

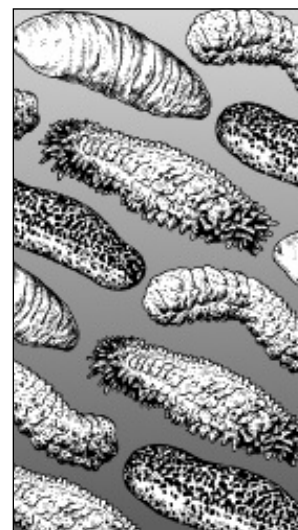


Secretariat of the Pacific Community

BECHE-DE-MER

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I N F O R M A T I O N B U L L E T I N



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Editorial

It is a great pleasure to present this 21th issue of the *Beche-de-Mer Information Bulletin*.

First, I would like to draw your attention to the proceedings and recommendations from the workshop "Advances in Sea Cucumber Aquaculture and Management", which are now available (contact: Lovatelli@fao.org or order from Steven Simpson Books, Melton Street, GB - Melton Constable NR24 2DB, England: <http://www.stevensimpsonbooks.com>).

In this issue, several original contributions focus on sea cucumber fisheries.

The commercial use of *Thelenota rubralineata* in the Solomon Islands, a relatively rare species, is presented by Kinch and shows that fishermen exploit other species when traditional ones are overfished (p. 3).

After six years of uninterrupted legal commercial exploitation, the Galápagos sea cucumber (*Isostichopus fuscus*) fishery, which is well documented and monitored, is showing signs of severe depletion. This example, presented by Toral-Granda, demonstrates that overexploitation is now a theme of interest (p. 5).

A new questionnaire dealing with overexploitation and management, following a brief synthesis on overexploitation, is proposed, to *Beche-de-Mer* readers by Uthicke and Conand with the hopes of stimulating local contributions on the subject (p. 9).

Madagascar's sea cucumber fishery is now studied from different points of view (see also the Abstracts section). McVean et al. document the traditional sea cucumber fisheries in southwest Madagascar using a 2002 case study of two villages (p. 15).

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The holothurian fishery in the Seychelles has experienced rapid development during the past seven to eight years. Riaz and Skewes present a resource assessment currently underway, which will examine the holothurian population. The assessment will be used in the preparation of a management plan for the fishery (p. 19).

In her second contribution to this bulletin, Pouget presents the distribution and abundance of the main sea cucumber species in Mayotte, South West Indian Ocean (p. 22).

Answers to the different questionnaires — on natural spawning, asexual reproduction and juveniles — show that these themes are relevant and useful to the community. Thanks to the contributors.

Because of the relative scarcity of knowledge obtained through direct observations of juveniles in the wild, Shiell submitted a questionnaire in issue #19 of this bulletin. He summarizes here some information from DB James (p. 26). It is hoped that responses to the questionnaire will continue, and will be of use in helping to better understand this critical life stage of sea cucumbers.

Desurmont, a regular contributor to the "Observations of Natural Spawning" section, reports on the observation of a mass-spawning event involving — in the same area and at the same time — numerous specimens of *Bohadschia vitiensis* and an isolated specimen of *Holothuria scabra versicolor* (p. 28).

Giraspy and Ivy write about Australia's first commercial sea cucumber culture hatchery, which officially started operations in May 2003 and is now fully operational (p. 29).

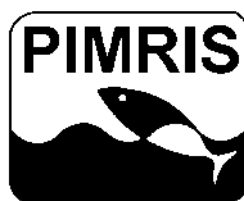
Friedman describes a visit he made to the sea cucumber hatchery in Tarawa, Kiribati. Despite the interruption of overseas funding for the project in 2001, the local team continued their work and obtained several successful spawnings of white teatfish (*Holothuria fuscogilva*) (p. 32).

Previous issues of this bulletin, in English and French, are available on the web at: <http://www.spc.int/coastfish/News/BDM/bdm.htm>

The Swedish Museum of Natural History is currently remodelling its website, which involves temporary changes in the URL. The new address of the Echinoderm Portal is: <http://www2.nrm.se/ev/echinoderms/echinportal.html.en>

Chantal Conand

PIMRIS is a joint project of five international organizations 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



Pacific Islands Marine Resources Information System

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.



new info

beche-de-mer

The commercial use of *Thelenota rubralineata* in the Solomon Islands

Jeff Kinch¹

Thelenota rubralineata was first described in the late 1980s (Massin and Lane 1991). It is considered to be rare and sightings of it are generally of single individuals. *T. rubralineata* has a current described range over much of the “coral triangle”, and extends into the Pacific. In Southeast Asia it has been sighted in Indonesia, the Philippines, East Malaysia and islands of the South China Sea (Jeng 1998; Lane 1999). From the Pacific region, it has been reported in New Caledonia, Guam, the Solomon Islands and possibly Fiji, with most accounts coming from Papua New Guinea (PNG) (see Lane 1999; Gosliner et al. 1996; Skewes et al. 2002). To date, there have been no reports of *T. rubralineata* in the Indian Ocean.

Lane (1999) notes that the historical absence of *T. rubralineata* in the beche-de-mer trade may be due to the fact that this species has very low population densities. In Sulawesi, Indonesia, *T. rubralineata* was recorded by Lane (1999) to have an average density of one animal per 220 m² over an area of 3750 m². Massin and Lane (1991) recorded the sighting of only one *T. rubralineata* during 1200 dives at Laing Island in PNG. During the 2001 Milne Bay stock assessment conducted by the Commonwealth Science and Industry Research Organisation (CSIRO), the PNG National Fisheries Authority and Conservation International (see Kinch 2002), only four specimens of *T. rubralineata* were recorded during 1126 dives, covering a surveyed area of 256,000 km² (Skewes et al. 2002a). Even though it has been recorded on the south coast of PNG it has not yet been recorded in any surveys by CSIRO in the Torres Strait in northern Australia (Skewes et al. 2002b).

The current status of sea cucumber stocks in the Solomon Islands is poorly known, but the beche-de-mer fishery as a whole is declining (Kinch 2004). The Nature Conservancy has recently conducted a rapid ecological assessment (REA) of the Solomon Islands as part of its wider marine eco-regional conservation assessment for the Bismarck-Solomon Seas Eco-region (Hunnam et al. 2001). Although the REA is a biodiversity taxonomic survey and does not entail rigorous stock abundance work, the results from this survey may add to the distributional knowledge of *T. rubralineata* and other sea cucumber species in this part of the Pacific.



Figure 1. Live specimens of *Thelenota rubralineata*
Photos: CSIRO, 2001

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T. rubralineata is an exploited and targeted commercial beche-de-mer species in the Solomon Islands and is traded under the name lemonfish and is currently purchased by traders in the islands and in Honiara, the capital, for 25 Solomon Island dollars (USD 3.60) per kg (Kinch 2004). Unfortunately, it is not possible to quantify at present the scale of the fishery for *T. rubralineata* in the Solomon Islands because beche-de-mer purchasing and export figures are lumped together and not by individual species, and this makes it difficult to provide opinions on individual species status. The Licensing Branch of the Division of Fisheries and Marine Resources (DFMR) is slowly addressing this issue by determining the species names that companies use. DFMR also wishes to implement more in-depth export return sheets, which detail individual species. The return of these sheets yearly is a prerequisite for re-issuance of an export license. Once this is set in place, some assessment of the exploitation of *T. rubralineata* will be possible.



Figure 2. Processed *Thelenota rubralineata*
Photo: M. Bae, 2004

There have been recent moves to list some threatened sea cucumber species on either Appendices II or III of CITES (Anon. 2002). These moves culminated in a gathering of sea cucumber specialists in March 2004 at the CITES Technical Workshop on the Conservation of Sea Cucumbers in the families Holothuriidae and Stichopodidae, which was held in Kuala Lumpur, Malaysia. The focus of this meeting was to discuss the issues and to garner an assessment of the impacts or benefits of listing sea cucumbers with CITES. It may be possible that *T. rubralineata* could be considered for listing due to its rarity and low population densities, which unfortunately also makes it extremely vulnerable to overexploitation. Given the low monetary value of *T. rubralineata* in the Solomon Islands, DFMR should at least, consider banning the collection and harvest of this rare species.

Acknowledgements

I would like to thank Tim Skewes, Chantal Conand, Aymeric Desurmont, Mark Baine and Kim Friedman

in participating in a round-robin email discussion group to assist me in identifying commercial species of sea cucumbers in the Solomon Islands.

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Requiem for the Galápagos sea cucumber fishery?

M. Verónica Toral-Granda¹

After six years of uninterrupted legal commercial exploitation, the Galápagos sea cucumber (*Isostichopus fuscus*) fishery is showing signs of severe depletion. The fishery began in the Galápagos Islands in 1991 after the commercial extinction of this species in mainland Ecuador (Camhi 1995), and rapidly became the most profitable fishing activity in the islands (Murillo et al. 2004).

Since 1998, the Galápagos Marine Reserve (GMR) has been managed under a participatory and adaptive management scheme. The Participatory Management Board (PMB), locally known as "Junta" (Toral-Granda and Martínez 2004; Altamirano et al. 2004), includes the five members of the management board, who are directly involved in activities within the GMR: fishing, nature guides, tourism (Galápagos Tourism Chamber – CAPTURGAL), science/conservation (Charles Darwin Foundation – CDF), and the Galápagos National Park Service (GNPS) as the administrator of the GMR. In the PMB, decisions are consensus-based and later analysed by the Interinstitutional Management Authority (IMA). The IMA comprises different stakeholders at the national government level: Ministry of Environment (Chair), Ministry of Defense, Ministry of Tourism, Ministry of Fisheries, CEDENMA (Ecuadorian Committee for the Protection of the Environment), as well as some local users: Galapagos Chamber of Tourism, fish-

ing sector, and GNPS (Secretary). The CDF acts as the scientific advisor for the IMA, and is primarily responsible for advising managers of the fishery on the state of the sea cucumber population in the GMR. In the IMA, all decisions are made by voting, and later put into effect by the GNPS (for further detail, see Altamirano et al. 2004, Toral-Granda and Martínez 2004).

The first legal fishery in 1994 took between 3 and 6 million sea cucumbers (De Miras et al. 1996), and then an illegal fishery persisted until the reopening of a legal fishery in 1999 (Piu 1998, 2000; Martínez 1999), when all stakeholders became involved in the process of scientific data collection, analysis and dissemination of stock assessment findings. The total number of sea cucumbers captured was 4.4 million in 1999, 4.9 million in 2000, 2.7 million in 2001, 8.3 million in 2002 and 5.0 million in 2003 (Murillo et al. 2004). Overall, more than 25.3 million sea cucumbers (over 6800 tonnes live weight) have been extracted legally from the GMR since 1999 (Murillo et al. 2004).

Every year, before and after each fishing season since 1999, teams of managers, scientists, nature guides and fishers have surveyed sea cucumber populations at sites off six islands where legal fishing occurs (Fig. 1) (Toral-Granda and Martínez 2004). For these trips, monitoring sites were chosen



Figure 1. Sea cucumber population surveys include several sites in Española, Floreana, San Cristóbal, Santa Cruz, Western Isabela and Fernandina. The Bolívar Channel has been recognised as a sea cucumber nursery ground and has remained closed to fishing activities for the last three fishing seasons.

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jointly amongst the participative team, and included extractive and non-extractive areas of the provisional zoning scheme. All data gathered during the trip is distributed to all stakeholders straight after the trip. Furthermore, the data is analysed jointly amongst all the sectors and later on delivery to the PMB, who evaluates the information given and decides on a total allowable catch (TAC) or, to close down islands that show signs of depletion or have significant numbers of juveniles. This decision is later evaluated by the IMA, which decides on the final regulations for the fishery.

The last population survey (November 2004) revealed an alarming continuing decline. Population densities of *I. fuscus* declined to a historical minimum, although populations were “presumably robust” after a five-year fishing ban that ended in 1999 (Fig. 2). The densities of legal size individuals (≥ 20 cm TL) were the lowest ever registered (Fig. 3). The 2000–2001 recruitment pulse is now almost fished out, with no new recruitment pulse evident, either in the western islands (Hearn et al.

submitted) or elsewhere. A joint CDF/GNPS fisheries research program has gathered valuable information, all indicating a highly depleted state of the resource (Murillo et al. 2004; Shepherd et al. 2004). Average catch per unit of effort (CPUE) has decreased over time from 37 kg diver⁻¹ day⁻¹ in 1999 to 22 kg diver⁻¹ day⁻¹ in 2003 (Murillo et al. 2004) (Table 1). Areas that were previously important fishing sites (i.e. sites that yielded high catches) are now seldom visited due to the low numbers of sea cucumbers there. But, the average CPUE is maintained by the exploitation of new fishing sites where more individuals can be found. Hence CPUE is now exhibiting hyperstability in the face of declining populations and changing behaviour of divers, who now concentrate their searches in the few places where sea cucumbers remain. In this situation, CPUE has little value as an indicator of abundance, and can be quite misleading, as often noted for benthic sedentary or strongly aggregating stocks (Orensanz et al. 1998). Additionally, the mean size of individuals harvested has decreased from 25.2 cm total length in 1999 to 20.9 cm in 2003

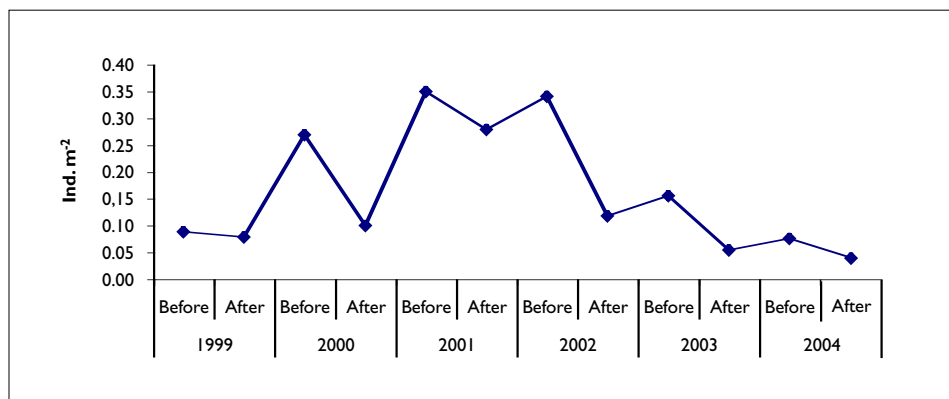


Figure 2. Mean values (\pm SE) of population density of *I. fuscus* before and after the fishing seasons. Information was collected in participatory surveys between 1999 and 2004.

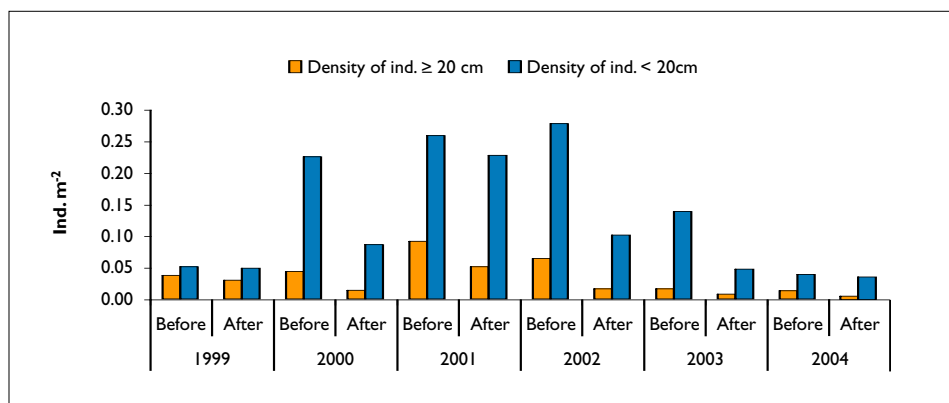


Figure 3. Population density of individuals ≥ 20 cm and < 20 cm total length of *I. fuscus* throughout the participatory surveys between 1999 and 2004.

Table 1. Catch per unit of effort (kg diver⁻¹ day⁻¹) of *I. fuscus* in the last five fishing seasons, 1999–2003 (adapted from: Murillo et al. 2004).

	1999	2000	2001	2002	2003
Western Isabela	33	32	38	41	26
Fernandina	54	°	44	39	26
Española	46	21	°	29	°
Floreana	-	20	32	16	°
North and East Isabela	-	34	20	29	23
South Isabela	32	21	22	36	17
San Cristóbal	26	19	15	°	15
Santa Cruz	29	24	21	°	27
Average	37	24	27	32	22

- no data available; ° no-fishing zone

(Murillo et al. 2004), showing a possible growth overexploitation. Yet despite the scientific findings and warnings, the fishery has been opened each year, in large part for political reasons and due to socioeconomic pressures.

The 2004 season was due to open on 31 May 2004 for 60 days, subject to the following regulations: a TAC of 4 million individuals, minimum landing size of 20 cm (total length), landing exclusively in fresh state, and fishing permitted only in Española, Floreana, Western Isabela, Santa Cruz, and San Cristóbal (Fig. 1). Fernandina and the Bolívar Channel (Fig. 1) were to remain closed due to their high importance as nursery grounds and the fact that most of the individuals present were below minimum landing size. However, the artisanal fishing sector presented a lawsuit against the agreed regulations; and after many incidents, including rioting and the invasion and occupation of the Galápagos National Park Service offices, the fishing season was postponed until 12 August. In addition, the regulations of this season were modified: Fernandina Island was to remain open instead of Floreana, and sea cucumbers were allowed to be landed in brine, with a minimum size of 7 cm. The 2004 fishing season closed on 10 October. Results show that the TAC was not met, as only 2.9 million individuals were caught during this fishing season.

Although data from the 2004 fishing season have yet to be analysed, preliminary observations and results show that CPUE is lower than in previous years. CPUE may have been influenced by the oceanographic conditions prevailing during the 2004 season, and by the fact that the lobster fishing season was opened on 1 September, hence possibly splitting the fishing effort. In other fishing seasons, most of the catches have originated from the west-

ern macrozones (Murillo et al. 2004) but in 2004, the fishing effort was concentrated in these zones during the first month only. Many fishers preferred to make daily fishing trips to nearby sites, rather than investing in long trips to the west, where not many sea cucumbers are left. Eighteen decompression illnesses were registered during this season, with one fatality. This number is likely to be underestimated as many sea cucumber fishers performed “domestic” decompression dives at nearby sites without medical supervision. Upon recognition of decompression sickness symptoms, the fishers decided on the depth and period underwater to eliminate the symptoms. In most cases, these fishers continued fishing immediately after their decompression dives.

The market price for *I. fuscus* in the Galápagos has fluctuated during the season. At the beginning, an average of USD 30.25 were paid per kg of sea cucumber in brine, while at the end of the 2004 fishing season, a kg of sea cucumber in brine fetched USD 33.9. In the 2003 season, the average price paid was USD 22.8 per kg of sea cucumber in brine (Murillo et al. 2004), indicating a market trend to higher prices as the supply diminishes.

CDF's efforts to persuade users and managers of the precarious state of *I. fuscus* populations in the Galápagos Islands have largely gone unheeded to date. Despite much progress in co-management, it is clear that more community and educational work must be done if this species is not to continue declining to commercial extinction. Moreover, additional research is required on many aspects of the sea cucumber's biology and ecology, which can only be achieved through increased capacity building and funding. CDF's efforts to conserve biodiversity within the Galápagos Islands and the GMR

are presently at risk due to funding constraints. Also, increased global awareness is probably necessary before managers of the *I. fuscus* fishery are convinced to conform to a comprehensive management plan that gives priority to the conservation of the resource according to the best scientific evidence available.

Acknowledgements

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Local examples of beche-de-mer overfishing: An initial summary and request for information

Sven Uthicke¹ and Chantal Conand²

Introduction

It is generally agreed that holothurians are now overfished in many areas of the Indo-Pacific. This conclusion has generally been drawn from export statistics, movements on the import market, and case studies (Conand 1989, 1990, 1998, 2001, 2004).

In examining the literature, we noticed that there is a dearth of data and observations from single regions. These data could be crucial for future improved management and we aim to initiate a database on both positive developments (e.g. sustainable fishing in local areas or observed recovery of stock), which seem rare or poorly documented, and negative examples (overfishing, absence of recovery).

Because of their slow rates of movement and easy access to fishermen, most holothurians are vulnerable to overfishing. Several characteristics of holothurians make them a particularly vulnerable species. Some of these characteristics are currently only inferred, however initial biological data on at least some species suggest that these are quite long lived and have naturally low recruitment rates (e.g. black teatfish – Uthicke et al. 2004).

Reduced breeding and/or recruitment success occurs when population density is reduced below a critical level. Because holothurians are broadcast spawners, they rely on the proximity of other animals for successful fertilisation. Simply stated, male and female beche-de-mer must be close enough to each other to enable eggs and sperm to meet in the water column. When population density is too low, individuals may be too far apart for this to occur in sufficient numbers.

Unless it can be shown that animals occur at densities higher than those required for a 100 per cent fertilisation rate of each oocyte produced, reduction of densities through fishing will also reduce the number of larvae produced. A disproportional reduction in breeding success caused by reduced population densities has been dubbed the Allee effect. The effect of this is likely to be larger than that through direct take; for example, if densities are reduced by 50 per cent it can be expected that recruitment is reduced by more than 50 per cent.

Overexploitation is a concept in fishery science that is still debated. The application to the sea cucumber fisheries needs to be based on local data, which must be detailed enough and take into account several parameters. Basically, overexploitation can be of either a biological or economic origin and has therefore different characteristics. (Conand 1990) Examples are:

- 1) biological overexploitation: sandfish *Holothuria scabra* and *H. scabra versicolor* and teatfish *H. nobilis*, *H. whitmaei* and *H. fuscogilva* (Uthicke and Benzie 2000)
- 2) economical overexploitation: when the investment costs increase without increase of captures or with increased dive-accidents.

Surprisingly, it is not just data on overfishing that are missing, but also data on potential recovery of stocks after the fishery has been closed or is no longer economical. To our knowledge, the only studies that survey stock recovery after overfishing are Lincoln-Smith et al. (2000) in the Solomon Islands, Skewes et al. (2000) on sandfish recovery in the Torres Strait, and Uthicke et al. (2004) on black teatfish on the Great Barrier Reef.

In this brief paper, we first summarise some data on local overfishing known to us from the literature, as reports from colleagues and fishermen, or searches on the Internet. Then, we ask for your participation to enhance our knowledge on these important issues by providing us information on local overfishing or stock recoveries from the area you live in or other areas you are familiar with.

Local examples of overfishing in the Indo-Pacific region

Many tropical areas in the Indo-Pacific region are heavily overfished for holothurians (see Fig. 1). Many areas are overfished for sandfish, but other examples are often cited, the evidence for this is anecdotal because the fishery has not been adequately managed, and no scientific data on stock size before or after fishing are available. The list given below is very preliminary and it is the aim of this request to gather further information.

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2. ECOMAR, Université de La Réunion, 97715 Saint Denis, France. Email: Chantal.Conand@univ-reunion.fr

Galapagos

After six years of uninterrupted legal commercial exploitation, the Galápagos sea cucumber (*Isostichopus fuscus*) fishery is showing signs of severe depletion. Every year, before and after each fishing season since 1999, teams of managers, scientists, nature guides and fishers have surveyed sea cucumber populations at sites off six islands where legal fishing occurs. The last population survey (April 2004) revealed an alarming continuing decline. Population densities of *I. fuscus* declined to a historical minimum, although populations were “presumably robust” after a five-year fishing ban ended in 1999. The 2000–2001 recruitment pulse is now almost fished out, with no new recruitment pulse evident (Toral-Granda in this issue) These islands are a good example of fishery development and decline due to recruitment overfishing, accompanying political and socioeconomic issues. This fishery has attracted much attention and *I. fuscus* is listed on CITES Appendix III (Toral-Granda and Martinez 2004).

Ashmore Reef

This Australian reef is heavily fished by Indonesian fisherman. In 1988, Russell and Vail reported the presence of sandfish and golden sandfish from this reef. Subsequent surveys by CSIRO (Skewes et al. 1999) and AIMS (Smith et al. 2001, 2002; Rees et al. 2003) more than 10 years later failed to detect any animals of these species.³

Indonesia

Indonesia is probably one of the main exporters of sandfish. However, minimal fisheries management exists, and fishing takes place on many islands and often in small communities. Although it is suspected that overfishing is widespread, not many documented examples exist.

During a faunal survey in Sulawesi, Massin (1999) noted that sandfish had been overfished, and that in some locations it was regarded as a rare species. The author of the present report could only obtain few and small specimens during a field trip to Bali and Lombok in 1998. According to fisherman and scientists contacted during that trip, stocks on both islands are also extremely depleted.

Philippines

The Philippines are one of the largest beche-de-mer exporters (Gamboa et al. 2004). Similar to

Indonesia, the fishery takes place in many areas. Reports on fishing are insubstantial, but a report by Heinen (date unknown: <http://www.ozamiz.com/earthcalls/seacucumber.html>) implies that overfishing is severe and widespread, and that poaching in marine protected areas is common.

Malaysia

Overfishing of *H. scabra* stocks in Malaysia was demonstrated by Forbes and Ilias (1999, cited from Hamel et al. 2001) and Poh-Sze (2004). According to the latter source, curryfish (*Stichopus hermanni*) is exploited close to the point of extinction.

Torres Strait

Warrior Reef in the Torres Strait was fished both from the PNG and the Australian side. Heavy fishing between 1994 and 1998 led to severe overfished stocks of sandfish (Skewes et al. 2000). The fishery was closed in 1998, and the stock recovery has been monitored since then. There are only very limited signs of stock recovery, providing support for the proposed low recruitment rates in holothurians. More recently, black teatfish and surf redfish fisheries also had to be closed.

Papua New Guinea

The first reports of a sandfish overfishing to near extinction came from the Togak region in 1988 (Lokani 1990). Total catch rates (for several species) in PNG have slowly declined over recent years (Polon 2004). Recent stock surveys in Milne Bay failed to detect any sandfish and it was recommended that the fishery for this species be closed (Kinch 2002).

Solomon Islands

The export of sandfish was banned because of indications of severe overfishing. Although this export ban was lifted several years later, there is no evidence that stocks had actually recovered.

New Caledonia

Overfishing of sandfish in New Caledonia has been demonstrated by Conand (1989, 1990, etc.) based on captures and CPUE data. *Holothuria fuscogilva* was “scientifically overfished” by Conand due to her monthly sampling of this species, and this was shown by a strong decrease in CPUE.

3. It is currently not known if sandfish (*H. scabra*) and golden sandfish (*H. scabra* var. *versicolor*) are distinct species or varieties. However, recent genetic research (Uthicke, Purcell and Blockmans, unpublished research) shows that these two are indeed separate species.

Hervey Bay, East Coast Australia

The sandfish fishery on the east coast was closed in 2000 because of a severe stock decline. A developmental fishery now takes place further south in Moreton Bay. Some deeper-occurring stocks of golden sandfish are fished along the east coast.

Great Barrier Reef, Australia

The black teafish fishery (*H. whitmaei*) had to be closed in 1999 due to overfishing. Stocks on reefs fished were reduced to less than 25 per cent of that found in no-take zones (Uthicke and Benzie 2000), and had not recovered two years after a fishery closure (Uthicke et al. 2004).

Fiji Islands

The reports on overfishing from Fiji are mainly anecdotal. However, it was already reported in 1993 (Steward 1993, cited from Hamel et al. 2001) that catches of sandfish had declined by 80 per cent when compared to 1979.

Egypt – Red Sea

A beche-de-mer fishery in Egypt began in 1998. After only two years after the opening, however, the first signs of overfishing became apparent (Lawrence et al. 2004). A survey conducted in 2002 and 2003 suggested low densities for most commercial holothurians and overfishing for the most valuable species such as *H. scabra*, *H. nobilis*, *H. fuscogilva* (Lawrence et al. 2004). Based on these results, the holothurian fishery in the Red Sea was closed in 2003.

Madagascar

Detailed information on overfishing is available (Conand et al. 1998; Rasolofonirina and Conand 1998, Rasolofonirina et al. 2004). Fishing pressure appears to be very high nowadays, a fact that is also supported by market and FAO data. Evaluation and management programs have started locally through the collaboration between administration, traders and scientists, and a National Trepanng Traders Group (ONET) was set up in 1996. This experience is of interest to other countries. In a regional context, holothurians are one of the resources studied in order to develop a durable management system. Some qualitative indications are apparent from these fisheries:

- 1) all species available on reef flats or in shallow waters, regardless of size or commercial interest, are collected, including rare and unidentified species;
- 2) scuba divers complain that they must dive deeper and look for other fishing grounds; in addition, diving accidents have increased markedly;
- 3) the sizes of the different species (and the processed products) are diminishing; and
- 4) a strong competition appears among collectors, leading to a decline in processing quality. These observations, found at different levels of the "fishery system" (Conand 1998) are indicative of overexploitation.

Overfishing of sandfish has also been documented in India and Mozambique (summarised in Hamel et al. 2001). There are currently no examples of a sustainable fishery anywhere in the Indo-Pacific region.

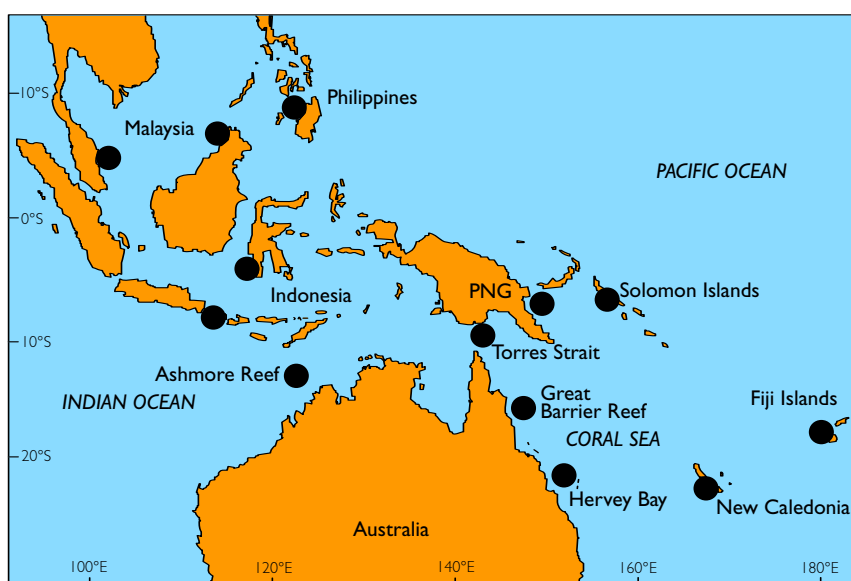


Figure 1. Reported areas of overfishing in the West Pacific region.

A call for information on local cases of beche-de-mer overfishing

Figure 1 is a preliminary example of data already available. In the following, we would like your help in providing more detailed information to draw a more complete picture and to assist with the final aim of managing this resource sustainably.

The parameters listed below (others may be necessary) that are needed to better understand local over-exploitation and thus to better manage the fisheries. They are also based on recommendations made during sessions I and II on fisheries and management of the ASCAM meeting (Lovatelli et al. 2004):

Biology

- 1) Species exploited (note the trading name, local name and/or scientific name). Which species are recovering/being overfished?
- 2) Site description with information about bottom surface, habitat and depth and time-scale.. Could you name the location and area as precisely as possible (name of the island or individual bay, or even GPS positions).
- 3) Catch (give unit for numbers or weights).
- 4) Densities and biomass of the species in the site and their evolution.
- 5) Size of the specimens, specifically changes in sizes of species. and their evolution
- 6) Changes in species fished, sites, depth, etc.
- 7) Did you observe any other changes in the environment that may be related to stock recovery/overfishing? Examples: (e.g. changes in seagrass beds, development of algal mats, etc.)?

Socioeconomics

- 1) Changes in local situation, for example, was the availability of a more profitable exploitation opportunity (e.g. nickel mining in New Caledonia has sometimes been more profitable than fisheries – Conand 1989), etc.
- 2) Changes in the local economic situation of the fishermen.
- 3) Changes in local management such as laws, management measures, or aquaculture.
- 4) How does the stock recovery or decline affect the community economically?

Useful information for this purpose would include any details on the points above. In addition, to catalogue data in databases and analyses the data, we would appreciate the following information:

- 1) What is your involvement with the beche-de-mer fishery: Are you a fisherman, trader, manager, community member, fisheries staff?

- 2) Are you reporting on a stock recovery or a stock decline?
- 3) How did you come to the conclusion the area is overfished, or stocks are recovering:
 - Declining/increasing catch rates?
 - Available historic data?
 - Observation by elders?
 - Different species caught, animals smaller or deeper dives required?
- 4) Did the government respond to the overfishing? (e.g. were areas closed to fishing or were certain species protected?)

We hope that you agree that this subject is important and that you will contribute, sending your information to us at:

s.uthicke@aims.gov.au

or/and

conand@univ-reunion.fr

Please indicate if you wish to remain anonymous, we would also appreciate photographic material of local species or varieties, habitats, fishing and trading practices,

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Traditional sea cucumber fisheries in southwest Madagascar: A case-study of two villages in 2002

A.R. McVean¹*, G. Hemery¹*, R.C.J. Walker¹*, Ralisaoana B.L.R.² and E. Fanning¹

Introduction

The sea cucumber fishery has a long history in Madagascar and it is still very active in the south-western region of Toliara (Conand et al. 1997; Rasolofonirina and Conand 1998) (Fig. 1). Traditional fisheries in general represent a key source of income and food in this region, which is characterized by arid climatic conditions (restricting coastal vegetation to drought resistant species) and which limits agricultural production (Laroche and Ramanarivo 1995). The increasing human population size in the Toliara region (324% between 1975 and 1993 – Cooke et al. 2000) coupled with limited employment opportunities and low agricultural productivity, has resulted in five-fold increase in the number of fishers in the region in a period of 17 years (DRH/FAO 1992). This increase has been due,

in part, to the migration of traditionally farming and gathering ethnic groups (e.g. the Mahafaly, Andandroy and Mikea) to coastal areas in order to supplement their incomes and diets through fishing. The result has been an increase in fishing pressure on marine resources (including finfish, turtles, molluscs, crustaceans and sea cucumbers) leading to concerns about the majority of these fisheries' sustainability at present rates of exploitation.

As part of a survey of intertidal and shallow subtidal collecting activities of two villages south of Tulear during May 2002, information regarding the collection, preparation and trade of sea cucumbers was obtained and is summarised here. Data were collected through direct observations and a series of questionnaire-based interviews with gleaners (inter/shallow subtidal collectors) (Fig. 2) and local authorities from two villages: Anakao, approximately 20 km south of Tulear (Fig. 1) and Ampasipoty, approximately 2 km north of Anakao. These villages were chosen because of their locations, being situated at either end of a large, shallow (<1 m deep at spring low tide), lagoonal area that is enclosed by a section of fringing reef approximately 500 m offshore. The area is known to be regularly used for collecting by residents of these two villages.

Species collected

Four species of sea cucumbers were identified as being collected by gleaners from the two villages surveyed (Table 1) (Conand 1999). All species were generally collected in water depths of less than 1 m, with fishing generally considered to be better after low tide due to increased sea cucumber activity at that period. All four species were typically found on sand patches, in seagrass beds, or in the rubble/debris areas near the backreef, but not on rocky substrates around small coral heads or in algal beds. *Holothuria scabra* was more often found in seagrass *Actinopyga miliaris* was more common in the debris zone near the backreef, and *H. nobilis* and *Stichopus hermanni* were found more on sand banks close to the spring low water mark. Gleaners stated that February and March were considered to be the best months for sea cucumber collecting as this marked the end of the reproductive season (January). This conflicts, however, with results ob-

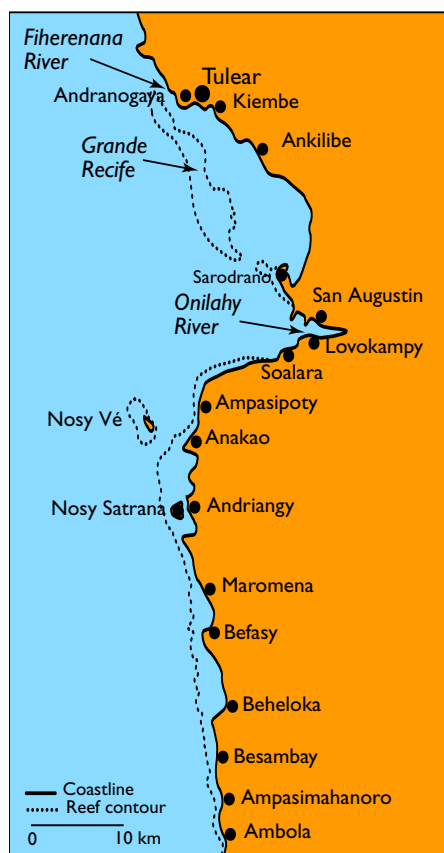


Figure 1. Southwest Madagascar with villages surveyed.

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tained by Rasolofonirina and Conand (1998) during their study of sea cucumber fishing in two villages situated approximately 20 km north of Ampasipoty. Direct observation in those villages indicated that catches were highest from November to January in Ankiembe, and from April to June in Besakoa (Rasolofonirina and Conand 1998). However, February to March roughly correlates with the end of the annual period of high turbidity in the area studied here. This turbidity is due to increased outflow from the Onilahy River (Fig. 1) between November and December, following the rains inland. The turbidity reduces visibility and hampers gleaning in shallow waters. This could account for the differences between the villages studied here and those studied by Rasolofonirina and Conand (1998), with the latter villages fishing on reefs farther offshore and, therefore, potentially less impacted by sediment from river outflow.

Sea cucumbers collected typically ranged between 6 cm and 20 cm wet length. Lengths of dried sea cucumbers varied by species, with dry *H. scabra* ranging from 4–21 cm but with 80 per cent of individuals under 12 cm in length. *S. hermanni* individuals were typically around 8 cm in length; larger individuals are rare and smaller individuals are not purchased by village buyers. Similarly, the minimum dry length accepted for *A. miliaris* was 15 cm (although individuals as small as 12 cm were accepted in some circumstances). No information was available for dry *H. nobilis*.

Preparation and drying

The gutting of sea cucumbers prior to boiling and drying varies with species. *H. nobilis* and *A. miliaris* individuals are cut along the whole length while *H. scabra* and *S. hermanni* individuals are only cut in the centre. In the case of *H. nobilis*, this is to ensure that individuals dry more quickly to prevent spoiling. *S. hermanni* individuals are gutted immediately after capture as otherwise they will deform and spoil.

After gutting, the sea cucumbers are processed and dried. The processing begins with boiling in seawater until the sea cucumbers take on a rubber-like consistency. The boiled individuals are then buried under 10–20 cm of sand for 24 hours before being scraped with a knife to remove the skin. They are



Figure 2. Sea cucumber gleaners

Table 1. List of sea cucumber species collected by gleaners in the villages of Anakao and Ampasipoty with local names and minimum dry lengths purchased by village collectors.

Scientific name	Local name	Minimum dry length for sale
<i>Actinopyga miliaris</i>	stylo or kalalijaky	15 cm (12 cm on occasions)
<i>Holothuria nobilis</i>	fotsytretake	not available
<i>Holothuria scabra</i>	zanga foty	4 cm
<i>Stichopus hermanni</i>	tracteur or jijaty	8 cm

then boiled again in fresh water with salt added. The final stage involves leaving the skinned, twice boiled sea cucumbers to dry in the sun on wooden planks until completely ready for sale. Gleaners stated that sea cucumbers are harder to prepare between November and January, this being attributed to the reproductive season in January. From February–March, sea cucumbers become less fragile and easier to process again.

Sale and trade

Prices paid to the gleaners vary by species, but the average price paid by the collectors in the villages is between USD 5.20 and USD 6.00 kg⁻¹ of dry sea cucumber. The most valuable species is *H. scabra*, which sells for USD 9.00 kg⁻¹ (dry weight), followed by *H. nobilis*. *S. hermanni*, which ranks third in terms of value, sells for USD 3.75–4.50 kg⁻¹ (dry weight) while *A. miliaris* is the lowest valued species.

After being purchased from the gleaners, the sea cucumbers are sold to three collectors based in Toliara (the administrative capital of the region and one of the largest cities in Madagascar). These collectors visit Anakao on a weekly basis to purchase sea cucumbers from the two village collectors there (one

collects from Anakao Bas, which is inhabited by members of the Vezo tribe, and the other from Anakao Haut, which is inhabited by members of the Tanalana tribe). The village collector for Ampasipoty, however, usually travels to Toliara twice a month to sell the accumulated sea cucumbers. The prices paid by the Toliara collectors again varies and ranges between USD 3.00 and USD 11.00 kg⁻¹ (dry weight), depending on species and quality, although good quality *H. scabra* can fetch up to USD 15.00 kg⁻¹ (dry weight). From Toliara, the sea cucumbers are then transported to the capital, Antananarivo, where they are sold to exporters to Asian markets. No figures were obtained regarding the prices paid to the Toliara collectors by the exporters as they were unwilling to divulge the information. However, it was discovered that due to their low quality, dry *A. miliaris* are usually only bought by the exporters every two to three months to supplement the total weight and complete shipments for export.

Socioeconomic importance of sea cucumber collecting

In total, 57 individuals were interviewed during the study to determine the importance of gleaning to the villages surveyed: 26 from Ampasipoty (10 men and 16 women) and 31 from Anakao (5 men and 25 women), including 2 collectors.

In Ampasipoty, gleaning was named as the primary activity for 100 per cent of women, and for children under 10 years of age. Of the men, 60 per cent gleaned and/or fished with nets as a primary activity, while the remaining men relied on spearfishing or hook-and-line fishing as their primary activity, with gleaning or raising livestock (cattle or goats) as a secondary activity. Gleaning at night was also important, with 95 per cent of villagers gleaned during the night tides. In Anakao, these figures were reduced, with only 60 per cent of households relying on gleaning as their principal activity, with others relying on other forms of fishing, running village stores or raising livestock, with gleaning a secondary source of food/income.

Only a few gleaners limit their activity to sea cucumbers. Most gleaners also collect fish and a variety of invertebrate species including molluscs, bivalves, echinoids and crustaceans for subsistence, or limited local sale. Generally, fish are collected by men while women tend to focus on collecting invertebrates, including sea cucumbers. The estimated value of sea cucumber for the families involved was USD 15.00–30.00 family⁻¹ week⁻¹. This equates to 2.5–5.7 kg of dry sea cucumber family⁻¹ week⁻¹ (based on the average prices detailed above) or roughly 7.5–17.1 kg of wet sea cucumber (based on the rough wet-dry conversion of 3:1 given by the

gleaners). On a monthly basis, this gives an estimated income of USD 30–60 for families collecting sea cucumbers as gleaning is typically restricted to 8–12 days per month during spring low tides (with the exception of tides between 16:00 and 20:00 when no gleaning takes place).

This average income from collecting sea cucumbers compares favourably with other livelihoods. Gleaners collecting *Euchema* sp., which they sell to a processing company based in Toliara, earn USD 18–22 week⁻¹ or USD 37–44 month⁻¹, and the estimated average income for the region is USD 41 month⁻¹. This has, as a result, led to an increase in the number of people collecting sea cucumbers according to the village leaders. The population of Ampasipoty has increased due to people moving to the village to collect sea cucumbers, and traditional farmer/gatherer Tanalana villagers from Anakao Haut also now glean due to the good revenues to be gained from sea cucumber collecting. (Fishing began amongst the Tanalana in 1986 when a drought led to poor harvests but the low income they were able to earn from fishing led them to continue with their traditional activities.)

Discussion and conclusions

This study demonstrates the socioeconomic importance of sea cucumber collecting in the two villages investigated; sea cucumber collecting provides the primary source of income for significant proportions of both populations. Unfortunately, due to the small number of collectors, their demographics could not be compared with results obtained by Rasolofonirina and Conand (1998). However, figures for Ampasipoty and anecdotal observations suggest that sea cucumber collecting is predominantly an activity undertaken by women and children, as was the case for Ankiembe in the 1998 study. This predominance of women and children in Anakao and Ampasipoty is probably due to the proximity of the collecting areas to the villages, and their accessibility from the shore, eliminating the need for boats and therefore for men to drive them. This thereby frees the men to participate in other fisheries that require boats, such as spearfishing, netting, and line fishing for larger reef fish, turtles and sharks. To this extent at least, the villages surveyed in this study are likely to be representative of a number of the villages south of Soalara (Fig. 1), where the fringing reef lies close to shore and shallow lagoonal environments offer good collecting areas. This would seem to be supported by comments by the village collector from Anakao Haut, who stated that he also purchased sea cucumbers from Maromena, Befasy and Beheloka to the south of Anakao (Fig. 1), with estimates of up to 100 kg of dried sea cucumbers per week being collected for

the four villages combined. This amount of 100 kg per week does not seem unfeasible considering catches of up to 18 kg family⁻¹ are claimed for a single tide during daylight hours, and up to 25 kg family⁻¹ at night. However, the few records of individual catches seem to indicate individual daily catches only in the range of 1–8 kg (average = 3.5 kg, n = 10). These figures compare well with those of 1.7–9.8 (mean = 4.86) and 1.7–11.8 (mean = 5.43) kg fisher⁻¹ day⁻¹ reported for the two villages studied by Rasolofonirina and Conand (1998).

Based on the estimated average monthly earnings, between 1500 and 3500 kg of dry sea cucumber may be collected annually by the 26 families in Ampasipoty. This again is similar to the figures for Ankiembe and Besakoa (Fig. 1) reported by Rasolofonirina and Conand (1998). Converting mean monthly wet catch weight figures reported for these villages to dry weight (using Conand and Byrne's 1993 estimate of a 10-fold weight loss during drying) gives estimates of 1100 and 2128 kg of dry sea cucumber per year for Ankiembe and Besakoa, respectively. However, anecdotal reports from the gleaners in the two villages suggest that these catch rates are unsustainable, as both overall catch and individual sizes of sea cucumbers collected are declining each year. The gleaners involved attribute this decline in part to the increasing numbers of people moving to coastal areas to harvest easily exploitable, high value products such as sea cucumbers.

These indications of declines in the fishery support concerns raised previously regarding the sustainability of current exploitation levels of sea cucumbers in Madagascar, with reports that fishing on foot is in decline and that scuba divers collecting sea cucumbers are noticing that it is harder to find sea cucumbers (Conand et al. 1997). At present, exploitation in the two villages surveyed is restricted to collecting on foot, which limits the area fished to lagoonal and shallow reef areas; the accessibility of these fishing areas and the period of collecting also restricted to approximately 2.5 hours each spring low tide. However, as catches decline, prices are likely to increase, as has been observed in traditional fisheries supplying export trades in other parts of the world, maintaining the incentive to collect sea cucumbers for those that depend on the fishery for their primary source of income. This could lead to increased collection of sea cucumbers in deeper waters outside intertidal areas and put more pressure on sea cucumber populations in the region, further jeopardising this potentially already declining fishery.

In response to the threats facing sea cucumber populations in the Toliara region, a sea cucumber hatchery and mariculture project started in Tulear

in 1999 (Jangoux et al. 2001). The goal was to breed and grow-out juveniles of commercially important species for restocking fished areas and reducing fishing pressure on wild populations. However, at the time of this study, this goal has not yet been attained. Therefore, while more in-depth work is required to evaluate the status and exploitation levels of sea cucumber stocks, it is clear that some form of education and interim management at the village level is required to ensure the long-term future of this important source of income.

Acknowledgements

The authors would like to acknowledge the help and support of the staff and research assistants of Frontier-Madagascar, a collaboration of *L'Institut Halieutique et des Sciences Marines* and the Society for Environmental Exploration. We would also like to thank the residents of Anakao and Ampasipoty for their cooperation and patience. This work was funded by the Society for Environmental Exploration.

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Resource assessment of the holothurian populations in the Seychelles

Riaz Aumeeruddy¹ and Timothy Skewes²

Background

The holothurian fishery in the Seychelles has seen a rapid development during the past seven to eight years due to the high demand for beche-de-mer on the international market, and higher prices offered (Aumeeruddy and Payet 2004b). This has turned a previously unimportant and unregulated fishery into one where fishers have increased their fishing efforts. By 1999 the fishery was showing signs of population depletion, including lower volumes of high value species, fishers having to travel farther to collect sea cucumbers, and concerns raised regarding the sustainability of the fishery.

The Seychelles Fishing Authority (SFA), the national body responsible for fisheries management, started regulating the fishery in 1999 by the introduction of a licensing system for sea cucumber fishers and processors. Because there was no baseline data on the fishery, a precautionary approach was adopted: the number of licenses was limited to 25 fishing vessels, and each vessel was limited to four divers. One of the conditions of the licenses is that the licensees must furnish fisheries-related data (catch, effort) to the management authority on a monthly basis.

The SFA was asked to undertake a resource assessment of the holothurian population that would be used in the preparation of a management plan for the fishery. Funding was secured for that exercise in late 2003 through a Technical Cooperation Project of the FAO. Initial studies started in December 2003, and several surveys were completed in 2004. The project is expected to be completed by mid-2005. Details of the objectives of the project can be found in the last edition of the Beche-de-Mer Bulletin (Aumeeruddy and Payet 2004a).

Methodology

Due to the Seychelles' extensive EEZ (1.4 Mkm²), it was decided to concentrate the surveys on the two main fishing grounds, the Seychelles Bank (where the main inhabited islands are located), and the Amirantes Plateau.

The study area was subdivided, or stratified, by:

- bathymetry, including the following classes: outline of the shallow reefs, the 20 m isobath, and all areas below 20 m depth;
- "bio-geographic regions" mostly drawn from a substrate map (only available for the Seychelles Bank); and
- limits of marine national parks.

This was done with a geographical information system (GIS) package, which produced a table of possible combinations of layers of spatial physical data. This process gave a final count of 14 bioregions or strata. These strata were then used to produce the sample design. The stratification and estimates of holothurian density and variance were used in an optimal allocation procedure. This procedure allocated sampling effort among the strata in the most efficient manner for producing the best stock estimate for all commercial holothurians combined. A total of 329 survey sites were obtained by this means.

Visual surveys are done to estimate the standing stock of sea cucumbers (Conand 1990). For sites less than 30 m deep, transects are surveyed by a pair of divers swimming along a transect line 100 m long and 8 m wide. All sea cucumbers within that belt are collected and brought to the surface, where they are identified, measured, weighed and photographed. Other information is also collected during the dive, including: substrate type, coral cover, seagrass and algal cover, estimates of other invertebrates (e.g. lobsters, urchins, starfish, pearl oysters) that have either a commercial interest or which pose an environmental threat when they occur in large quantities.

For sites deeper than 30 m, a video camera is lowered to the bottom and the research vessel is allowed to drift for 15 minutes. Data are recorded on-board the vessel on a video recorder, and the transect position is given from GPS coordinates that are overlaid on the data tape. This helps calculate the length of the transect; the width is estimated from the video recording.

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Sea cucumber surveys

Three surveys were conducted. A pilot survey was organised in December 2003 on the Seychelles Bank, with the main aim of testing the equipment and to train the divers in survey methods. Twenty-nine sites were surveyed by divers, mostly in shallow areas, and 19 different species of sea cucumbers were collected. Average abundance of all holothurians varied significantly between sites, ranging from 12.5 to 113 individuals per hectare; for high value commercial species the average abundance ranged from 6.25 to 43.33 individuals per hectare.

The main full-scale survey took place in March and April 2004 for four weeks on the Seychelles Bank and the Amirantes Plateau. For this survey, both diver transects and video transects were done. A total of 156 sites were surveyed, including 109 video transects and 47 diver transects. When the weather and sea conditions were good, the video proved to be capable of surveying at depths greater than 60 m.

It was not possible to sample all the sites during this survey due to bad weather, unavailability of some specific gear, and the relatively slow speed of the research vessel. It was thus decided to conduct another two-week survey in November 2004, when the weather was expected to be calm. This has just

been completed, and data have not yet been analysed. Another 65 (43 videos and 22 dives) sites were surveyed during that period (Fig. 1, Table 1), bringing the total number of sites surveyed to 250 (152 videos and 98 dives). This is still short of the 329 sites allocated during the sampling design. The main limitation in reaching the target number of sites was bad weather during part of the surveys that restricted both diving and video recordings, and the long distances the research vessel had to travel between two sample sites. Once the data has been analysed, we will decide whether the results are statistically robust enough, or whether there is a need to do another trip to survey the remaining sites. The species list now stands at 23, with a total number of specimens of 597 having been collected during the three surveys. However, it should be noted that some species have been difficult to identify with certainty, and have been given tentative names. There is definitely a need for taxonomic work on these species, but this is outside the scope of this project.

Other activities

Several other activities have also been taking place since the start of the project, and are still ongoing.

A geographical information system (GIS) has been set up where fisheries-related data submitted by the fishers, and all data collected during the sur-

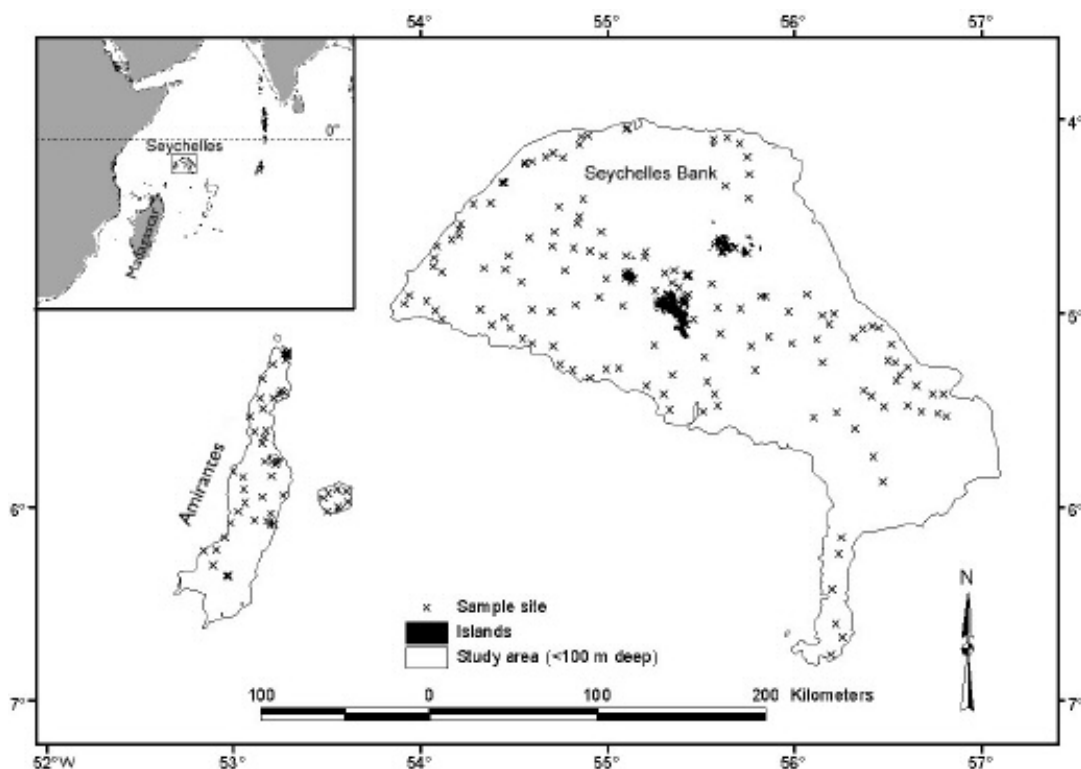


Figure 1. The study sites

Table 1. Data collected during the surveys

Survey	Dates	No. sites surveyed	Dive transects		Video transects	
			No. dives	No. sea cucumbers collected	No. videos	No. sea cucumbers observed
Pilot	1–5 Dec. 2003	29	29	129	0	0
Main 1	23 Mar.–02 Apr., and 13–23 Apr. 2004	156	47	257	109	138
Main2	3–16 Nov. 2004	65	22	66	43	32
Total:		250	98	452	152	170

veys will be incorporated. This will give the management access to up-to-date and geo-referenced data that will help in the decision-making process.

An assessment of the socioeconomic importance of the fishery is being conducted, based on interviews of the different stakeholders involved in the fishery (e.g. divers, boat owners, processors). The results of this assessment will be helpful in the preparation of the management plan.

A communication exercise has also started, targeting mainly those involved in the fishery, but also the general public. One meeting has been organised with the licensed sea cucumber fishermen and processors to explain the objectives of the project, and another is planned soon. The local television station has produced a documentary on the sea cucumber fishery, which has already been broadcasted on the local television network. In addition, a poster on the project has been produced and displayed during an underwater festival organised in October 2004.

It is now expected that complete results of the surveys will be available during the first quarter of 2005, and a draft management plan can then be tabled for discussions with all stakeholders.

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Abundance and distribution of holothurians on the fringing reef flats of Grande Terre, Mayotte, Indian Ocean

Adeline Pouget¹

Introduction

Lying at the northern end of the Mozambique Channel, between the East African coast and Madagascar, Mayotte is part of the Comoros island group. Mayotte lies inside an enclosed lagoon comprising exceptionally diverse biotopes.

No detailed research has yet been carried out on holothurians, or “papacajo” in the Mahorian language, in Mayotte. Contrary to Madagascar, the gathering and exploitation of this resource for the Asian market have only developed recently, and on a limited scale (Pouget 2004). No special action has been taken towards sustainable management of the fishery. The potential development of this activity therefore justifies research into the fishery and the state of the resource. This article presents an assessment of the specific richness, abundance and distribution of holothurians on the fringing reef flats of Grande Terre.

Materials and methods

Mayotte, which is 376 km² in area, comprises two main islands: Grande Terre and Petite Terre. Eight million years old (Marty 1993), these volcanic islands are surrounded by a reef and lagoon complex spread out over some 1500 km², making it the biggest in this part of the Indian Ocean. Fringing reefs, 50–800 m wide, abut the islands and islets. The holothurians of Grande Terre’s fringing reef were studied between 28 May and 21 July 2003. Twenty sampling stations were selected (Fig. 1).

At each station, sampling was carried out at two locations on the reef flat: the outer reef flat and the inner reef flat. Within each of these biotopes, the tide and current, biological, bathymetric and sedimento-

logical conditions are relatively uniform and are therefore determining factors in species distribution (Conand 1990).

At each station, two transects (inner and outer reef flat) 50 m in length and 5 m in width were made at random, parallel to the shore, resulting in a sampled area of 250 m² for each biotope. The choice of this surface area was due to the assumed widespread distribution of this megafauna.

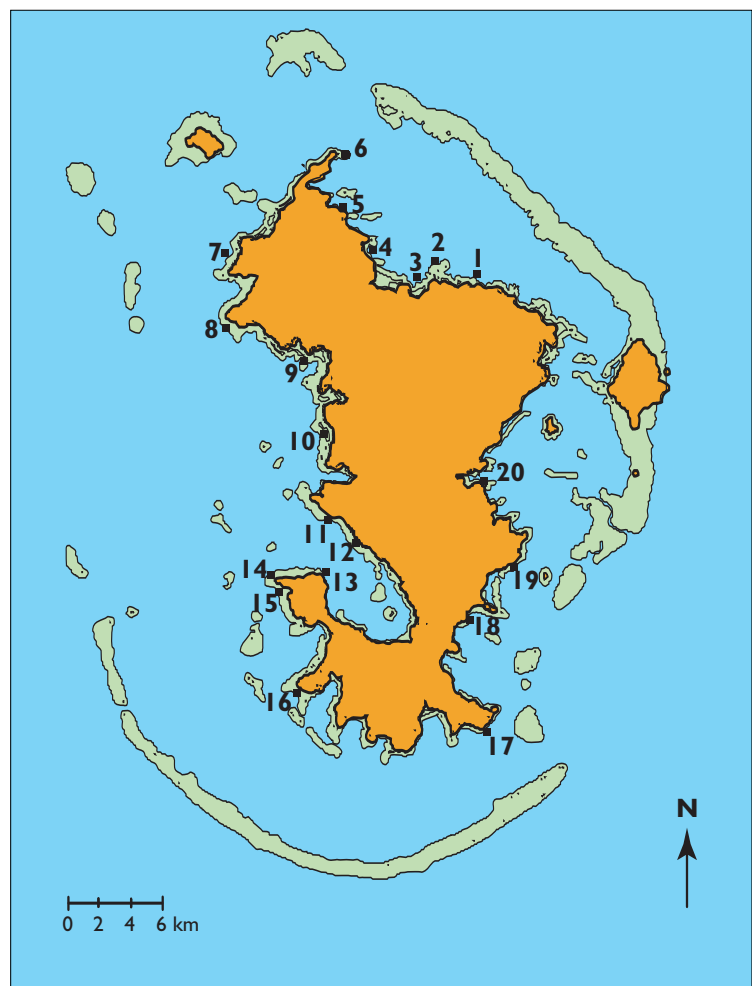


Figure 1.

Location of the 20 sampling stations

Numbers correspond to the following stations: Trevani (1), Pointe de Longoni (2), Longoni (3), Dzoumogné (4), M'tsangaboua (5), Pointe d'Handrema (6), M'tsangadoua (7), Tanaraki (8), Hambato (9), Sohoa (10), Tahiti plage (11), Poroani (12), Hagnoundrou (13), Le Soleil Couchant (14), Le Poulpe (15), N'Gouja (16), Saziley (17), Musical plage (18), Sakouli (19), Iloni (20).

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Results

Specific richness, abundance and general species distribution

Nine species of holothurians were found during the sampling carried out on the fringing reef flats of Grande Terre (Table 1).

With relative proportions of 42% and 22%, respectively, *Holothuria atra* and *Bohadschia atra*, a recently described species (Massin et al. 1999), were the two most abundant species found. These two species were also those with the highest observation frequencies: *H. atra* and *B. atra* were observed at 30% and 35% of sampling stations, respectively. At these stations, *H. atra* was the characteristic species of the inner reef flat, where it occurred in a mean density of 88 specimens 10^{-4} m^{-2} (Fig. 2). Conversely, *B. atra* was characteristic of the outer reef flat, occurring in a density of 44 10^{-4} m^{-2} .

Bohadschia subrubra and *B. vitiensis* were also two relatively abundant species on Grande Terre's fringing reef, representing 13% and 10% of all holothurians found. However, specimens of these species were only observed at 5% of the sampling stations and only on the inner reef flats. On the scale of the island, therefore, the mean density on the inner reef flats corresponded to 30 specimens 10^{-4} m^{-2} for *Bohadschia subrubra* and 22 10^{-4} m^{-2} for *B. vitiensis*.

In terms of abundance, *Stichopus chloronotus* and *Holothuria nobilis* represented 6% and 4%, respectively of all holothurians observed. Their frequency of observation (number of stations where the species has been observed/total number of stations), however, was 15% and 20%. *S. chloronotus* was present on both the inner reef flat (mean density of 8 specimens 10^{-4} m^{-2}) and on the outer reef flat (mean density of 6 specimens 10^{-4} m^{-2}), as opposed to 2 specimens 10^{-4} m^{-2} on the inner reef flat).

Table 1. Relative abundance of each species (number of ind. from one species/total number of holothurian specimens) on the fringing reef of Grande Terre (on the inner and outer reefs, or a total area of $2 \times 20 \times 250 \text{ m}^2 = 10,000 \text{ m}^2$) and observation frequency of each species (number of stations where the species has been observed/total number of stations)

Species	Relative abundance	Observation frequency
<i>Actinopyga mauritiana</i>	1%	5%
<i>Bohadschia atra</i>	22%	35%
<i>Bohadschia subrubra</i>	13%	5%
<i>Bohadschia vitiensis</i>	10%	5%
<i>Holothuria atra</i>	42%	30%
<i>Holothuria nobilis</i>	4%	20%
<i>Holothuria scabra versicolor</i>	1%	5%
<i>Stichopus chloronotus</i>	6%	15%
<i>Thelenota ananas</i>	2%	5%

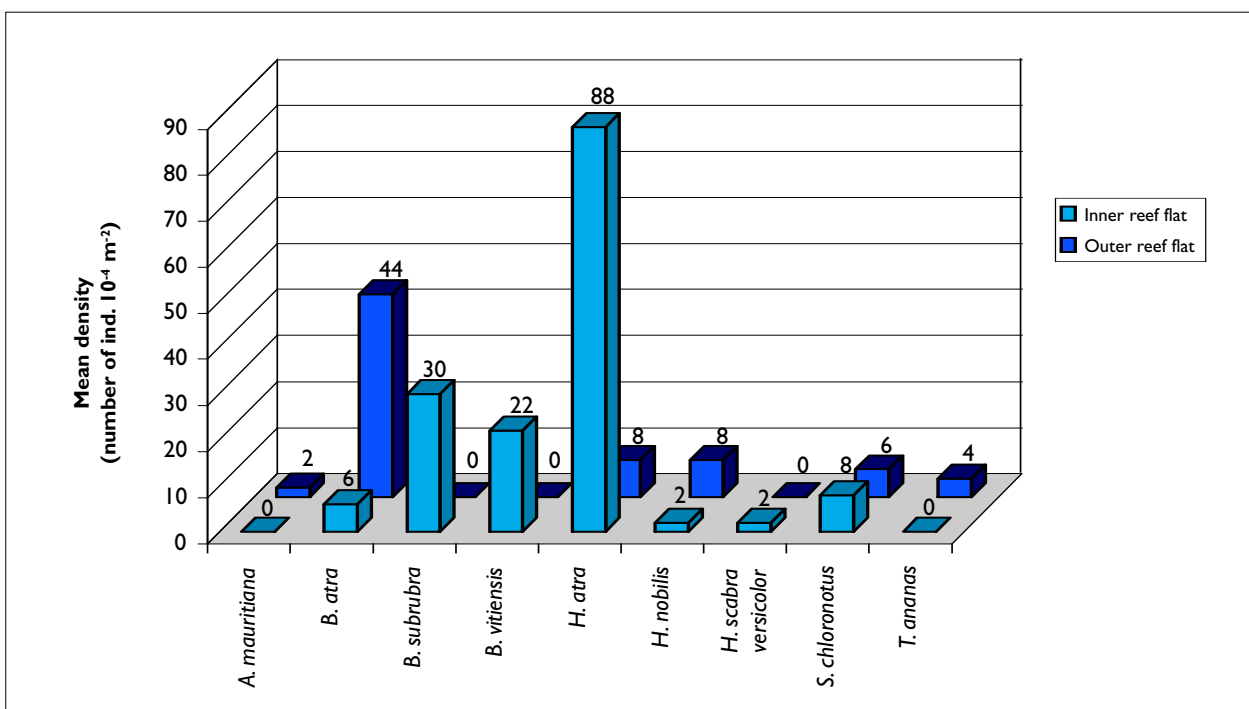


Figure 2. Mean density of each species present at the 20 sampling stations on Grande Terre's fringing reef (inner and outer reef flat).

Actinopyga mauritiana, *H. scabra* var. *versicolor* and *Thelenota ananas* can be considered as scarce species on the fringing reef flats. Only 4% of the specimens sampled from all transects belonged to one of these three species. Each of these species also showed low observation frequencies (5%). Over the reef flats as a whole, their distribution was limited to a single biotope: *A. mauritiana* and *T. ananas* were only observed on the outer reef flat, whereas *H. scabra* var. *versicolor* was only present on the inner reef flat.

Distribution of the most common species

Figure 3 shows the heterogeneous distribution of the four most frequent species (*H. atra*, *B. atra*, *S. chloronotus* and *H. nobilis*) at the various stations. Only 9 of the 20 sampling stations were concerned by the presence of the species.

Holothurian densities were particularly high at the following stations: “Le soleil couchant”, Sakouli, and especially N’Gouja, where the density of the main species on the inner reef flat reached 880

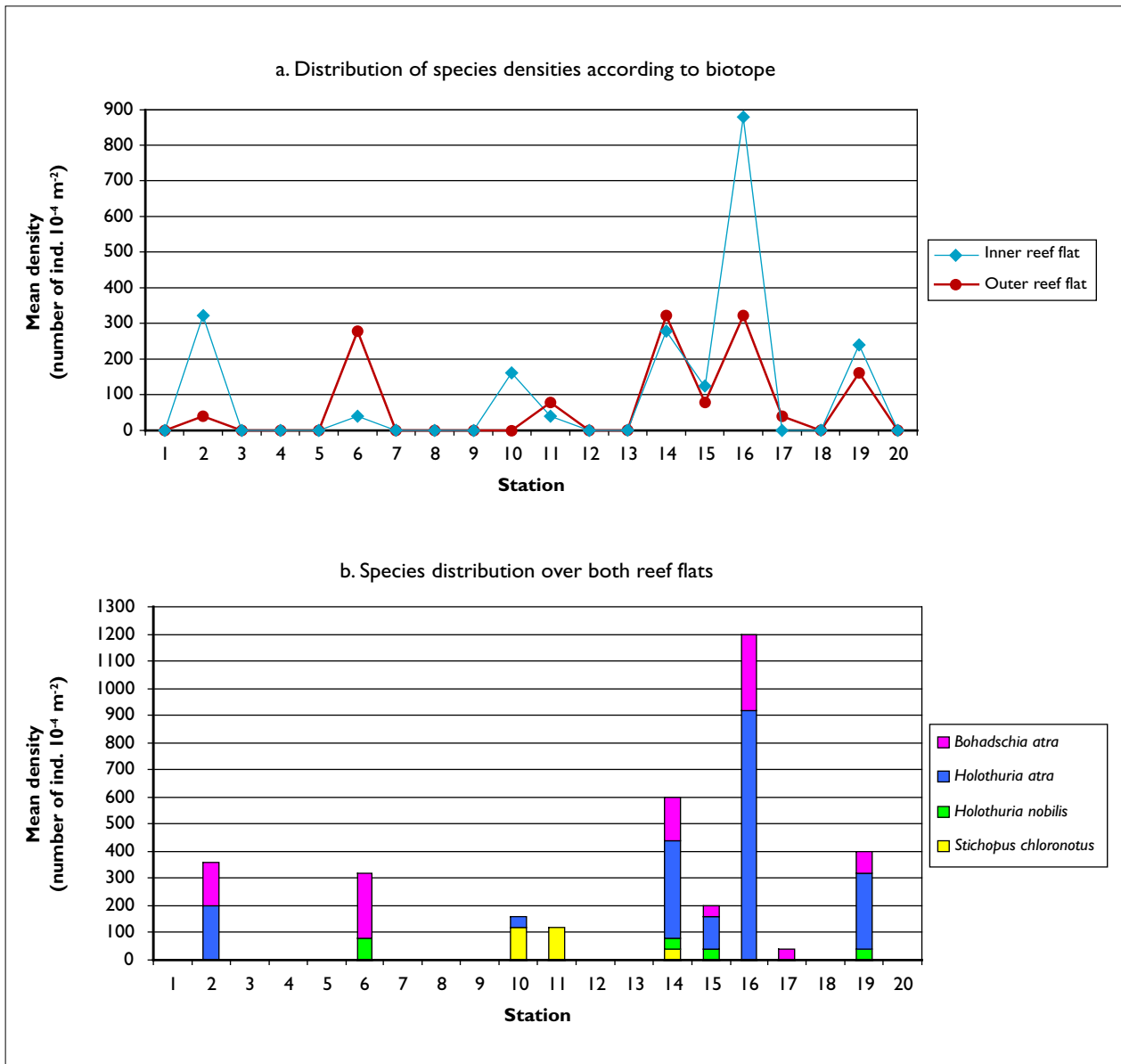


Figure 3.

Density distribution of the four main species (*Bohadschia atra*, *Holothuria atra*, *Holothuria nobilis* and *Stichopus chloronotus*) by station and biotope.

Numbers correspond to the following stations: Trevani (1), Pointe de Longoni (2), Longoni (3), Dzoumogné (4), M’tsangaboua (5), Pointe d’Handrema (6), M’tsangadoua (7), Tanaraki (8), Hambato (9), Sohoa (10), Tahiti plage (11), Poroani (12), Hagnoundrou (13), Le Soleil Couchant (14), Le Poulpe (15), N’Gouja (16), Saziley (17), Musical plage (18), Sakouli (19), Iloni (20).

specimens 10^{-4} m^{-2} . At these three stations, only *H. atra* was present on the inner reef flat. The maximum density for *B. atra*, the dominant species on the outer reef flat, was also observed at N'Gouja: 280 specimens 10^{-4} m^{-2} .

Within the two biotopes, the dominance of these two species could be seen at the majority of stations. However, certain sampling areas did not show this distribution pattern:

- On the inner and outer reef flats of Tahiti plage, only *S. chloronotus* was observed; its overall density was 120 specimens 10^{-4} m^{-2} .
- The Sohoa Station is also dominated by *S. chloronotus*. Present only on the inner reef flat, its density was 120 specimens 10^{-4} m^{-2} .
- At Handrema Point, *H. nobilis* was the only species present on the inner reef flat, where its density was 80 specimens 10^{-4} m^{-2} .
- On the outer reef flat of the "Le Poulpe" station, *H. nobilis* was found in a density of 40 specimens 10^{-4} m^{-2} , in other words a density equal to that of *B. atra*.

Discussion

This survey of nine species was the first of its kind on Mayotte. Because the survey only covered the fringing reef flat of Grande Terre, the list is not comprehensive for Mayotte overall. A parallel study of the fishery (Pouget 2004) revealed the presence of two other species: *A. echinites* and *H. fuscopunctata*. These two joint studies make it possible to conclude that a total of 11 species of holothurians are present in Mayotte.

Also, the specimen densities observed during this survey appear to be lower than those recorded in other islands of the Indian Ocean. *H. atra* was in fact the most abundant and common species over the main island as a whole. However, the maximum density observed on the inner reef flat at N'Gouja station was only 920 specimens 10^{-4} m^{-2} . At Reunion Island, however, where *H. atra* is also the dominant species (Conand and Mangion 2002), maximum density in this biotope was 0.25 specimens 10^{-4} m^{-2} . It should also be noted that the species with high commercial value (Conand 1999), such as *H. nobilis* and *H. scabra versicolor*, only represented 4% and 1% of the species found on Grande Terre. *H. nobilis*, however, was the most frequently gathered species on Mayotte (Pouget 2004). The majority of the exploitable stock on Mayotte would not therefore appear to be located on the fringing reef of Grande Terre.

The distribution of these species around the perimeter of Grande Terre in Mayotte would ap-

pear to be very uneven. Over half of the stations sampled had no holothurians whatsoever. There are two possible reasons for these absences: 1) the stations selected for this survey have a very wide range of reef structures and physical and chemical characteristics (particularly related to the proximity of a river, a mangrove area or an urban area). These environmental parameters could influence the development and therefore the distribution of these echinoderms around the island perimeter; or 2) within the biotope itself, the holothurians show aggregating behaviour, probably linked to feeding (Hammond 1983; Uthicke and Karez 1999). In each part of the reef flat, only a single transect was performed at random. Despite the large surface area concerned (one transect of 250 m^2 per biotope in our survey), it is possible that this sampling technique was not the optimum one for this type of animal. The use of a larger number of transects or quadrats along radials perpendicular to the shore might make it possible to gain a better picture of the abundance of these animals on the reef flat.

Conclusions and prospects

This survey, carried out on the fringing reef of the main island of Mayotte, revealed the presence of nine species of holothurians, of which two were broadly dominant: *Holothuria atra* and *Bohadschia atra*. The distribution of these species around the main island emerged as very heterogeneous. The continuation of this study on all the islands and islets of the main island of Mayotte would complete this survey as regards the fringing reef. In addition, a similar review of the double inner barrier reef and the barrier reef proper would make it possible to complete a more accurate review of the areas harvested. Research on the population structures (weighing and measuring animals) and regular monitoring would make it possible to introduce sustainable management measures for this resource.

Acknowledgements

I wish to thank Olivier Abellard, Director of the Fisheries and Marine Environment Department of Mayotte for having enabled me to carry out this survey, Julien Wickel, my supervisor and Chantal Conand. My thanks are also due to the Fisheries and Marine Environment Department team and especially Didier Fray for his logistical assistance and thorough knowledge of the island.

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Information on juvenile holothurians: A contribution by Dr D.B. James

As communicated by Glenn Shiell¹

Following a request for anecdotal information on the habitat preferences of juvenile holothurians (see Beche-de-Mer Information Bulletin #19), issue #20 included a short article entitled, “Field observations of juvenile sea cucumbers”. The aim of the article was to consolidate observations of juveniles in their natural environment and identify differences in habitat preferences between adult and juvenile holothurians. By consolidating this information, the article ultimately aimed to identify juvenile ecology research directions and to clarify some of the details of the little-known but important juvenile life phase. At the time of writing the article, I had received 26 responses covering 18 different species.

However, since that time, I have received further information from Dr D.B. James of India. Given the range of species covered in his list of observations (many of which were not included in the previous article), and the extensive time frame over which these observations were made, it seemed appropriate to include the observations in this issue as a follow up to that published in the previous issue.

In his list, Dr James includes 21 holothurian species (see Table 1). Of these, 17 were observed concur-

rently in the same habitat as adults, and 4 in the absence of adults. These observations again reflect the patterns identified in the article published in issue #20. In examples provided by Dr James, there appears, in most cases, to be a close association between the habitat preferences of adult and juvenile holothurians of the same species. However, Dr James also provides evidence to suggest that juveniles of selected species may occupy different habitats to that of the adult form. This trend, which is now reported in a number of species (*Holothuria fuscogilva*; *H. whitmaei* [previously *H. nobilis*]; *Cucumaria frondosa* and *Stichopus hermanni* — see issue #20 for corresponding references), requires further and more detailed research.

At this point, I would like to take the opportunity to thank those who contributed observations of juvenile sea cucumbers. This information may help to provide a starting point for future research into this interesting, but poorly understood aspect of holothurian biology. I will continue to compile this information and welcome further correspondence regarding this subject.

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Table 1. Observations of holothurians from Indians seas (contributed by Dr D.B. James)

Species observed	Approx. size and number	Location	Habitat	Time	Date	Adults present?
<i>Acaudina molpadioides</i>	6.5–8 cm (several transparent specimens)	Pamban (Gulf of Mannar)	At low tide on muddy flat	13:00	1969	No
<i>Actinocucumis typicus</i>	3–4 cm	Thondi (Palk Bay)				Yes
<i>Actinopyga echinites</i>	8–10 cm	Vedalai (Gulf of Mannar)	7 m depth		1990	No
<i>Actinopyga miliaris</i>	10 cm	Tuticorin (Gulf of Mannar)	5 m depth		1993	Yes
<i>Afroccumis africana</i>	3.5–5 cm	South Point, Port Blair (Andamans)	In rock crevices along with adults			Yes
<i>Havelockia versicolor</i>	3.1 cm (n =1)	Mandapam (Gulf of Mannar)	In 1 m of water			
<i>Holothuria arenicola</i>	3 cm	South Point, Port Blair (Adamans)	Buried in sand along with adults			Yes
<i>H. atra</i> (note: these animals possibly resulted from fission – D.B. James)	9 cm	Tuticorin (Gulf of Mannar)	In the intertidal zone along with adults		1998	Yes
<i>H. edulis</i>	8.5–10 cm	Port Blair (Andamans)			1965	Yes
<i>H. hilla</i>	5 cm	South Point, Port Blair (Andamans)	Under rocks along with adults		1976	Yes
<i>H. impatiens</i>	6 cm	South Point, Port Blair (Andamans)	Under coral stones along with adults		1976	Yes
<i>H. pardalis</i>	5 cm	South Point, Port Blair (Andamans)	Under coral stones along with adults		1976	Yes
<i>H. rigida</i>	2-5 cm	South Point, Port Blair (Andamans)	Buried in sand along with adults		1976	Yes
<i>H. scabra</i>	0.5–16 cm (n=432)	Sesostri Bay, Port Blair	At low tide on reef flat	16–18:00	Feb. 1978	No
<i>H. scabra</i>	3 cm (n=1)	Mandapam (Gulf of Mannar)	Upon algae in 1 m depth		April 1970	
<i>Holothuria (Semperothuria) cinerascens</i>	5 – 7 cm (n=52)	Vizhinjam, near Trivandrum (SW coast of India)	Under rocks	8–10:00	Feb. 1964	Yes
<i>Labidodemas rugosum</i>	9–10 cm	South Point, Port Blair (Andamans)	Buried in sand along with adults			Yes
<i>Labidodemas rugosum</i>	6–7 cm	South Point, Port Blair (Andamans)	Buried in mud along with adults			Yes
<i>Patinapta ooplax</i>	7 cm	South Point, Port Blair (Andamans)	In the supralittoral zone along with adults		1976	Yes
<i>Phyrella fragilis</i>	0.4–6 cm	South Point, Port Blair (Andamans)	Buried in sand along with adults			Yes
<i>Polycheira rufescens</i>	40 cm	South Point, Port Blair (Andamans)	Buried in sand along with adults		1976	Yes
<i>Stichopus hermanni</i>	10 cm	Vedalai (Gulf of Mannar)	On algal beds		1963	No
<i>Synaptula recta</i>	2 cm	Mandapam (Palk Bay) On algal beds along with adults			1963	Yes

Observations of natural spawning of *Bohadschia vitiensis* and *Holothuria scabra versicolor*

Observer: Aymeric Desurmont¹

Date: 24 November 2004
 Observation time: 15:45–17:45
 Location: Baie des Citrons, Noumea, New Caledonia
 Tide: 3–1 hours before high tide
 Moon phase: 3 days before full moon
 Species: *Bohadschia vitiensis* (mass spawning)
Holothuria scabra versicolor (1 specimen spawning)

Description

Bohadschia vitiensis are found in high density on the soft sandy-muddy bottom (approx. 30 ind. 100 m⁻²) in the middle of the bay. During the time of the observation, about half of the visible individuals were in classical upright spawning posture. One isolated specimen of *Holothuria scabra versicolor* (see picture) was also spawning.

Other sea cucumber species in the same location (*Stichopus hermanni*, *H. atra*, *H. coluber* and one specimen of *H. scabra*) showed no sign of spawning behaviour.

Concerning the “solitary” spawning of the *H. scabra versicolor*, it is interesting to note that animals can and do spawn alone. This confirms observations made before at the same location and elsewhere (see past issues of this bulletin). Was this spawning triggered by the massive *B. vitiensis* spawning, or did this individual simply react to the same environmental factors (i.e. tide, moon, water temperature) that triggered the *B. vitiensis* spawning? It would be an interesting question to investigate with tank experiments and further field observations.



Bohadschia vitiensis



Holothuria scabra versicolor

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Australia's first commercial sea cucumber culture and sea ranching project in Hervey Bay, Queensland, Australia

Daniel Azari Beni Giraspy¹ and Grisilda Ivy

Introduction

The sea cucumber *Holothuria scabra*, commonly called sandfish, yield one of the largest sea cucumber catches worldwide (Brookes and Shannon 2004). *H. scabra* also forms an important fishery in Torres Strait and the east coast of Queensland, Australia. In Queensland, the beche-de-mer fishery is probably one of the oldest commercial fisheries, with harvesting of wild stocks beginning in the early 1800s (Breen 2001). Although the fishery was interrupted during the world wars and gradually declined thereafter, it experienced a new boom period in the 1980s (Breen 2001).

During the late 1980s, state government fisheries introduced new measures to ensure that fisheries resources were used in an ecologically sustainable way (Breen 2001). Most recently, the Great Barrier Reef regions were progressively restricted to fishing for beche-de-mer on a quota system to comply with the Marine Park protected area zoning arrangements. During the last two decades, a considerable number of research and commercial hatcheries have been established worldwide, producing sea cucumber juveniles for stock enhancement or for commercial purposes.

Australia's first commercial sea cucumber culture hatchery, Bluefin Seafoods Hatchery officially started operations in May 2003 and is currently fully operational. Bluefin Seafood's Hatchery is in the Great Sandy Strait in Hervey Bay on Queensland's mid-north coast. The hatchery is owned by Ross Meaclem and Theresa Rimmer, Managing Directors of Bluefin Seafood Pty. Ltd., Hervey Bay, Queensland.

The present commercial sea cucumber project arose from the current limited beche-de-mer fishery in Queensland and also the increased demand for the product in Asian markets. The hatchery was built under the federal government's Farm Innovation Program to produce sea cucumber juveniles. The aim of the hatchery is to commercially produce sea cucumbers (sandfish *H. scabra* and golden sandfish *H. scabra versicolor*) to supply the industry as an alternative to harvesting wild populations.

Development of the program

The sea cucumber culture program's two phases (hatchery and grow-out) is guided by more than 10 years of commercial sea cucumber culture experience (larval rearing, settlement and grow-out) acquired in India and the Republic of Maldives by the authors of this paper. The purpose of the hatchery is to routinely mass-produce sea cucumber juveniles in three stages: larval culture (i.e. fertilisation, embryonic development, larval growth, and settlement of juvenile), juvenile rearing (nursery phase in flow through system) and farming of hatchery produced juveniles in the natural habitat (seeding area approved by the Department of Primary Industries, Queensland) for grow-out and harvesting.

The future scope of the project is well designed to enhance and refine technologies for mass production of *H. scabra* and *H. scabra* var. *versicolor*, with increased survival rate in the hatchery and field. Our ongoing research on white teatfish (*H. fuscogilva*) and black teatfish (*H. whitmaei*) should allow us to better understand these species. In addition to this, the project will benefit the sea cucumber industry by improving techniques for processing the gut of harvested sea cucumbers ("konowata"), plus developing value-added products from the gonad and body wall.

Hatchery

The hatchery building consists of a 300 m² area with more than 50, 1000-L fibreglass tanks for spawning and larval rearing. The incoming water inside the hatchery is passed through a series of cartridge filters and UV disinfection chambers, at a rate of 80,000 L day⁻¹. Air is supplied by two blowers.

Microalgal culture facility

The microalgal mass culture facility consists of a 40 m² temperature controlled room for culturing six species of algae and four species of benthic diatoms. The microalgal species are cultured in 44-L transparent bins set upon the racks. Luminescent lights

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are fixed to provide enough light needed for microalgal growth. Around 5000 L of pure microalgal cultures can be produced using this setup (Fig. 1).



Figure 1. Indoor microalgal culture

Other facilities

The hatchery has a temperature controlled stock culture room for maintaining microalgal species. The laboratory has full water-quality testing equipment, microscopes and computers for processing water quality and larval development data.

Broodstock collection and maintenance

For successful spawning, it is essential to use healthy sea cucumbers with mature gonads (Hamel et al. 2001). Therefore, a selected number of adult specimens (breeders) are collected during the spawning season (November to January) from Hervey Bay waters. The broodstock are collected by diving and are transported to the hatchery with considerable care in order to avoid any damage. The animals are spawned on the day of collection and a few animals are dissected in order to effectively assess the maturation stage of their gonads. Normally, specimens weighing 350–500 g and measuring 12–15 cm are preferred breeders. The sea cucumbers are maintained in the hatchery at constant water temperature (26°C) and the quality of the water is maintained with sufficient water exchange.

Spawning

About 35 breeders are induced to spawn in a one-tonne tank by thermal stimulation. Several trials are carried out during the spawning season from November to January. *H. scabra* spawning occurs generally between 17:00 and 23:00; a quiet environment and dark conditions are preferred conditions for spawning. Generally, males spawn first, which

then induce the females to release their eggs. Only a few males are allowed to spawn in a tank to maintain the water quality.

Egg collection

Fertilisation occurs inside the spawning tank. After spawning, sea cucumbers are removed from the spawning tanks and the fertilised eggs are collected using 65- μ sieve. The collected eggs are washed gently for 15 minutes to remove impurities, and transferred to 1- μ filtered UV sterilised seawater. The hatching rate is generally 75 to 90 per cent.

Larval rearing

The following microalgae are suitable for the sea cucumber larvae: *Chaetoceros mulleri*, *C. calcitrans*, *Rhodomonas salina*, and *Pavlova lutheri*. For better larval development, using a mix of microalgae species is important. The algae such as diatoms and *Rhodomonas salina* can be used as the main food, supplemented with *Pavlova* sp. and *Isochrysis* sp. The algae are given twice a day in increasing concentrations as larvae develop from early auricularia to late auricularia. For the early-stage auricularia, the feeding regime should be 15,000–20,000 cells ml⁻¹ while for late auricularia it can be increased to 30,000–40,000 cells ml⁻¹.

Water exchange and aeration

The water in the larval tank is exchanged once a day, in the morning. Debris such as dead algae, faeces and dead larvae that have settled to the bottom of the tanks are removed in the evening by siphoning. During larval rearing, the water is aerated continuously but gently. The optimum water temperature ranges from 26–29°C and the dissolved oxygen is maintained above 5.5 mg L⁻¹. The optimum salinity ranges from 33–37‰ and pH is 8.2.

Larval settlement

After 10–12 days the auricularia larvae metamorphoses into doliolaria, the non-feeding stage. The doliolaria transforms into pentacula and starts to settle on the tank bottom or in the settlement substrates. For a better survival rates, the density of the larvae on the substrate is maintained between 1–3 individuals cm⁻². Benthic diatoms and Algamac 2000 are given as food for the early settled juveniles.

Nursery rearing

Juveniles measuring more than 5 mm are transferred to outside nursery tanks. Twenty-five 3900-L tanks and ten 10,000-L tanks fitted with flow

through system are used for nursery rearing of juveniles. The water exchange in these tanks is above 250 per cent per day. In the early stages, Algamac 2000 and benthic diatoms are used as food and in the later stages, extracts of seaweeds and seagrass mixed with fine sand forms the primary food. Differential growths of juveniles are common in all the tanks and the juveniles are thinned out with the removal of well-grown juveniles in separate tanks. Initial production of juvenile sea cucumbers, which began in November 2003, has led to the production of more than 530,000 sandfish juveniles. We have successfully bred the golden sandfish *Holothuria scabra* var. *versicolor* (Fig. 2) for the first time and produced more than 33,500 juveniles, well suited for seeding in lagoons and bays with rubble bottoms.

Sea ranching

Sea ranching of sea cucumbers has become very popular in recent years. Results suggest that the substrata of the seeding area play an important role in the survival of released juveniles, as they need protection from predators and require an abundance of natural feed (Jiixin 2003). The present seeding area at Hervey Bay has been selected because of its sheltered nature and availability of seagrass beds and preferred habitats such as small pools and channels.

The hatchery-produced juveniles were transferred to the 62-ha seeding area allocated by the Department of Primary Industries, Queensland, and released into a habitat comprising mostly mudflats and seagrass beds. Ongoing monthly observations show better survival and good growth

rates in the wild (Fig. 3). The completion of one full year of continuous monitoring will provide some interesting ideas about the success of sea cucumber sea ranching in Australia, as there is a lack of data on the survival and success of seeding hatchery-produced juveniles in the wild.

Acknowledgements

The authors wish to thank Dr Colin Shelley, Manager, Aquaculture, Queensland Fisheries Service for his cooperation and help in obtaining the seeding areas for the hatchery produced juveniles.

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Figure 2. Marine biologist Grisilda Ivy holding a golden sandfish



Figure 3. Monitoring released juveniles at the seeding area

White teatfish at Kiribati sea cucumber hatchery “Local technicians getting them out again”

K. Friedman¹ and M. Tekanene²

The following short communication was written by Kim Friedman following a visit to the sea cucumber hatchery in Tarawa while on EU/SPC PROCFish work in Kiribati. The information was gathered during an interview with the leader of the facility, Michael Tekanene.

Mr Tekanene and his team at Kiribati Fisheries on Tarawa are having great success in rearing juvenile teatfish. To date, 20,000 juvenile *Holothuria fuscogilva* have been placed on the reefs around Tarawa and neighbouring Abaiang Atoll, and another 10–15,000, are being readied for release following successful spawnings in 2004. The sea cucumber hatchery on the capital island of the Republic of Kiribati has for the last three years been maintained by local expertise after originally being established with overseas assistance.

The Overseas Fishery Cooperation Foundation (OFCF) project began in 1995 by assessing sea cucumber stocks in Kiribati's atoll systems. After the hatchery was built, spawnings commenced in 1997 and numerous small batches of white teatfish and prickly redfish (*Thelenota ananas*) were produced before the funding came to an end in 2001. Despite the closure of the project, the team continued their work, using available equipment and relying on ongoing support of Kiribati Fisheries to produce a further 7–8 batches of *H. fuscogilva* within the facility (Fig. 1). The majority of the approximately 20,000 small juveniles have been released locally, but some have also been sent to neighbouring Abaiang Atoll.

Spawnings of white teatfish are conducted with wild broodstock collected in Tarawa and neigh-

bouring atolls (Fig. 2). Mr Tekanene said that the ratio of males to females in their collections was usually skewed (5 males to 1 female), and that spawning females yielded more than 5 million eggs. The team stress-induces the broodstock around the time of a full moon during two periods of the year: March–June and August–September. Frozen sperm have also been added to tanks to stimulate spawning. The larval rearing phase lasts 14–21 days before settlement and Mr Tekanene said his team tended to have more success when handling fewer larvae; the management of 2 million has proven to be more feasible than trying to manage over 5 million.

Settled juveniles are held on plates seeded with pennate algal diatoms (*Navicula* sp.) with some addition of “Livic” powder before moving them to sand-bottomed raceways. Juveniles being held on plates, as of November 2004, averaged 4 and 8 mm from two spawnings, one in late August and a second in late September (the largest juveniles are 6 mm and 17 mm from each batch, respectively) (Table 1). New substrate from local fishponds containing milkfish (*Chanos chanos*), is regularly added. Faeces are also collected from nearby raceways holding trochus, *Trochus niloticus*. “Livic” powder can also be added as a supplement three times a week.

Table 1. Spawning experiments

Spawning run	Relation to lunar cycle	Sizes (mid November 2004)	
		Av. length (mm)	Max length (mm)
27 August 2004	3 days before full moon	7.7	16.8
28 September 2004	1 day before the full moon	4.1	6.2
Spawning run	Size at release (Hatchery/May 2003)	Size at recapture (Abaiang Atoll/Feb.–March 2004)	
May 2002	60 mm	120–130 mm	

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At present juveniles 1–2 cm long are placed out in rocky areas at approximately 10 m depth. There have been inadequate resources for carefully following these releases, or to design and assess the efficacy of release techniques. Michael is confident that the team is now able to produce juveniles, and stated that if there was any area where they could use further assistance it was in re-seeding. As stated, release and the post release monitoring process has been somewhat haphazard to date, although anecdotal evidence points towards recovery of stocks in the passages that have been stocked. Records of small numbers of white teat that have been followed more closely after release for about six months give a hint of the kind of data

that could be gained for fishery and aquaculture needs of this species (Table 1, see Figs. 3 and 4). It is hoped that more careful monitoring of the present batch of juveniles will yield more answers on growth and survival of hatchery reared white teat after release in the wild.

Kiribati Fisheries is also producing juvenile trochus (approximately 20,000 10–40 mm re-seeded to date) and blacklip pearl oysters *Pinctada margaritifera* (>10,000 seeded to date). This success suggests that Kiribati Fisheries is building a critical mass of local expertise suitable for spawning and enhancement programs. Their progress will be watched with great interest.



Figure 1. Hatchery raceways with plates.



Figure 3. Juvenile specimen of *Holothuria fuscogilva*

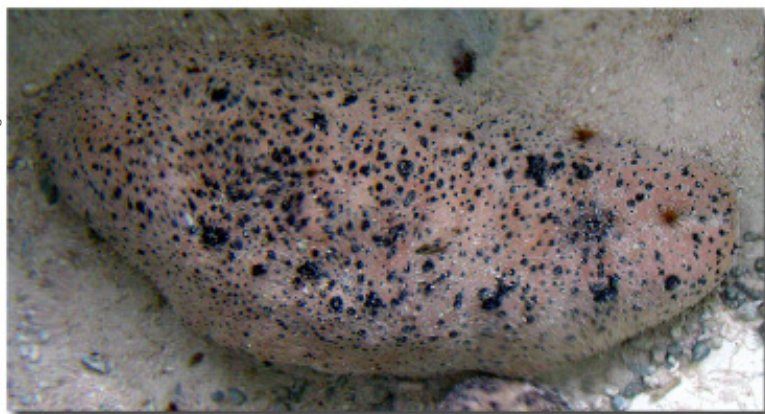
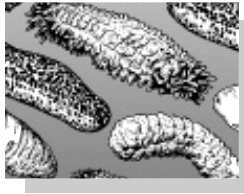


Figure 2. Adult specimen of *Holothuria fuscogilva* kept at the hatchery



Figure 4. Juvenile specimens of *Holothuria fuscogilva* at Abaiang Atoll (100–130 mm in length)



Correspondence

beche-de-mer

CONICYT Project: Development of the cultivation technology of the sea cucumber *Athyonidium chilensis*, in the Chilean South Central Region.

Correspondence from Professor Chita Guisado

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Sea cucumbers have been used as food for centuries, particularly in eastern countries. They are commercialized in dry form, generally referred to as beche-de-mer, or trepang. According to data from Conand (1996), the international trade in beche-de-mer increased dramatically in the 1980s, reaching a global volume of 10,000 t a year.

The main countries importing of dry sea cucumber are China (Hong Kong), Singapore, Taiwan, Malaysia, South Korea and China.

These markets have been an opportunity for countries with natural stocks, including Chile, to develop fisheries, which in many cases have led to an overexploitation of the natural banks. For instance, in Chile, sea cucumber landings have increased from none in 1990 to 1510 t in 2000 (Sernapesca 2001).

The working group that will undertake the CONICYT Project has considerable experience in echinoderm cultivation, having actively participated in sea urchin cultivation projects in Chile. As Director of the project, I have been working in the development of the reproductive cycle, maintenance of adult specimens in a controlled system (i.e. a hatchery), feeding captive individuals, reproduction, fecundation and larval cultivation of the species *Athyonidium chilensis*.

Because this fishery is declining around the world and because there is a basic knowledge that can be used in the culture of the resource, the main objective of this project is to develop cultivation technology of the sea cucumber *Athyonidium chilensis* in central southern Chile. For this purpose, 100 repro-

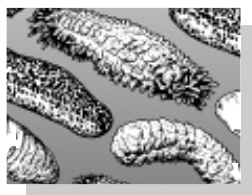
ducers were collected from natural banks. These will be subjected to conditioning techniques in order to induce spawning and to obtain ova. Larval culture will be carried out under a controlled system; after nine days, the larvae will be taken to an intermediate culture system for their growth. Afterwards, the sea cucumbers will be transferred to the sea. After 24 months of cultivation, 1000 specimens of about 15 cm in length are expected to be cultivated.

Due to the biological cycle of this species, the project is limited to 24 months. The Universidad de Valparaíso and the Universidad Arturo Prat, and some centres of the IV and X Regions will be participating in this project.

Because this is an inter-institutional project, it will have an impact on the scientific community. It will generate new knowledge about the biology, nutrition and ecology of these holothurians. In the entrepreneurial sector, it will assure the supply of a resource with a known market. It will allow artisanal fishermen, to diversify their activities.

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Abstracts & publications beche-de-mer

Preservation of genetic diversity in restocking of the sea cucumber *Holothuria scabra* investigated by allozyme electrophoresis

Sven Uthicke and Steven Purcell

Source: Canadian Journal of Fisheries and Aquatic Sciences, 2004

Population genetics analyses should be considered when releasing hatchery-produced juveniles of the sea cucumber *Holothuria scabra* when spawners from nonlocal populations are used. In New Caledonia, within-region genetic heterogeneity of *H. scabra* populations (examined through allozyme electrophoresis of 258 animals) indicated high gene flow between nine sites and FST values did not deviate significantly from zero. However, exact tests indicated that populations at two sites with limited water exchange in the southern location were significantly different from populations at three other locations on the west coast. Inclusion of *H. scabra* sampled in Bali (n = 90) and Knocker Bay, Australia (n = 47), and comparisons with existing data from the west Pacific (Torres Strait, Solomon Islands, Upstart Bay, Hervey Bay) showed that populations were significantly different (using exact tests) and samples partitioned distinctly using un-weighted pair group method with arithmetic mean clustering. Rogers, genetic distance values between populations were significantly related to geographic distances, showing a pattern of isolation by distance. The rapid increase in genetic distance over the first few hundred kilometres supports the view that the spatial extent of any translocation needs to be carefully considered on the basis of knowledge of variation in allele frequencies within the target area.

Species composition and molecular phylogeny of the Indo-Pacific teatfish (Echinodermata:Holothuroidea) bêche-de-mer fishery

Sven Uthicke, Tim D. O'Hara and Maria Byrne

Source: Marine and Freshwater Research, 2004, 55:1–12

Using mtDNA sequences we found that the Indo-Pacific teatfish fishery comprises at least three species, clarifying confusion on the taxonomic status of these commercially important holothurians. Traditional taxonomic characters, including the morphology of skeletal structures, could not be used to differentiate the species. Sequences of the COI gene (529 bp) distinguished three haplotype clusters, corresponding to distinct colour forms and, to some extent, previously described species. The white teatfish, *Holothuria fuscogilva*, comprises a range of colour morphs and has a wide distribution over the tropical Indo-Pacific region. The large sequence divergence indicates potential for the presence of several cryptic species in the white teatfish complex. In contrast to current taxonomy, we identified two species of black teatfish that appear to be allopatric: *H. whitmaei* is entirely black and has a Pacific distribution; whereas *H. nobilis* has white ventro-lateral dots and only occurs in the Indian Ocean. There is evidence for allopatric speciation between the black teatfish species, possibly driven by separation of the oceans and altered current patterns during the Pliocene, resulting in relatively young species with low intraspecific sequence divergence. These results provide insight into speciation in these tropical holothurians and are crucial for their conservation management.

Amplified fragment length polymorphism (AFLP) analysis indicates the importance of both asexual and sexual reproduction in the fissiparous holothurian *Stichopus chloronotus* (Aspidochirotrida) in the Indian and Pacific Ocean

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Source: Coral Reefs – Online First, 7 October 2004. <http://springerlink.metapress.com>

Asexual reproduction in the fissiparous holothurian species *Stichopus chloronotus* from eight populations between Madagascar and the Great Barrier Reef (total N = 149) was investigated using amplified fragment

length polymorphism (AFLP) markers; and results compared to previous allozyme studies. Specifically, we tested the hypotheses that (1) genetic diversity in this species is reduced in the West Indian Ocean and that (2) some populations rely nearly exclusively on asexual reproduction. Using 21 polymorphic markers (obtained by two primer combinations) resulted in 51 genotypes in the whole sample, with up to 20 individuals (nearly all within populations) having the same genotype. These repeated genotypes most likely represent clones. In most populations, more than 50% of individuals were inferred to result from asexual reproduction. In two extreme populations, both of which are comprised nearly entirely of male individuals (Great Palm Island, Trou d'eau), only up to 20% of all individuals were sexually produced. Although, the genetic diversity in two populations of La Réunion was reduced, the fact that diversity is high in a third population and on Madagascar showed that low genetic diversity in *S. chloronotus* is not a general feature of the West Indian Ocean. Cluster analysis using Rogers genetic distance did not result in distinct geographic clusters. This supports previous suggestions that although asexual reproduction is important for the maintenance of populations, large distance dispersal of sexually produced larvae provides the genetic link between populations.

Slow growth and lack of recovery in overfished holothurians on the Great Barrier Reef: Evidence from DNA fingerprints and repeated large-scale surveys

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Source: Conservation Biology 18(5):1395–1404, October 2004

Commercially fished holothurians have important functions in nutrient recycling, which increases the benthic productivity of coral reef ecosystems. Thus, removal of these animals through fishing may reduce the overall productivity of affected coral reefs. To investigate the potential for recovery of overfished holothurian (*Holothuria nobilis*) stocks on the Great Barrier Reef (GBR), we (1) conducted field surveys on 23 reefs after fishery closure, (2) modeled total virgin biomass and compared it with the total amount fished, and (3) estimated individual growth rates with a DNA fingerprinting technique. Two years after fishery closure, no recovery of *H. nobilis* stocks on reefs previously open to fishing was observed. Densities on reefs protected from fishing since the onset of the fishery in the mid 1980s remained about four times higher than on fished reefs. Based on density estimates and geographic information system data on the habitat area of each reef, we calculated that the virgin biomass (in the main fished area between 12°S and 19°S) was about 5500 t and is now about 2500 t. The reduction is on the same order of magnitude as the total amount fished until 1999 (approximately 2500 t). The DNA analysis of repeated samples on three locations indicated high recapture rates of fingerprinted and released individuals of *H. nobilis*. Fitting growth curves with Francis's growth function indicated that medium-sized individuals (1 kg) grew 35–533 g year⁻¹, whereas large animals (2.5 kg) consistently shrank. Small animals (<500 g) were rarely observed. In combination, these data indicate that production of *H. nobilis* stocks is very low, presumably with low mortality, low recruitment, and slow individual growth rates. Consistent with anecdotal evidence, recovery of *H. nobilis* stocks on the GBR may take several decades, and we suggest a highly conservative management plan to protect both the stocks and the ecosystem.

The Galápagos sea cucumber fishery: management improves as stocks decline

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Source: Environmental Conservation 31(2):102–110. 2004.

The Galápagos islands, a world heritage region for the protection of the unique terrestrial and marine wildlife, are also home to a small human population, dependent on fisheries. There was a lucrative sea cucumber (*Stichopus fuscus*) fishery in the islands, which began in 1992. After a rapid expansion in the Galápagos archipelago, the fishery has declined and now persists predominantly around the western islands. Initially, the fishery was largely illegal and uncontrollable. Subsequently, a co-management frame-

work developed, with fisher participation. Gradually enforcement improved, apparent corruption declined, and research capacity increased. Although stock abundance surveys have been carried out annually since 1993, the paucity of background biological and fishery information does not allow rigorous stock assessment. The achievements of co-management through the participation of fishers in research and management have been: an acceptance of management controls on numbers of fishers and quotas, a reduction in conflict with increased co-operation. Persistent problems have been: weak enforcement capacity, limited funds for patrolling and research, corruption and declining stock abundance. Proposed application of precautionary principles to management, including a range of fishery indicators, may save the fishery from collapse. The principles are applicable to many other data-poor fisheries globally.

Estimating the abundance of clustered and cryptic marine macro-invertebrates in the Galápagos with particular reference to sea cucumbers

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Source: Noticias de Galápagos 62:36–39. 2003.

Estimating abundance of marine macro-invertebrates is complicated by a variety of factors: 1) human factors such as diver efficiency and diver error; and 2) biological factors, such as aggregation of organisms, crypsis, and nocturnal emergence behavior. Diver efficiency varied according to the detectability of an organism causing under-estimation of density by up to 50% in some species. All common species were aggregated at scales from 10–50 m. Transects need to be long enough to transcend the scale of patchiness to improve accuracy. Some species of sea urchin and sea cucumber (pepinos), which are cryptic by day emerged at night so that daytime censuses underestimate their abundance by up to 10 times. In the sea cucumber fishery, estimates of abundance need to be made at the scale of the population, i.e. at hundreds of kilometers. A strategy for this is proposed.

Echinoderm larvae in the lagoon of the “Toliara’s Great Coral Reef Barrier” (Madagascar): abundance and seasonal variations.

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Source: DEA in Applied Oceanology, University of Toliara, IH-SM, Aqua-lab, March 2003

The study on larvae of echinoderms was carried out in the lagoon of Tuléar’s Great Coral Reef Barrier. In general, four samplings were carried out on a monthly basis from December 2000 to May 2002. On a total of 61 samplings, 9108 larvae were registered. They are split up in the four following classes: Holothuroidea (32,43%), Echinoidea (35,23%), Ophiuroidea (30,99%) and Asteroidea (1,35%).

The study of the space and time distribution shows that echinoderms larvae are observed from the lagoon to the outside of the reef. They are observed in the lagoon waters yearlong. Nevertheless, their average density is variable according to the seasons. Average density observed during the warm seasons (from November to April) amounts to 228,26 larvae 350 m⁻³ of seawater and only 18,87 larvae 350 m⁻³ around during cold seasons (May to October).

Different groups and families of echinoderms were identified in the course of this study. Qualitative study shows that only the larvae of Synaptidae (holothuroids) and Spatangoida (sea urchins) are considered as perennial. They can be observed at least 8 months during the yearly period. Those of other groups are seen only during the warm season, especially on December and February.

For holothuroids, larvae of the Holothuriidae family are the most dominant and occupy 86,22% of the class. For sea urchins, echinometrids (29,11%) and spatangoids (26,29%) are dominant. For ophiuroids, the specie of Ophiactidae (22,61%) and Amphiuroidae (21,29%) are dominant.

All different larvae stages (young, advanced, metamorphosizing) were also observed in the course of this study. Juveniles of Echinoidea and Ophiuroidea are as well observed.

The spawning period of echinoderms species occurs in general during hot season (November–April) in the Toliara area (south-west of Madagascar).

Relationship between sea cucumber (echinoderm) nutrition and reef sediment microbenthos in Reunion Island (Indian Ocean)

Adeline Pouget

Source: DEA (Post-Master's qualification) in Biological Oceanography, July 2004

Sea cucumber nutrition and its relationship with microbenthos (bacteria and microphytobenthos) were studied during the hot season at two stations in a reef complex on Reunion Island. These micro-organisms were quantified in the sediment in three different areas, i.e. sediment next to the tentacles, sediment from the anterior digestive tube and, finally, sediment in the faeces. An analysis protocol adapted to coral sediment had to be implemented in order to count the bacteria by flow cytometry. This sea cucumber population structure study showed that Planch'Alizés is a station that is conducive to their development. The results of the microbial counts revealed a strong contrast between the sediment areas, with a concentration peak in sediment from the anterior digestive tube (up to a factor of 18 for diatoms). Only the quantities of bacteria differed between the two stations. This study showed that bacteria, especially microphytobenthos (in particular, diatoms) are selectively ingested and absorbed by sea cucumbers in Reunion Island. At both stations, which differ greatly in terms of eutrophication, the distribution of these echinoderms seemed to be linked to the sediment's bacterial composition. This study provided the initial information needed to reveal the role sea cucumbers play in Reunion Island's sediment matter cycle.

***Holothuria scabra* sea cucumber reproduction and development in Madagascar (Holothuroidea: Echinodermata)**

Richard Rasolofonirina

Source: Doctoral thesis – Université libre de Bruxelles (Belgium) – Marine Biology Laboratory, August 2004

The *Holothuria scabra* is the most-widely distributed and exploited high-market-value edible sea cucumber in the tropical Indo-Pacific region. Due to this fact and the increasing demand from importing countries and consumers, the natural stocks of this species are faced with overexploitation. In Madagascar, the difficult economic, social and political conditions and the lack of an effective plan to develop this fishery make the situation even more risky. Overexploitation has led to a decrease in production, a decline in certain species, and a drop in product quality. It has brought about strong competition between fishers and a lack of respect for existing legislation. A plan for developing this fishery is proposed in this paper. This paper covers fishery management, restoring natural stocks and ensuring their sustainability and increasing added value for this product. Sea cucumber farming is considered as the future solution for mitigating the ever-increasing demand for trepang, restoring natural stocks and saving those species in danger of extinction.

This work involved studying those biological aspects of this species linked to successful farming of larvae and juveniles. Studies were conducted on the reproductive cycle of the local population (Toliara Bay, 23°27'S and 43°41'E, south-west coast of Madagascar), oocyte maturation and larvae and post-larvae development and growth (including skeletal development). The goal was to optimize production of *H. scabra* juveniles in hatcheries based on existing and newly-acquired information.

H. scabra's reproductive cycle was studied from November 1998 to April 2001 by monitoring monthly variations in the gonad index, maturity index and percentages of each stage of sexual maturity. The study population displayed a yearly reproductive cycle. Mature gonads were observed in the population throughout the year but mature individuals ready to reproduce were more numerous between November and April. This annual cycle involves five periods, whose relative lengths may vary from one year to another. Monthly gonad samples were relatively heterogeneous.

The gonads of *H. scabra* are formed of a tuft of several branched tubules. Their development does not follow the progressive tubule recruitment model. While the tubules that form the gonad are not all the same length, they are at the same level of maturity.

The third part of the paper covers developing and raising *H. scabra* larvae in aquacultural facilities, as well as the production of juveniles. Larval development takes place over a period of two weeks on average but is influenced by temperature and farming density factors. Farms with low temperatures and densities have better growth performances and better survival rates. On the other hand, development is slower at lower temperatures. The epibiont juvenile stage is estimated to last about six weeks, at the end of which the juveniles average 20 mm in length (0.5 g). After this, they move into a burrowing stage. The development and growth of these juveniles are less affected by temperature than larvae are but they are affected by food

quality. Burrowing juveniles (endobionts) gain less in length but more in weight (respectively, 0.19 mm day⁻¹ and 39 mg day⁻¹) than epibiont juveniles (respectively, 0.356 mm day⁻¹ and 12.89 mg day⁻¹).

The appearance and development of skeletal structures was monitored in *H. scabra* larvae and juveniles. The appearance of the first postlarval spicules was observed as soon as they began metamorphosis.

This work revealed new aspects of the biology and farming of *H. scabra*, a Indo-Pacific species that plays a major role both economically and ecologically. Knowledge about its reproductive biology and developmental is vital for sustainable management of this fishery and for exploiting the species.

Causes of collapse of holothurian fishery in México

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Source: 10th International Coral Reef Symposium website (http://www2.ims-plaza.co.jp/icrs2004/img/02oral_11-57.pdf, p. 37)

The holothurian *Isostichopus fuscus* is a common inhabitant of coral communities in the Gulf of California and in the Pacific coasts of México. It is specially associated with corals of the genus *Pocillopora*, which is highly vulnerable to environmental changes. It was the basis of an artisanal fishery of relative importance in the early 1990's, but was closed in 1994 because the species was considered as endangered by the Mexican Government. However, this decision was erroneously taken since almost nothing was known about *I. fuscus* and there were no regulation measures for the fishery because of this lack of information. Generating biological data was then a priority and so it has been done to this date. The objective of this work was to assess the *status* of the fishery in México and analyse the possible causes of collapse. This study is the result of the analysis of all the biological information generated to this date for this holothurian, and also by the analysis of catch and effort data from 1989 to 2001. The results obtained indicate that this is a very vulnerable resource. First, it is the largest aspidochirotid of the Mexican Pacific coasts, reaching maximum length and weight of 30 cm and 800 g respectively, and because of its size fishermen easily spot them. Second, the species shows an inverse relation between growth rate and longevity, it has a life span of 17 years and attains sexual maturity at 5 years of age. Reproduction occurs once a year during summer, when sea-surface temperature reaches 27°C. Fishermen extracted specimens all year long and the age of first capture was 4 years old, so the fishery targeted immature specimens too. *I. fuscus* populations are scattered with low densities (about 0.7 ind. m⁻²), a slight increase in effort results in a reduction in population size. By 1994, the number of boats practically doubled in one year and, consequently, catch decreased drastically. In addition, the collapse of the *I. fuscus* fishery can be attributed to the strong levels of exploitation and the lack of information. But also to the biological characteristics of the resource, which should be considered of most importance for management and conservation purposes.

Shallow-water Holothuroidea (Echinodermata) from Kenya and Pemba Island, Tanzania

Yves Samyn

Source: Steven Simpson Books, 23 Melton Street, GB - Melton Constable NR24 2DB, England. (<http://www.stevensimpsonbooks.com>)

Holothuroidea, commonly known as sea cucumbers, make up one of the five extant classes of echinoderms. A total of 225 specimens, representing three orders, four families, 12 genera, 44 species and one variety, collected in the shallow-waters of Kenya and Pemba Island (Tanzania), are here investigated in detail. Of these, *Bohadschia cousteaui*, *B. similis*, *Holothuria (Metriatyla) albiventer*, *Pearsonothuria graeffei*, *Thelenota anax*, *Euapta godeffroyi*, *Opheodesoma Holothuroidea grisea*, *O. spectabilis*, and *Synaptula recta* are new records for Kenya (with Pemba Island), while *H. (M.) timana* is a new record for the western Indian Ocean. Diagnostic characters and descriptions, including some brief notes on the ecology, are provided for most species. Identification keys up to the species level are also included. The holothuroid fauna of Kenya (with Pemba Island) is now represented by 48 species. The present monograph further relates this updated and annotated taxonomic list to the holothuroid fauna of the western Indian Ocean, the area stretching from Suez to Cape Town and from the East African Coast (Red Sea and Persian Gulf included) to 65° E. The motive for this extension is to promote further studies on causal zoogeography; studies that should direct the conservation of this over-exploited group.

Echinoderm investigations in the Russian Far East

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Source: Echinoderm Research 2001, Féral & David (eds.). © 2003 Swets & Zeitlinger, Lisse, ISBN 90 5809 528 2

Data on biomass of sea urchins and holothurians in the Russian Far Eastern Seas are cited. Echinoderm species distribution in the Bering, Okhotsk and Japan Seas is shown. Information on the direction of echinoderm investigations at the Pacific Research Fisheries Centre and some of their results are cited. The major research direction is the investigation of spatial distribution, biology and abundance dynamics of commercial species. Sea urchins *Strongylocentrotus intermedius*, *Strongylocentrotus nudus*, *Strongylocentrotus droebachiensis* and the holothurian *Cucumaria japonica* form the basis of the commercial harvest.

Gonad morphology and gametogenesis of the sea cucumber *Isostichopus badionotus* from southeast Brazil

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Source: Echinoderm Research 2001, Féral & David (eds.). © 2003 Swets & Zeitlinger, Lisse, ISBN 90 5809 528 2

Specimens of *Isostichopus badionotus* were collected monthly from Ilha Grande Bay in order to relate the stages of gametogenesis with the morphology of gonadal tubules. Gonads were prepared for histological examination and stained with hematoxylin and eosin. The gonadal development was classified into 5 stages: recovery, growing, mature, partly spawned and spent. Diameter of the gonadal tubules and the oocytes were measured. The numerous tubules of the gonad varied greatly in size and colour throughout the reproductive cycle. The mature stages had the largest gonad tubule diameter. Spent gonads had tubules of 0.21 mm diameter in females and 0.16 mm in males. Different stages of gametogenesis produced changes in the morphology of the gonad tubules. The features of the "Tubule Recruitment Model" were observed in this tropical aspidochirotid holothurian *I. Badionotus* on a faster time scale than that proposed by the model.

A bibliography of Indian sea cucumbers

James D.B.

Source: Tech. Bull. 2, the Fisheries Technocrats Forum, Chennai-600. 2004.

This bibliography compiled by subjects is presented on the Echinoderm site: <http://www2.nrm.se/ev/echinoderms/echinportal.html.en>

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