Papua New Guinea: a hotspot of sea cucumber fisheries in the Western Central Pacific

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SUMMARY

Papua New Guinea (PNG) is one of the largest countries in the Western Central Pacific region and is now the third largest producer of bêche-de-mer in the world, supplying around 10 percent of the global market.

Species of commercial importance recognized by the National Fisheries Authority (NFA) include *Actinopyga echinites, A. lecanora, A. mauritiana, A. miliaris, Bohadschia argus, B. similis, B. vitiensis, Holothuria atra, H. coluber, H. edulis, H. fuscogilva, H. fuscopunctata, H. scabra, H. scabra* var. *versicolor, H. whitmaei, Pearsonothuria graeffei, Stichopus chloronotus, S. herrmanni, S. horrens, Thelenota ananas* and *T. anax.* Other species that are occasionally taken include *A. caerulea, H. leucospilota, S. pseudohorrens, S. vastus* and *T. rubralineata.*

Sea cucumbers are not a common "traditional" food in PNG, hence almost all are exported. They are mainly harvested by hand by free divers, or with spears and lead bombs in deeper water. Night fishing with torches and underwater breathing devices are used now despite their prohibition.

Management of the sea cucumber fishery in PNG was recognized as necessary after catches declined from the fishery's inception in the nineteenth century. Today, the NFA is responsible for the conservation and management of PNG's sea cucumber fishery. It has gazetted the *National Bêche-de-mer Management Plan* in 2001, which aims to maximize the long-term economic benefits from the fishery while ensuring resource and environmental sustainability.

Despite the national management plan, PNG still faces difficulties in enforcement and compliance. The two most continual infringements reported to the NFA involve the illegal buying of bêche-de-mer and seizure in urban centres. There are also occasional discrepancies between export figures and the import figures from Asian markets.

Factors that contribute to management problems include the remoteness of fishers and the limited human and financial resources of provincial fisheries offices. Moreover, export volumes continue to rise as fishers are collecting large quantities of low-value species. There is growing awareness by fishers that sea cucumbers are no longer abundant. Past stock assessments have been largely independent of each other and used differing methodologies and scales, making it difficult to see changes in abundance over time.

Perhaps CITES listing of some sea cucumber species in PNG could help management. However, implementation issues would need to be considered; for example, NFA's policy objectives, administrative capacity, adequate financing and regulatory ability. CITES listings could contribute to enhanced opportunities for technical assistance from regional agencies and promote increased partnerships with importing countries. It could also provide a mechanism for comprehensive and standardized trade and quota reporting. Arguably, the declines in abundances of *H. scabra* and *H. whitmaei* could qualify them for CITES listing.

Recent studies among several Provinces revealed a high economic reliance on sea cucumbers fishing; 12–75 percent of surveyed households gained some or most of their income from this fishery. Fishers currently receive around 65 percent of the export price across all species at the point of sale. Undoubtedly, a collapse of the sea cucumber fishery would have dire social and economic consequences for village-based fishers in PNG. Of all of PNG's existing fisheries, the sea cucumber fishery is one in which good management, appropriate regulation and enforcement could continue to deliver economic benefits, particularly at the rural level.

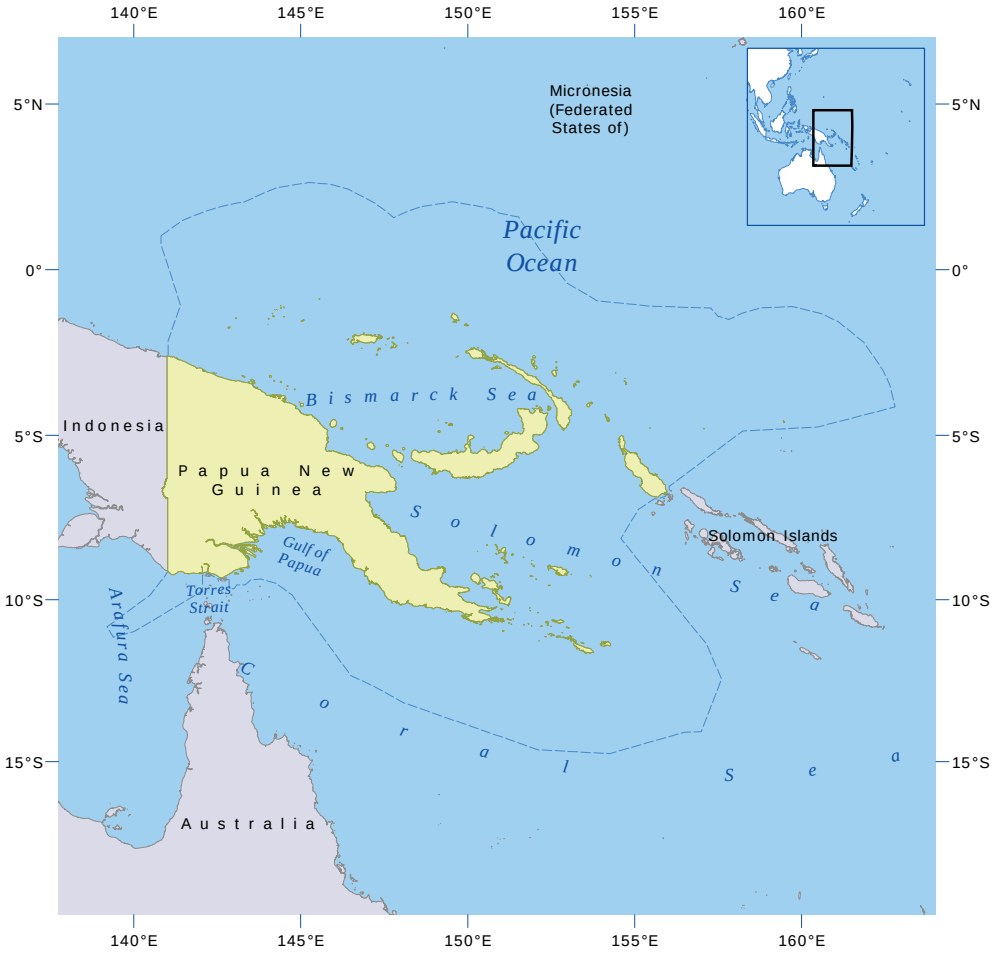
1. INTRODUCTION

Papua New Guinea (hereinafter referred to as PNG) is the largest country in the Western Central Pacific region and occupies the eastern half of the island of New Guinea, the largest equatorial island in the world (Figure 1). The country includes the islands of New Britain, New Ireland, Bougainville and Manus, and thousands of smaller islands. PNG has a total coastline of approximately 17 110 km, and its coral reefs are among the most diverse in the world. Although all reef types are represented, most are fringing and/or barrier reefs, with an estimated area of 40 000 km².

Papua New Guinea is now the third largest producer of sea cucumbers supplying the China Hong Kong Special Administration Region (SAR) and other Asian markets (Conand, 2004; Kinch, 2004), accounting for roughly 10 percent of all bêche-de-mer entering the global market.

Note: To be consistent with the terminology for this fishery, "holothurians" or "sea cucumbers" are used throughout this report when referring to live animals and "bêche-de-mer" is used when referring to the dead animal when processed for commercial purposes. Where older taxonomic classifications have been used in referenced texts or in information provided by colleagues, these have been changed to their new taxonomic determinations.

FIGURE 1
Location of PNG in relation to the Western Central Pacific region



2. BIOLOGICAL AND POPULATION STATUS

2.1 Current species in trade

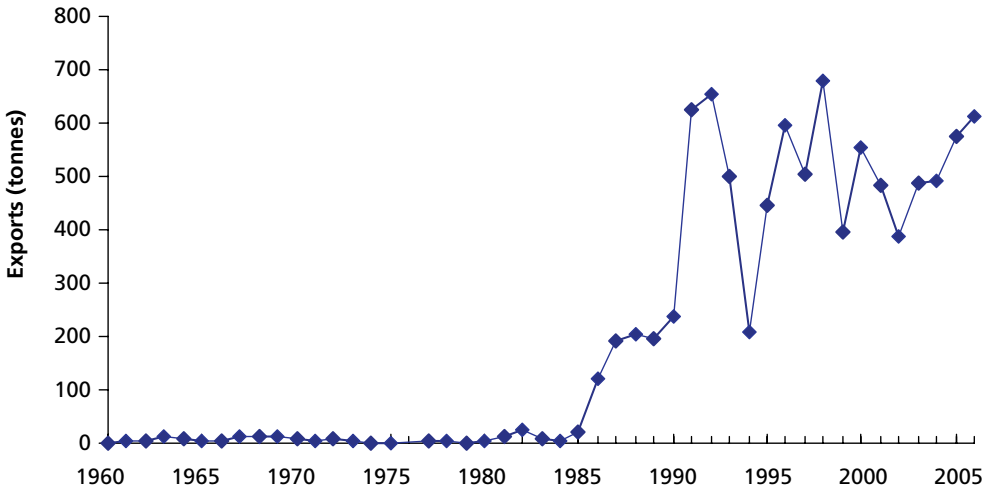
There are 26 currently known species of sea cucumbers harvested from PNG waters, with most being low-value species. The main species recognized by the PNG National Fisheries Authority (NFA) as having commercial importance include: *Actinopyga echinites, A. lecanora, A. mauritiana, A. miliaris, Bohadschia argus, B. similis, B. vitiensis, Holothuria atra, H. coluber, H. edulis, H. fuscogilva, H. fuscopunctata, H. scabra, H. scabra* var. *versicolor, H. whitmaei, Pearsonothuria graeffei, Stichopus chloronotus, S. herrmanni, S. horrens, Thelonata ananas* and *T. anax.* Other species that are known to be taken include *Actinopyga caerulea, H. leucospilota, S. pseudohorrens, S. vastus* and *T. rubralineata.*

The actual number of species in trade is difficult to determine accurately due to mis-identifications by both fishers and companies and because some companies use their own trade names. During a recent assessment of purchasing data provided by the NFA, a total of 53 commercial names were reported in use by companies in PNG, of which 13 had not yet been accredited to known species (Kinch *et al.*, 2007).

2.2 Population status

Population surveys have been conducted in several provinces of PNG, Central (Shelley, 1981), East New Britain (Gisawa, 2002), Madang (Massin and Doumen, 1986; Lokani,

FIGURE 2
Bêche-de-mer exports from Papua New Guinea, 1960–2006



Mobiha and Wafy, 1992), Manus (Lokani and Chapau, 2002), Milne Bay (Skewes *et al.*, 2002), New Ireland (Lokani, 1996; NFA, 2007), Western (Mobiha *et al.,* 1993; Lokani, 2000) and West New Britain (Lokani, 1991). Most of these stock assessments have been one-off assessments in some cases conducted over limited areas, thus making comparisons difficult (see Appendix A). However, a recent survey conducted by the NFA (2007) in the New Ireland Province has shown marked depletion of some sea cucumber species when compared against density levels recorded by an earlier survey in 1992 (Lokani, 1996). The Secretariat of the Pacific Community's Pacific Regional Oceanic and Coastal Development Project Coastal Component (SPC-PROCFish/C) has also conducted recent assessments in the Manus, New Ireland and Milne Bay Provinces.

2.3 Catches

Sea cucumbers are harvested in PNG by hand-collection and free-diving. In deeper water, fisher will dive down and spear them or use the lead bomb (a small harpoon embedded in a lead weight) (Kinch, 2002, 2004). Once arriving at a potential site and sea cucumbers have been located, fishers (including women) will enter the water. If the water is shallow enough, fishers will collect sea cucumbers by wading on the reef. In deeper water, fishers will dive down and spear them or use lead bombs. The use of lights is a common practice and hookah and SCUBA gear has been used in recent years, even though these have been officially banned for numerous years.

Sea cucumber production or catch data is not currently available, and subsequently export data has been used as a determinant of production (Figure 2; Appendix B). Harvesting of sea cucumbers for bêche-de-mer increased dramatically in 1986.

All exports from PNG are as dried bêche-de-mer from capture fisheries. Sea cucumbers do not appear to be a major item on either traditional or modern menus of most PNG communities. However, there are some exceptions. Lokani (1990) notes that some *Actinopyga* species are consumed in West New Britain and some areas in Manus use the toxins of *H. atra* to fish for octopus. In the Milne Bay Province, Trobriand Islanders are also known to consume *H. scabra* (Lindholm, 1978). *Holothuria scabra* is also consumed in the Western Province (Kinch, 2004; Kinch *et al.*, 2007).

2.4 Management of the fishery

The need for the management of the sea cucumber fishery in PNG was recognized from its inception in the nineteenth century due to declining catches. In 1881, a closed season was attempted by the colonial government, but failed to stop illegal harvesting.

In the early twentieth Century attempts were made to manage the sea cucumber fishery under the 1911–1934 *Pearl, Pearl Shell and Bêche-de-mer Ordinance*, which prohibited the harvesting of sea cucumbers between the high water mark and a line drawn parallel to and 800 m distant from the high water mark (Hyndman, 1993; Kinch, 2002, 2004; Kinch *et al.,* 2007; Tom'tavala, 1990, 1992).

In 1992, a *Prohibition of Taking Sedentary Resources* was gazetted under the *Continental Shelf (Living Natural Resources) Act.* Under this gazettal notice, the forerunner of present management strategies was outlined. These included minimum legal dry size limits, prohibitions on the use of hookah and SCUBA, lights at night and ships used in the harvesting of sea cucumbers.

Today, the NFA is responsible for the conservation, management, development and sustainable use of PNG's fisheries under the 1998 *Fisheries Management Act*. The NFA has gazetted the 2001 *National Bêche-de-mer Management Plan* for regulation and management of the sea cucumber fishery (Polon, 2004). Its aim is to ensure that PNG and its people obtain the maximum economic benefit from the fishery, and that fishing is sustainable and has a minimal impact on the marine and coastal environment (Table 1). The *National Bêche-de-mer Management Plan* now over-rides all previous *Provincial Bêche-de-mer Fisheries Management Plans*. Provinces that had management plans previously include Milne Bay (1998), Western Province and Torres Strait (1995), Manus (1997) and New Ireland (2000). The NFA re-emphasized the prohibition on taking sedentary resources at night with the use of lights, and by hookah and SCUBA.

Monitoring and enforcement costs for the sea cucumber fishery in PNG have steadily increased, causing concern for the NFA (Kinch, 2004; Kinch *et al.,* 2007). The two most continual infringements reported to the NFA involve the illegal buying of bêche-de-mer and seizure in urban centres (Kinch *et al.,* 2007) (Table 2). Villagers continue to dive at night and during the closed season, and there has been reported use of hookah and SCUBA (Kinch, 2002; 2004, Kinch *et al.,* 2007).

TABLE 1
Management strategies detailed in the National Bêche-de-mer Management Plan

Permits	Harvest season	Gear type	Total allowable catch (TAC)	Size limits
PNG citizens only Licence for storing or export Reporting requirements attached to licenses	Open season from 16 January to 30 September	Hookah, SCUBA and lights prohibited	TAC for each Province TAC divided into two value groups (high and low)	Minimum legal sizes for most live and dried species

TABLE 2
Notification of infringements to the National Fisheries Authority, 2001–2005

Activity	2001	2002	2003	2004	2005	Total	% of total
Buying of bêche-de-mer		3	3	3	2	11	14.5
Buying undersize		1			1	2	2.6
Foreign involvement				3		3	3.9
Harvesting bêche-de-mer from vessel					1	1	1.3
Harvesting bêche-de-mer in closed season					1	1	1.3
Illegal export by air		1				1	1.3
Illegal shipment of bêche-de-mer to Alotau			1			1	1.3
Illegal shipment of bêche-de-mer to Port Moresby	1	10	11	3		25	32.9
Illegal shipment to West Papua		1				1	1.3
Illegal storage of bêche-de-mer	1	8	6	5	2	22	28.9
Operating outside of home province		1	1			2	2.6
Poaching in Australian waters				1		1	1.3
Use of other export license			1			1	1.3
Use of underwater breathing devices		1	2	1		4	5.2
Total	**2**	**26**	**25**	**16**	**7**	**76**	**100.0**

Although not reflected in the infringement data, poaching by fishers in the Western Province is also of concern for Australian authorities. Villagers from the Western Province regularly move to the Torres Strait Islands for trading and social reasons, and have traditionally claimed fishing rights as far south as the southern end of the Warrior Reef complex which is situated in Australian waters (Kinch *et al.,* 2007).

When the sea cucumber fishery reopened in the Western Province in the early-1990s, Torres Strait Islanders and Australians were not fishing, and harvesting by fishers from the Western Province became prominent on the Warrior Reef complex. During the early 1990s, hundreds of fishers from the Western Province were apprehended in Australian waters, forcing the PNG Government to place a moratorium on fishing. Regular apprehensions are common, and today most fishers time their runs across the border with low tides as this allowed fast collection (Schug, 1995, 1996). The Australian surveillance authority, Coastwatch, sees the Warrior Reef complex as a high risk area, and because incursions/poaching from fishers from the Western Province is ongoing, steps are being undertaken by Australian authorities to improve the effectiveness of future patrol work in the area.

Bêche-de-mer is also moved illegally from the Western Province via Yule Island or Kerema on its way to Port Moresby. Some product is also thought to leave PNG via logging or fishing vessels.

The *National Bêche-de-mer Management Plan* limits the harvest of sea cucumbers and the export of bêche-de-mer. The limits are imposed by setting a Total Allowable Catch (TAC) for each Province (Table 3), intended for a single season. Most TACs in PNG are not based on scientific research. Currently, TACs for some Provinces are set on 70 percent of the total harvestable estimate by dry weight (converted), and from the results of previous stock assessments. For Provinces with no recent stock assessments, the TAC is calculated based on historical catch record.

Sea cucumber species are divided into two groups, high and low value (Table 4). A TAC is set for both groups because the higher value species are more heavily fished than the lower value species. Once the TAC of a value group has been reached, fishing for those species is supposed to stop, though NFA has never enforced a closure by value group. If the allocated TAC for a Province is reached and exceeded by more than 5 tonnes, then the total excess amount should be taken off the next season's TAC. This reduction in TACs has never been enforced by the NFA.

TABLE 3
Papua New Guinea provincial total allowable catches (TACs)

Province	High value (tonnes)	Low value (tonnes)	Total TAC (tonnes)	Previous provincial management plans TACs (tonnes)
Bougainville	20	40	60	
Gulf	(0.5)	(0.5)	(1)	
East New Britain	10	20	30	
East Sepik	7	13	20	
Madang	15	25	40	
Milne Bay	60	80	140	60
Manus	18	32	50	54
Morobe	10	20	30	
NCD and Central	(25)	(55)	(80)	
New Ireland	25	55	80	80
Oro	15	25	40	
West New Britain	20	40	60	
West Sepik	7	13	20	
Western	10	7	17	40
Total	**242.5**	**425.5**	**668**	

Note: Figures in brackets are provisional estimates only. NCD = National Capital District.

TABLE 4
High and low value species and associated live and dry size limits

Low value species	Live length (cm)	Dry length (cm)
Actinoypga echinites	(25)	(15)
Bohadschia similis	(25)	(7)
Holothuria atra	(30)	(15)
H. coluber		
H. edulis	(25)	(10)
H. fuscopuntata	(45)	(15)
Pearsonothuria graeffei		
Thelenota anax	20	10
High value species		
Actinoypga lecanora	15	10
A. mauritiana	(20)	(8)
A. miliaris	15	10
Bohasdchia argus	20	10
B. vitiensis	20	10
Holothuria fuscogilva	35	15
H. nobilis	22	10
H. scabra	22	10
Stichopus chloronotus	20	10
S. herrmanni	25	10
Thelenota ananas	25	15

Note: Figures in brackets are provisional estimates only.

Movement of bêche-de-mer between Provinces without written permission is prohibited in the *National Bêche-de-mer Management Plan*. Where an exporter's nearest port for export is in another province, or is not functional (or economical), the company may apply for written authorization, from the Managing Director of NFA, to use another port for export. The issue of intra-provincial transfers is an area that needs greater attention by the NFA because they are poorly documented and are not accredited back to the Province of origin (Kinch *et al.*, 2007).

Size limits for harvesting and export of sea cucumbers are set by the *National Bêche-de-mer Management Plan* (Table 4). It also prohibits the trade of undersize bêche-de-mer. However, is doubtful if the minimum legal live sizes limits have achieved the desired goal of protecting individual sea cucumbers until they have spawned at least once. High levels of harvesting persist and undersized animals are still fished, as evident by the large number of undersized product recorded in recent studies by the NFA. A further complicating factor, is that the natural adult sizes of animals differ across regions and habitats (due to location, water quality, depth, differences in temperatures, etc.) making current size limits ineffetual or not respected in some locations.

The appropriateness of minimum legal live sizes limits in PNG (or anywhere in the Western Pacific Region for that matter) as a management tool depends on more studies being conducted on the size at first spawning and location-specific growth rates. The size limits also depend on other variables, such as catchability. Skewes *et al.* (2006) suggests a more sensible approach to reviewing the minimum legal live sizes limits of sea cucumbers is to conduct detailed analyses of egg production (e.g. egg-per-recruit analysis). Minimum legal size limits would therefore be prudent to maximize yield-per-recruit in sea cucumber stocks, since it seems they are often affected by recruitment overfishing. Studies that determine egg-per-recruit would be more beneficial. The trouble with egg-per-recruitment analysis is that it requires data on fecundity at size, some idea about fishing pressure and the population structure, which are currently lacking for most species.

The *National Bêche-de-mer Management Plan* also includes a compulsory closed season each year. This closed season occurs between 1 October and 15 January. If

a Province has reached its TAC before the 1 October, then the closed season will commence from the date the TAC was acknowledged to have been reached. Usually Western, Manus and Milne Bay Provinces close early having reached their allotted TACs. Some companies have argued against this imposed closure, citing seasonal weather conditions that make it difficult for fishers to harvest.

The use of hookah and SCUBA, and underwater or surface lights for the fishing of sea cucumbers is prohibited under Section 7d (also refer to G57 National Gazette 4th April 2002). There is no serious enforcement on this regulation, and the use of hookah and SCUBA is a common practice in some provinces. Fishers in all Provinces regularly use lights for the harvesting of sea cucumbers, notably *B. vitiensis* and *A. lecanora* (Kinch, 2004; Kinch *et al.,* 2007).

3. TRADE

Countries that import bêche-de-mer from PNG include Australia, Canada, China Hong Kong SAR, Indonesia, Republic of Korea, Malaysia, New Zealand, Singapore, the People's Republic of China and Taiwan Province of China (Kinch, 2004). Most companies will regularly export to one or two of the same companies, as these are usually their financiers. Papua New Guinea is now the third largest global producer of bêche-de-mer supplying the Chinese Hong Kong SAR and other Asian markets (Conand, 2006; Kinch, 2004, 2006; Kinch *et al*., 2007).

Records of exports and imports are important elements of management as well as providing documentation along the market chain. There is some cause for concern for understanding the bêche-de-mer trade as PNG exports and imports into China Hong Kong SAR, show anomalies for 2001 and 2004 (Table 5), whereby PNG declared exports are actually smaller in some years then customs records report from China Hong Kong SAR. For example, in 2001 China Hong Kong SAR imported eight tonnes more than PNGs total exports and in 2004 it was over by 45 tonnes. It is also probable that before the moratorium in the Solomon Islands that bêche-de-mer was also being shipped from Bougainville through the Solomon Island's Western Province for onward shipping out of Honiara. It is also more than probable that bêche-de-mer is channeled into the Indonesian Province of West Papua from the West Sepik (Sanduan) and Western Provinces in PNG.

Prices for bêche-de-mer in PNG have increased significantly from 1991 and 2007 (Table 6). Price increases are linked to a multiple of reasons, including new species

TABLE 5
Papua New Guinea bêche-de-mer exports and imports into China Hong Kong SAR

Year	PNG exports (tonnes)	China Hong Kong SAR imports of total PNG exports (tonnes)	Percentage of total PNG exports
1992	655.5	240.0	36.6
1993	499.5	186.2	37.3
1994	208.8	150.3	72.0
1995	444.6	256.0	57.6
1996	596.2	351.6	59.0
1997	505.4	470.1	93.0
1998	678.8	639.8	94.2
1999	394.5	350.3	88.8
2000	553.9	532.0	94.6
2001	485.4	541.1	>100?
2002	389.3	380.6	97.8
2003	488.0	445.5	91.3
2004	490.8	518.3	>100?
2005	577.0	469.0	81.3
2006	611.8	–	–

Note: The last column is the China Hong Kong SAR, imports as a percentage of PNG Exports. All figures supplied by the National Fisheries Authority are indicative only, as the database is continuously updated. When multiple sources have been utilized, the highest value has been incorporated.

TABLE 6
Buying prices (USD/kg) to fishers for bêche-de-mer in 1991 and 2007

Species	Grade	Price (USD/kg)	
		1991	2007
Actinoypga lecanora	A	–	33.30
	B	–	27.25
	C	–	15.15
	D	–	9.10
A. mauritiana	A	–	27.25
	B	–	24.25
	C	–	12.10
	D	–	9.10
A. miliaris	A	2.70	30.30
	B	2.70	27.25
	C	2.70	15.15
Bohadschia argus	A	–	13.65
	B	–	9.10
	C	–	6.05
B. similis	–	–	3.65
B. vitiensis	A	2.70	9.10
	B	2.70	7.60
Holothuria atra	–	3.60	3.65
H. edulis	–	–	3.65
H. fuscogilva	SL	7.20	42.40
	A	7.20	39.40
	B	7.20	30.30
	C	7.20	21.20
H. fuscopunctata	–	–	3.65
H. scabra	SL	–	60.60
	A	16.20	54.55
	B	12.60	48.50
	C	10.80	24.25
	D	–	12.10
H. whitmaei	A	7.20	30.30
	B	7.20	24.25
	C	7.20	15.15
	D	–	9.10
Stichopus chloronotus	A	3.60	33.30
	B	3.60	27.25
	C	3.60	18.20
S. herrmanni	A	1.20	30.30
	B	1.20	27.25
	C	1.20	15.15
	D	1.20	9.10
Thelenota ananas	A	4.50	33.30
	B	4.50	27.25
	C	4.50	18.20
T. anax	–	–	3.65
Pearsonothuria graeffei	–	–	3.65

Note: Grades are determined by length and quality. "**A**" is the highest grade. **SL** = Super Large.

Source: Kinch *et al.*, 2007

entering the market, the increased demand by Asian consumers and the rise and fall of the PNG currency. Following recent research, and the high proportion of undersized bêche-de-mer being purchased by exporting companies, the NFA is now considering a three-year moratorium on the sea cucumber fishery, with consultation currently being conducted amongst stakeholders.

From a review of customs declarations for 2006–2007, whereby buying prices were compared to export prices, fishers appear to receive a major proportion of the export value of bêche-de-mer in PNG. On average across all species, fishers received 65 percent

TABLE 7
Average percentage of export value returned to fisher

Species	Grade	Percentage
Actinopyga lecanora	A	74.4
	B	65.7
	C	59.5
A. mauritiana	A	81.1
	B	67.4
A. miliaris		60.4
Bohadschia argus		70.0
B. similis		65.7
B. vitiensis		53.8
Holothuria atra		56.4
H. edulis		63.9
H. fuscogilva	A	85.6
	B	77.6
	C	68.8
H. fuscopunctata		69.4
H. scabra		54.4
	A	69.2
	B	65.1
H. whitmaei	A	73.4
	B	59.4
	C	46.7
Pearsonothuria graeffei		56.4
Stichopus chloronotus		66.8
S. herrmanni	A	65.4
	B	66.6
	C	53.2
Thelenota ananas		63.8
T. anax		59.5
Average		**65.0**

Note: Grades are determined by length and quality. "**A**" is the highest grade. These figures should be treated as indicative only.

Source: Kinch *et al.*, 2007.

of the export price at the point of sale. Certain species had greater returns then others, but the proportionate return to fishers was not very variable (s.d. = 8.7 percent) (Table 7). Generally, higher value species and higher grades within species, provide a proportionately higher share of the export price to fishers than lower value species or lower grade bêche-de-mer. Since large animals yield higher grade bêche-de-mer, it follows that fishing out large and high-value sea cucumbers concomitantly results in fishers harvesting animals of lower value and receiving proportionately less of the export value.

A sobering aspect of the global marketing system for bêche-de-mer is that as the supply of a certain species declines, the demand drives the price up, providing greater incentive for fishers to harvest the remaining vestiges of each species. Alternatively, low pricing by companies forces overexploitation and the harvesting of undersize as fishers attempt to make an adequate profit. Companies in PNG also exert pressure on local fishers to provide bêche-de-mer by giving cash-advances or other materials, and in some cases creating a loan-debt cycle that is difficult to break.

4. SOCIO-ECONOMIC IMPORTANCE TO LOCAL FISHING COMMUNITY

During the lead author's (Jeff Kinch) PhD work at Brooker Island in the Milne Bay Province, bêche-de-mer sales contributed 46.7 percent of all household incomes (Kinch, 1999). A socio-economic survey conducted by the Coastal Fisheries Management and Development Programme (CFMDP) in the Milne Bay Province showed that

FIGURE 3
Juvenile green turtle (*Chelonia mydas*) caught as bycatch in the sea cucumber fishery in Papua New Guinea Western Province

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21.9 percent of households surveyed, harvested sea cucumbers for income (NFA, 2006). A similar survey in the New Ireland Province showed that 12 percent of households harvested sea cucumbers for income (NFA, 2005). In the West New Britain Province, Koczberski *et al.* (2006) also found the sale of bêche-de-mer to be an important source of income.

A recent socio-economic assessment of the sea cucumber fisheries in the Western, Central and Manus Provinces by Kinch *et al.* (2007) showed that on average, households that harvested sea cucumbers could make between USD 1 000–3 000/year from the sale of bêche-de-mer. In Manus Province, of all households surveyed, 75 percent stated that harvesting sea cucumbers was their most important income stream (Kinch *et al.,* 2007). During this survey, between 24 and 40 percent of all households stated they would move to other forms of fishing and harvesting other marine resources if they could no longer harvest sea cucumbers, and thus possibly starting a spiral of fishing down other valuable species. Of particular concern would be the fishing for sharks for shark fins and sea turtles (Figure 3).

The PNG Government has undertaken a range of financial and economic reforms in recent years, including the Medium Term Development Strategy (2005–2010), the Poverty Reduction Strategy and an Export Oriented Growth Strategy. The majority of this growth is likely to be in export-oriented sectors, such as the sea cucumber fishery because bêche-de-mer is predominantly export-oriented in PNG.

Of all of PNG's existing fisheries, the sea cucumber fishery is the one in which good management, appropriate regulation and enforcement is most likely to continue to deliver economic benefits, particularly at the rural level. Undoubtedly, a collapse of the sea cucumber fishery would have dire social and economic consequences for the rural fishers in PNG.

5. ADDITIONAL THREATS TO SEA CUCUMBER POPULATIONS

As in the Western Pacific Region, the biggest threat to sea cucumber fisheries in PNG is overharvesting (see Dalzell, 1990; Kinch, 2002, 2004; Lokani, 1996; NFA, 2007; Skewes *et al*., 2002, 2004, 2006). Other impacts on sea cucumber populations and their associated habitats include degradation of habitats around urban centres (Lock, 1986), bleaching events (Davies, Dunne and Brown, 1997) and cyclones (Miller *et al.,* 2004).

6. RECOMMENDATIONS FOR IMPROVING FISHERIES MANAGEMENT AND CONSERVATION

The sea cucumber fishery in PNG has not been well studied, despite its importance in terms of revenue it generates for PNG and the income it provides to a majority of coastal communities. Subsequently, NFA contracted the lead author (Jeff Kinch) to review the sea cucumber fishery and its management (Kinch, 2004) and conduct a socio-economic study (Kinch *et al.,* 2007). Based on those investigations, the following actions for improved management have been recommended (these are in no order of priority or importance):

- To conduct extensive awareness campaigns for coastal and island fishers on the biology and reproductive ecology of holothurians (i.e. spawning, fertilization, larval dispersal and settlement), the dangers of harvesting undersize animals, the importance of protecting them until they reach marketable size or are mature enough to produce the next cohorts, and the susceptibility of sea cucumbers to overharvesting and subsequent decline in yield.
- To conduct research into breeding seasonality, growth rates (due to regional and habitat variations) and size at first spawning to help determine accurate minimum legal live size limits for sea cucumbers in a given area. Size limits can be a useful tool for maximizing the economics of the bêche-de-mer fishery, but use of size limits depends on proper biological information and modeling.
- To carry out research to determine the taxonomic identity of species in trade.
- To develop a standardized and effective assessment sampling protocol for estimating population abundances. This would assist in future replication and permit comparisons between different habitats and regions. It would allow for the collation of a time series of fishery-dependent information, which could be used to determine harvesting impacts within these areas.
- To study the supply and marketing chain, in order to determine the real values of bêche-de-mer along the buying chain, and help accurately determine the equity to the fisher.
- To conduct data collection in order to document the number of bêche-de-mer/grade/kg. This could be used to determine weights for individual grades which could also be used as a measure along with minimum legal dry size limits. The international market sells by weight, rather than size and this could help ameliorate the differences in marketing strategies.
- To determine the conversion ratios from live sea cucumber to dry bêche-de-mer for all species, for converting pooled catch data from one state to another.
- To host workshops and training to encourage value-added processing by coastal and island fishers to the fullest extent possible and to the highest standard possible. This training should be carried out by the industry where possible, and linked to licensing, such that licenses will not be issued unless company employees have been put through this course, and actually carry out extension services.
- To educate fishers and companies on standardized trade names to enable accurate reporting of bêche-de-mer species in trade. The NFA should canvass exporters of differing species in trade and ask for samples that exporters distinguish as

different to the ones that are produced in the SPC *Sea Cucumber and Beche-de-Mer Identification Cards*[1].

- To develop and promote better reporting systems based on suitable logbooks that uses four carbon invoice/receipts with one copy given to the fisher, one copy to the Provincial Fisheries Office, one to the NFA and the book copy retained by the company. This would enable standard collection of catch and effort data when purchasing products from the fishers, and could be converted to a standard unit.
- To investigate equity distribution/reward models to act as an incentive for exporters to add value through better processing and targeting of larger size grades as well as providing a disincentive to the practice of under-declaring export prices.
- To investigate mechanisms for companies to pay a fisheries management levy to NFA to cover the costs of research and management of this fishery. The levy could be a fixed amount/kg exported, rather than a percentage of export value. This would also dissuade exporters from under-declaring their revenues and also to make it less economical to process really low-value product.
- To investigate the impacts of introducing species-specific TACs for heavily-exploited species, or for trials on new commercial species. It is probably better, however, to set zero TACs for depleted species, given that the species value groups are not effectively monitored by the NFA.
- To examine possibilities of co-management of the bêche-de-mer fishery with villages. Assessment criteria could be devised to determine if it would be practically feasible, such as social cohesion, existing management structures, dependency on resources, etc.
- To investigate the possibility of a register of foreign financiers/technical advisors, and further involve them in management discussions. Guidelines could also be developed taking into account the interest of both the non-citizen and the PNG Citizen.
- To limit the number of licences issued for each province. Too many companies make it difficult for the NFA to monitor purchasing and exporting data. Whilst it is generally thought good economic theory that competition raises standards along with prices, this does not appear to have happened as companies compete against each other to secure adequate product, and this leads to increased infringements of some regulations, particularly buying undersize bêche-de-mer. Competition from illegal operators also undermines any incentive licensed operators have to operate legally.
- To monitor intra-provincial transfers and reassign transfers back to province of origin as current export figures are not representative of actual production from a given province.
- To re-introduce buyer's licences that are linked to a specific company. This would assist companies to provide accurate information on catch, size distribution and quality, which could then be used to support management of the fishery.
- To standardize the issuance of exporting licences to a single month, meaning all licenses of intending exporters are submitted during a specific period, followed by inspections of facilities, with all licences given out for the same start month. This would help the NFA in knowing who is legal and who is not, as there is currently considerable confusion over how many legitimate exporters are licensed for each province.
- To establish an industry code of conduct that covers product pricing, size limits, training of fishers in processing methods, and provision of purchasing and exporting data to the NFA. Companies that do not abide by the code of conduct would have their licenses withdrawn.

[1] SPC. 2004. Pacific Island sea cucumber and bêche-de-mer identification cards.

7. EVALUATION OF THE PROS AND CONS OF A CITES LISTING

Bruckner, Johnson and Field (2003) and Sant (2006) give accounts of the process and progress for the possibility of having sea cucumbers listed with the Convention on the International Trade in Endangered Species (CITES). According to these authors, under Resolution Conf. 9.24 (Annex 2a Bi), some sea cucumber species such as some temperate Stichopodidae species meet CITES criteria for Appendix II inclusion because harvesting for international trade is having a detrimental impact on species by exceeding, over an extended period, the level that can be continued in perpetuity.

Papua New Guinea has the most well developed sea cucumber/bêche-de-mer management plan in place, anywhere in the Western Central Pacific region, but as noted above, it is still having difficulties in implementing successful and sustainable management due to a variety of scientific, social, economic and political reasons. Of particular note are the remote locations where coastal and island fishers reside and the limited resources available for monitoring, management and enforcement. Compounding these difficulties is the lack of clear evidence on the surface from aggregate national export data that fishery depletion is actually occurring, as exports of bêche-de-mer continue to increase. This is invariably due to the exploitation of new areas and new species, masking stock depletion of at least some species in some areas. However, stock assessments have not been carried out for most provinces, so there is still substantial uncertainty about this question. There appears to be however, a growing awareness amongst fishers that sea cucumber resources are no longer abundant (Kinch *et al.*, 2007).

In terms of conservation costs and benefits of listing sea cucumber species with CITES, it is clear that a number of implementation issues would need to be addressed in order for benefit to be derived from such a listing in PNG. As noted above, identification of individual species in trade is a problem in PNG. Proper identification is important as is the ability to distinguish taxa in the form they are traded.

Undoubtedly, CITES listing of sea cucumbers in PNG could provide an additional tool to ensure that harvesting to supply international markets is conducted in a sustainable manner. CITES listings could contribute to enhanced opportunities for technical assistance from regional agencies such as the Food and Agriculture Organization (FAO) and SPC, but also draws on financial support from the Australian Centre for International Agricultural Research (ACIAR), and technical support from the Commonwealth Science and Industry Research Organisation (CSIRO) and the Australian Institute of Marine Sciences (AIMS). Finally, CITES listings could help promote increased partnerships with importing countries, and provide a mechanism for comprehensive and standardized trade and quota reporting.

Future prospects for the sea cucumber fishery in PNG and consideration of CITES participation, will however, depend upon several factors including the NFA's policy objectives, administrative capacity, adequate financing and regulatory ability.

It could already be argued that *H. scabra* and *H. whitmaei* could qualify for CITES listing due to their decline over most of their distributional range (Skewes *et al.*, 2002, 2004, 2006).

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APPENDIX A

Sea cucumber densities in Papua New Guinea

Species	Density (ind. ha^{-1})	Province	Reference
Actinopyga echinites	1 800.0	Central	Shelly, 1981
	<0.1	East New Britain	Gisawa, 2002
	6.7	Madang	Lokani *et al.,* 1992
	241.3	Madang	Massin and Doumen, 1986
	105.5	Manus	Lokani and Chapau, 1992
	25.0	New Ireland	Lokani, 1996
	119.0	New Ireland	NFA, 2007
	1.8	Western	Lokani, 2000
A. lecanora	<0.1	East New Britain	Gisawa, 2002
	0.9	Madang	Lokani *et al.,* 1992
	<0.1	Milne Bay	Skewes *et al.,* 2002
	3.0	New Ireland	Lokani, 1996
	0.2	New Ireland	NFA, 2007
	2.4	Oro	Anon, 1994
	<0.1	Western	Lokani, 2000
A. mauritiana	13.0	East New Britain	Gisawa, 2002
	38.7	Madang	Lokani *et al.,* 1992
	9.4	Madang	Massin and Doumen, 1986
	9.5	Manus	Lokani and Chapau, 1992
	0.1	Milne Bay	Skewes *et al.,* 2002
	12.0	New Ireland	Lokani, 1996
	1.8	New Ireland	NFA, 2007
	5.0	Oro	Anon, 1994
A. miliaris	2.0	East New Britain	Gisawa, 2002
	4.3	Madang	Lokani *et al.,* 1992
	36.9	Manus	Lokani and Chapau, 1992
	0.1	Milne Bay	Skewes *et al.,* 2002
	15.0	New Ireland	Lokani, 1996
	1.2	New Ireland	NFA, 2007
	57.0	Oro	Anon, 1994
	1.4	Western	Lokani, 2000
A. palauensis	0.2	New Ireland	NFA, 2007
Bohadschia argus	18.0	East New Britain	Gisawa, 2002
	9.5	Madang	Lokani *et al.,* 1992
	24.4	Madang	Massin and Doumen, 1986
	1.3	Milne Bay	Skewes *et al.,* 2002
	5.0	New Ireland	Lokani, 1996
	3.7	New Ireland	NFA, 2007
	8.8	Oro	Anon, 1994
	6.9	Western	Lokani, 2000
B. similis	411.0	New Ireland	Lokani, 1996
	3.2	New Ireland	NFA, 2007
	3.5	Western	Lokani, 2000
B. vitiensis	2.0	East New Britain	Gisawa, 2002
	4.4	Madang	Lokani *et al.,* 1992
	1.0	Milne Bay	Skewes *et al.,* 2002
	136.0	New Ireland	Lokani, 1996
	1.2	New Ireland	NFA, 2007
	5.9	Oro	Anon, 1994
	6.5	Western	Lokani, 2000

APPENDIX A (continued)

Sea cucumber densities in Papua New Guinea

Species	Density (ind. ha^{-1})	Province	Reference
Holothuria atra	38.0	East New Britain	Gisawa, 2002
	80.0	Madang	Lokani *et al.,* 1992
	4 870.6	Madang	Massin and Doumen, 1986
	9.8	Milne Bay	Skewes *et al.,* 2002
	584.0	New Ireland	Lokani, 1996
	40.0	New Ireland	NFA, 2007
	232.9	Oro	Anon, 1994
	143.5	Western	Lokani, 2000
H. coluber	4.6	New Ireland	NFA, 2007
H. edulis	6.0	East New Britain	Gisawa, 2002
	2.2	Milne Bay	Skewes *et al.,* 2002
	6.7	New Ireland	NFA, 2007
	<0.1	Western	Lokani, 2000
H. fuscogilva	3.0	East New Britain	Gisawa, 2002
	3.3	Madang	Lokani *et al.,* 1992
	3.5	Manus	Lokani and Chapau, 1992
	0.4	Milne Bay	Skewes *et al.,* 2002
	23.0	New Ireland	Lokani, 1996
	1.2	New Ireland	NFA, 2007
	2.0	Oro	Anon, 1994
H. fuscopunctata	<0.1	East New Britain	Gisawa, 2002
	18.2	Madang	Lokani *et al.,* 1992
	<0.1	Milne Bay	Skewes *et al.,* 2002
	4.0	New Ireland	Lokani, 1996
	0.1	New Ireland	NFA, 2007
H. hilla	5.5	New Ireland	NFA, 2007
H. leucospilota	<0.1	East New Britain	Gisawa, 2002
	3.3	Madang	Lokani *et al.,* 1992
	<0.1	Western	Lokani, 2000
H. whitmaei	3.0	East New Britain	Gisawa, 2002
	16.8	Madang	Lokani *et al.,* 1992
	9.4	Madang	Massin and Doumen, 1986
	9.8	Manus	Lokani and Chapau, 1992
	0.2	Milne Bay	Skewes *et al.,* 2002
	5.0	New Ireland	Lokani, 1996
	0.9	New Ireland	NFA, 2007
	6.6	Oro	Anon, 1994
H. scabra	2 900.0	Central	Shelly, 1981
	1.0	East New Britain	Gisawa, 2002
	22.2	Madang	Lokani *et al.,* 1992
	19.1	Manus	Lokani and Chapau, 1992
	<0.1	Milne Bay	Skewes *et al.,* 2002
	122.0	New Ireland	Lokani, 1996
	17.0	New Ireland	NFA, 2007
	0.4	Oro	Anon, 1994
	34.9	Western	Lokani, 2000
Pearsonothuria graeffei	3.5	Madang	Lokani *et al.,* 1992
	0.4	Milne Bay	Skewes *et al.,* 2002
	4.0	New Ireland	Lokani, 1996
	6.4	New Ireland	NFA, 2007
	3.3	Western	Lokani, 2000

APPENDIX A (continued)

Sea cucumber densities in Papua New Guinea

Species	Density (ind. ha^{-1})	Province	Reference
Stichopus chloronotus	128.2	Madang	Lokani *et al.,* 1992
	16.0	Manus	Lokani and Chapau, 1992
	3.8	Milne Bay	Skewes *et al.,* 2002
	25.0	New Ireland	Lokani, 1996
	<0.1	New Ireland	NFA, 2007
	51.8	Oro	Anon, 1994
	2.8	Western	Lokani, 2000
S. herrmanni	1.0	East New Britain	Gisawa, 2002
	8.1	Madang	Lokani *et al.,* 1992
	8.6	Manus	Lokani and Chapau, 1992
	0.1	Milne Bay	Skewes *et al.,* 2002
	31.0	New Ireland	Lokani, 1996
	0.3	New Ireland	NFA, 2007
	3.7	Oro	Anon, 1994
	4.1	Western	Lokani, 2000
S. horrens	216.0	New Ireland	Lokani, 1996
	0.4	New Ireland	NFA, 2007
	1.5	Western	Lokani, 2000
Thelenota ananas	12.0	East New Britain	Gisawa, 2002
	8.0	Madang	Lokani *et al.,* 1992
	1.6	Manus	Lokani and Chapau, 1992
	0.5	Milne Bay	Skewes *et al.,* 2002
	8.0	New Ireland	Lokani, 1996
	1.4	New Ireland	NFA, 2007
	1.5	Oro	Anon, 1994
T. anax	6.0	East New Britain	Gisawa, 2002
	6.0	Madang	Lokani *et al.,* 1992
	4.5	Manus	Lokani and Chapau, 1992
	0.6	Milne Bay	Skewes *et al.,* 2002
	1.0	New Ireland	Lokani, 1996
	0.7	New Ireland	NFA, 2007
T. rubralineata	<0.1	New Ireland	NFA, 2007

APPENDIX B

Papua New Guinea bêche-de-mer exports from 1960–2006

Year	Volume (tonnes)	Value (USD)	Reference
1960	1.6	–	Lindholm, 1978
1961	2.4	–	Lindohlm, 1978
1962	4.4	–	Lindohlm, 1978
1963	12.8	–	Lindohlm, 1978
1964	6.3	–	Lindohlm, 1978
1965	4.1	–	Lindohlm, 1978
1966	4.4	–	Lindohlm, 1978
1967	10.5	–	Lindohlm, 1978
1968	11.2	–	Lindohlm, 1978
1969	12.4	–	Lindohlm, 1978
1970–71	6.5	–	Lindohlm, 1978
1971–72	3.9	–	Lindohlm, 1978
1972–73	9.9	–	Lindohlm, 1978
1973–74	4.1	–	DFMR, no date
1974–75	1.2	–	Lindohlm, 1978; DFMR, no date
1975–76	1.7	–	Lindohlm, 1978; DFMR, no date
1977	5.3	–	Lindohlm, 1978
1978	5.9	–	Lindohlm, 1978
1979	1.3	–	DFMR, 1979
1980	2.4	–	Kailola and Lokani, no date
1981	11.1	–	Kailola and Lokani, no date
1982	23.0	–	Kailola and Lokani, no date
1983	7.6	–	Lokani and Kubohojam, 1993
1984	4.7	–	Lokani and Kubohojam, 1993
1985	19.5	–	Lokani and Kubohojam, 1993
1986	119.4	–	Lokani and Kubohojam, 1993
1987	192.1	–	Lokani and Kubohojam, 1993
1988	202.8	–	Lokani and Kubohojam, 1993
1989	194.9	–	Lokani, 1990
1990	238.9	–	Lokani and Kubohojam, 1993
1991	626.0	–	Lokani and Kubohojam, 1993
1992	655.5	–	Myint, 1996
1993	499.5	–	Myint, 1996
1994	208.8	–	NFA database
1995	444.6	3 560 728	NFA database
1996	596.2	5 959 645	NFA database
1997	505.4	5 185 737	NFA database
1998	678.8	8 147 423	NFA database
1999	394.7	4 157 870	NFA database
2000	553.9	5 832 439	NFA database
2001	485.4	5 266 819	NFA database
2002	389.3	5 629 250	NFA database
2003	488.0	6 376 835	NFA database
2004	490.8	7 181 587	NFA database
2005	577.0	9 284 756	NFA database
2006	611.8	11 488 601	NFA database

Note: All figures are indicative only, as the National Fisheries Authority database is continuously updated.