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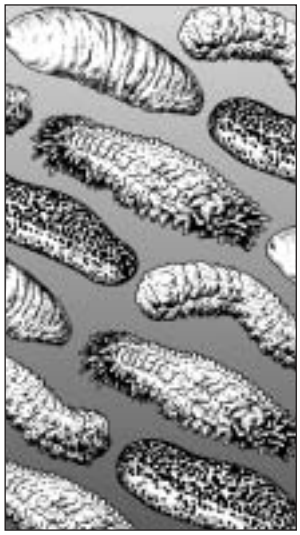

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Editorial

In this issue of the Bulletin, we present several original articles:

Jeff Kinch provides detailed information on the historic, social and economic aspects of a sea cucumber fishery in Papua New Guinea along with its management options (p. 2).

Few papers have been published on operations in the Philippines, the subject of an article by Akamine Jan on page 17.

Peter Fankboner describes an unusual biological phenomenon, salinity-related seasonal atrophy of the viscera in a temperate species, *Parastichopus californicus* (p. 22).

No inventory of the sea cucumbers of Reunion Island, Indian Ocean, had ever been made before the article by Chantal Conand and Perrine Mangion (p. 27). The article also provides information on abundance and population structures for the dominant fringing reef species.

The problems encountered by Mexican fisheries are presented in an article by Alonso Aguilar Ibarra and Georgina Ramirez Soberón on page 33.

Andrew Morgan describes problems related to farming certain sea cucumber species and explains how his work is developing (p. 36; also see previous issues of the Bulletin).

At the end of the Bulletin, you will also find the regular features, such as *Correspondence* (p. 38) and *Abstracts, Publications, Workshops & Meetings* (p. 41), along with the addresses of the new members of our Special Interest Group (p. 43)

Previous issues of the Bulletin are available on the SPC website at www.spc.int/coastfish/ in both French and English. I also draw

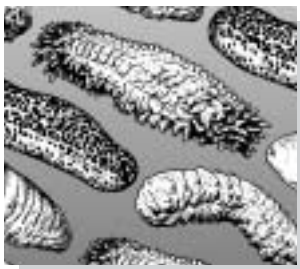
Inside this issue

your attention to the very informative Virtual Echinoderms Newsletter. Issue no. 26 is available on the Web at www.nmnh.si.edu/iz/echinoderm.

An echinoderms forum was created after the International Conference in Dunedin. You can subscribe to it by contacting sabine.stohr@nrm.se or by sending an e-mail to listserv@nrm.se and including on the first line of the message SUBSCRIBE ECHINODERM-L, your surname and first name, but no other text.

The 11th International Echinoderm Conference will be held at the Ludwig-Maximilians-Universität, Munich, Germany, from 6–10 October 2003. More information can be found at: www.iec2003.uni-muenchen.de

Chantal Conand



new info
beche-de-mer

Overview of the beche-de-mer fishery in Milne Bay Province, Papua New Guinea

Jeff Kinch[1]

Introduction

Milne Bay Province (MBP), at the far eastern tip of Papua New Guinea (PNG) (Fig. 1), has a population of approximately 205,000 people and an estimated 32 per cent of the country's total reef area (Munro 1989; Dazell and Wright 1986). MBP is the largest producer of beche-de-mer in PNG. Beche-de-mer is presently an artisanal fishery involving coastal and island communities, including fishermen, buyers who purchase processed beche-de-mer products from fishermen, and exporters (both licensed and illegal) who export the processed beche-de-mer to the international market.

Average annual income per household has been estimated at USD 130.00 (Kinch 2001a; Mitchell et al. 2001), with most communities relying mainly on beche-de-mer harvesting, fishing and subsistence agriculture for their cash income, food security and livelihoods. The income derived by coastal communities from the sale of beche-de-mer increased dramatically throughout the 1990s, and communities are currently landing large amounts of beche-de-mer. This increase in production can be attributed to the decline in copra prices, the effects of drought in previous years, increased fishing for beche-de-mer in remote locations, a decline in the value of trochus and blacklip pearl oysters, and the establishment of new markets for previously low-value or non-commercial species. The diversity of beche-de-mer is now being altered in some areas due to this intensified and extensive exploitation, which represents a threat to community livelihood strategies, the fishery itself and the overall biodiversity of MBP's reef ecosystems.

Harvesting and processing

Traditional methods of harvesting beche-de-mer in MBP are either by hand or by free diving using spears or a small harpoon embedded in a lead weight. A typical dive day starts early in the morning with boats leaving for harvesting areas and outer reefs. With favourable weather conditions, clear sky, calm sea and non-turbid water, beche-de-

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mer is collected in water up to 30 metres deep. Boats are out for most of the day and actual dive time in the water may average between three and four hours. Dinghies are now beginning to take the place of sailing canoes, which represents an increase in household income due to the value of beche-de-mer and the need to range farther to locate fresh stocks. The use of lights is a common practice throughout MBP (Kinch pers. observ.). For example, in the Trobriand Islands most sandfish are caught at night using torches (Rawlinson pers. comm.). Hookah gear has been used in recent years by a local businessman and his associates.

Beche-de-mer is produced by a process of boiling, cleaning, drying and smoking (Conand 1990) (Fig. 2). The first stage of processing is pre-cleaning, which entails slamming the beche-de-mer down on the sand, expelling the air trapped inside the body, and inducing the beche-de-mer to eviscerate itself. While pre-cleaning, a large container of clean sea water is set to boil. This is usually done in discarded 200-L oil drums for a period of two to three hours. After boiling, the cooled, cooked beche-de-mer is taken to the sea where it is washed, and remnants of the intestines removed. It is then placed on drying racks to be smoked and/or sun dried. The drying racks are usually kept in a small, wooden stick-framed building covered with woven coconut palm fronds that help concentrate heat and smoke. After the curing process, the beche-de-mer is then packed in copra sacks or plastic bags to await the exporters purchasing vessels, or sold direct or to trade stores.

History of commercial exploitation

Beche-de-mer was first harvested commercially in PNG in 1878 but it was probably exploited earlier than that (see Russell 1970; Shelley 1981; Conand 1990). During the late 1800s, MBP was visited by considerable numbers of foreign boats seeking pearl shell and beche-de-mer (Roe 1961). MBP inhabitants initially avoided these vessels because

Figure 1. **Milne Bay Province**

Figures 2a. **Beche-de-mer awaiting processing (photo: J. Kinch 1999)**

Figure 2b. **Boiling and processing beche-de-mer (photo: J. Kinch 1999)**

they had a reputation for mistreating the islanders (Milne Bay Provincial Government 1981), and several incidences between villagers and beche-de-mer traders resulted in loss of life (see Murray 1912; Moore 1992; Kinch 1999). Chinese beche-de-mer traders were also among the first foreigners in MBP, particularly in the Engineer Group, bartering with Tubetube people for beche-de-mer, shells, and employing some men as both assistants and divers (MacIntyre 1983; Bromilow 1929).

Anecdotal evidence suggests that the exploitation of beche-de-mer in MBP declined in the latter half of the 19th century probably because of overfishing. The harvesting of beche-de-mer was also affected in the first half of the 20th century when the Chinese and Japanese markets were closed due to the Sino-Japanese War and World War II. Exports from MBP during the 1960s and 1970s was due to enterprising Chinese based in Samarai (DFMR n.d.), a plantation owner based at Nivani, and the former Samarai Fisheries Project (the forerunner of the Milne Bay Fishing Authority, see below). From Department of Primary Industries files located at Samarai, beche-de-mer exports from July 1969 to June 1970 were 58 tonnes at a value of AUD 7562. There were limited exports until the Bwanabwana Fishing Company (the forerunner of Kiwali Exports) began operations in the mid-1970s and MBP beche-de-mer fishery has operated from this time onwards.

The Milne Bay Fishing Authority

The Milne Bay Fishing Authority (MBFA) began operations in 1980 mainly as a fish buying operation, but it also purchased beche-de-mer, shells, clam muscle, shark fins and jaws, prawns, lobster and mud crabs. The premise behind the creation of MBFA under the Coastal Fisheries Development Plan was that there were sufficient stocks of fish and marine invertebrates in each established fishing station area to supply the needs of that station without adversely impacting the food needs of the village people or the long-term productivity of the reefs (Maurice Pratley and Associates 1989). High staff wages, absenteeism, misappropriation of funds, and a breakdown in organisational structure finally contributed to the demise of this programme in 1990, eventually costing around USD 12 million (Maurice Pratley and Associates 1989; ANZDEC 1995). Added to this was a lack of government protection from illegal fishing activities and buyers from other provinces, and no strong policing of government regulations. It was finally recommended that the MBFA operation be commercialised by involving private enterprises. In 1995, most of MBFA's assets, boats, staff and the manager were acquired by Nako Fisheries, the sister company of Kiwali Exports (see below).

Current industry players

Bwanabwana Fishing Company was the forerunner of Nako Fisheries and Kiwali Exports, which now operate under the company name Nako Marine Ltd. Previous to this they were all subsidiary companies of Masurina Ltd. Masurina's founders parted company in 2001 after a 26-year business relationship with one of the founders retaining the two marine resources companies.

Asiapac, the other main exporter started operations in 1992. It was the only other commercial buyer licensed for MBP and it purchased shell, beche-de-mer and sharkfin. Presently, Kiwali Exports and Asiapac dominate the industry. They have a fleet of buying vessels, compete against each other in pricing, and offer incentives and bonuses to fishermen for the right to buy their product.

The National Fisheries Authority (NFA) previously allowed for the provision of three exporter licenses in MBP. A company called Crome Investments was operating in the mid-1990s but ceased operations in 1996. Coral Sea Delights, based at Misima, purchased produce in 1998 and 1999. Recently, with the implementation of the National Beche-de-mer Management Plan several other companies have entered the scene. These include RFI Enterprises, Chou Traders and Tikay Maintenance Services.

Sandfish in the Trobriands

In 1987, Sandfish Enterprises Ltd was formed as a joint venture between a Trobriand Islands entrepreneur and some Asian investors. Mua Island in the Trobriands became the centre of *Holothuria scabra* (sandfish) production (Kailola with Lokani n.d.). The company used poorly paid local labour, and conducted operations in locations considered to be traditional fishing grounds. For a period of six months, from July to December 1987, the company produced 47.12 tonnes of sandfish (Mahara 1988) and it has been estimated that 96 tonnes of dried beche-de-mer was eventually exported (Crittin pers. comm.). The company ceased operations in 1990 and sandfish were reported to be severely depleted after this period of intense fishing (Tom'tavala 1990, 1992; Anon. 2000). In 1989, sandfish accounted for 70 per cent of the total beche-de-mer export for PNG (Lokani 1990) with the majority of this amount coming from MBP.

Exports

The main reason behind the present boom in exploitation and exports is linked to the removal of trade barriers to the People's Republic of China

during the latter 1980s (Lokani 1995; Conand 1990). Exports from MBP go via Hong Kong and Singapore. China's great rate of industrialisation and concurrent increase in wealth has vastly increased the demand for seafood, with significant impacts on prices paid. This may also explain the recent demand for species that were previously considered of little or no commercial value. Some species of previously low-value beche-de-mer in MBP have shown substantial increases in prices, between approximately 1000 and 3000 per cent (Table 1).

Because beche-de-mer is an export driven industry, production should equate closely with export data. In liaison with NFA, the exporting companies and

Table 1. **Purchasing price and increase for beche-de-mer – 1991 and 2001**

Species	Size	Price in kina 1991 (October)	Price in kina 2001 (December)	Approximate price in USD 2001 (December)	% increase
Holothuria scabra (sandfish)	Large Grade 1	16.20	60.00 (120.00*)	20.00	**270**
	Medium Grade 1	12.60	40.00 (80.00*)	13.30	**217**
	Small Grade 1	10.80	30.00 (60.00*)	10.00	**178**
H. fuscogilva (white teatfish)	Large	7.20	60.00	20.00	**733**
	Medium		40.00	13.30	
	Small		35.00	10.00	-
H. nobilis (black teatfish)	Large	7.20	50.00	16.65	**594**
	Medium		40.00	13.30	-
	Small		30.00	10.00	-
H. fuscopuntata (elephant trunkfish)		-	7.00	2.30	-
H. atra (lollyfish)	Smooth/Large	3.60	5.00	1.65	**39**
	Smooth/Small		4.00	1.30	-
	Rough		4.00	1.30	-
Thelenota ananas (prickly redfish)	Large	4.50	40.00	13.30	**788**
	Small		30.00	10.00	-
T. anax (amberfish)		-	8.00	2.65	-
Actinopyga mauritiana (surf redfish)	Large	-	35.00	11.65	-
	Small		25.00	8.30	-
A. miliaris (blackfish)		2.70	40.00	13.30	**1381**
A. lecanora (stonefish)	Large	-	40.00	13.30	-
	Medium		30.00	10.00	-
	Small		20.00	6.65	-
Stichopus chloronotus (greenfish)	Large	3.60	45.00	15.00	**1150**
	Small		35.00	11.65	-
S. hermanni (curryfish)	Smooth	1.17	35.00	11.65	**2891**
	Rough		35.00	11.65	-
Bohadschia argus (tigerfish)		-	16.00	5.30	-
B. vitiensis/B. marmorata (brown sandfish)**		2.70	15.00	5.00	**456**
B. similis (chalkfish)		-	6.00	2.00	-

Price lists supplied by Kiwali Exports.

* Price for hot air-dried sandfish.

** As there is often confusion over what species brown sandfish actually is, this paper identifies both *Bohadschia vitensis* and *B. marmorata* as having the same common name.

the Planning Division of the Milne Bay Provincial Government have noted discrepancies in export figures, which gives cause for concern (Table 2). NFA's data sets are still under development and in some instances are incomplete. Also, the point of export is not always an indicator of harvest point because products exported from MBP also come from Tufi, in Oro Province, and Mailu, in Central Province (Anon. 2000). These data sets also do not include those animals that have been harvested and rejected at the point of sale and this wastage should also be considered when working out a suitable total allowable catch (TAC).

MBP has also seen a rise in the contribution it makes to the total PNG exports[2]. In the early to mid-1990s this percentage fluctuated between 10 and 15 per cent but rose to nearly half of all exports from PNG in 2001 (Table 3). The increased production can also be related to declines in other provinces of PNG, and also to the opening up of previous unfished areas within MBP.

Resource decline and territorial disputes

Rural livelihoods are important to an estimated 90 per cent of the people in MBP (Kinch 2001a;

Table 2. **Milne Bay beche-de-mer exports 1981 – 2001***

Year	Weight (kgs)	Value (kina)	Reference
1981	Approx 8,000	-	Kailola with Lokani n.d.
1984	2,070.00	5,796.00	Ito and Selemat 1985
1989	39,399.00	-	Kailola with Lokani n.d.
1990	58,207.00	-	Kailola with Lokani n.d.
1991	120,999.00	-	Milne Bay DPI (compiled from Kiwali purchasing figures)
1992	69,703.00	-	Kailola with Lokani n.d.
1993	47,783.86	276,376.02	NFA 1997; Lokani and Ada 1998
1994	32,489.90	-	Compiled from figures supplied by the exporting companies
1995	56,929.50	-	Compiled from figures supplied by the exporting companies
1996	65,455.00	683,203.73	NFA database
1997	46,263.40	-	Compiled from figures supplied by the exporting companies
1998	118,505.60	2,468,373.40	MBP Govt Derivation Grant Figures (compiled from customs' records)
1999	52,151.20	1,143,017.47	NFA database
2000	183,719.90	4,197,103.01	NFA database
2001	209,579.80	7,791,632.14	NFA database

Notes: This table is to be used as a guide only as the NFA database may be incomplete.
Before 1992, most beche-de-mer exports from MBP were shifted to Port Moresby for export.
* When several sources of data were available, the highest figure was used.

Table 3. **Percentage of beche-de-mer supplied by MBP for the total PNG export: 1992–2000***

Year	MBP (kgs)	PNG (kgs)	% of BDM from MBP
1992	69,703.00	655,462.00	10.6
1993	47,783.86	499,489.46	9.6
1994	32,489.90	208,795.70	15.6
1995	56,929.50	444,747.00	12.8
1996	64,114.60	586,201.80	10.9
1997	46,263.40	505,402.40	9.1
1998	118,505.60	678,848.85	17.5
1999	52,151.20	394,682.45	13.2
2000	183,719.90	607,311.06	30.3
2001	209,579.80	482,281.40	43.4

Note: This table is to be used as a guide only as the NFA database may be incomplete.
* When several sources of data were available, the highest figure was used.

2. See Appendix A, on page 16, for a list of PNG's export figures for beche-de-mer from 1960 to 2000.

Mitchell et al. 2001). For many people in remote areas of PNG, beche-de-mer and the local fishing companies (through their buying programmes) offer the only source of cash. Unfortunately, this often leads to the not-too-judicious harvesting of marine resources. Many of the characteristics that make beche-de-mer economically important also make them vulnerable to overharvesting.

Experience in the past, and in several countries, has shown that excessive fishing can cause a large-scale export fishery such as beche-de-mer to no longer be economically viable. This has occurred elsewhere in PNG, notably with the continuing moratoriums on harvesting in the Manus and Western Provinces' fisheries as mentioned above. The economic and social problems caused by a decline in beche-de-mer stock levels in MBP would be considerable. NFA is faced with the difficult decision of whether to take further management measures — in an effort to make the fishery sustainable (albeit at a lower level of catch, and without any assurance of success) — or to accept the unsatisfactory 'boom and bust' cycle of harvesting and wait for a long-term recovery.

Linked to resource decline is the increase in territorial disputes that are now becoming commonplace all over MBP (see Maolai 2001). As resources decline, people manipulate clan and kin ties to gain access to other waters where remaining stocks are still to be found (Kinch pers. observ.). A number of works show that, in Melanesia at least, territoriality in coastal waters only comes into existence in response to the commencement of commercialisation of valuable resources such as trochus, beche-de-mer and pearl shell. In numerous cases this was deemed sufficient to aggravate disputes over tenure and resource rights (see Carrier 1981; Johannes 1982; Akimichi 1995; Polunin 1984; Wright 1985; Kinch 1999, 2000, 2001a). This is also true for MBP. As the commercial value for marine products has increased, so has the establishment of territoriality and arguments over exactly where traditional boundaries lie and who, by virtue of clan or village ties, has the right to fish within these boundaries. In response to this, some communities have started their own resource owners associations (see below), have established closed areas and have divided reef sections by clan ownership.

Stock research

The earliest stock assessments for MBP are noted by Lindholm (1978) who reports that McElroy, in 1971, made several stock assessments at Bubuleta (Killerton Islands), Samarai, the Trobriands and Goodenough Islands. In 1976, Lindholm, following up on this earlier work, also conducted a survey of beche-de-mer stocks in the Trobriand and Goodenough Islands (Lindholm 1978). The overall density of beche-de-mer from this survey ranged from 300–350 animals / ha. According to Kailola with Lokani (no date) this stock assessment would have been of almost virgin stock.

Chesher (1980) conducted a marine resource inventory around the Samarai Islands, and along the barrier reef system that stretches from Ware to Bramble Haven. The average number of beche-de-mer was 31 animals / km at Sidea Island, 48 animals / km at Kosmann Reef, 79 animals / km at Steurs Islands and 106 animals / km on the Long Reef (Chesher 1980). Most of these beche-de-mer were *Thelenota ananas* (prickly redfish) with lesser sightings of *Holothuria nobilis* (black teatfish) and *H. fuscogilva* (white teatfish). At this time, the area from Ware to Jomard Entrance was not heavily fished, though Chesher (1980) notes that reefs around Ware, were already overfished.

A beche-de-mer and giant clam abundance survey was undertaken in 1997 by NFA in conjunction with the South Pacific Commission (SPC) to assess the exploitation of these species across MBP. Due to logistical problems and bad weather, the survey was conducted at only 63 sites in the Samarai and Engineer islands (SPC 1996). A total of 18 species were identified from the survey with densities ranging from 0.208 to 33.05 animals / ha (Lokani et al. 1997). The level of abundance recorded at this time was considered to be well below sustainable levels with the abundance of high value species being low.

In 2000, Conservation International (CI) conducted a marine biodiversity survey as part of its Marine Rapid Appraisal Program. This taxonomic survey of fish, corals and shellfish attempted to do a basic stock assessment of sedentary resources notably for beche-de-mer and giant clam. Fifty-seven sites were surveyed throughout MBP and species diversity and abundance of commercial-size beche-de-mer and all giant clams were recorded for each site. A total of 15 species representing four genera were recorded from 53 sites throughout MBP. The most commonly observed species (percentage of occurrence from transects are in parentheses) were: *Bohadschia argus* (tigerfish) (43.40%), *B. graeffei* (flowerfish) (39.62%), *Thelenota anax* (amberfish) (30.19%), *Holothuria atra* (lollyfish) (24.53%), and *Stichopus variegatus* (curryfish) (24.53%) (Allen et al. in press). The most abundant species recorded during the survey were *Thelenota anax*, *Bohadschia argus*, and *B. graeffei*, whose combined numbers comprised roughly half of the total count.

The CI survey noted the depletion of the higher value species and advocated the need for a further in-depth stock assessment. At the request of the Provincial Fisheries Management Committee in March 2001 (see below) a thorough stock assessment of MBP was made in October and November 2001 as a collaborative effort between the Commonwealth Science and Industry Research Organisation (CSIRO), NFA and CI. Specific objectives of the CSIRO / NFA / CI stock assessment were to:

- Assess the current state of holothurian resources in Milne Bay by visiting >1000 sites in the study area and record abundance, distribution, size frequency and biological data. Other benthic resources (e.g. clams) and habitat data were also collected during the survey;
- Calculate stock size estimates for the area, for each of the commercially important beche-de-mer species;
- Provide an indication of stock status for each of the commercially important species of beche-de-mer in the study area;
- Recommend and implement management strategies for the sustainable use of beche-de-mer in Milne Bay beginning in early 2002, and recommend efficient monitoring strategies to gauge their success;
- Provide sufficient training to PNG NFA staff to enable them to carry out / supervise beche-de-mer surveys in other areas of PNG.

The CSIRO / NFA / CI stock assessment employed rapid marine assessment techniques that have been developed, improved and applied by CSIRO for habitat surveys in the Torres Strait, Great Barrier Reef and Timor Box. The James Cook University research vessel, the RV *James Kirby* was used for the survey and a total of 1126 sites were visited over a six-week period (Fig. 3).

Small teams of divers operating from dinghies located sample sites using portable GPS. On the reef top, divers swam along a 40-m transect and recorded resource and habitat information one metre either side of the transect line. Beche-de-mer and other benthic fauna of commercial or ecological interest were counted and, where possible, returned to the dinghy and measured. At each site, substrate was described in terms of the percentage of sand, rubble, consolidated rubble, pavement and live coral. The growth forms and dominant taxa of live corals were noted, and the percentage cover of all other conspicuous biota such as sea grass and algae were also recorded. On the reef edge, a diver swam along a 100-metre transect between in water 1 m to 20 m deep, recording resource and habitat variables similar to those recorded on the reef top. Video was also taken at representative sites, but was not used in the final analysis.

The results of the stock assessment show that even though there are still significant numbers of commercial beche-de-mer species left in MBP, their overall density of (21.24 / ha) is lower than those for comparable fisheries in the Torres Straits and the northern Great Barrier Reef (160.40 / ha) (Long et al. 1996) and similar to heavily depleted fisheries such as Timor Box (26.80 / ha) (Skewes et al. 1999). Some Local Level Government (LLG) areas and species in MBP are showing signs of being heavily overfished and the current total allowable catch (TAC) of 140 metric tonnes is reaching the maximum level for sustainability. Another indicator of overfishing in MBP is the reduction in the proportion of catch of high value species from around 36 per cent in the early 1990s to around 15 per cent by 2002.

The beche-de-mer fishery in MBP is currently changing from a low-volume, high-value fishery to a high-volume, low-value fishery. *Holothuria nobilis*

Figure 3a. Surveying beche-de-mer (photo: P. Seeto 2001)

Figure 3b. Villagers aboard the RV *James Kirby* (photo: CSIRO 2001)

were found in very low numbers and *H. fuscogilva* and *Thelenota ananas* are showing signs of harvesting pressure. *H. scabra* was not observed during sampling (Fig. 4). *H. atra* was the most abundant beche-de-mer species surveyed making up approximately half of all beche-de-mer stocks in MBP. It has been recommended that the TAC of high value species be reduced by half to 30 metric tones and that the *H. scabra* and *H. nobilis* be closed or have species specific TACs attached to them (Skewes et al. 2002).

Individual species had mean densities as follows: *Holothuria nobilis* at 0.18/ha, *H. fuscogilva* at 0.42/ha, *H. edulis* (pinkfish) at 2.15/ha, *H. atra* at 9.81/ha, *H. fuscopunctata* (elephant trunkfish) at 0.04/ha, *Bohadschia graeffei* (flowerfish) at 0.37/ha, *B. argus* at 1.33/ha, *B. marmorata* (brown sandfish) at 0.99/ha, *Stichopus chloronotus* at 3.81/ha, *S. hermani* (previously *variegatus*) (curryfish) at 0.09/ha, *Thelenota ananas* at 0.47/ha, *T. anax* (amberfish) at 0.63/ha, *Actinopyga miliaris* (blackfish) at 0.12/ha, *A. lecanora* (stonefish) at 0.02/ha, and *A. mauritiana* (surf redfish) at 0.12/ha (Skewes et al. 2002). High value species as per the National Beche-de-mer Management Plan mean density was 5.22/ha. When compared with other species in other areas in PNG, the mean densities for the MBP beche-de-mer fishery definitely show signs of extreme fishing pressure (see Lokani 1991; Lokani and Chapau 1992; Lokani et al. 1992; Mobiha et al. 1993; Mobiha et al. 2000; Gisawa 2002).

Further follow up work is required if the beche-de-mer fishery in MBP is to remain viable. There have been no annual surveys done during closure and prior to opening to assess the inter-annual change in stock variability. Based on current information from the stock assessment, there is definite evidence of overfishing in certain areas of MBP and the TAC now requires review.

Management

In the early 20th century, attempts were made to manage beche-de-mer in the Trobriand Islands within MBP with an Act in the Colonial Administration. The *Pearl, Pearl Shell and Beche-de-mer Ordinance, 1911–1934*, prohibited the harvesting of pearl shell, trochus or beche-de-mer in between the high water mark and a parallel line 800 metres seaward of this (Territory of Papua 1934; Hyndman 1993; Tom'tavala 1990, 1992; Kinch 2001a). This was passed with the aim of

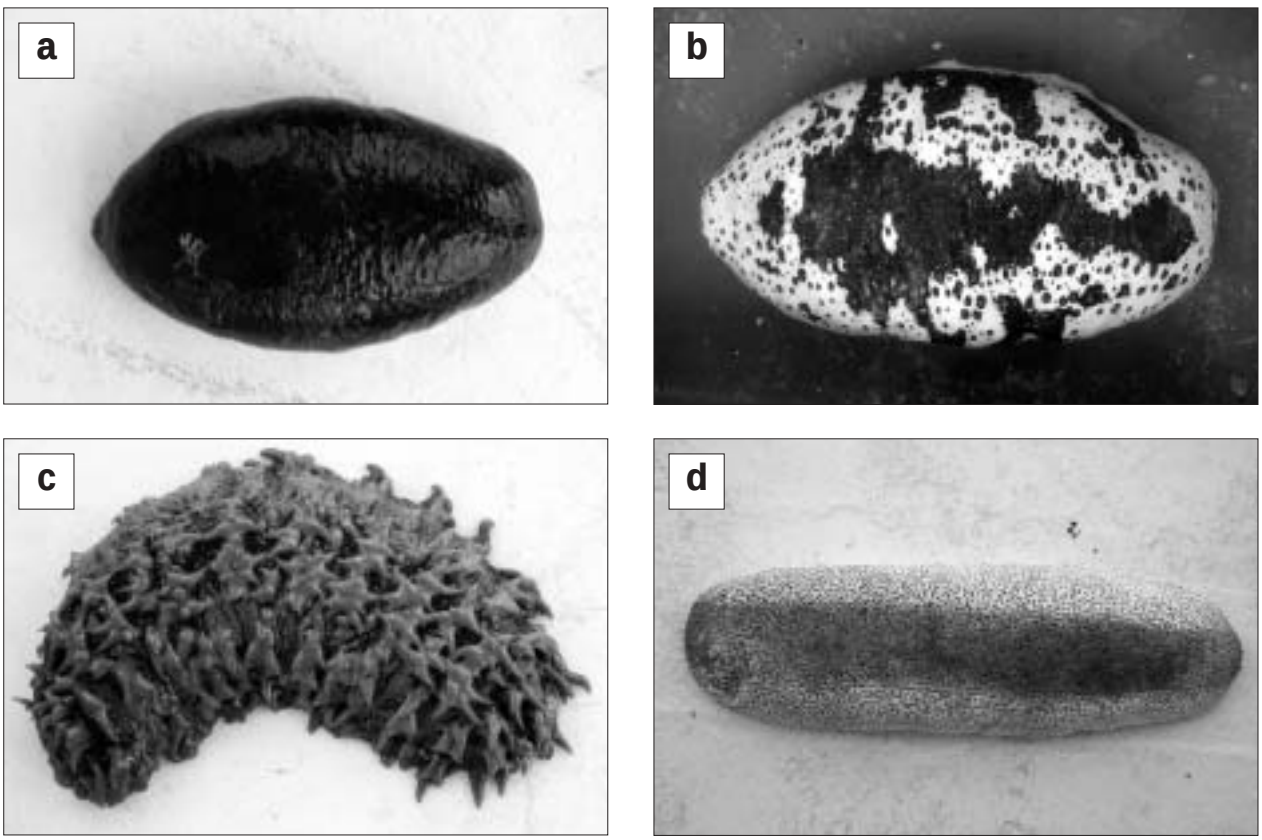

Figure 4. a. ***Holothuria nobilis*****; b.** ***H. fuscogilva*****; c.** ***Thelenota ananas*****; d.** ***H. scabra***
(photos: CSIRO 2001)

protecting villagers' rights to make a living from their resources.

Today, the National Fisheries Authority has gazetted the National Beche-de-mer Management Plan 2001, for regulation and management of the industry and the implementation of Provincial Management and Advisory Committees (PMACs). This plan now over-rides the previous Milne Bay Beche-de-mer Management Plans 1998 and 2000.

One issue that needs to be addressed in MBP is the lack of information for fishers on minimum size limits, appropriate collection and processing techniques. Recommended wet lengths of beche-de-mer for collection are virtually unknown by fishers throughout MBP (see Kolkolo 1998; Kinch pers. observ.; Rawlinson pers. comm.). This has resulted in a loss of potential income and depletion of future stocks through the indiscriminate collection and subsequent rejection of undersized beche-de-mer. Also, a proportion of animals is rejected by purchasers due to decomposition caused by incomplete processing, drying and improper storage. In light of inadequate Provincial Fisheries Authority (PFA) resources, exporters and buyers should be involved in extension work and better processing techniques, as it is in their interest to sell Grade 1 product should be involved in extension work and better processing techniques, not only at the buying premises but actively in the villages. The author has produced and distributed education and awareness materials to villagers and conducted workshops on such issues (see Kinch 2001b).

Currently, the TAC for MBP stands at 140 metric tonnes up from 60 metric tonnes. A compulsory closed season occurs each year from 1 October to 15 December, or when this TAC is reached, and this is in line with the knowledge of spawning seasons in the western Pacific. These dates are taken from spawning research in other parts of the Pacific. The figure of 60 tonnes was based on export data that was assessed by NFA in 1997. An issue for NFA — who has responsibility for enforcing the TACs and the beche-de-mer fishery in MBP — is that the TAC has been continuously exceeded in recent years. For example, the TAC set for MBP in 2000 was 60 metric tonnes, but records show that nearly 184 metric tonnes were exported. In 2001, the TAC was set at 140 metric tonnes and nearly 210 metric tonnes was exported. All of this adds pressure on beche-de-mer stocks for future harvesting and is an obvious area for better enforcement of exporters.

Overall, enforcement of previous management plans has been poor in MBP. Previously, the National Fisheries Inspector was alleged to be corrupt (see Timothy 2000) and Provincial Fisheries Inspectors, given new rights under the devolution of power under the Organic Law, are for a variety of reasons unable to do checks of field purchasing practices. Capacity building and training should be provided for these officers to be able to fulfil their functions adequately. There is also a need for greater transparency within the business sector that deals with exporting beche-de-mer.

Illegal activities

Illegal harvesting of beche-de-mer continues to be a problem in MBP despite NFA regulations. Harvesting in the closed season is particularly evident from the Engineer Group year after year (Jaymes 2000b, 2001a), and throughout the course of the stock assessment it was observed that most communities ignored the closure. It has also been reported that fishers sold to a local businessman who kept the processed beche-de-mer until the closure ended, and then sold to a major exporter.

Illegal buyers sponsored by foreign citizens in National Capital District were a problem in 2000 for MBP and there were consistent illegal exports of beche-de-mer products (see Post Courier 2000). This problem is still an issue and recently NFA stated that there was widespread trading of beche-de-mer in the provinces but that NFA was unable to control them (Dau 2001). Surveillance in the closed season by PFA is difficult due to financial constraints and vast distances. This is complicated by a lack of understanding of their rights under the Organic Law, as some previous national functions have been devolved to the provincial level. One major issue of smuggling activities is that there are no official records, which has serious implications for the enforcement of the TAC.

Finally, there are constant reports and allegations of a local businessman who uses hookah gear to harvest beche-de-mer. Under previous and current beche-de-mer management plans the use of underwater breathing apparatus (i.e. hookah or scuba) and the use of underwater lights or surface lights to harvest beche-de-mer at night is banned. Recently, two of the three hookah gears belonging to a local businessman were confiscated. The people caught using this equipment are now awaiting trial.

Resource management projects

To conserve the marine environment and to provide sustainable incomes, village livelihoods must maintain or enhance village capabilities and assets, and provide livelihoods opportunities for future generations. A variety of NGOs and donors, are attempting to assist communities to integrate conser-

vation, management and development at the local level. These include the Asian Development Bank's Coastal Fisheries Management and Development, the Australian Maritime College in collaboration with the National Research Institute, and the Milne Bay Community-Based Coastal and Marine Conservation Program (CMCP), which consists of multiple partners, including CI, the United Nations Development Program, the Global Environment Facility, and all levels of the provincial and national government.

Management regimes developed by communities, with or without the assistance of the above programmes, can be recognised by NFA under Section 30 of the Fisheries Management Act, 1998, though any traditional open seasons that are inconsistent with those set out under the National Management Plan for beche-de-mer are prohibited.

Traditional management

Throughout MBP, the practice of closing reefs or fishing grounds is/was carried out for a certain length of time following a death. After a period of several months to several years the area is reopened and people can once again access that area for harvesting. People are well aware of the benefits of such reef closure in resource regeneration and a modified version of this practice offers the most culturally appropriate way to introduce resource management in MBP.

Criticism levelled at closure systems are that they are not effective or efficient for fishery management. This is because each time the closure is lifted and there is a harvest, the removal of most or all of the spawning stock occurs. This means that all new recruits have to come from elsewhere, unless the closure has been left on for long enough that the population is actually starting to self-seed a bit (depending on local currents), and there is a population of (possibly cryptic) pre-recruits that is larger than before (Foale pers. comm.). Also, if there is a heavy economic pressure a closed season does not work well. There is a need for the CMCP to link modified traditional closures with awareness raising and extension work on quotas, and/or size limits. Once people understand the relationship between husbanding breeding stocks and increasing the rate of recruitment (and thus yields), then they can start to use closure systems effectively.

Resource owner associations

Numerous resource owners associations have been started over the last couple of years, expressly to address concerns for proper management of their marine resources and to have a voice against the actions of exporters and buyers. The Woodlark Islanders decided to set up the Woodlark Island Fishermen's Association in June 2000 to protect against the overexploitation of the island's marine resources (Jaymes 2000a). The leadership of this organisation was also instrumental in the development of the Milne Bay Resource Owners Association (MBROA) in March 2001.

According to its constitution, MBROA plans to facilitate and conduct training programmes to educate its members to apply sustainable management to their resources and to acquire an export license to gain maximum benefits for the villager. MBROA's concerns were the failure of the government to assist the resource owners to develop their resources and to improve their livelihoods, and the prospect of the Milne Bay Provincial Government getting the third license for beche-de-mer export. MBROA stated that the government does not have effective control over the exporters whose prime interest was to make fast money (Jaymes 2001a). There was also a call to abolish the existing Fisheries Management Consultative Working Group (FMC) because of unfair representation. It was believed that the current members abused their responsibilities and exploited their island communities (MBROA 2001; also see below). MBROA is now in the process of registering itself as a formal organisation.

Other resource owner associations that have been developed with similar goals and objectives include the Engineer Islands Resource Owners Association, the Yealeamba Resource Owners Association, and the Deboyne Islands Development Association.

The Provincial Fishery Management Committee and industry concerns

The year 1998 saw the beginning of FMC, the forerunners of the Provincial Management and Advisory Committees (PMACs). The FMC for MBP formally sat at the end of 2000 and in 2001 (see below for issues). The National Management Plan now encourages the provinces in forming PMACs that will advise the National Management and Advisory Committees (NMAC) on provincial management arrangements.

A Beche-de-mer Management Consultative Workshop was held in September 2000 to re-evaluate the Milne Bay Beche-de-mer Management Plan 2000 by gauging views and submissions from stakeholders, developers and provincial authorities to ensure that the benefits of the beche-de-mer industry were shared in an equitable manner. At

another public meeting in December 2000, resource owners alleged that there was mass corruption in the newly appointed FMC as all members had interests tied up with one of the exporting companies. The people claimed that the board made decisions to protect their own interests and had left the islands undeveloped regardless of the long span of time spent in their mobile operations (Jaymes 2001b). It was also alleged that one of the exporting companies had substituted their own version of the management plan to the Provincial Executive Council (PEC) and had been distributing these to communities, particularly in the Engineer Group, which caused alarm amongst some resource owners.

At the second FMC meeting held in January 2001 (the first meeting being for the discussion of sitting fees) it was proposed by one of the Director of a major exporting company to impose a six per cent levy on beche-de-mer produced for each local level government (LLG). Each LLG was to be allowed four buyers. LLG functions would include establishing measures to settle disputes over ownership, monitoring and reporting unlicensed buyers, and reporting illegal fishing activities (Inuwai 2000). NFA later informed the FMC that it did not have the power to collect any such tax as the beche-de-mer fishery is covered by National legislation and functions and the idea was abandoned.

The third FMC meeting was held in March 2001. At this meeting it was proposed by the Director of one a major exporting companies and seconded by the Chairman that the stock assessment be organised immediately and the author took responsibility for this to happen. The same Director then moved that Milne Bay Properties, the business arm of the MB Provincial government pursue the avenue of obtaining an export license (Eastern Star 2001). Concerns were later raised with the PEC when it was alleged that Milne Bay Properties were to purchase 50 per cent shares of a company called Samarai-Murua Exports, which was held under the name of a local businessman who is associated with one of the major exporting companies. Later, the NFA stated that Milne Bay Properties would not get the license because government involvement in commercial enterprises has proven to be unsuccessful in the past and NFA would be reluctant to give a government owned entity an export license, and again the idea was abandoned.

A final beche-de-mer forum was later held in Alotau on in June 2001 just before the closure to discuss the seasonal closure and what the chairman was going to do to rectify the apparent misrepresentation in the makeup of FMC. Coinciding with the closure of the beche-de-mer season last year, FMC was disbanded and new nominations should now be brought forward for membership of PMAC. PMAC did not sit in 2002.

Conclusion

Management of the beche-de-mer fishery in MBP is required in order to achieve sustainable levels because it provides the only realistic, self-generated source of cash to island and coastal communities. It is therefore important to establish sustainable management systems with supporting policy incentives to ensure that commercially valuable species do not become extinct. Because beche-de-mer stocks are under increasing pressure from overfishing, some immediate steps need to be taken to limit the effort exerted on the stocks as a loss of income and depletion of future stocks through the indiscriminate collection and subsequent rejection of undersized beche-de-mer will cause dire social problems.

Management strategies that could be tested include the following: having TACs set at the LLG level, species specific TACs or total closures for certain species with low abundance. Resources need to be allocated for awareness and capacity building at the village level for management of these valuable resources. This would include extension and training materials on processing and appropriate harvesting methods; village awareness of overfishing on resource sustainability; the possible incorporation of traditional closed seasons or areas (the best means of policing closed areas may be through village involvement) and limited entry. Effective monitoring is necessary to prevent overexploitation and depletion of beche-de-mer resources and further study is required on models of resource extraction. There is a need to continue stock assessments; monitor active fisheries and recovery rates; apply proper enforcement of recording of data; provide empowerment and support for fisheries inspectors and monitoring of overseas market. Finally, the potential for hatchery and re-seeding programs should be investigated. Undoubtedly, there are major requirements for immediate reform in order to establish a sustainable fishery and improvement of this important industry.

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About the author

Jeff Kinch began his PhD thesis in 1997 with the University of Queensland, Australia on the investigation of property and tenure rights, marine resource management regimes, and livelihood strategies on Brooker Island in the Louisiade Archipelago of the Milne Bay Province, Papua New Guinea. He has been employed by Conservation International since early 2000, first as the Social Feasibility Expert and currently as the Community Development and Artisinal Fisheries Specialist on the United Nations Development Program's Milne Bay Community-based Coastal and Marine Conservation Program in Papua New Guinea.

Appendix A. PNG beche-de-mer exports 1960–2001*

Year	Quantity (kg)	Price in Kina	Reference
1960	1,623.00	-	Lindholm 1978
1961	2,400.00	-	Lindholm 1978
1962	4,448.00	-	Lindholm 1978
1963	12,845.00	-	Lindholm 1978
1964	6,295.00	-	Lindholm 1978
1965	4,092.00	-	Lindholm 1978
1966	4,413.00	-	Lindholm 1978
1967	10,468.00	-	Lindholm 1978
1968	11,183.00	-	Lindholm 1978
1969	12,401.00	-	Lindholm 1978
1970-71	6,527.00	-	Lindholm 1978
1971-72	3,872.00	-	Lindholm 1978
1972-73	9,869.00	-	Lindholm 1978
1973-74	4,068.00	7,041.00	DFMR n.d.
1974-75	1,214.00	2,590.00	Lindholm 1978; DFMR n.d.
1975-76	1,665.00	4,470.00	Lindholm 1978; DFMR n.d.
1977	5,325.00	13,297.00	Lindholm 1978
1978 (Jan-Apr)	5,903.00	-	Lindholm 1978
1979	1,300.00	4,000.00	DFMR 1979
1980	2,351.00	7,445.00	Wright 1986 cited in Kailola with Lokani n.d.
1981	11,090.00	25,966.00	Wright 1986 cited in Kailola with Lokani n.d.
1982	22,960.00	73,409.00	Wright 1986 cited in Kailola with Lokani n.d.
1983	7,630.00	23,938.97	Lokani and Kubohojam n.d.; Lokani 1990
1984	4,668.00	13,472.49	Lokani and Kubohojam n.d.; Kailola with Lokani n.d.; Lokani 1990
1985	19,491.00	58,192.00	Lokani and Kubohojam n.d.; Lokani 1990
1986	119,376.00	361,336	Kailola with Lokani n.d.
1987	192,055.00	591,009.22	Lokani and Kubohojam n.d.; Lokani 1990
1988	202,789.00	801,770.13	Lokani and Kubohojam n.d.; Lokani 1990
1989	194,896.00	1,146,584.85	Lokani 1990
1990	238,923.00	-	Lokani and Kubohojam n.d.
1991 (Jan-Aug)	626,047.50	4,637,807.43	Lokani and Kubohojam n.d.
1992	655,462.00	4,993,123.00	Myint 1996
1993	499,489.46	3,044,843.86	Myint 1996
1994	208,795.70	-	NFA database
1995	444,747.00	4,491,037.71	Myint 1996
1996	586,201.80	7,872,385.78	NFA database
1997	505,402.40	7,683,437.15	NFA database
1998	678,848.85	16,892,866.13	NFA database
1999	394,682.45	11,023,884.90	NFA database
2000	607,311.06	16,311,191.35	NFA database
2001	482.281.40	17,196,625.33	NFA database

Note: This table is to be used as a guide only. All data supplied by the NFA database may be incomplete as the database is still under development and all entries may not have been included yet.

* When several sources of data were available, the highest figure was used.

Trepang exploitation in the Philippines: Updated information

Akamine Jun[1]

Introduction

The trepang, or dried holothurian, market is almost exclusive to Chinese culture. It has been a major export commodity from Japan and Southeast Asia to China for at least 300 years. Interestingly, no trepang is consumed by the producers. It has been developed as an export-oriented commodity from the beginning, and the market plays an important role in holothurian resource management.

Since 1997, I have been conducting field research as an ecological anthropologist on marine resource exploitation, its trade networks, human flows, and social changes in a community in the southern part of Palawan Island.[2] Every September or October I examine trepang market prices from a leading middleman in Puerto Princesa City. This is one of the most active trepang entrepôts in the Philippines. This article has two objectives. One is to share current trepang trade data with other researchers who are interested in holothurian studies, and the other, is to encourage further research in trepang consumption and production.

Trepang exports from the Philippines

Trepang appeared in Philippine trade statistics in 1970 for the first time since World War II. Export statistics from 1970 to 2000 are illustrated in Figure 1. Not less than 80 per cent of the quantity has been exported to Hong Kong.

In 1970, the Philippines shipped only 12 metric tonnes (t) of trepang, which increased to nearly 100 t in 1976, 226 t in 1977 and as much as 647 t in 1978. Between 1978 and 1982, the Philippines annually exported more than 500 t with the exception of 1979. Surprisingly, the Philippines has maintained a 1000-tonne export level since 1983, a level achieved only by the Philippines and probably Indonesia.[3]

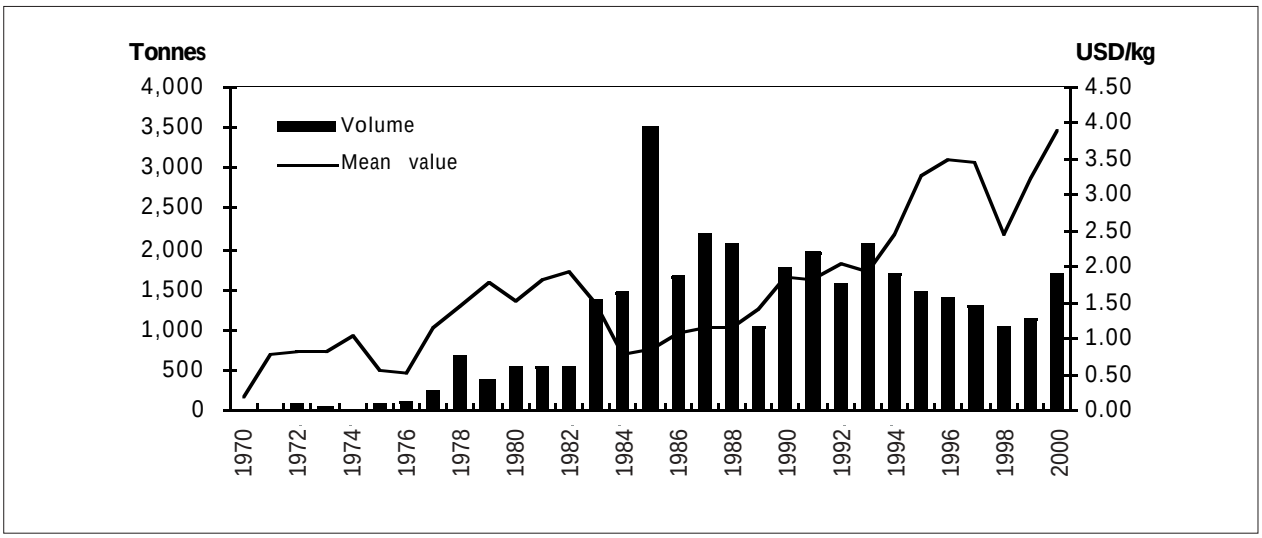

Figure 1. **Volume and mean value of trepang exports from the Philippines, 1970–2000**

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2. The main portion of the data used in the present paper was collected during fieldwork in the Philippines in July 1997, July to October 1998, August to September 2000, and September 2001. At the time of the research, USD 1.00 equaled to: PHP 29 in 1997, PHP 44 in 1998, PHP 40 in 1999, PHP 45 in 2000 and PHP 51 in 2001 respectively.

3. According to the FAO Yearbook of the Fishery Statistics, in 1988 Indonesia and the Philippines were the two largest exporters of trepang in the world. In that year, both countries shared 44.4 per cent of the total volume traded. Both exported more than 1000 t for the first time in 1983 and have maintained this level. According to available statistics, Indonesia reached peak production in 1988. Unfortunately, Indonesian statistics are not available beyond 1988 and only a few studies have dealt with Indonesian trepang fishing, which makes it difficult to compare the Indonesian trepang industry with that of the Philippines (see Vail and Russell 1989; Tuwo and Conand 1992, 1996; and Moore 1998 for Indonesian trepang information).

In 1985, the Philippines reached its peak production of 3499 t worth almost 3 million US dollars. After that year the export volume decreases, especially in 1989 with 1022 t and in 1998 with 1040 t, marking the lowest export volume. However, the export volume seems to be recovering and was 1692 t in 2000. Interestingly, the average price per kilogram since 1984 has increased except for a sharp drop in 1998. According to Philippine trepang exporters, this drop was due to one of the heaviest floodings of the Yangtze River. That flood in southern and central China, from June to September, was so severe that even a 30 per cent depreciation of the Philippine peso against the US dollar, which normally helps exports, did not help in maintaining the level of exports.

One of the exporters in Manila said he had a lot of trepang stock in September 1998, especially over 40 t of 'legs' (*Thelenota anax*), and he had to control his stock by discontinuing purchases and down-pricing for a while. Thus, we understand that there is a strong economic relationship between the Chinese market and Philippine production.

Trepang trade networks in the Philippines

Of the 1200 holothurian species known today, there are at least 24 commercially exploited species in the Philippines (Table 1). Of those identified, almost half belong to the genera *Holothuria*. Other genera traded in the Philippines are *Actinopyga*, *Bohadschia*, *Stichopus* and *Thelenota*.

Almost all the islands in the archipelagos produce trepang. Among them, Zamboanga City in Mindanao and Puerto Princesa City in Palawan are the largest entrepôts in the Philippines (Trinidad-Roa 1987).

There are four major trepang exporters in the Philippines (Schoppe 2000), all of whom are Chinese-Filipino, who also deal with other dried marine products such as sharks fin and dried sea horse. The main market for these is China as well.[4] All of the exporters have close business ties with wholesale importers in Hong Kong and, for some, in Singapore. They have branches or agents in other parts of the Philippines (henceforth, called A, B, C and D). The exporters A, B and C have their branches in Puerto Princesa City (shown as middlemen A', B' and C' in this paper). Strong business ties exist between exporter D and the middleman D' in Puerto Princesa City.[5]

The purchasing value of the four middlemen remains competitively similar. They prepare the price list for the price inquiry from their customers, on which Table 1 is based. Generally, larger trepangs with a thick body wall are preferred. The prices listed are for well dried and well-shaped top-quality specimens.

Trepang is further categorised into three classes according to size. Only *Holothuria scabra*, *H. fuscogilva*, and *H. nobilis* are classified by individual weight, which is estimated by hand. The second type of classification is related to length, as measured against one's middle finger. Less valuable species are not classified either by weight or length. For weight and length, clothing size classifications — XL, L, M, S, and XS — are employed. The common categorisation uses a quartile classification. Only the top two most valuable species have five levels of classification. Three categories are used to classify *lawayan* (13) and *H. atra*, while two are used for *H. edulis*.

In addition to the categories indicated in the list, there is a common practice of categorising those considered as 'reject' or 'class B' in real transactions. Wet, ill-shaped, or half-cooked product is classified as 'reject', and is valued at about 40 per cent of the maximum price. However, not all species are categorised this way. Of the 15 purchase receipts from middlemen A', B', and C', only *H. fuscogilva*, *H. nobilis*, *H. scabra*, *Stichopus hermanni*, *S. horrens* and *Actinopyga* spp., all of which are expensive species, have the 'reject' category.

Trepang price changes in the Philippines

Table 2 shows trepang price changes from 1998 to 2001. Two trnds are dicernable from the table: commercial species expansion and decreased prices after September 2000.

Between October 1999 and September 2000, *patola red* (16) and *patola white* (24) became newly classified. They were formerly classified as just *patola* (19). Surprisingly, two species *hudhud payat* (10) and *lawayang Hong Kong* (12) gained new commercial value after September 2000.

There is quite a difference in price among the three *patolas* and it is reasonable to differentiate them. However, the price differences of *hudhud* (9) and its sub-classified *hudhud payat* and those of *lawayan* (13) and *lawayang Hong Kong* are not considerable.

4. A major exporter branch in Puerto Princesa City bought 12 t of dried trepang, sharks fin, dried sea horse and shells during the month of September 1999, which had a value of 5 million pesos, equivalent to USD 125,000.
5. Aside from the major middlemen who affiliate with the exporter in Manila, there are innumerable small-scale trepang buyers in Puerto Princesa City, locally called 'buy-and-sell', who resell their stock with a little margin to the major middlemen in the city.

Table 1. Trepang names and prices in Puerto Princesa City (per kilogram)

No.	Vernacular name	Scientific name[1]	Size assesment		Size	Price per kg	
			Weight[2]	Length[3]		PHP	USD[4]
1	putian	*H. scabra*	15		XL	1,900	37.3
			20		L	1,500	29.4
			40		M	1,100	21.6
			60		S	700	13.7
			80		XS	650	12.7
2	susuan	*H. fuscogilva*	3-4		XL	1,800	35.3
			5-6		L	1,700	33.3
			7-8		M	1,100	21.6
			8-10		S	800	15.7
			11-15		XS	500	9.8
3	buliq-buliq	*Actinopyga* spp.		3" up	L	1,100	21.6
				2.5"	M	800	15.7
				1"-2.5"	S	600	11.8
				(<1")	XS	400	7.8
4	hanginan	*S. horrens*		3.1" up	L	1,100	21.6
		S. hermanni		2.5"-3"	M	800	15.7
				2"-2.5"	S	600	11.8
				(<2")	XS	300	5.9
5	bakungan	*H. nobilis*	5-6		L	1,000	19.6
			7-8		M	900	17.6
			8-10		S	700	13.7
			11-15		XS	500	9.8
6	katro kantos	*S. chloronotus*		na		1,000	19.6
7	tinikan	*T. ananas*		na		700	13.7
8	khaki	*A. mauritiana*		3" up	L	650	12.7
				2.5"	M	450	8.8
				1.5"-2.5"	S	280	5.5
				1"-1.5"	XS	120	2.4
9	hudhud	*A. echinites*		na		650	12.7
10	hudhud payat*	?				450	8.8
11	leopard	*B. argus*		na		420	8.2
12	lawayan Hong Kong*	*Bohadschia* sp.		na		320	6.3
13	lawayan	*Bohadschia* spp.		4" up	L	300	5.9
				2.5"	M	270	5.3
				(<2.5")	S	170	3.3
14	red beauty	*H. edulis*		na	L	240	4.7
					S	200	3.9
15	white beauty	?		na		230	4.5
16	patola red**	?		na		230	4.5
17	brown beauty	?		na		220	4.3
18	black beauty	*H. atra*		5" up	L	200	3.9
				4"-5"	M	120	2.4
				2"-4"	S	80	1.6
19	patola	*H. leucospilota*		na		200	3.9
20	legs	*T. anax*		na		190	3.7
21	sapatos	*H. fuscopunctata*		na		140	2.7
22	bulaklak	*B. graeffei*		na		90	1.8
23	patola white**	?		na		20	0.4
24	labuyuq	?		na		20	0.4

Source: Price list of Exporter A (as of September 2001)

1. A, B, H, S and T in the *Scientific name* column are genera *Actinopyga, Bohadschia, Holothuria, Stichopus* and *Thelenota,* respectively.
2. The nominal number of individuals needed for one kg; this is assessed by weighing each specimen by hand.
3. Assessment in relation to length of middle finger. The brackets indicate figures inferred by the author. Not applicable (na) indicates the size was not assessed.
4. At the date of research, USD 1.00 ≈ PHP 51.00.

* Did not appear in the September 2000 list

** Did not appear in the October 1999 list.

Table 2. **Changes in trepang prices in Puerto Princesa City 1998–2001 (USD/kg)[1]**

No.	Vernacular name	Scientific name	Size assesment		Size	Price (USD/kg)			
			Weight[2]	Length[3]	label[4]	1998	1999	2000	2001
1	putian	*H. scabra*	15		XL	29.7	35.0	36.7	37.3
			20		L	22.8	27.5	31.1	29.4
			40		M	16.0	18.8	24.4	21.6
			60		S	9.1	11.3	16.7	13.7
			80		XS	6.9	8.8	12.2	12.7
2	susuan	*H. fuscogilva*	3-4		XL	21.7	30.0	35.6	35.3
			5-6		L	20.5	27.5	34.4	33.3
			7-8		M	17.1	22.5	26.7	21.6
			8-10		S	12.6	15.0	17.8	15.7
			11-15		XS	9.1	12.5	12.4	9.8
3	buliq-buliq	*Actinopyga* spp.		3" up	L	14.8	20.0	24.4	21.6
				2.5"	M	10.3	13.8	15.6	15.7
				1"-2.5"	S	8.0	11.3	11.6	11.8
				(<1")	XS	5.7	10.0	10.4	7.8
4	hanginan	*S. horrens*		3.1" up	L	12.6	20.0	21.1	21.6
		S. hermanni		2.5"-3"	M	9.1	12.5	14.4	15.7
				2"-2.5"	S	6.9	10.0	11.6	11.8
				(<2")	XS	4.1	6.3	6.7	5.9
5	bakungan	*H. nobilis*	5-6		L	14.8	17.5	26.7	19.6
			7-8		M	12.6	15.0	22.2	17.6
			8-10		S	10.3	11.3	17.8	13.7
			11-15		XS	9.1	8.8	11.1	9.8
6	katro kantos	*S. chloronotus*			na	16.0	18.8	23.3	19.6
7	tinikan	*T. ananas*			L	10.3	13.3	14.4	13.7
					S	-	-	10.0	-
8	khaki	*A. mauritiana*		3" up	L	8.2	11.3	14.4	12.7
				2.5"	M	5.0	7.5	11.1	8.8
				1.5"-2.5"	S	3.7	6.3	8.0	5.5
				1"-1.5"	XS	2.3	3.0	4.0	2.4
9	hudhud	*A. echinites*			na	9.6	11.3	15.6	12.7
10	hudhud payat	?			na	-	-	-	8.8
11	leopard	*B. argus*			na	5.3	7.0	8.4	8.2
12	lawayan Hong Kong				na	-	-	-	6.3
13	lawayan	*Bohadschia* spp.		4" up	L	3.7	5.5	6.9	5.9
				2.5"	M	2.7	5.0	6.2	5.3
				(<2.5")	S	1.8	3.0	4.0	3.3
14	red beauty	*H. edulis*		?	L	2.3	3.3	5.3	4.7
				?	S	-	-	4.9	3.9
15	white beauty	?			na	2.5	4.0	5.6	4.5
16	patola red	?			na	-	-	5.6	4.5
17	brown beauty	?			na	2.3	3.3	5.3	4.3
18	black beauty	*H. atra*		5" up	L	2.5	4.0	5.3	3.9
				4"-5"	M	1.6	2.1	3.1	2.4
				2"-4"	S	0.7	1.0	2.2	1.6
19	patola	*H. leucospilota*			na	1.8	3.3	4.9	3.9
20	legs	*T. anax*			na	3.4	4.3	4.9	3.7
21	sapatos	*H. fuscopunctata*			na	1.8	2.8	2.9	2.7
22	bulaklak	*B. graeffei*			na	1.4	2.1	2.4	1.8
23	labuyuq	?			na	0.6	1.0	1.7	0.4
24	patola white	?			na	-	-	0.4	0.4

Source: Akamine (2001) and price list of Exporter A.

1. Prices given by middleman A' in Puerto Princesa City in October 1998, October 1999, September 2000 and September 2001. USD 1 equals to PHP 44 in 1998, PHP 40 in 1999, PHP 45 in 2000, and PHP 51 in 2001, respectively.
2. The nominal number of pieces needed for one kg; this is assessed by weighing the trepang by hand.
3. Assessment in relation to length of middle finger. The brackets indicate figures inferred by the author.
4. Not applicable (na) indicates no size given.

Payat means 'thin' or 'skinny' and *hudhud payat* seems thinner than the ordinary *hudhud*. I have no clear idea what *Hong Kong* denotes but it is a fatty species. The reason for sub-classifying *hudhud* and *lawayang* into two classifications is unknown. According to middleman A', their Manila representative ordered the price changes and species classification and that information would be derived from importers in Hong Kong.

Every year since 1998, a new species becomes popular and gains commercial value (Akamine 2001). However, the value of most species has decreased since 2000. Even though some prices increased, the profit from these species did not increase because of the 113 per cent depreciation of the PHP against the USD between September 2000 and September 2001. Two examples are *susuan* and *tinikan* whose values in PHP increased but whose values in USD decreased. For this reason, it is clear that demand for *putian* and *hanginan* was tremendous because it offset the value of the depreciating PHP.

Furthermore, the observed trend should be examined in a broader perspective. Trinidad-Roa, a marine biologist, reported in 1986 that only 16 trepang species were traded in the Philippines (Trinidad-Roa 1987), with no mention of *red beauty* (14), *white beauty* (15), *bulaklak* (22) and *labuyuq* (23), possibly because they had no commercial value at that time. These four species are of a relatively lower grade, though the new commercial species after September 2001, *hudhud payat* (10) and *lawayang Hong Kong* (12) are relatively valuable species.

Concluding notes

There are no concrete data available to compare market price changes in other trepang producing countries. A comparative study is necessary to understand global expansion of trepang consumption as well as production. For example, there are no precise studies of how trepang is cooked. To my understanding, *H. scabra* and *H. fuscogilva* are the most popular species sold in Hong Kong and Singapore retail markets and cooked at the restaurants; *Actinopyga echinites* is a most popular Shanghai dish; *Actinopyga* spp. is commonly consumed in the Philippines; *Stichopus horrens and S. hermanni* are the most popular species in the Korean market, where they are cooked with shrimp and shellfish meat. This is called '*samsun*' or '*samseon*' in Korea.

The species mentioned above are expensive. How are the cheaper priced species consumed? Some are cooked together with vegetables and meat, sometimes in a hot pot style dish. High value species are used as the main item in a dish while low value species are just one of the many ingredients. In addition, the latter is seldom seen in retail markets. The Philippine trepang industry produces more and more low value species for export and therefore we should look more closely at how those cheaper species are traded and consumed.

Acknowledgements

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Seasonal visceral atrophy and response to salinity by *Parastichopus californicus* (Stimpson): Osmoregulation?

Peter V. Fankboner[1]

Introduction

Autonomy in response to physical or physiological stress is characteristic of many echinoderm species. Expressions of this phenomenon include brachial loss (sea stars and brittle stars) and ejection of the viscera in sea cucumbers. Although evisceration by sea cucumbers has rarely been observed *in situ*, it is a response commonly evoked by holothuroids mistakenly hooked by fisherman, following rough collection, being husbanded in stagnant sea water, exposed to elevated temperatures, or artificially traumatised in the laboratory via electric shock, mechanical pinching, injections of ammonium hydroxide, or strychnine (see Byrne 2001).

Numerous anecdotal observations of evisceration by holothurians *in vitro* have led to the premature conclusion that sea cucumbers also eviscerate in their natural environment, and may do so as a natural response to predation. Presumably, ejected viscera function as a decoy to occupy a predator while the sea cucumber makes an escape (Mottet 1976; Pearse et al. 1987). Direct observations of evisceration occurring in nature are singular. A study by Byrne (1985) reports on seasonal evisceration behaviour occurring *in situ* by the dendrochirotid sea cucumber *Eupentacta quinquesemita*. Seasonal evisceration has been concluded to occur (in the absence of direct observation) for *Actinopyga agassizi* (Mosher 1965), *Parastichopus californicus* (Swan 1961), *Stichopus regalis* (Bertolini 1932), and *Stichopus tremulus* (Jerpersen and Lutzen 1971; Lutzen 1979).

Swan (1961) noted that of the 81 specimens of *Parastichopus californicus* he collected during autumn at Friday Harbor, Washington USA, 49 individuals possessed incomplete visceral organs. During the winter months, however, all of the 70 specimens he examined contained normal and complete viscera. Thus, Swan concluded that *P. californicus* had undergone spontaneous seasonal evisceration. However, when the visceral condition in a population of *P. californicus* was examined monthly over a period of three and more years (Fankboner and Cameron 1985), it was discovered that the gut, respiratory tree, circulatory system and gonad were annually lost as a result of atrophy of these organs (Figs. 1 and 2), and not, as Swan (1961) had concluded, the outcome of spontaneous, seasonal evisceration. Accompanying atrophy of the visceral organs is the expulsion of visceral particulates, parasitic gastropods, parasitic worms, their eggs and parasitic protozoans (gregarines) through hundreds of transrectal (AKA perianal) coelomoducts connecting the coelom with the sea cucumber's cloacal chamber (Fankboner and Cameron 1985; Shinn 1985; Shinn et al. 1990). Atrophied viscera of *P. californicus* regenerate within several weeks following clearance of the coelomic cavity. Metabolites — arising during the atrophy process from the viscera and the body wall — sustain the sea cucumber in the absence of feeding. The latter experiences a 25 per cent reduction in mass during loss and regeneration of the viscera (Fankboner and Cameron 1985). Seasonal shrinking of individual visceral organs has also been reported in *Stichopus japonicus* (Choe 1963; Tanaka 1958; Suguri 1965).

Clearly there are two beneficiaries from the occurrence of seasonal visceral atrophy. Symbionts living within the coelom of the sea cucumber benefit evolutionarily when they (and their eggs) are evicted from the coelom, allowing for new generations of their species to infect *P. californicus*. Parasitic eugregarine protozoans, the umagillid turbellarians *Ozametra* sp. and *Anoplodium hymanae* live within the coelom of *P. californicus* and consume the sea cucumber's intestine and coelomocytes, respectively (Shinn 1985). It is evident that the free-floating eggs of the parasitic gastropod *Enteroxenos bonnevie* (Lutzen 1979) are released from *P. californicus* through these same ducts. Thus, seasonal visceral atrophy provides the host, *P. californicus*, an opportunity and means to replace viscera damaged by coelomic parasites. Although seasonal visceral atrophy occurs over a brief period in the fall, this process may also improve the resistance by *P. californicus* to environmental salinity extremes created by seasonal increases in precipitation. The experiments

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described in this article, test the hypothesis that seasonal visceral atrophy in *P. californicus* reduces the surface area of its tissues exposed to osmotic stress, and by so doing, may improve its resistance to short exposures to autumnal lows in salinity.

Methods

Forty-five adult specimens of *P. californicus* were collected in late August using scuba at depths between 6 m and 10 m adjacent to Croker Island, Indian Arm Fjord, British Columbia (49°20'N, 122°55'W). The sea cucumbers were quickly replaced in saltwater aquaria at Simon Fraser University and acclimatised for one week at a salinity of 25‰ and a constant temperature of 12°C. None of the experimental *P. californicus* fed during the periods of acclimation and the experiments.

Figure 1. ***P. californicus*** **which has ceased tentacular feeding/locomoting and has become soporific. This sea cucumber is undergoing the process of seasonal visceral atrophy.**

Experimental animals were sorted into five replicate groups with each group containing nine specimens similar in size range to the other four groups. At the beginning of each of five experimental series, nine sea cucumbers were individually labelled by anchoring a numbered spaghetti tag (Flow Tag Inc., 4616 Union Bay Place NE, Seattle, Washington USA 98105) through each sea cucumber's body wall. By so doing, the progress of individual sea cucumbers could be followed at 1.5-hour periods throughout the six hours of coelomic fluid sampling. Earlier testing of spaghetti tags in *P. californicus* at Friday Harbor Laboratories, Washington State, USA, indicated that their presence had no significant influence the sea cucumber's behaviour nor did they affect its ability to react to shifts in the salinity of the experimental medium.

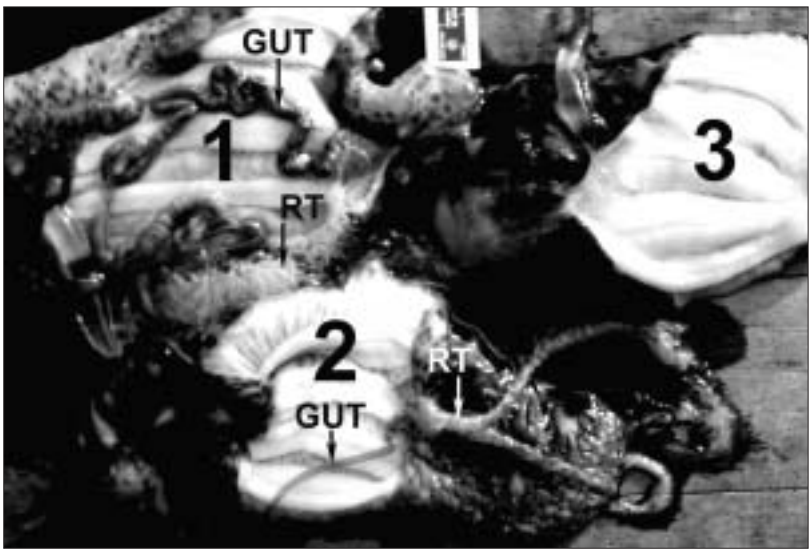

Figure 2.

Three specimens of *P. californicus* that have been dissected to reveal the condition of their visceral organs.

1: ***P. californicus*** **which has normal viscera. The gut (GUT) is filled with food; respiratory trees (RT) complete.**
2: **The empty gut (GUT) in the specimen of *P. californicus* has become shrunken, and brittle in the course of the early phase of seasonal visceral atrophy; the respiratory trees (RT) in this preparation have been partially resorbed.**
3: **Completed visceral atrophy in *P. californicus*.**

Each replicate of nine sea cucumbers was placed in a separate 250-litre aquarium and processed on sequential and separate days. At the beginning of each test series, dechlorinated fresh water was added to resident sea water in the aquarium until the salinity was lowered from the *in situ* salinity of 25‰ (mixing time ≈ 5 minutes) to sea water representing the minimum salinity 15‰ *P. californicus* might experience during periods of fresh water winter runoff. Next, the volume of sea water in the experimental aquarium was adjusted to equal to its original 250 litres.

Two to three drops of coelomic fluid were extracted from each sea cucumber at 0.0 hours, 1.5 hours, 3.0 hours, 4.5 hours, and 6.0 hours using separate 1.0 ml disposable TB syringes and No. 21 gauge 1.5" needles. Extracts of coelomic fluid were kept ice cold within the syringes and analysed within 15 minutes to

reduce potential errors in measurement of osmotic pressure, which might result from degeneration of the samples. A 10 µl subsample was taken from each syringe and analysed in a Wescor Model 5100B Vapor Pressure Osmometer. Typically, osmotic determinations took less than 1.5 minutes.

The osmotic pressure data for coelomic fluid sampled from each sea cucumber was placed into one of two groups based on the presence or absence (atrophy) of visceral organs in the sea cucumbers. Within the two separate groups, sample data were pooled for individual time periods. After applying light pressure on the body wall to clear the rectal lumen and/or the respiratory trees of sea water, each experimental *P. californicus* was weighed at 0.0 hours and 6.0 hours to ascertain whether the sea cucumbers might experience volume changes of coelomic fluid in response to osmotic stress.

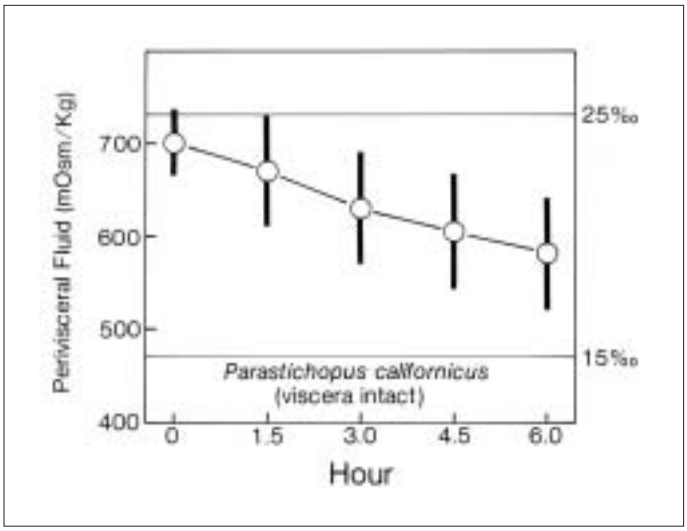

Figure 3. Changes in the osmotic pressure of coelomic fluid of *P. californicus* with intact viscera when transferred for six hours from a salinity of 25‰ to 15‰.

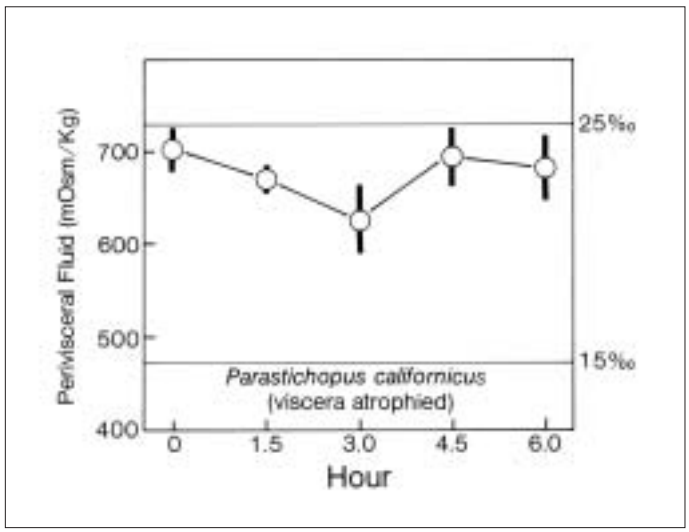

Figure 4. Changes in the osmotic pressure of coelomic fluid of *P. californicus* with atrophied viscera when transferred for six hours from a salinity of 25‰ to 15‰.

Results

The osmotic pressure of the coelomic fluid from *P. californicus* (Fig. 3) with intact viscera fell steadily throughout the six-hour experimental period from 701.23 mOsmol/kg to 581.50 mOsmol/kg. Coelomic fluid from *P. californicus*, which lacked visceral organs (Fig. 4), followed a similar decline in osmotic pressure for the first three hours of the experiment, but rose dramatically to a level nearly that of pre-experimental values by 4.5 hours. Coelomic fluid osmolality in *P. californicus* lacking viscera appeared to stabilise at between 4.5 and 6.0 hours, and at the termination of the experiments had attained a value that was 90 mOsmol/kg higher than sea cucumbers with intact viscera. This recovery of osmotic pressure in the coelomic fluid of viscerally atrophied *P. californicus* to nearly pre-experimental levels suggests that these sea cucumbers possess at least a limited ability to osmoregulate against a declining salinity gradient.

During the six-hour experimental period, body weights increased in both viscerally atrophied (15.3%) and viscerally intact sea cucumbers (29.5%) indicating that volumetric increases occurred in *P. californicus* during the course of the experiments. *P. californicus* with intact viscera increased its body weight during the experimental period by 29.5%, a level of increase that was effectively twice that found in viscerally atrophied sea cucumbers. No doubt this difference could be explained by the presence of viscera in the former, which provided additional pathways (the respiratory trees and the intestine) for osmotic transport of hyposaline water to the coelom than in viscerally atrophied sea cucumbers.

Discussion

The phylum Echinodermata has been characterised by the absence of discrete nephridial organs (Ruppert and Barnes 1994; Hyman 1955). Indeed, it is the inability of echinoderms to osmoregulate (Binyon 1972) that may have inhibited members of this extensive deuterostome phylum (6000 species extant) from invading fresh water and terrestrial environments. There is, however, some evidence that indicates that at least limited resistance to sudden changes in environmental salinity occurs in some echinoderms (Choe 1963; Freeman 1966; Giese and Farmanfarmaian 1963; Pearse 1967; Stickle and Denoux 1976; Stickle and Diehl 1987; Turner and Meyer 1980; Kashenko 2002). In addition, the discovery of a podocyte-lined channel connecting the axocoel to an external pore in both the bipinnaria larvae of the sea star *Asterias forbesi* (Ruppert and Balser 1986), and the auricularia larvae of *Holothuria grisea* (Balser and Ruppert 1993) suggest that organs for osmoregulation could be present in some adult echinoderms.

The results of the experiments described in this paper suggest that coelomic fluid from viscerally atrophied specimens of *P. californicus* loses osmotic pressure for the first few hours at the same rate as *P. californicus* with intact visceral organs. After hour 3, the coelomic fluid of *P. californicus* with intact viscera continues its downward trend, while in contrast, the coelomic fluid in viscerally atrophied *P. californicus* recovers and stabilises to about its pre-experimental level. These data suggest that viscerally atrophied *P. californicus* possess at least a limited capacity for osmoregulation against a lowering in salinity. In viscerally intact *P. californicus*, 15‰ sea water contacting the high surface areas of the respiratory trees and the intestine diffuses easily into the sea cucumber's perivisceral coelom. This incursion of sea water progressively dilutes the 25‰ coelomic fluid until it establishes a 90 mOsmol/kg mean differential with the osmotically stabilised coelomic fluid of viscerally atrophied animals.

There are two pathways for osmotic regulation of the coelomic fluid of viscerally atrophied *P. californicus*. First, the formation of additional particulates in the coelomic fluid would attenuate the effects of brackish water influx, and could maintain the osmotic pressure at pre-experimental levels. There is no evidence, however, to suggest that such an increase in coelomic fluid particulates has occurred in these experiments. A second proposed pathway for viscerally atrophied *P. californicus* to regulate the osmotic pressure of its coelomic fluid would include removal of lower salinity water from the coelomic fluid and ejecting it to the outside medium. One potential metanephridial system that might facilitate osmoregulation of the coelomic fluid in *P. californicus* are the ciliated transrectal duct organs connecting the coelom to the outside medium (see Goodrich 1946; Ruppert and Barnes 1994; Ruppert and Smith 1988; Shinn 1985; Shinn et al. 1990). These ciliated coelomoducts can number in the hundreds in large specimens of *P. californicus* (Shinn et al. 1990), and connect the coelomic spaces near the insertion of the rectal suspensor muscles at the posterior wall of the rectum to the outside at the base of the anal fold. These ducts are located perianally and nominally function in removal of unwanted material from the coelom of *P. californicus* during seasonal visceral atrophy (Dybas and Fankboner 1986; Fankboner and Cameron 1985; Shinn 1985), and are believed to regulate the influx/efflux of the coelom's sea water (Shin et al. 1990). However promising, it remains to be established whether the ciliated transrectal duct organs could also function as osmoregulation organs in *P. californicus*.

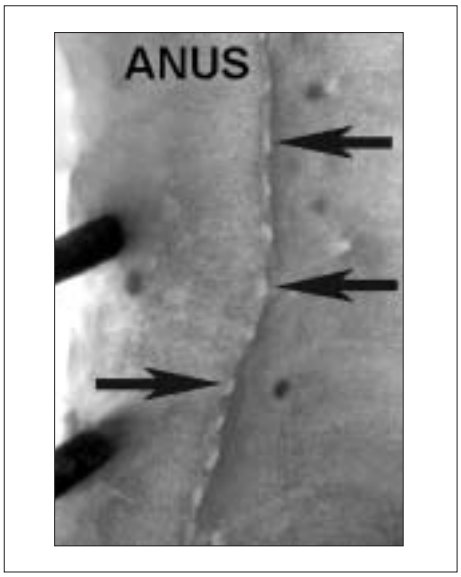

Figure 5. The perianal coelomoducts of *P. californicus*. Arrow points identify the exit openings of these ducts encircling the anus (ANUS), which may number in the hundreds in large representatives of this species.

Acknowledgements

Funding for this research was provided by the Natural Sciences and Engineering Research Council of Canada (Operating Grant A6966), and this is gratefully acknowledged. I also thank Dr Brian Hartwick, Ms Linda Sams, Ms Beth Stevenson and the Friday Harbor Laboratories of the University of Washington for their support.

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Sea cucumbers on La Reunion Island fringing reefs: Diversity, distribution, abundance and structure of the populations

Chantal Conand[1a] and Perrine Mangion[1b]

Introduction

A broken line of coral formations, about 25 kilometres long, are found off the western coast of La Reunion Island in the Indian Ocean. As the island's only reefs, these structures are a few hundred meters wide at most, and have a modest surface area (about 12 km^2). La Reunion's main coral structures are the Saint Leu, Etang-Salé, and Saint Pierre reefs and the Saint Gilles/La Saline reef system; the latter is the most extensive, measuring 9 km. These reefs are very important in terms of natural heritage and tourism and with regards to international, national and regional research. Inventories of the biodiversity of the diverse zoological groups in these coral ecosystems have begun. This needs to be done so that the many types of reef degradation can be monitored, particularly those caused by humans.

Some relatively dated information exists for a few sea cucumber species (Cuet et al. 1989; Naim and Cuet 1989; Semple 1993). In addition, studies have been made on the biology of various sea cucumber populations (e.g. *Holothuria atra, H. leucospilota, Stichopus chloronotus*), particularly the influence of scission on these populations (Conand et al. 1997; Conand et al 1998; Jaquemet et al. 1999; Uthicke et al. 2001; Conand et al. 2002). However, no inventory of species in various biotopes has been made nor has a list of the dominant species and population structures been compiled until this recent survey (Mangion 2002). A synopsis of these data is presented in this paper.

Material and methods

The species inventory was made using a wide range of information and photos taken over the past 10 years, which the authors collected from various people involved in "reef research" on La Reunion.

To get data on dominant sea cucumber species abundance and population structures, we limited ourselves to the Saint Gilles/La Saline reef where sampling was conducted at three sites that our laboratory monitors on a regular basis (i.e. Toboggan (Tb) and Trou d'Eau (Tr)). These sites are considered to be relatively healthy, and Planch'Alizes (Pl) is a site with a high level of eutrophication. At each site, transects were made in two biotopes: the back reef hollow (Station 3) and the inner reef flat (Station 2). The external reef flat (Station 1) will be studied later.

The quadrat method was used for this study. As during previous studies by Cuet et al. (1989) and Semple (1993), a 20 m^2 surface area (2 m x 10 m) was sampled at each station. Counting and weighing specimens was done by going along a 10 m x 1 m corridor in one direction and then sampling another 10 m x 1 m corridor in the opposite direction. These elongated 10 m x 1 m quadrats, located side by side parallel to the beach, were marked using two 50-meter tape measures laid out on the bottom, one meter apart and attached at either end. All the sea cucumbers in the quadrat were counted and weighed. The stations surveyed corresponded to the median zone of each biotope (inner reef flat or back reef hollow) for the study sites.

The quadrats were surveyed during the summer season, from 20 March to 9 May 2002.

Population structures were obtained from live weights, measured on-site during sampling or during additional experiments. Each specimen was weighed using a spring scale and tray. Weight frequency distributions then made it possible to compare population characteristics.

Results

Distribution and abundance

Table 1 lists 17 sea cucumber species collected from or photographed on La Reunion reefs, as well as certain aspects of their distribution and abundance.

Several categories of species became apparent, depending on classification criteria based on: 1) observation frequency (i.e. the number of stations where the sea cucumber was observed in comparison to the total number of stations) and 2) abundance (i.e. species density).

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Table 1. **List of La Reunion Island sea cucumber species with reefs and observation sites. Site where species is: + very rare, ++ quite rare, +++ abundant, ++++ very abundant**

	St. Gilles-La Saline				St. Leu	Étang Salé	St. Pierre	Dominant populations and main biotopes
	Tobog-gan	Planch' Alizés	Trou d'eau	Other				
Actinopyga echinites	++	+	+	Hermitage sea grass bed	+	+	+	outer reef flats at various stations
Actinopyga mauritiana	+	+	+			+	+	outer reef flats and reef front
Bohadschia vitiensis		+	++			+		back reef hollow
Holothuria atra	+	++++	++		+		+	back reef hollow
Holothuria leucospilota	+++	++++	+++		+++		+	mainly inner reef flat; outer reef flat and back-reef
Holothuria pervicax	+			Hermitage sea grass bed				inner reef flat
Holothuria hilla					+	+		inner reef flat
Holothuria nobilis	+	++	+	Outer slope of Cap Homard at 15 m	+			reef flats and outer slope
Holothuria difficilis	+							outer reef flat
Holothuria cinerascens	+			Boucan Canot – Cap Homard – Hermitage sea grass bed				area with heavy wave action
Holothuria sp.1			+					back-reef
Holothuria sp.2	+	+						reef flat
Stichopus chloronotus	+	++	++++	small 15 m deep canyons. 3 basins	++	++	+	back reef hollow, reef flats, outer slope
Stichopus hermanni								
Stichopus horrens		+	+					
Thelenota ananas				Grand Fond, at a depth of 15 m				outer reef flat
Synapta maculata	++	+++	+		++	+	+	back reef and reef flats

Table 2. **Abundance (specimens per 20 m²) for main species, by station and by site, and overall percentages. Stations: 2 inner reef flat, 3 outer reef flat. Sites: Tb Toboggan, Pl Planch'Alizes, Tr Trou d'Eau.**

Station	*Holothuria leucospilota*	*Holothuria atra*	*Synapta maculata*	Total
Tb 2	7	0	0	7
Tb 3	0	0	1	1
Pl 2	20	5	0	25
Pl 3	8	132	1	141
Tr 2	5	1	0	6
Tr 3	3	1	1	6
Total	43	139	3	185
Each species' percentage in comparison to Holothuridea total	23.24	75.13	1.62	100

The first category corresponded to species that were both frequent and abundant. The dominant species were *Holothuria atra, H. leucospilota, Actinopyga echinites, Stichopus chloronotus* and *Synapta maculata.* Detailed information on their characteristics at the Saint Gilles / La Saline reef are given below.

The second category corresponded to those species that were fairly frequent and whose abundance could vary. Sparse populations of *Actinopyga mauritiana* were observed on the outer reef flats on a regular basis.

Holothuria nobilis, which always had white ends on its teats — a problem for its taxonomy as they are black in specimens in the Pacific (Conand 1989) — was also generally a solitary species.

The third category corresponded to species that were fairly rare.

Because *Holothuria pervicax* is beige, and is nocturnal and solitary in its habits, it is difficult to see in the daytime. It is easy to recognise due to its large Cuverian tubules. On La Reunion, it was most often found in seagrass beds or coral rubble areas on the inner reef flat.

Holothuria difficilis is a small cryptic species whose population was fairly dense under boulders. Its Cuvierian tubules are very thin.

Holothuria cinerascens is a medium-size species whose outstanding feature are its dendritic tentacles. It was the only filter feeding aspidochirote found, and was occasionally abundant under boulders where there is strong wave action.

Bohaschia vitiensis was only abundant on a limited part of the back reef at the Trou d'Eau station where it dug down into the sediment.

Individual *Holothuria hilla* specimens were observed near seagrass beds or in the coral rubble.

Stichopus hermanni was rare. The photos come from the outer reef flats at Planch'Alizes.

Stichopus horrens is nocturnal and solitary.

The fourth and final category covered two rare species. *Holothuria* sp.1 was collected on 6 March 2002 in the sediment at the Trou d'Eau back reef and *Hololthuria* sp.2 was photographed twice at the Toboggan and Planch'Alizes stations.

Thelenota ananas is rare on La Reunion's outer reef flats. One specimen was recorded at Grand Fond at 15 m.

Table 2 and Figure 1 show total specimen abundance for the main three species — *Holothuria atra, H. leucospilota* and *Synapta maculata* — at Saint Gilles / La Saline reef along with the relative size of each species group. Certain characteristics did appear.

Table 2 and Figure 1 also show that sea cucumbers are not evenly distributed throughout La Reunion's reefs. In fact, the dominant species that were found during this field survey were widely distributed, depending on the reef zone and sampling site. In general, sea cucumber populations appeared to be particularly abundant at the so-called degraded Planch'Alizes site. In fact, about 90 per cent of the sea cucumbers were recorded from there. A closer look at the data on each species shows that this particular abundance could be explained by the *Holothuria atra* population in the Planch'Alizes back reef. In fact, these specimens accounted for nearly 80 per cent of the sea cucumbers found at the site, all stations combined. Moreover, this population reached a density of 6.6 specimens / m^2. This high density signals a very unique population at the station. In fact, at the inner reef flat station of the same site, the *Holothuria atra* density was only 0.25 specimens / m^2. In addition, no *Holothuria atra* specimens were recorded at either Toboggan or Trou d'Eau during this survey. Calculated densities were on the order of 0.05 specimens / m^2 for both the inner reef flat and the back

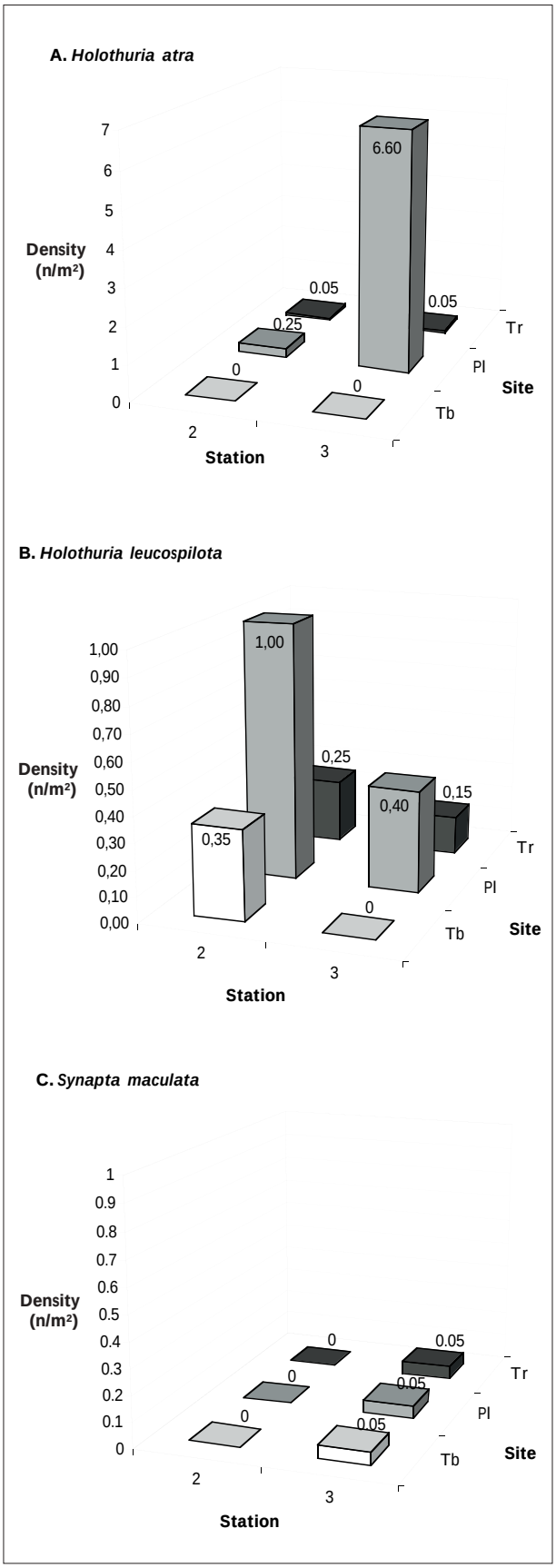

Figure 1. Density of the three dominant sea cucumber species at Saint Gilles/La Saline reef. Stations: 2 inner reef flat, 3 back reef. Sites: Tr Trou d'Eau, Pl Planch'Alizes, Tb Toboggan.

reef hollow (i.e. much lower than those at the Planch'Alizes back reef hollow).

Holothuria leucospilota was another sea cucumber species that was fairly numerous at Planch'Alizes. It was also more abundant on the inner reef flat at this site, where it reached densities of 1 specimen / m^2. This was also the highest density recorded at St. Gilles / La Saline reef for this species. This population appeared to be fairly unusual in that the densities recorded elsewhere were much lower (i.e. from 0 to 0.4 specimens / m^2).

Table 3. **Live weight characteristics of main sea cucumber species at Saint Gilles/La Saline reef. Stations: 2 inner reef flat, 3 back reef; sites: Tr Trou d'Eau, Pl Planch'Alizes, Tb Toboggan.**

Species	Variables	TR 2	TR 3	PL2	PL3	TB2	TB3
Holothuria leucospilota	Mean weight (g)	770	320,5	422,6	341,5	382,1	
	Min. weight (g)	610	142	140	72	250	
	Max. weight (g)	980	500	690	660	500	
	n	4	4	19	8	7	0
Holothuria atra	Mean weight (g)	162	54	110	51		
	Min. weight (g)	162	54	80	6		
	Max. weight (g)	162	54	140	130		
	n	1	1	5	132	0	0
Synapta maculata	Mean weight (g)		500		610		480
	Min. weight (g)		450		610		480
	Max. weight (g)		550		610		480
	n	0	2	0	1	0	1

The fact that *H. atra* had a higher density than *H. leucospilota* can be explained by the smaller size of *H. atra* specimens. Overall, densities for both species were much higher at Planch'Alizes than at other sites. This site seems to be favourable for sea cucumbers, probably because of the high level of eutrophication, which results in a greater availability of organic material resources.

Finally, the species seemed to be distributed differently depending on the reef zone. *H. atra* and *Synapta maculata* were found in the back reef hollow, while *H. leucospilota* was located on the inner reef flat.

Table 4. **Live weight characteristics for the species *Actinopyga echinites* and *A. mauritiana* at Planch'Alizes outer reef flat station (Pl 1)**

Species	Variables	Pl 1
Actinopyga echinites	Mean weight (g)	138.3
	Min. weight (g)	84
	Max. weight (g)	227
	n	13
Actinopyga mauritiana	Mean weight (g)	374
	Min. weight (g)	270
	Max. weight (g)	440
	n	5

Population structures of the dominant species

Table 3 gives the weight characteristics by site and by station for the principal species sampled. Live weight frequency distributions are only shown for *Holothuria atra* (Fig. 2) and *H. leucospilota* (Fig. 3), as the number of specimens from other species was too low.

The structures of the two *Holothuria atra* populations (i.e. the inner and outer reef flat populations), differed greatly in terms of weight frequencies. Specimens from the back reef hollow population were, in fact, much smaller. Their mean weight was half that of the inner reef flat population — going from a modal weight of 51 g for Station Pl 3 to a modal weight of 110 g for Pl 2. The low number of specimens at the other stations where *Holothuria atra* was observed made it impossible to make any comparison with the Planch'Alizes populations.

In contrast to *H. atra*, both *Holothuria leucospilota* populations at Planch'Alizes followed the same weight distribution trend. Modal weights only differed slightly with 422 g at Pl 2 and 341 g at Pl 3, and both curves followed the same trend, with a maximum number of specimens between 300 and 400 g. In the same way, weight frequencies at the Toboggan inner reef flat station had the same shape as previous ones and the modal weight value was also similar. For those reasons, the two different *Holothuria leucospilota* populations seemed to have similar structures.

In addition, the abundance of *Actinopyga echinites* and *A. mauritiana* on the Planch'Alizes outer reef flat justified sampling, the results of which are presented in Table 4. *Actinopyga echinites* was found in the transition zone between the inner and outer

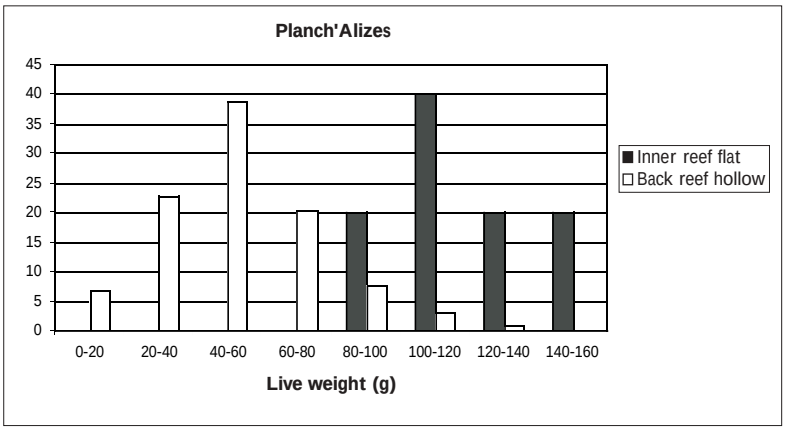

Figure 2. Live weight frequency distributions for *Holothuria atra* at Planch'Alizes site

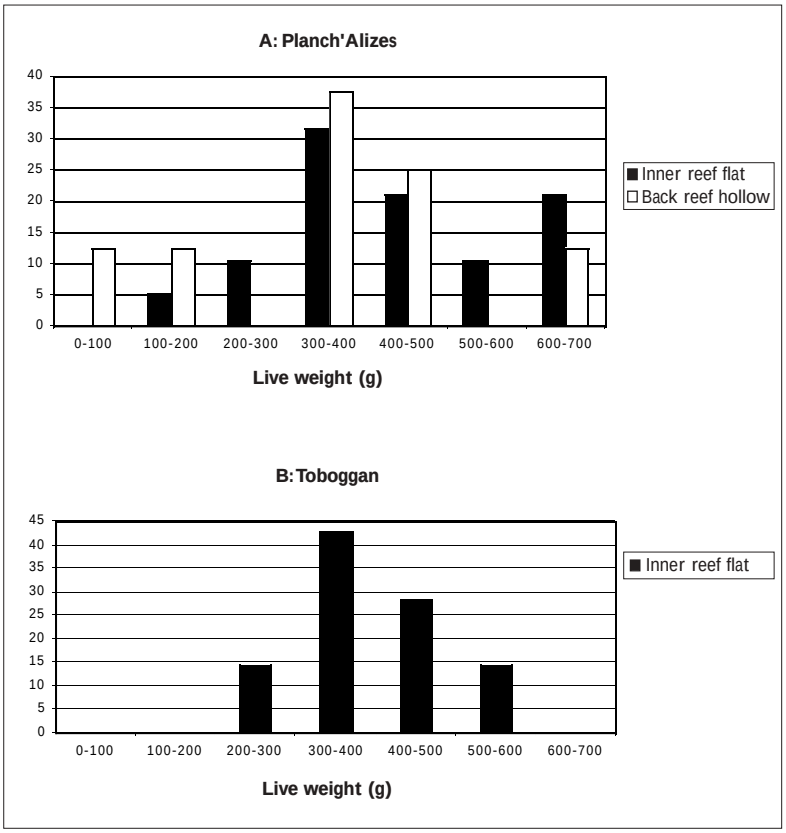

Figure 3. Live weight frequency distributions for *Holothuria leucospilota*: A: Planch'Alizes inner reef flat and back reef B: Toboggan inner reef flat

reef flats, while *A. mauritiana* was found in the surf zone (reef front), where the small starfish *Asterina burtoni* can be found under the boulders (Emeras and Falquet 2002). *A. echinites* was more abundant and smaller (mean weight about 140 g) than *A. mauritiana* (mean weight about 375 g).

Discussion

This initial inventory of 17 species on La Reunion is probably not comprehensive. In particular, no dendrochirote sea cucumbers have been collected yet and small sized species were probably underestimated. In addition, most observations came from the Saint Gilles/La Saline reef, generally on the reef flats and back reef.

For these reasons, the most common species are *Holothuria atra, H. leucospilota, Actinopgya echinites, Stichopus chloronotus* and *Synapta maculata.* They were also the most abundant species. However, frequency and abundance classification can differ. For example, when *H. cinerascens* was observed in the slab or rocks with heavy wave action biotopes, it was abundant. In the same way, *H. difficilis*, a small cryptic species, could be very abundant under boulders on the outer reef flat. It would also be wise to identify the two *Holothuria* species observed recently.

Species ecology generally corresponded to the biotopes occupied elsewhere, as these are all species found throughout the tropical Indo-Pacific region (Conand 1989, 1998).

Species diversity was relatively low, and five of the 17 species were dominant.

The results on abundance obtained here can be compared to existing data for La Reunion (Cuet et al 1989; Semple 1993), which are rare outside of some studies on sexual reproduction and scission in certain populations of *H. atra, H. leucospilota* and *S. chloronotus* (Conand 1996; Conand et al 1997; Conand et al 1998; Conand et al 2002; Hoareau and Conand 2001; Jaquemet et al 1999; Uthicke et al 2001). Semple (1993) presented detailed information on abundance for the same three species — *H. atra, H. leucospilota* and *S. maculata* — using quadrats every 20 metres in radials

going from the shore to the reef front. He gave the results for two sites, Planch'Alizes and Trois Chameaux (TC), a site which is very close to Toboggan and which has the same characteristics. According to his results, there were no *H. atra* specimens at TC, as had already been mentioned by Cuet et al (1989); it was very abundant at Pl and a maximum number were found at 80 m from the shore, corresponding to Pl 3 (i.e. some 110 specimens / m^2). It considerably decreased in numbers toward Pl 2, which is comparable to our data. *H. leucospilota* was found at the various stations studied by Cuet et al (1989) and Semple (1993), as also shown here. The highest density was at Planch'Alizes at about 140 m with 25 specimens / 20 m^2, with numbers decreasing towards the reef front. At TC, the maximum density was at about 120 m with 10 specimens. These densities are very close to those measured in 1997 (Conand et al. 1997) which found a higher density (0.96 specimens / m^2) at Trou d'Eau. The density values for these two species are consistent with those from our study. This relative stability had also been demonstrated on an annual basis for *H. atra* at Pl 3 (Jaquemet et al 1999). *S. maculata* was abundant 60 m from the shore (Pl 3) with 10 specimens / 20 m^2, but the density dropped to two specimens, which is also the TC value (Semple 1993). These values are much higher than those observed here and must be confirmed by a large sampling.

With regards to the population structure of the dominant species at the Saint Gilles / La Saline reef (*H. atra* and *H. leucospilota*), the difference in live weight distributions for *H. atra* between the back reef (modal weight of about 50 g) and reef flat (modal weight of about 110 g) stations confirms Conand's 1996 results and can be correlated to the frequency of scission, a phenomenon that brings about reduced specimen weights and high densities in the back reefs, where rates are high. *Holothuria leucospilota* populations from various stations were, in contrast, very similar. Conand et al. 1997 demonstrated that scission also took place in this species, but this did not seem to affect the various populations at the Saint Gilles / La Saline reef. Unlike *H. atra*, there did not seem to be any major differences between the *H. leucospilota* populations.

Comparisons with other Indian Ocean sites can be made with Madagascar, where diversity is much higher. In fact, Cherbonnier (1988) described 122 species, 47 of which were new to science, and Conand (19998) listed 28 exploited species (i.e. only those which are both large in size and whose populations are dense and readily accessible). Richmond (1997) presented 26 species in his guide to east African coasts and islands. In New Caledonia, Conand (1989) recorded some 49 aspidochirote sea cucumber species and Guille et al. (1986) described 54 species of various orders.

In conclusion, the low level of diversity observed on La Reunion can be linked to the fringing reefs' relatively recent appearance, their reduced size and low level of structure. In fact, habitat size appears to be a primary factor for biodiversity, as has been demonstrated with fish and coral in the tropical Indo-Pacific region (Bellwood and Hughes 2001). However, the high densities of certain populations indicate an important ecological role, which will be assessed in later studies.

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Economic reasons, ecological actions and social consequences in the Mexican sea cucumber fishery

Alonso Aguilar Ibarra[1] and Georgina Ramirez Soberón[2]

Introduction

Increasing attention is being given to the effects of international trade on the environment, especially in situations where biodiversity conservation is opposed to export-led industries such as fisheries. Even many small-scale fisheries are not an exception. When a natural resource represents high revenues to artisanal fishermen, fishing effort rapidly increases and fish stocks become overexploited. This is what Grainger and Garcia (1996) call the 'boom and bust' cycle of fisheries. When an open-access fishery develops, it passes through four phases:

- Undeveloped: the fishery commences and stocks remain under-exploited.
- Developing: the catch keeps on growing and the industry flourishes.
- Mature: the level of captures becomes constant but more and more fishing effort is needed to maintain these levels.
- Senescent: captures decrease in spite of increasing fishing effort. The stocks become overharvested and a number of jobs are put at risk.

Once this cycle finishes, a new fishing ground, a new stock, or a new fishery is developed, and the cycle starts all over again. Sea cucumber fisheries around the globe have gone through this cycle (Conand 1998, 2001). In order to find a solution to this problem, the United Nations organised the 1992 Conference on Responsible Fishing, which

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was held in Cancun, Mexico as a follow-up to the Rio Declaration on Environment and Development. The Mexican government then became committed to protecting marine biodiversity. One of its actions was to impose a total closure for the *Isostichopus fuscus* fishery. In this paper, we present a brief description of how this fishery was constrained by biodiversity conservation concerns, and by the high international price. We discuss as well few recommendations for its management.

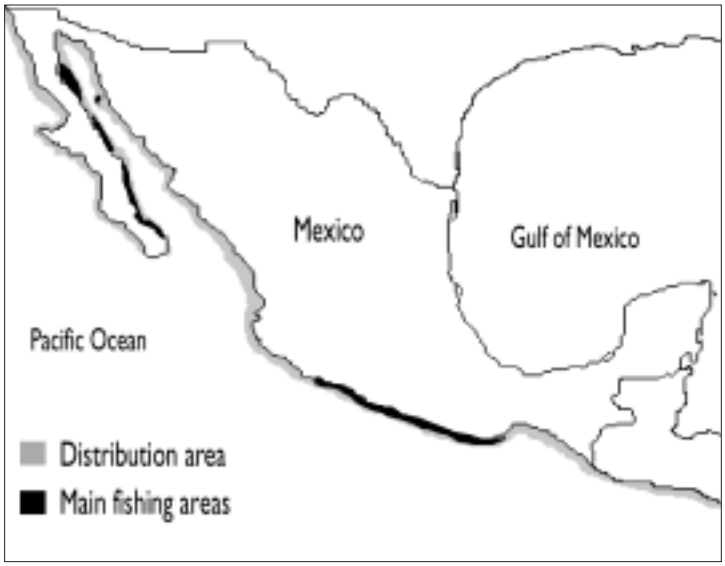

Figure 1. Distribution of *Isostichopus fuscus* in Mexico

The Mexican sea cucumber fishery

The sea cucumber fishery is a small-scale fishery that started in the late 1980s in response to elevated prices in Asian markets, which especially favoured a Mexican species: *I. fuscus*. The international price rose from 11 USD per kilo in 1989 to 25 USD per kilo in 1993 (Fajardo-León and Vélez 1996). Although intermediaries paid a much lower price to fishermen, the latter obtained attractive benefits as their cost of capture was very low. Usually, fishermen process their catch either as whole, gutted and dried, boiled, semi-frozen, or as raw-fresh muscle (Castro 1995). Once processed, they sell the product to intermediaries who export it to California where it is re-exported to the main markets: Hong Kong, Taiwan and Singapore (Conand 1998, 2001).

In only three years, captures in Baja California Sur state — the main fishing area (Fig. 1) — reached an historic high of nearly 2000 t in 1991, decreasing steadily afterwards. The fishery showed typical signs of the fisheries cycle as described above, developing faster than the ability of authorities to implement precautionary management measures. Even when the stage of exhaustion appeared, little information was available, hampering reliable evaluations of population parameters (Reyes-Bonilla and Herrero-Perezrul 2002).

Given that information on the biology of *I. fuscus* was very limited, the real level of abundance was unknown. Consequently, the Mexican government, trying to comply with biodiversity conservation principles, declared this species as threatened with extinction and imposed a total closure to the fishery in 1994. A Mexican legal provision (the official standard NOM-059-ECOL-94) was enacted and published in the Official Diary of 16 May 1994. However, this decision did not take into account that *I. fuscus* is distributed from California to Ecuador, and that Mexican law defines a threatened species as 'a species whose distribution areas or population size have been dramatically diminished, putting at risk its biological viability along its whole distribution range'.

Because fishermen were opposed to such a suddenly-implemented measure, they did not stop fishing, and sea cucumber stocks continued to be exhausted as enforcement costs were prohibitive for the environmental enforcement agency — Profepa. Fajardo-León and Vélez (1996) argue that fishermen were willing to cooperate with scientists and managers in order to preserve stocks and to benefit from the high international price. However, with no controls or monitoring of captures, *I. fuscus* stocks reached a level of approximately two per cent of the original estimated population in Baja California state in 1997, according to the research fisheries agency (INP). It was evident that the permanent closure did not solve the problem of stock depletion.

An experimental approach with the aid of fishermen

Milliman (1986) demonstrated, using certain assumptions, that with illegal fishing, the costs of the transgressors increase as enforcement spending increases. However, in the case of the sea cucumber fishery, officers of Profepa cannot afford to survey the entire area where the fishing takes place. Another option is to distribute the costs of enforcement and surveillance among users. Nevertheless, managing a fishery is not just a matter of costs,

fishermen need to have a feeling of stewardship for the resource (Young 2001). Involving fishermen in both biomass assessments (e.g. the level of the populations) and management measures has been a successful way to deal with several shellfish fisheries in Latin America (Castilla and Defeo 2001). Yet the lack of reliable biomass assessments remains a serious problem. Perry et al. (1999) have proposed an experimental design for sea cucumber fisheries and other sessile organisms. It consists of following the behaviour of the population using known exploitation rates by defining reference areas subject to different levels of harvesting, and leaving one area as a no-take area in order to have a control for allowing further comparisons. Biomass assessment would be made in cooperation with fishermen, discussing with them ways to achieve a certain biomass level.

Assigning territorial rights to fishermen cooperatives could be a complementary option. The idea behind this is that once fishermen have defined sea cucumber fishing areas, they will have an incentive to survey the biomass level and keep it sustainable, thereby reducing the problem of uncontrolled open-access fisheries. Such systems of territorial rights are already applied 'de facto' for lobster fisheries in Mexico (Castilla and Defeo 2001). This may lead to more efforts on mariculture as another good option for stock rebuilding (Gutierrez-Garcia 1999) and, as Conand (1998) puts it, a way for achieving economic sustainability.

It should to be noted that, for carrying out such a management programme, the category of threatened species for *I. fuscus* has to be changed, which would then end the permanent closure, and allow for commercial fishing. In fact, in March 2000, a modification to the official standard (NOM-059-ECOL-94) took place, placing *I. fuscus* as 'species under special protection', authorising scientific monitoring to be carried out by both fishermen and government scientists. Although it can be reckoned as a first step in the right direction, the implementation of cooperative surveys in the harvesting areas has not yet been achieved at a large scale, and the illegal fishing continues.

Final considerations

We described in this paper how export prices for sea cucumbers induce fishermen to overharvest the resource in a short period. However, a drastic measure such as a total closure did not alleviate fishing pressure on stocks. The government chose to protect a species without taking into account other options for fishermen and, except for illegal middlemen, no one was better off. A high export price will continue to be an incentive for illegal fishing, losing valuable information on biomass levels. If fishermen participate in: experimental fishing designs, management measures for enforcement, and commercialisation channels, and have the exclusive access to defined fishing areas, the sea cucumber fishery may become a rewarding activity in economic, ecological and social terms. Participatory management of the sea cucumber fishery in the Galapagos Islands, as described by Martinez (2001), may be a promising example.

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Hatchery research sheds light on problems in sea cucumber aquaculture

Andrew D. Morgan

Hatchery research on the reproductive biology and culture of *Stichopus mollis* has given great insight into some of the problems facing the sea cucumber aquaculture industry. During four months of the reproductive season, some 60 or more spawning trials were conducted, and 300 dissections and 300 biopsies performed. Morphometric measurements were made on 5000 larvae spread across eight replicated experiments. A number of bulk rearing trials of 30,000 to 50,000 larvae each were conducted.

Reproductive behaviour and spawning

Considerable problems in developing hatchery technology for sea cucumbers have stemmed from the fact that it is difficult to control reproduction. A semi-lunar rhythm of reproduction and spawning was found for *Stichopus mollis* over a four-month period, both in a wild population and in captivity. This coincided with the gonad index (body wall weight to gonad weight ratio), which fluctuated depending on when spawning events occurred. Asynchrony between males and females also occurred with the gonad index of one sex often peaking before the other sex every few weeks. However, gonad index was not an accurate reflection of spawning condition.

Animals were collected from the wild every two weeks and held under controlled conditions in the laboratory. In captivity, spawning trials were always conducted at dusk as this was when their natural spawning behaviour occurred. Broodstock were always kept for two weeks, similar to the semi-lunar rhythm of gonad index and reproductive condition occurring in natural populations. Spawning also occurred naturally and with a predictable rhythm in broodstock holding tanks and lasted approximately 45 minutes.

Three spawning trials a week were conducted to determine the pattern of spawning in relation to the lunar cycle. During a trial in which animals spawned the synchrony of spawning was increased to greater than 80 per cent by placing animals in a temperature shock bath about 3–5°C above ambient. Individuals of both sexes often spawned across several days. Some asynchrony in spawning was observed as males often spawned in the days preceding a major spawning event, as did females on occasion.

Reproductive condition and gamete viability

Dissections and wet mounts of gonad tissue under microscopic examination indicated that the reproductive condition of broodstock was similar to that of natural populations. Under macroscopic examination, ripe male gonad often contained a visible lumen as did the female gonad.

Another problem facing the industry is that in a lot of cases the use of temperature shock does not induce large numbers of individuals to spawn. To investigate why this may occur, all individuals collected every two weeks from the wild for spawning trials were biopsied (a strand of gonad was extracted using a hypodermic needle and syringe) and the gonad tissue samples examined microscopically to compare differences in sperm and egg quality between spawners and non-spawners. A section of gonad tissue was also stored for later histological examination.

The index of sperm quality provided an accurate tool for assessing readiness to spawn. Predicting the readiness of females to spawn was more of a problem. With no differences in egg size and often

no difference in the distribution in egg size between spawners and non-spawners, it proved difficult to determine which females would spawn. A bioassay has been developed that may assist in determining the processes occurring prior to a spawning event that are related to ovulation and germinal vesicle breakdown in the oocyte. This will help determine which females are more likely to spawn.

The number of spawned eggs, hatch rate, time of season and the number of competent larvae developing to the feeding stage were all indicators of the quality of larvae spawned from each female. Fertilisation rate (controlled by the researcher) was usually 100 per cent and was not an indicator of larval quality.

Larval development and settlement

Larvae grew and survived through to settlement on fairly low concentrations of algae (600–3000 cells / ml / day). This was in both replicated experiments in 1-litre jars and bulk rearing trials in 100-litre tanks.

The proportion of larvae metamorphosing and settling in jar experiments was variable across different feeding regimes. Overfeeding and starvation had similar effects on larval quality and the ability of larvae to complete the larval cycle.

In bulk tanks, larvae (30,000 to 50,000) were fed 2000 cells / ml / day resulting in about 30 per cent survival through to metamorphosis with 15 to 20 per cent of these completing the transition to the pentacular stage.

Maternal effects on larvae were found throughout development in jar experiments. Egg quality effected larval lifespan, growth, survival and the proportion of larvae metamorphosing. There may be a relationship between maternal origin and the number and size of lipid spheres appearing in the larval arms prior to metamorphosis.

Larval quality and transition to subsequent stages of development was best assessed by measuring elongation of the left somatocoel, number and shape of lateral arms (looping of the ciliated band), growth in total length and the time of appearance and number of lipid spheres.

Conclusions

Two simple conclusions can be stated that directly benefit this industry:

- Always keep individual broodstock separate when spawning them
- Do not overfeed larvae

Never before has such an intensive study of inter-individual variation in reproduction of a single population of sea cucumbers both in the wild and in captivity been undertaken. The results obtained have important implications for both the sea cucumber aquaculture industry and further understanding the life history of aspidochirote sea cucumbers and echinoderms in general.

The processes that occur and contribute to spawning success and the reproductive cycle in populations of sea cucumbers have, until now, been little understood and limited to the study of whole populations and life history theory applied at the level of the population. Understanding the processes and the variation occurring at the level of the individual will greatly expand our knowledge of echinoderm life history.

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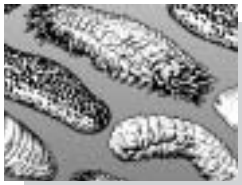

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From: Pr C. Conand (sea cucumber expert), Université de la Réunion, Faculté des Sciences, 15 Ave René Cassin, 97715-SAINT-DENIS Cedex, France

To: A. Bruckner, CITES, NOAA, Silver Spring, Colorado, USA, and C. Shelley, Australia, for R. Gabel US DI Washington, USA.

RE: CITES: sea cucumbers for Appendix II – Reply to request for information

Dear colleagues

I shall first introduce myself as sea cucumber expert following numerous studies in the tropical Pacific and Indian oceans. I am the scientific editor of the Beche-de-Mer Information Bulletin published by the Secretariat of the Pacific Community (SPC), the only publication devoted to world sea cucumber issues (biology, fisheries, markets). It can be found on the web at http://www.spc.int/coastfish.

Recent studies have shown the worldwide overexploitation of most collected species. I believe it is the right time to draw international attention to these resources, but it is important to look in detail at which actions to undertake. I will give here a few personal opinions to help the discussion.

The exploited sea cucumbers are only a few species among the 1200 presently described. Their taxonomy is very difficult and only a few specialists are still working and describing new species even among the exploited ones (see Madagascar and Kenya…) (see references).

As they are often considered in developed countries as 'ugly or exotic', the scientific studies are, therefore, not as advanced as for other marine resources and there is an urgent need for integrated studies.

Exploitations generally occur in artisanal fisheries in the less developed countries. The trade, however, is in the hands of the Chinese, because the processed product is exported to Chinese markets for consumption in Asian countries.

It is very difficult to determine the species from the dried processed product, which is another difficulty for future control. Very few people are capable of identifying even to the genus level at this stage. There are some photos of dried specimens of the main commercial species of the western tropical Pacific in a booklet published by SPC (see references).

Therefore I would recommend:

1) Drawing international attention to this exploitation and trade. I do not know if putting the species on Appendix II is useful for this goal.
2) Drawing attention to the fragility of most stocks based on different biological reasons and increase the poor knowledge on these items.
3) Be cautious on the CITES effects, as these exploitations are bringing money to villagers in many poor countries (there is no need of costly or special equipment) and the trade is very complex (see references). Is there no danger of increasing illegal trade (as in abalone fisheries of South Africa for example)?

I hope that this information is useful to the presently needed discussion. My opinion is that it is important to bring regulations only when we are capable to make them effective.

I enclose a few of my recent references in the following appendix. Many interesting papers are published in the SPC Beche-de-mer Information Bulletin. Any information on the subject is very important and could be included in one of the coming issues. Could you please prepare a short summary and send it by to me by e-mail.

Copy to:

- Geneviève Humbert, Responsable de l'Expertise au MNHN, Autorité scientifique française pour la CITES IEGB/SPN 57 rue Cuvier 75005 Paris France (humbert@cimrs1.mnhn.fr)
- Madame Sylvie Guillaume, Chargée du Bureau de la CITES au MEDD (sylvie.guillaume@environnement.gouv.fr)

APPENDIX: Pr Conand's recent references

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market news
beche-de-mer

Beche-de-mer prices on the Asian markets (May to September 2002)

Species	Size		Indicative price in US$/kg (C&F) May – September 2002					Market area	Origin
			May	Jun.	Jul.	Aug.	Sep.		
White teatfish (skin-on)	3–5 pc/kg	A	26.0	26.0	26.0	23.0	23.0	SE Asian ports	S. Pacific
		B	13.0	13.0	13.0	13.0	13.0	SE Asian ports	S. Pacific
Prickly redfish *(Thelenota ananas)*	6-15 pc/kg		12.0	12.0	13.0	12.0	15.0	SE Asian ports	S. Pacific
Black teatfish	3-5 pc/kg	A	20.0	20.0	22.0	22.0	23.0	SE Asian ports	Australia
		B	12.0	12.0	12.0	12.0	12.0	SE Asian ports	Australia
Sandfish		A	37.0	37.0	37.0	37.0	37.0	Singapore	Indonesia
	10-30 pc/kg		45.0	45.0	45.0	45.0	45.0	Singapore	Australia
	15-40 pc/kg		35.0	35.0	35.0	35.0	35.0	Singapore	S. Pacific
Greenfish *(Stichopus chloronotus)*	50-120 pc/kg		15.0	15.0	18.0	18.0	18.0	Singapore	S. Pacific
Lollyfish			1.5	1.5	1.5	1.5	1.5	Singapore	S. Pacific
Stonefish			14.0	14.0	14.0	14.0	14.0	Singapore	Indonesia
Surf redfish *(Actinopyga mauritiana)*	15-35 pc/kg		10.0	10.0	10.0	10.0	10.0	Singapore	S. Pacific
Tigerfish	25-55 pc/kg		3.0	3.0	3.0	3.0	3.0	Singapore	S. Pacific
Brown sandfish *(Boadschia marmorata)*	25-110 pc/kg		3.0	3.0	3.0	4.0	4.0	Singapore	S. Pacific
Curryfish *(Stichopus variegatus)*	30-50 pc/kg		14.0	14.0	16.0	16.0	16.0	Singapore	S. Pacific
	70-120 pc/kg		8.0	8.0	8.0	8.0	8.0	Singapore	S. Pacific
Elephant trunkfish	3-8 pc/kg		2.0	2.0	2.5	2.5	2.5	Singapore	S. Pacific

Source: *INFOFISH Trade News*
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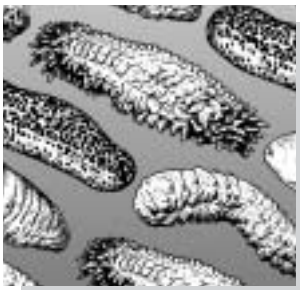

abstracts, publications, workshops & meetings
beche-de-mer

Reproduction and development of *Holothuria* and *Actinopyga* species (Echinodermata: Holothuroidea) from Solomon Islands: Implications for aquaculture

Christain Ramofafia

General abstract of Christain Ramofafia's PhD Thesis

The beche-de-mer fishery that supports the livelihood of many coastal communities in the Indo-Pacific is based on the exploitation of about 20 sea cucumber species belonging to the order Aspidochirotida (Echinodermata: Holothuroidea). Unsustainable exploitation of these species is widespread, and in many countries severe depletion of wild populations is reported. Current management strategies to promote sustainable exploitation are ineffective due to limited human resources. The focus now in many countries in the region, including Solomon Islands, is to artificially culture sea cucumbers and to restore depleted wild populations through the release of juveniles. A major constraint to the successful implementation of restocking programmes is the lack of biological and fisheries data, which are essential for the aquaculture of the most valuable species.

This thesis documents reproduction and development of three tropical aspidochirote sea cucumbers, *Holothuria fuscogilva*, *H. scabra* and *Actinopyga mauritiana.* All three species are commercially important for the production of beche-de-mer, a dried body wall product. Depletion of wild stocks and interest in aquaculture of these species prompted the current investigation of aspects of their biology essential for artificial culture. The study was conducted over a five-year period and represented the first detailed study of holothurians from Solomon Islands.

H. fuscogilva and *A. mauritiana* had annual reproductive cycles while *H. scabra* spawns year-round. Based on the macroscopic appearance of the gonad tubules, reproductive cycles for each species progressed through five maturity stages: indeterminate, growing, mature, partly-spawned and spent. These maturity stages corresponded to discrete stages of gametogenesis identified by histology. *H. fuscogilva* spawned from August through to October with increased spawning activity in October. Spawning in *A. mauritiana* occurred from October to December. In *H. scabra*, a period of enhanced spawning activity occurred from September to November with the greatest activity in September. Histology revealed that gamete release was partial in all three species. In *H. fuscogilva* and *A. mauritiana*, spawning occurred before the maximum gonad indices (GI) were reached. Maximum GI values were variable among months and among years. Once gamete release commenced, the gonads of all three species contained spawned and unspawned tubules. Both these types of tubules were resorbed during the spent stage. Spawning in all three species coincided with longer day length and increased water temperature. Successful induction of spawning during the breeding period in all three species corroborated the GI and histological data. For *H. scabra* and *A. mauritiana*, stress due to transportation or temperature shock was used to induce spawning. Spawning in *H. fuscogilva* required temperature shock and addition of dried algae.

Gametogenesis was initiated in March–April in *H. fuscogilva* and *A. mauritiana* with oogenesis and spermatogenesis occurring in parallel within each species. Initiation of gametogenesis coincided with the change from longer to shorter days in Solomon Islands, and was marked by the appearance of previtellogenic

oocytes in females and spermatocytes in males. The mature stage was reached in August and October for *H. fuscogilva* and *A. mauritiana*, respectively. Histology revealed that re-initiation of gametogenesis occurred in partly-spawned gonads but the rationale for this gametogenic renewal was unclear as the tubules containing these new gametes were subsequently resorbed in the spent stage. In *H. scabra*, gametogenesis was asynchronous across the population. Individuals with advanced gametes were encountered throughout the year. Females with partly-spawned ovaries and males with mature testes were encountered most frequently.

The gonads of the three species comprised a single cohort of numerous tubules that developed uniformly to maturity from the gonad basis. Tubule growth involved an increase in the size and branching of tubules. Branching always occurred by bifurcation. Gonads in the mature and the partly-spawned stages were the largest, occupying the posterior regions of the coelomic cavity. Ovary tubule morphology of the three species, coupled with histological evidence showed that ovary development did not conform to the 'tubule recruitment model' suggested for oogenesis in the Holothuroidea.

In *H. fuscogilva* and *A. mauritiana* examination of gonad biopsies could be used to assess gonad maturity due to the synchronous nature of gametogenesis in these species. For *H. scabra* this tubule biopsy method can be used for selective harvesting of mature broodstock from the wild.

Development of the three species was investigated under hatchery conditions. All three species have planktotrophic development similar to most aspidochirote sea cucumbers. *H. scabra* was reared successfully to settlement at 26 to 28° C on a mixed microalgal diet. The larvae developed through the feeding auricularia and nonfeeding (lecithotrophic) doliolaria and pentactula stages. Settlement occurred at the pentactula stage after 14–17 days of development. *H. fuscogilva* and *A. mauritiana* larvae were raised to the late auricularia and doliolaria stages, respectively. In all three species, the early auricularia stage was reached by day 3 and the late auricularia was reached on days 10–12. The mean length of the late auricularia ranged from 700 to 900 µm for all three species. Transition of the larvae from the late auricularia stage to the doliolaria stage resulted in a reduced larval size. The development of hyaline spheres, potential nutritive stores, during the late auricularia stage appeared to be a good indicator of larval competence. Larvae of *H. scabra* lacking hyaline spheres did not settle. Although the percent survival of *H. scabra* by the settlement stage was low, thousands of juveniles were produced for grow-out experiments. The larvae of *H. fuscogilva* and *A. mauritiana* lacked or had poor hyaline sphere development. This indicates that the diet failed to promote hyaline sphere development in these species. The development of the three species is discussed in terms of their potential for aquaculture.

Regeneration of digestive tract in the pentactulae of the far-eastern holothurian Eupentacta fraudatrix (Holothuroidea: Dendrochirota)

Vladimir S. Mashanov and Igor Yu. Dolmatov

Source: Invertebrate Reproduction and Development (2001) 39(2):143–151

The regeneration of the digestive system in five-month-old pentactulae of the holothurian *Eupentacta fraudatrix* was examined using light and transmission electron microscopy. Transversely bisected pentactulae are devoid of posterior intestinal parts and a rectum. The regeneration of the intestine proceeds at the expense of the tissues of the gut remnant. The most important morphogenetic events are proliferation of the differentiated cells in the lining epithelium, and dedifferentiation followed by mitotic division, migration and redifferentiation in the mesothelium. The dividing cells are scattered randomly and no blastema is formed. Both dividing and migrating cells retain their intercellular junctions. The rectal rudiment appears as an epidermal invagination. Both intestinal and rectal rudiments move toward each other before merging. A hypothesis is advanced that the pattern of gut regeneration in the pentactulae of *E. fraudatrix* is a recapitulation of the ancestral mechanism of gut regeneration in holothurians.

Another reference to note

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Meetings

Echinoderms 2000 book

The Proceedings of the 10th International Echinoderm Conference held in Dunedin, New Zealand, are now available: Barker, M.F. (ed). 2001. Echinoderms 2000 – Proceedings of the 10th International Conference, Dunedin, New Zealand, 31 January – 2 February 2000. Rotterdam: A.A. Balkema. 612 p.

Echinoderms 2003 Meeting

The 11th International Echinoderm Conference will be held at the Ludwig-Maximilians-Universität, Munich, Germany, from 6 to 10 October 2003. Registration and abstracts as well as special requests, comments and proposals should all be sent to T. Heinzeller, and whenever possible by e-mail (Heinzeller@anat.med.uni-muenchen.de). When e-mail is not available, post to: 11th IEC 2003, Prof. Dr. Thomas Heinzeller, Anatomische Anstalt der LMU, Pettenkoferstrasse 11, D-80336 Muenchen, Germany.

More information on the meeting is available on the website: www.iec2003.uni-muenchen.de

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beche-de-mer

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PIMRIS is a joint project of 5 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS
Pacific Islands Marine Resources Information System