate some of the adverse effects of organic matter enrichment in coastal ecosystems.

Community members of nearby Tausug collect *H. scabra* during ebb tides when they can forage the intertidal area on foot. This probably enables them to overharvest *H. scabra,* including those that are in pre-spawning stages.

The lowest *H. scabra* density was recorded in Macatimbol (see Fig. 3). According to gleaners, the area was once a rich place of *putian*, the local term for *H. scabra*. The reason for the reduction of stocks here is certainly due to overexploitation. In 2011, *H. scabra* were sold to visiting sea cucumber buyer boats from Davao for USD 6.50 per pail (a local type of bucket), which is a very high price by local standards. This was also observed in the fishing areas of Kunduchi and Magemani (Mmbaga 2013). Wild populations of sea cucumbers are very vulnerable to overfishing, and unregulated exploitation most often results in the demise of the fishery (Hasan 2005; Utchike and Conand 2005). Because reproduction among sea cucumbers requires a minimum number of individuals in a given area to be successful, overexploitation may quickly lead to unsuccessful reproduction (Levitan and Young 1995).

The allometric coefficient calculated for all three stations is 1.85, which is lower than the few published values for *Holothuria scabra* in Vietnam (2.84; Pitt and Duy 2004), New Caledonia (2.28; Conand 1990), and Oman (2.18; Al-Rashdi et al. 2007). The differences in values might be due to different procedural techniques in measuring or could be due to the shallowness of areas being assessed for this present study.

A possible factor that may explain the significantly larger sizes and aggregations of *H. scabra* during a new moon phase is the presence of biologically active chemicals secreted by other adult *H. scabra* in synchrony with the lunar phases. Chemicals can be a means of communication for invertebrates, mostly for purposes of reproduction. In the case of *H. scabra,* Hamel and Mercier (2004) showed that chemicals work synergistically with other factors to induce gonadal development in mature individuals.

Conclusion and recommendations

The present study shows that the size distribution of *Holothuria scabra* is influenced by lunar phases, with larger-sized individuals found during the new moon phase. The abundance of individuals collected was also greater during a new moon. The sex ratio, however, remained constant at 1:1 during new and full moon phases. Further study is recommended on the possible influence of other environmental factors related to lunar cycles on *H. scabra*, such as tides, wave action and light. Because *H. scabra* is a local delicacy, it is also recommended to further study its reproductive biology in order to establish conservation and management measures based on scientifically sound assessments. Precise knowledge of the timing of *H. scabra* spawning events in Sarangani Bay would enable the establishment of prohibitions on collection during the maturation season (or months before spawning) to ensure the healthiness of the stock, thereby positively affecting the recruitment rate in the bay.

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References

Akamine J. 2001. Holothurian exploitation in the Philippines: Continuities and discontinuities. Tropics 10(4):591–607.

Akamine J. 2005. Role of the trepang traders in the depleting resource management: A Philippine case. In: Kishigami N. and Savelle J.M. Indigenous use and management of marine resources. Senri Ethnological Studies 67:259–278.

Al-Rashdi K.M., Claereboudt M.R. and Al-Busaidi S.S. 2007. Density and size distribution of the sea cucumber, *Holothuria scabra* (Jaeger, 1935), at six exploited sites in Mahout Bay, Sultanate of Oman. Agricultural and Marine Sciences 12:43–51.

Baskar B.K. 1994. Some observations of the biology of the holothurian *Holothuria (Metriatyla) scabra* (Jaeger). Bulletin of the Central Marine Fisheries Research Institute 46:49–43.

Bruckner A.W., Johnson K.A. and Field J.D. 2003. Conservation strategies for sea cucumbers: Can a CITES Appendix II listing promote sustainable international trade? SPC Beche–de–Mer Information Bulletin 18:24–33.

Conand C. 1989. Les holothuries aspidochirotes du lagon de Nouvelle Calédonie: Biologie, écologie et exploitation. Paris: ORSTOM. 393 p.

Conand C. 1990. The fishery resources of Pacific island countries. Part 2: Holothurians. FAO Fisheries Technical Paper 272.2. Rome: FAO. 143 p.

Guzman H.M. and Guevarra C.A. 2002. Population structure, distribution, and abundance of three commercial species of sea cucumber (Echinodermata) in Panama. Caribbean Journal of Science 38(3–4):230–238.

Hamel J.F. and Mercier A. 2004. Synchronous gamete maturation and reliable spawning induction methods in holothurians. Workshop on Advances in Sea Cucumber Aquaculture Management, Dalian, China, 14–18 Oct 2003.

Hasan M.H. 2005. Destruction of a *Holothuria scabra* population by overfishing at Abu Rhamada Island in the Red Sea. Marine Environmental Research 60:499–511.

Kithakeni T. and Ndaro S.G.M. 2002. Some aspects of sea cucumber along the Coast of Dar es Salaam. Western Indian Ocean Journal of Marine Science 1(2):163–168.

Levitan, D.R. and C.M. Young. 1995. Reproductive success in large populations: Empirical measurements and theoretical predictions of fertilization in the sea biscuit *Clypeaster rosaceus*. Journal of Experimental Marine Biology and Ecology 190: 221–241.

MacTavish T., Stenton-Dozey J., Vopel K. and Savage C. 2012. Deposit-feeding sea cucumbers enhance mineralization and nutrient cycling in organically-enriched coastal sediments. PloSONE7(11): e50031. doi:10.1371/journal.pone.0050031

Mercier A., Battaglene S.C. and Hamel J.-F. 1999. Daily burrowing cycle and feeding activity of juvenile sea cucumbers *Holothuria scabra* in response to environmental factors. SPC Beche-de-Mer Information Bulletin 12:29.

Mercier A., Battaglene S.C. and Hamel J-F. 2000. Periodic movement, recruitment and size related distribution of sea cucumbers *Holothuria scabra* in the Solomon Islands. Hydrobiologia 440:81–100.

Mmbaga T.K. 2013. The effect of fishing on the ecology of sea cucumbers (Holothuroidea: Echinodermata) *Holothuria scabra* and *Holothuria nobilis* in Tanzanian sea water. International Journal of Development and Sustainability 2(2):1099–1126.

Ong Che R.G. and Gomez E.D. 1985. Reproductive periodicity of *Holothuria scabra*, Jaeger at Calatagan, Batangas, Philippines. Asian Marine Biology 2:21–30.

Pitt R. and Duy N.D.Q. 2004. Length-weight relationship for sandfish, *Holothuria scabra*. SPC Beche-de-Mer Information Bulletin 19:39–40.

Purcell S.W., Samyn Y. and Conand C. 2012. Commercially important sea cucumbers of the world. FAO Species Catalogue for Fishery Purposes. No. 6. Rome, FAO. 150 p. + 30 colour plates.

Rasolofonirina R., Vaitilingon D., Eeckhaut I. and Jangoux M. 2005. Reproductive cycle of edible echinoderms from the South-Western Indian Ocean, II: The sandfish *Holothuria scabra* (Jaeger, 1833). Western Indian Ocean Journal of Marine Science 4(1):61–75.

Uthicke S. 1997. The seasonality of asexual reproduction in *Holothuria (Halodeima) atra*, *Holothuria (Halodeima) edulis* and *Stichopus chloronotus* (Holothuroidea: Aspidochirotida) on the Great Barrier Reef. Marine Biology 129:435–441.

Uthicke S. and Conand C. 2005. Local examples of beche–de–mer overfishing: An initial summary and request for information. SPC Beche-de-Mer Information Bulletin 21:9–14.