Severely overfished sea cucumbers in the Autonomous Region of Bougainville

Richard Hamilton[1] and Paul Lokani[2]

Abstract

In this paper we compare changes in populations of sea cucumbers that were surveyed on reef flats around Buka Island, in the Autonomous Region of Bougainville (ARB) in 1992 and 2008. Over this 16-year period, the abundances of eight species of sea cucumber declined dramatically. By 2008, six of the eight species sighted in 1992 and 2008 — *Actinopyga echinites*, *A. miliaris*, *Bohadschia similis*, *Holothuria atra*, *H. coluber* and *H. scabra* — had declined to between 1% and 5% of their 1992 abundances, providing quantitative evidence that the sea cucumber fishery in the ARB is severely overfished. In 1992, *H. scabra*, *H. atra* and *B. similis* constituted 92% of the sea cucumbers sighted on reef flats. These species were also the three most abundant sea cucumbers in the 2008 survey, comprising 62% of all sea cucumbers seen. Relatively high abundances of *Actinopyga mauritiana* and *Bohadschia vitiensis* were also sighted in 2008, species that were not encountered in the 1992 survey. Our findings provide support for the national moratorium that was placed on the sea cucumber fishery in Papua New Guinea in 2009, and we anticipate that many years of complete closure will be required before stocks in the ARB recover to 1992 levels.

Introduction

Sea cucumbers, or their dried form (beche-de-mer), are either eaten or used for medicinal purposes, and they have been a highly sought-after commodity in Asia for centuries (Toral-Granda et al. 2008). In the Pacific, most commercially valuable sea cucumbers occupy shallow clear seas, making the harvesting of these sessile and often conspicuous animals a relatively simple procedure. The combination of high value plus ease of capture has meant that many sea cucumber stocks around the world are now heavily overfished (Toral-Granda et al. 2008; Friedman et al. 2010). In Melanesia, sea cucumbers provide a very important source of income to rural coastal communities, being one of the few commodities that can be captured, processed locally, and then stored for extended periods of time (Kinch et al. 2008a).

In shallow habitats, sea cucumbers are typically gleaned from reef flats and the reef crest on a low tide; in deeper areas, free divers use masks and fins to pick up sea cucumbers. In water that is too deep to easily access (typically below 20 m), free divers often use "bombs" — a small harpoon or series of straitened hooks inserted into a lead weight — to harpoon sea cucumbers that are beyond their reach. In Melanesia, the sea cucumber fishery is a multispecies fishery. In Papua New Guinea (PNG) for example, at least 26 species of sea cucumbers are harvested (Kinch et al. 2008b). Like other regions in the western Pacific, many sea cucumber fisheries in Melanesia have exhibited boom and bust cycles. Initially, sea cucumber fisheries target only one or two high value species, but once these stocks are over fished the fishery typically shifts its focus to lower value species (e.g. Lokani 1990; Lokani et al. 1996). Stocks of high value species are often quickly depleted, as evidenced by a case study on the Carteret Islands that are northeast of Bougainville Island. In 1982, a beche-de-mer fishery targeting white and black teatfish (*Holothuria fuscogilva* and *H. whitmaei*) harvested approximately 10 t of sea cucumber from the Carteret Islands, but by 1983, total production had fallen to just over 2,000 kg and large, high grade beche-de-mer was virtually eliminated from the fishery (Dalzell 1990).

Although sea cucumber fisheries typically follow boom and bust cycles, today, their high value, a lack of alternative income opportunities, a wide network of beche-de-mer purchasers, and the ease of processing and storing means that artisanal fisheries can continue to place considerable pressure on these fisheries well after stocks have been overexploited (Friedman et al. 2010). Several recent surveys in Melanesia have shown that sea cucumber stocks are widely overfished (e.g. Friedman et al. 2008; PNG National Fisheries Authority 2007; Ramofafia 2004; Ramohia 2006).

1. The Nature Conservancy, Indo-Pacific Resource Centre, 51 Edmondstone Street, South Brisbane, QLD 4101, Australia. Email: rhamilton@tnc.org
2. The Nature Conservancy, Papua New Guinea Office, Suite 7, Monian Haus, Nita Street, Tabari Place, Boroko. Email: plokani@tnc.org

For many locations, however, a lack of historical scientific data (Friedman et al. 2010), coupled with a shifting baseline syndrome — long-term and usually negative changes that are often not immediately or readily apparent to new generations of fishers or scientists working in a data-poor area (Pauly 1995) — make it difficult for many managers to comprehend the scale of changes that have occurred in sea cucumber fisheries in recent decades.

In this paper we present data on the abundances of sea cucumbers on reef flats around Buka Island, ARB in 1992 and 2008. The scale of decline is dramatic, and provides a quantitative example of the magnitude of change that has occurred in this artisanal fishery over a 16-year time frame. It is hoped that this information will provide support for the national moratorium currently placed on all PNG sea cucumber fisheries, as well as providing ARB fisheries managers with targets to aim for (i.e. 1992 levels) when rebuilding their sea cucumber fishery.

Methods

In 1992, one of the authors on this paper (PL) surveyed sea cucumber abundances on three reef flat sites located on outer reefs on the western side of Buka Island (Lokani, unpublished data 1992). In 2008, we resurveyed sea cucumber abundances at nine reef flat sites within the same region (Fig. 1).

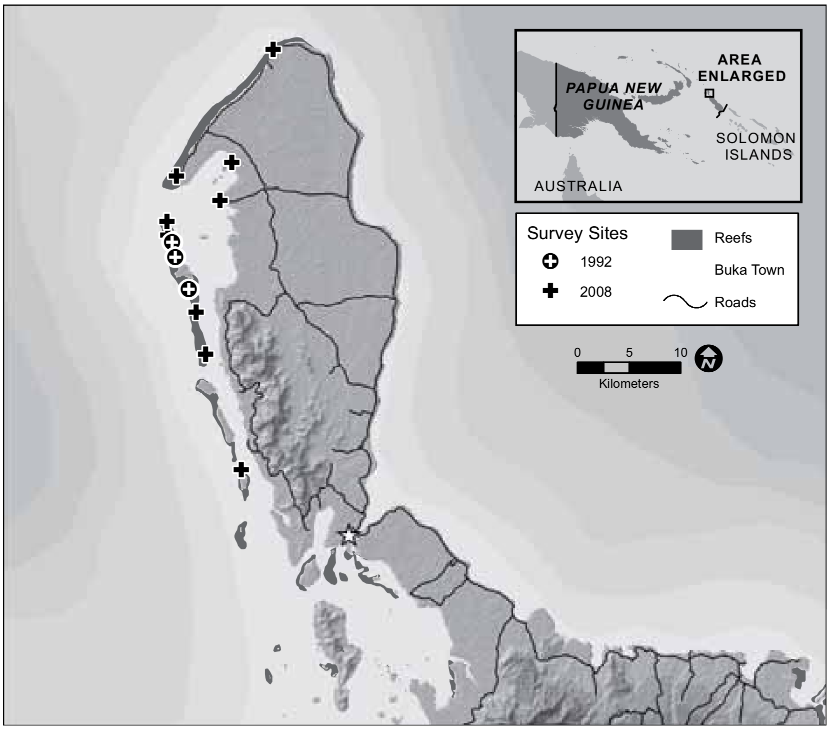

Figure 1. Locations of reef flat sites surveyed in 1992 and 2008 around the western side of Buka Island, Autonomous Region of Bougainville.

These nine sites were resurveyed as part of a larger marine assessment investigating the status of sea cucumbers, reef fishes and coral cover in the northern region of the ARB (Hamilton et al. 2010). In 1992, four 600 m^2 transects were sampled at each site. In 2008, ten 400 m^2 transects were sampled at each site. Both surveys were done on foot and transect lengths were measured by laying down a 50-m measuring tape across the reef flat prior to conducting the survey. Transect width was measured by pulling an 8-metre-long rope between two observers, with observers keeping the midpoint of the rope on the 50-m transect line. In each pass of a transect, the number of individual sea cucumber species was recorded onto underwater paper. Sea cucumber abundance estimates per transect were converted to the number of individuals per hectare (ind. ha^{-1}), and the mean abundances by species and year were graphed in SigmaPlot. Mann-Whitney Rank Sum Tests were used to compare differences in the mean abundances of sea cucumbers sighted in 1992 and 2008 because the data failed the assumption of normality.

Results

Species composition

In 1992, 3109 sea cucumbers representing eight commercial species (*Actinopyga echinites*, *A. miliaris*, *Bohadschia argus*, *B. similis*, *Holothuria atra*, *H. coluber*, *H. scabra*, *Stichopus herrmanni*) were counted on 12 transects. In 2008, 740 sea cucumbers representing 11 commercial species (*A. echinites*, *A. mauritiana*, *A. miliaris*, *B. argus*, *B. similis*, *B. vitiensis*, *H. atra*, *H. coluber*, *H. whitmaei*, *H. scabra*, *S. herrmanni*) were counted on 90 transects. The relative abundance of each sea cucumber species recorded on reef flats in 1992 and 2008 is shown in Table 1. In both surveys the three most abundant species were *H. atra*, *H scabra*, and *B. similis*. In 1992, these three species made up 92% of the sea cucumbers seen, while in 2008, this trio made up 62% of all sea cucumbers seen. In 2008, *A. mauritiana* and *B. vitiensis* comprised 31% of the sea cucumbers sighted; these species were not recorded in the 1992 survey.

Table 1. Relative abundance of each sea cucumber species recorded on reef flats in 1992 and 2008. Note: Common names follow those used by the Secretariat of the Pacific Community (2003).

Scientific name	Common name	1992 relative abundance	2008 relative abundance
Holothuria scabra	Sandfish	39.96%	21.08%
Bohadschia similis	Chalkfish	32.28%	21.08%
Holothuria atra	Lollyfish	20.35%	19.46%
Actinopyga echinites	Deep-water redfish	5.24%	0.95%
Actinopyga miliaris	Blackfish	1.02%	1.08%
Holothuria coluber	Snakefish	0.96%	0.54%
Stichopus herrmanni	Curryfish	0.16%	0.68%
Bohadschia argus	Tigerfish	0.03%	0.27%
Actinopyga mauritiana	Surf redfish	0	18.38%
Bohadschia vitiensis	Brown sandfish	0	13.24%
Holothuria whitmaei	Black teatfish	0	3.24%
Total:		**100%**	**100%**

Table 2. Mean abundance of sea cucumber species on the reef flats in 1992 and 2008. The percentage of each species still remaining on reef flats in 2008 is also shown.

Species	1992 (ind. ha^{-1})	2008 (ind. ha^{-1})	Percentage remaining since 1992	Difference significant?
Holothuria scabra	1879.51	48.33	3%	Yes (P < 0.001)
Bohadschia similis	1392.36	43.83	3%	Yes (P < 0.001)
Holothuria atra	877.78	40.00	5%	Yes (P = 0.004)
Actinopyga echinites	226.00	1.95	1%	Yes (P < 0.001)
Actinopyga miliaris	44.10	2.22	5%	No (P = 0.069)
Holothuria coluber	41.32	1.11	3%	Yes (P < 0.001)
Stichopus herrmanni	6.94	1.39	20%	Yes (P = 0.002)
Bohadschia argus	1.39	0.55	40%	No (P = 0.220)

Abundance

By 2008, the densities of the three most commonly sighted sea cumbers (*H. atra*, *H scabra*, *B similis*) were only a fraction of their former 1992 abundances (Fig. 2).

Of the eight species sighted on reef flats in both the 1992 and 2008 surveys, all declined to 1–40% of their former abundance. By 2008, six of the eight species that were sighted in both surveys showed reductions in abundance of 95% to 99% of 1992 levels. For most of these species, these declines were statistically significant (Table 2).

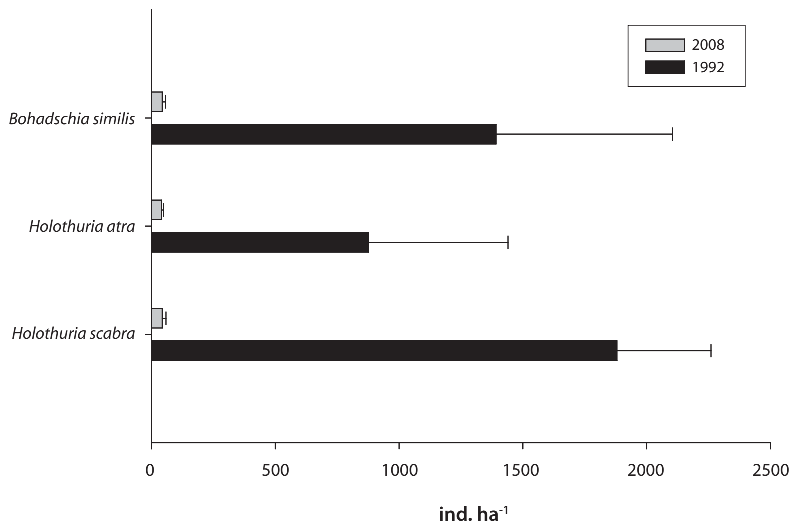

Figure 2. Mean abundance (ind. ha^{-1}) of the three sea cucumber species that were most commonly sighted on reef flats in 1992 (n=12) and 2008 (n=90).

Discussion

A comparison of 1992 and 2008 data provides compelling quantitative evidence that sea cucumber populations around Buka Island have been severely overfished. All species recorded on reef flats in both the 1992 and 2008 surveys showed major reductions in abundance over this 16-year period. These changes were typically extreme, with six of the eight species declining to between 1% and 5% of 1992 levels. While we only have historical data for a small spatial area, it seems highly probable that the declines seen on the reef flats in the Buka region are indicative of the fishery throughout ARB. In the much more intensive 2008 survey, we sampled 80 sites from five habitats (reef flat, reef crest, shallow reef slope, deep reef slope and lagoon) around the northern ARB, and at virtually all sites sea cucumbers were present in low to very low abundances (Hamilton et al. 2010). Several decades previously all of these habitats in the northern ARB had supported large abundances of sea cucumbers (Paul Lokani, pers. observ.). It is possible that declines in other habitats may be even more extreme than what occurred on reef flats. A comparison of sea cucumber densities in 1992 and 2006 in New Ireland Province showed that sea cucumber densities in reef flat environments declined less than in other habitats such as lagoons (PNG National Fisheries Authority 2007).

The only site in the 2008 survey that had a high abundance of sea cucumbers was a single reef crest site in the Tinputs region, which had high densities of *H. atra*. This site had been closed to fishing by the community for several years. The much higher-than-average densities of *H. atra* at this site provide evidence for the positive impact that protection can have for this species (Hamilton et al. 2010). In a recent survey of sea cucumbers in PNG's New Ireland Province, sea cucumber densities in two customary protected "control' sites were compared with densities from 40 other sites around New Ireland that are open to fishing. Similar to this study, the New Ireland survey revealed that at one of the two "control" sites *H. atra* (but not other species) were in far greater abundances on inter tidal habitats than at surrounding sites that were open to fishing (PNG National Fisheries Authority 2007).

Traditionally, many regions in Bougainville placed *tambus* on reefs in order to allow stocks to recover (Lokani 1995). Encouraging the reestablishment of such practices would be one way of managing sea cucumbers at the community level. The current moratorium that was placed on PNG's sea cucumber fishery in 2009 should also allow stocks the chance to recover. However a cautionary note is that even long-term closures have had mixed success at rebuilding overfished sea cucumber fisheries in the western Pacific (Friedman et al. 2010). Maintaining the current moratorium and conducting follow-up surveys in the future before a decision is made to re-open the sea cucumber fishery in the ARB is clearly desirable.

The 2008 survey recorded three sea cucumber species (*A. mauritiana, B. vitiensis* and *H. whitmaei*) that were not recorded in the 1992 survey. Of these three species *A. mauritiana* and *B. vitiensis* were relatively dominant, comprising 31% of all sea cucumbers sighted. Finding higher species diversity on overfished reefs is not what one expects. However, in this instance, it appears to relate in part to patchy distributions of these species and the fact that the 2008 survey covered a larger area than the 1992 survey. A close examination of the 2008 data reveals that nearly all *A. mauritiana* recorded were sighted at two sites just north of the sites surveyed in 1992. These two sites are on a narrow reef flat, and transects placed here intersected the surf zone. This was not the case for the three 1992 sites, which were on wider reef flats. This explains the relative dominance of *A. mauritiana* in the 2008 surveys, because this species is typically found in the surf zone. The higher abundances of *B. vitiensis* are more difficult to explain because this species occupies a similar habitat to *B. similis*, and *B. similis* was dominant in both the 1992 and 2008 surveys. It may be that B. vitiensis has reversed the general trend and shown a real increase in abundance over the 16-year period.

Acknowledgements

The 2008 marine resource survey of northern ARB was made possible because of the support of communities, the Autonomous Bougainville Government, the Papua New Guinea National Fisheries Authority and The Nature Conservancy. We thank Barbara Makise and Jinro Boisen for assisting with community liaison work prior to the 2008 survey. We also thank the other members of the 2008 survey team: Tapas Potuku, Freda Paiva, Joseph Aitsi, Catherine Siota, Francis Taniveke, Michael Giningele, Litau Pomat, Kilangis Komet, Miriam Giru, Kevin Anana and Ian Laviko. We also thank Nate Peterson from the TNC Brisbane office for producing Figure 1. Finally, we thank Kim Friedman for making improvements to an earlier version of this manuscript.

References

Dalzell P. 1990. Beche-de-mer production from three Papua New Guinean atolls between 1982 and 1983. SPC Beche-de-mer Information Bulletin: 1:6–7.

Friedman K., Kronen M., Pinca S., Magron F., Boblin P., Pakoa K., Awira R. and Chapman L. 2008. Papua New Guinea country report: Profiles and results from survey work at Andra, Tsoilaunung, Sideia and Panapompom (June to November 2006). Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C/CoFish). Noumea, New Caledonia: Secretariat of the Pacific Community (SPC). 471 p.

Friedman K., Eriksson H., Tardy E. and Pakoa K. 2010. Management of sea cucumber stocks: Patterns of vulnerability and recovery of sea cucumber stocks impacted by fishing. Fish and Fisheries. DOI: 10.1111/j.1467-2979.2010.00384.x

Hamilton R., Paiva F., Aitsi J., Potuku P., Siota C. and Lokani P. 2010. Northern Bougainville Marine Resource Assessment, Autonomous Region of Bougainville. Technical report of survey conducted from the 1st- 25th November 2008. A report by the Marine Program of the Asia Pacific Conservation Region, The Nature Conservancy. 2/10.

Kinch J., Purcell S., Uthicke S. and Friedman K. 2008a. Population status, fisheries and trade of sea cucumbers in the Western Central Pacific. p. 7–55. In: Toral-Granda V., Lovatelli A. and Vasconcellos M. Sea cucumbers. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. Rome, FAO.

Kinch J., Purcell S., Uthicke S. and Friedman K. 2008b. Papua New Guinea: A hotspot of sea cucumber fisheries in the western Central Pacific. p. 57–77. In: Toral-Granda V., Lovatelli A. and Vasconcellos M. Sea cucumbers. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. Rome, FAO.

Lokani P. 1990. Beche-de-mer research and development in Papua New Guinea. SPC Beche-de-mer Information Bulletin 2:8–11.

Lokani P. 1995. An oral account of overfishing and habitat destruction at Pororan Island, Papua New Guinea. Joint FFA/SPC workshop on the management of South Pacific inshore fisheries, Noumea, New Caledonia, 26 June – 7 July 1995. 12 p.

Lokani P., Polon P. and Lari R. 1996. Management of beche-de-mer fisheries in the Western Province of Papua New Guinea. SPC Beche-de-mer Information Bulletin 8:7–11.

Pauly D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution 10(10):430.

PNG National Fisheries Authority 2007. Sea cucumber survey, New Ireland Province. Kaveing, National Fisheries Authority and the Coastal Fisheries Management and Development Project.

Ramofafia C. 2004. The sea cucumber fisheries in Solomon Islands: Benefits and importance to coastal communities. WorldFish Center, Nusa Tupe Field Station.

Ramohia P. 2006. Fisheries resources: Commercially important macroinvertebrates. In: Green A., Lokani P., Atu W., Ramohia P., Thomas P. and Almany J. (eds). 2006. Solomon Islands Marine Assessment: Technical report of survey conducted May 13 to June 17, 2004. TNC Pacific Island Countries Report No 1/06.

Secretariat of the Pacific Community 2003. Papua New Guinea sea cucumber and beche-de-mer identification cards. Noumea, SPC.

Toral-Granda V., Lovatelli A. and Vasconcellos M. 2008. Overview. p. 1–4. In: Toral-Granda V., Lovatelli A. and Vasconcellos M. Sea cucumbers. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. Rome, FAO.