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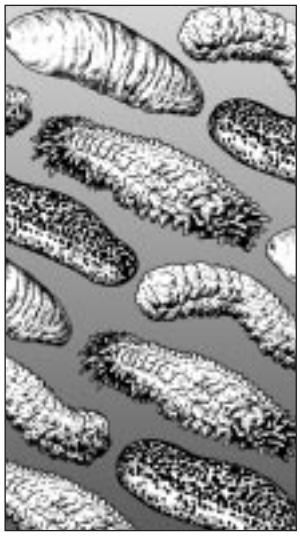

Editor and group coordinator: Chantal Conand, Université de La Réunion, Laboratoire de biologie marine, 97715 Saint-Denis Cedex, La Réunion, France. [Fax: +262 938166; E-mail: conand@univ-reunion.fr]. **Production:** Information Section, Marine Resources Division, SPC, B.P. D5, 98848 Noumea Cedex, New Caledonia. [Fax: +687 263818; E-mail: cfpinfo@spc.org.nc, Website: http://www.spc.org.nc/coastfish]. **Printed with financial assistance from France.**

EDITORIAL

Here is the 11th edition of the Bulletin, which has been issued more quickly than usual as enough information has been received to advance the publication date. Readers, I would like to take this opportunity to thank all those who have already contributed to the Bulletin and ask that you take an active role in its improvement, as many of you have already indicated that you find the Bulletin useful. Comments from new members are particularly welcome.

- Is the current presentation by section, i.e. 1) New Information, 2) Correspondence, 3) Publications, satisfactory?
- Which section should be given more space?
- In the 'New Information' section, are the parts on 'In situ spawning observations' and 'Asexual reproduction through fission observations' suitable?
- The column 'Aquacultural information' has been continued thanks to the collaboration of S. Battaglene from ICLARM. Do you find it useful?
- Are there any other new parts that you would like to see included?

Your suggestions and comments will be both useful and necessary for the Bulletin's development. This includes original articles about the resources of several countries, including Indonesia (p. 9), Canada (p. 21) and Mexico (p. 26). Many different aspects of the biology of asexual reproduction through fission (p. 12) and the biology of one rare species (p. 19) are discussed. A detailed summary of a publication by Infofish is presented in this issue due to high interest in the subject, even though the Bulletin generally gives priority to original articles.

We are pleased to announce that you can now find this and the last issue of the SPC *Beche-de-Mer Information Bulletin* on the Internet. To access SPC Coastal Fisheries Programme menu, go to: <http://www.spc.org.nc/coastfish/>. Then scroll down and open 'Newsletters'. Now, you can select any of the SPC information bulletins and newsletters available.

Chantal Conand

Inside this issue

new info
beche-de-mer

Beche-de-mer processing—A little more effort to get much more money while saving precious resources

by Johnson Seeto[1]

Primary beche-de-mer processing is well-known among the fishers in the Pacific. Sea cucumbers have been collected, boiled, slit, re-boiled, gutted, smoke-dried whole, bagged and then sold to Asian buyers for about 100 years. In earlier times of this period, European or Asian beche-de-mer merchants would use local labour to collect and process the holothurians. Nowadays, the locals sell their processed product to Asians but the processing technique has not changed.

The Secretariat of the Pacific Community (formerly South Pacific Commission) has produced various versions of its Handbook No. 18 called Beche-de-mer of the South Pacific Islands (1974), Beche-de-mer of the Tropical Pacific (1979) and Sea Cucumbers and Beche-de-mer (1994). The primary processing of holothurians is well documented in these booklets and widely used. Some species such as *Stichopus chloronotus* and *Holothuria scabra* will require special processing treatment.

After the dried holothurians have been bought by the Asian buyers locally, they are usually sold whole to markets in Asia. What happens between the time the whole beche-de-mer leave our shores (or enter local Asian premises) and end up as beche-de-mer soup or holothurian cooked with chicken in restaurants has never really concerned us because we do not eat them. While the way that we process holothurians now preserves the product, final processing will do the same too.

The final processing by some local companies or Asian factories abroad will require the re-boiling of our dried beche-de-mer to soften them. The outer skin, mud and sand are then scrubbed off totally. The 'inner skin', mouth piece and latitudinal/longitudinal muscles are totally removed. The cleaned animals are then re-boiled and diced into small pieces for soup or as larger chunks for adding to Asian meals.

The diced and cleaned beche-de-mer are then re-dried (usually by sun or oven) on trays, packaged in plastic bags and placed in a nice convenient box for sale to consumers at a high price. The final product can remain in the box for a long time provided it is dry and packed in an air-tight plastic bag. Final processing does not require elaborate factories. The same process can also be done in a restaurant and the diced product can be used immediately without drying or be frozen for later use.

With slightly more effort, local fishers can have value added to their product. Rather than sell whole, uncleaned and dry beche-de-mer to Asian middlemen now, locals can final-process them (from live to diced) while saving effort and resources (firewood, fuel and water) and also get a higher price later.

Though some buyers in Fiji will buy live animals (only high-priced species) because they want to do all of the processing themselves, we as Pacific Islanders should also try to do processing. While we may produce an inferior product in the beginning, by trial and error we will eventually get it perfect.

To encourage final production techniques, Fisheries Departments and Trade-Investment Boards should try to help establish markets in Asia. This may be the hardest part to achieve, but an excellent product will gain market share, especially if it is cheap. Workshops should be conducted by Asian buyers to train locals to do final processing

1. Marine Studies Programme, The University of the South Pacific, Suva, Fiji. Tel: +679 313900, Fax: +679 301305, E-mail: seeto_j@usp.ac.fj

well. The development banks should give loans to allow fishers to access equipment for final processing. In this way, we will try to eliminate the middle-person, keep earnings in our own countries, create more jobs locally and get more money for our precious marine resources.

We should not forget that there is a local market, too, for final processed beche-de-mer for local Asian consumers who eat it or export it overseas as gifts. In the Suva Market, local fishers sell boiled holothurians to local Asians who then final-process the product at home.

Final processing of holothurians produces organic waste which should be disposed of carefully.

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Beche-de-mer markets and utilisation

by Fatima Ferdouse[1]

Asian countries such as China, Hong Kong, Taiwan, Singapore, Malaysia and Korea, are major consumers of dried fishery products such as sharkfins, beche-de-mer, fish maws, dried molluscs, etc. Japan, though a leading market for fishery products, has a considerably lower beche-de-mer consumption than other Asian countries.

The market for beche-de-mer is dominated by only two trading nations, namely Hong Kong/China and Singapore, although products are imported from all over the world. Imports from South Pacific Island countries consist of high-value species of dried beche-de-mer.

The Asian market for beche-de-mer is estimated to be worth US$ 60 million annually. Seven countries account for almost 90 per cent of the total trade of fresh/frozen/dried beche-de-mer, with an average quantity of 13,000 mt.

Almost 95 per cent of the beche-de-mer is imported in dried form. A small volume of fresh, chilled and frozen products is imported into Hong Kong and Taiwan for speciality restaurants.

Generally dried beche-de-mer from the Pacific Island nations (PINs) are imported by Hong Kong and Singapore. In 1995 Singapore imported 135 mt of dried products, mainly from Fiji, Papua New Guinea and Solomon Islands, and Hong Kong bought about 900 mt the same year (Table 1).

Table 1: Imports of fresh/frozen/dried beche-de-mer, 1992–1994 (Q = mt, V = US$ 1,000)

Country		1992		1993		1994
Hong Kong	Q	7,030	Q	7,401	Q	7,281
	V	35,136	V	29,774	V	35,136
China*	Q	2,423	Q	3,508	Q	3,163
	V	N/A	V	9,140	V	8,260
Singapore	Q	1,435	Q	880	Q	1,242
	V	11,001	V	6,953	V	11,341
Malaysia	Q	401	Q	335	Q	400 (e)
	V	1,081	V	761	V	1000 (e)
Taiwan	Q	1,191	Q	1,135	Q	1,124
	V	9,229	V	6,030	V	5,543
Korea	Q	18	Q	21	Q	25
	V	265	V	327	V	400 (e)
Japan	Q	40	Q	17	Q	17 (e)
	V	1,263	V	635	V	635 (e)
Total	Q	12,538	Q	13,297	Q	13,252
	V	55,018	V	53,620	V	62,315

Note: (e) estimate; * imports from Hong Kong only

1. Trade Promotion Division, INFOFISH, P.O. Box 10899, Kuala Lumpu 50728, Malaysia. Tel: +60 3 2914466, Fax: +60 3 2916804, E-mail: infish@po.jaring.my or infish@tm.net.my

Some of these products imported from the Pacific Islands are re-exported world-wide after sorting, regrading and repacking at premium prices.

Products imported by Singapore are consumed locally and also exported to Malaysia and Hong Kong. China is the major outlet for products imported through Hong Kong. The Territory also exports to other South-East Asian countries, and to European and North American markets with sizeable Oriental populations.

Performances of major markets

Hong Kong

In 1995 Hong Kong imported 5,789 mt of dried beche-de-mer at a value of HK$ 316 million (US$ 40.5 million). Indonesia and the Philippines from Asia, and Madagascar and Tanzania from the Indian Ocean were leading exporters of sea cucumber to Hong Kong in 1995. Pacific Island countries supplied more than 800 mt of beche-de-mer in 1995 at a value of nearly HK$ 50 million (US$ 6.4 million). The leading suppliers from the Pacific Island nations were Fiji, the Solomon Islands and Papua New Guinea. Exports from these countries to Hong Kong have slightly increased over the years. On the other hand, supplies from Kiribati increased significantly from two mt in 1992 to 130 mt in 1994. Exports have also increased from Tonga, Vanuatu and Western Samoa during the last three years (table 2)

Products from the Pacific Island nations fetched high prices, as the bulk of exports were high-value sandfish and teatfish. The average import price was HK$ 76.8/kg (US$ 9.8/kg) in 1994, compared to prices of Indonesian and Filipino products, which were HK$ 31.9/kg (US$ 4.08/kg) and HK$ 16 (US$ 2.05/kg) respectively.

The domestic market uses only 10 per cent of the total beche-de-mer imported into Hong Kong. Analysis of domestic consumption indicated that between 500 and 700 mt of dried sea cucumber are consumed annually.

Population growth has remained static for the last few years. Immigrants from mainland China have not had any major impact on the total consumption of beche-de-mer, as these are considered expensive. Moreover, the products are popular only among those aged over 40 years, for their medicinal value, low fat and high calcium content. The product is also popular during Chinese New Year celebrations, wedding dinners and banquets.

Consumers in Hong Kong prefer large and medium-sized dried sandfish and teatfish with skin on and calcium-coated. Recently, chilled, skinless (split sandfish) beche-de-mer from New Zealand have been introduced into Hong Kong, mainly for restaurants and hotels. Frozen, gutted beche-de-mer are also imported from Canada and the USA for the domestic market or for re-export to the southern provinces of China.

Imports and exports

Imports of all fish and fishery products, including dried items, are not taxed. Most of the products imported into Hong Kong are regraded according to quality, size and species before being sold to

Table 2: **Hong Kong imports of beche-de-mer (dried, salted or in brine) (Q = mt, V = HK$ 1,000)**

Country	1993		1994		1995	
	Q	V	Q	V	Q	V
Indonesia	2,620	75,314	2,599	82,974	1,694	78,786
Philippines	1,872	28,951	1,726	28,053	1,270	28,132
Madagascar	379	10,267	318	8,948	170	13,215
South Africa	28	1,429	93	5,502	*	*
Tanzania	478	12,987	303	13,457	257	7,285
Kiribati	99	3,674	130	6,059	N/A	N/A
Solomon Islands	319	100,076	247	11,312	161	8,494
Fiji	119	7,601	176	11,245	402	27,046
Vanuatu	6	400	40	2,353	*	*
Papua New Guinea	179	8,655	150	9,289	236	14,443
Total (including others)	6,099	249,354	5,782	179,192	4,190	177,401

* included under others

domestic or re-export markets. Big importers maintain warehouses where sorting takes place.

According to official records, Hong Kong exports nearly 4,000 mt of beche-de-mer annually. Some 85 per cent of these exports are directed to China and 10 per cent to Taiwan, while the balance is exported to the USA, Europe, Korea, and Singapore. Products exported to China range from high-value sandfish to low-value lollyfish.

Singapore

Imports and exports

Beche-de-mer is a preferred seafood delicacy in Singapore. Imports of dried beche-de-mer have ranged from 800 to 1,200 mt during the last three years. During the late 1980s, the imports ranged from 500 to 600 mt a year. Total imports have decreased slightly in 1995 due to lower supplies from Madagascar and Tanzania.

Imports of African origin mainly consist of cheaper-quality sandfish and some white teatfish. Some of the best-quality products are imported from Tonga, Fiji and Australia. These products are usually consumed by the domestic market. A reasonable quantity of beche-de-mer is imported from Indonesia, but is not officially reported. The total import figures may therefore be much higher.

As in Hong Kong, imported products are regraded in Singapore and then re-exported. High-quality teatfish and sandfish are usually exported to Taiwan. Exports to Malaysia consist of medium-grade sandfish of various sizes and a small quantity of the high-value teatfish.

Consumption

Domestic consumption of beche-de-mer (primarily sandfish) in Singapore ranges from 150 to 200 mt annually. The market demands high-value products. Although the retail sector takes only 10 per

Table 3: **Singapore imports of beche-de-mer (dried, salted or in brine) (Q = mt, V = S$ 1,000)**

Country	1993		1994		1995	
	Q	V	Q	V	Q	V
Australia	13	308	47	1,154	80	3,013
New Zealand	4	159	9	182	N/A	N/A
The People's Republic of China	N/A	N/A	1	114	1	54
Taiwan	N/A	N/A	5	128	10	65
HongKong	44	1,151	46	936	43	497
India	16	240	39	900	121	2,844
Sri Lanka	36	592	39	1,597	63	1,459
Malaysia	25	128	17	125	14	164
Philippines	77	1,253	66	1,727	56	1,774
Myanmar	5	76	6	88	8	86
Vietnam	16	242	15	122	8	84
Fiji	3	75	8	131	17	345
Maldives	52	894	49	549	45	659
Papua New Guinea	146	1,840	80	838	89	281
Solomon Islands	3	72	4	38	N/A	N/A
Mauritius	N/A	N/A	6	96	3	66
Kenya	19	120	36	493	24	733
Madagascar	245	1,505	333	2,368	139	1,163
Mozambique	N/A	N/A	6	86	5	90
Tanzania	111	1,130	249	2,070	155	1,877
UA Emirates	14	380	18	704	6	191
Yemen	18	264	45	601	60	1,075
USA	3	55	N/A	N/A	2	42
Oceania	25	466	43	707	33	635
Other countries	5	175	49	1,258	71	1,474
Total	880	11,125	1,216	17,012	1,053	18,671

cent of the market share, the best products are usually sold through this sector. Restaurants, which are the main users of dried beche-de-mer, buy their products from wholesalers and reprocess their own products.

Reprocessors, who generally use small dried sandfish (40–80/kg), play an important role in Singapore. Retail outlets, which sell processed/wet beche-de-mer through wet markets and speciality shops, get their supplies directly from reprocessors. Consumption is high during the Chinese New Year, at mid-year and year-end festivals, dinners and at almost every wedding dinner, irrespective of income group.

Other markets

Consumption of dried seafood, especially of beche-de-mer, is popular in many countries in the region. China, Taiwan, Malaysia, Indonesia, Thailand, the Philippines and Vietnam import a significant volume of beche-de-mer for local consumption. The national trade liberalisation policy of China has in fact contributed to the high imports of dried beche-de-mer into China.

Taiwan, a traditional consumer of high-quality dried seafood, goes for high-value products. Imports of beche-de-mer products remained fairly stable at 1,100 mt per year. Malaysia imports about 300 to 400 mt of dried beche-de-mer annually, with Indonesia as the main supplier.

Prospects in oriental markets

The international trade in dried sea cucumber is almost exclusively limited to countries in the Indo-Pacific area. Trade with the western world is fairly low. However, with increasing settlement of ethnic oriental people in the USA, Europe and Australia, a constant flow of products to these markets has been noticed in recent years. For example, regular shipments of beche-de-mer from Hong Kong to the USA and Canadian markets were visible from 1992 to 1995 and the value of this trade is on the rise.

As major trading importers, trading centres and re-exporters, Hong Kong and Singapore are expected to maintain their stronghold in the market. However the emergence of China as the driving force in global trade appears to be a major challenger in this trade. Consumption of dried beche-de-mer is expected to increase in future and the market has the capability to absorb any volume of products, irrespective of species, quality, size and shape of products. The most important market areas in China are the Special Administrative Regions (SARs), where per capita income is high compared with the average per capita GNP of China.

Major cities such as Guangdong, Shangai, Shenzhen, Xiamen and Beijing demand good-quality, high-value products as a result of their high disposable family incomes, which are expected to grow in the next five years. Guanzhao and Shangai provinces, for example have 65 million and 13 million people respectively, with a per capita income of more than US$ 3,000. These areas have become important export markets for Hong Kong traders.

Although China is the biggest market for beche-de-mer, it is very unlikely that direct imports of these specialised products will increase in future. Due to long-existing social, cultural and ethnic ties with Hong Kong, most of these products are expected to be channelled to China through Hong Kong. Moreover, there has been a substantial investment by Hong Kong in China.

Because of cheap labour, available processing technology and common cultural understanding, importers will still prefer to use China as the main processing base. However, in the short term, better-quality raw materials from the PINs will fetch higher prices in these market areas.

Importers and reprocessors in Singapore are moving in a different direction from Hong Kong in product development. They are willing to process more value-added products in the producing countries, although their market share is low compared to Hong Kong. Demand for value-added beche-de-mer (skinless, cleaned, smoked) is expected to improve further in future. Even in mainland China, where skin-on and calcium-rich products are more popular, other forms of high value processed sea cucumber are expected to receive good market acceptance in view of the growing incomes, more health consciousness and preference for better-quality products.

Supply of beche-de-mer is not expected to grow much in the world market from its current level. Nevertheless, demand will continue to rise. This will eventually lead to upgrading of more species from medium value to high value, and lower value to medium value. However, quality is the major prerequisite to achieve this development. Introduction of new species to the market is also expected.

Prices of sea cucumber are likely to go up in the future. In Singapore, for example, beche-de-mer prices have increased by 100 per cent at wholesale level during the past three years. The same trend has also been noticed in China, Hong Kong and Taiwan.

Consumption of these high-value fishery products is likely to increase in Singapore and Malaysia, and there is also an upward trend from China, particularly from the Southern Province. Nevertheless, consumers will demand better quality and more convenience foods and are expected to pay good prices for these products.

Importers of sea cucumbers

Hong Kong

Heep Tung Hong Sanchon Co. Ltd.
13th & 17th Floor Wing Yue Building
60–64 Des Voeux Road West
Hong Kong
Tel: +852 25467005/25468313/25409737
Fax: +852 25484029

Hong Kong Pacific (David Cook)
11M–111 Mount Butler Road
Hong Kong.
Tel: +852 28905598

Leung Kai Hong
Yan Tak Tai Kee Co.
82 Des Voeux Road West
Hong Kong
Tel: +852 25477008/25483418
Fax: *They don't speak English*

Ricardo Trading Co.
Room 604, Kincheng, Commercial Centre
412–420 Castle Peak Road, Kowloon
Hong Kong
Tel: +852 23703807/23703391

Teng Fuh Holdings Ltd.
26–28 Bonham Strand West
Nam Pak Hong Bldg., Sheung Wan
Hong Kong
Tel: +852 25431983
Fax: +852 28540005

Wang Yip Shark Fin and Sea Products
G/F, 122 Des Voeux Road West
Hong Kong
Tel: +852 25408679
Fax: +852 25599924

Yip Union Trading C
188A Des Voeux Road West, Third Floor
GPO 11641
Hong Kong
Tel: +852 25472293
Fax: +852 25480540

Yu Ton Trading Co. Ltd.
Room 1401, Herms Commercial Building 4-4A
Hillwood Road, Tsium Sha Tsui, Kowloon
Hong Kong

Eurosia Holding Ltd.
11th Floor, The Leader Commercial Bldg
No. 54 Hillwood Road
Tsium Sha Tsui, Kowloon
Hong Kong
Tel: +852 23669309
Fax: +852 23663765/27215021

Dah Chong Hong Ltd.
12 Fl, Hang Seng Bldg
77 Des Voeux Road, Central
Hong Kong.
Tel: +852 28468111
Fax: +852 28450222
Telex: 73738 DACHO HX

Summer Sea Products
Room 808–809
Wing Tuck Commercial Centre
177–183 Wing Lok Street
Hong Kong
Tel: +852 25456035
Fax: +852 25438570
Telex: 653262 SUTCO HX

Success Food Trading Company Ltd.
Sino Industrial Plaza, 8th Floor Room 58
9 Kai Cheung Road, Kowloon Bay
Hong Kong
Tel: +852 27956565
Fax: +852 27954528

Tat & Company Limited (Hong Kong) Tat Hing Sharkfins Company Ltd.
144, Queen's Road West
Hong Kong
Tel: +852 28587000

Japan

AC International Co. Ltd.
Palais Royal Nagata-cho
Nagata-cho, Chiyoda-ku
Tokyo
Japan 100
Fax: +81 3 35921300

Ehedai East Asiatic Co. Ltd.
No 2 Osaka Ekimae Bldg.
l-chome Umeda Kita-ku, Osaka, Japan
Tel: +81 6 3445281/4
Fax: +81 6 3445285
Telex: 56781 GRANLTE

Wan Fu Lin Co. Ltd.
No 123–8, Yamashita-Cho
Naka-ku, Yokohama
Japan 231
Tel: +81 45 6216625
Fax: +81 45 6224440
Telex: 3822-717 WANFU J
Attn : Mr William Sui

Malaysia

Atlasic (Malaysia) Sdn Bhd
35B Jalan Beringin, Pelabuhan Kelang
Selangor
Malaysia
Tel: +60 3 3686779/3689215
Telex:MA 39662 AIMFRO
Attn : Mr Tan Suan Yong

Union Atlantic Sdn Bhd
1, Setia Kasih 4, Damansara Height
50490 Kuala Lumpur
Malaysia
Tel: +60 3 2545006
Fax: +60 3 2547058

Tat Hoong Enterprise
No 13 Jalan Dagang SG2/1G
Sri Datnansara, Kepong
Kuala Lumpur
Malaysia
Fax: +60 3 6352569

Hai Seng Hin
301, Seroja Apartment
Jalan 3/9A, Bandar Baru Selayang
68100 Batu Caves, Selangor
Malaysia
Tel: +60 3 6188075
Fax: +60 3 6188078
Attn : Mr Tan Tong Hua

Singapore

Algul Pte Ltd.
Taman Warna
P.O. Box 0215
Singapore 9127
Telex: RS 36897 ALGUL
Attn: H. J. Hoerndhli

A M Abdullah Sahib & Co.
Maxwell Post Office No 19
Singapore 9000
Tel: +65 5 343665/5 344074
Telex: RS 20847 AMAH

Chip Chiang
28 Hong Kong Street
Singapore 0105
Tel: +65 5 334745/2 228929
Telex: RS 26255 HSEAGO

Chia Huat Ong Lee Trading (Pte) Ltd.
69, Circular Road
Singapore 0104
Tel: +65 5 337684
Telex: RS 22774 CHYKCO

Toyoto Tsusho (Singapore) Pte Ltd.
79, Robinson Road, #15-05 CPF Building
Singapore 0106
Fax: +65 2 225674
Telex: RS 23691 TTSPL

Malhar Traders
Robinson Road, P. O. Box 268
Singapore 9005
Fax: +65 5 351640
Telex: RS 34418 MALHAR

Hiap Heng Chang (S) Pte Ltd.
5–6 North Canal Road
Singapore 0104
Tel: +65 5 351888
Fax: +65 5 357283
Telex: RS25106 FIBEACH

Mingee Seafood Products Pte Ltd.
Blk 83 Geyland Bahru #01-2580
Singapore 1233.
Tel: +65 2 985298/2 920076
Fax: +65 2 981498

Taiwan

Wealthy Ocean Corporation
P. O. Box 36-503, Taipei
Taiwan
Fax: +886 2 7624455
Telex: 19882 BIGWELL

Young Sunlit Inc.
P.O. Box 42-82, Taipei
Taiwan
Fax: +886 2 8112195
Telex: 26252 LIGACO

Lucky Ocean Trading Co. Ltd.
10F4, No 349, Chung Hwa 4th Road
Kaohsiung
Taiwan
Tel: +886 7 2617577
Fax: +886 7 2615810

Sen Power Trading Co. Ltd.
Floor 4, No 134-3 Hsing, Chin Road
Taichung
Taiwan
Tel: +886 4 2375530
Fax: +886 4 2365081

Ocean Bay Corporation
10-1 Flr., No 127 Sec. 2 Yen Ping, N. Rd.
Taipei
Taiwan
Tel: +886 2 5312321
Fax: +886 2 5615821
Attn: Mr Terence Jan

Cheng Cheng Enterprise Co. Ltd.
97, Lane 41, Cheng Kung Road
San Cnung City, Taipei
Taiwan
Tel: +886 2 9765654/9766041
Fax: +886 2 9771038
Attn: Mr Te Hai Chu

Republic of Korea

Nam-A Enterprise Co.
10-162 Jong Am-Dong, Sung-Buk-Ku
Seoul
Korea
Telex: MOCNDM K23231
Fax: +82 2 9190053

(Source: *INFOFISH International* 6/97, pp. 23–29)

Reproductive cycle of the holothurian *Holothuria scabra* in Saugi Island, Spermonde Archipelago, Southwest Sulawesi, Indonesia

by Dr Ambo Tuwo [1]

Introduction

Holothuria scabra is one of the 16 commercial holothurians harvested in Southwest Sulawesi (Tuwo & Conand, 1996). Its reproductive cycle has been studied at different sites, but there was confusion about its spawning periods. Some authors have described a semi-annual reproductive cycle or two spawning periods in a year (Ong Che &Gomez, 1985). The present research aims to study the reproductive cycle and to find explanations for the spawning period of *Holothuria scabra* in Sulawesi, Indonesia.

Methods

Specimens of *Holothuria scabra* were collected monthly during a year at Saugi Island, Spermonde Archipelago, South Sulawesi, Indonesia. Thirty specimens were collected from each sampling.

In the laboratory, the total length (TL), body-wall wet weight (BW) and gonad wet weight (GW) were measured. Gametogenesis was examined using histological observation. The individual maturity stage was determined according to the maturity stage of dominant tubules in the gonad. Percentages of different maturity stages were calculated for each sampling. Gonad indices (GI) were calculated using body-wall wet weight (BW) and gonad wet weight (GW):

$$GI = (GW \times 100)/BW$$

Results and discussion

Microscopically, characteristics for both sexes were similar to those of other holothurians (Tanaka, 1956; Tuwo & Conand, 1992). The maturing tubules contain the previtellogenic and vitellogenic oocytes in females (Figure 1A and 1B), and spermatocytes and spermatozoa in males (Figures 1E and 1F). The mature tubules contained only vitellogenic oocytes in females (Figure 1C) and only spermatozoa in males (Figure 1G). In spent tubules we observed the presence of relict oocytes in females (Figure 1D) and relict spermatozoa in males (Figure 1H).

Maturation (Stage III) was observed from July to March. Maturity (Stage IV) was present practically

1. Marine Biology Laboratory, Marine Science Department, Hasanuddin University, Ujung Pandang, Indonesia.

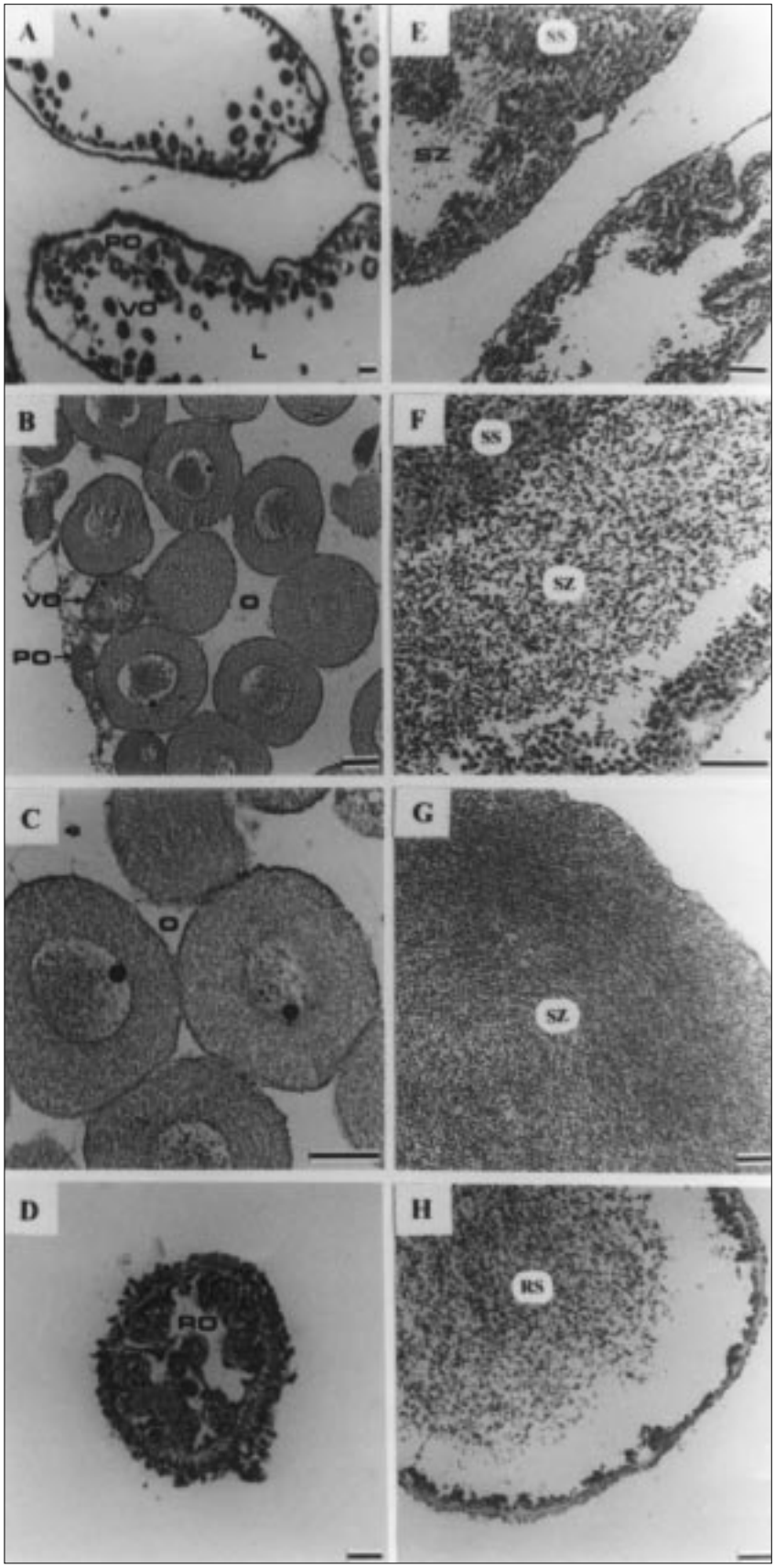

Figure 1

Microscopic characteristics of different maturity stages in the ovary and testis of *Holothuria scabra*. Stage III (early), (A) female, (E) male; stage III (late), (B) female, (F) male; stage IV, (C) female, (G) male; stage V, (D) female, (H) male. L, lumen; O, oocyte; PO, previtellogenic oocyte; RO, relic oocyte; RS, relic spermatozoa; SS, spermatocyte; SZ, spermatozoa; VO, vitellogenic oocyte

throughout the year (Figure 2). Post-spawning (Stage V) was accentuated in two periods. The first was at the beginning of dry season, from March to July, when the temperature increases. The second was at the beginning of the rainy season, from November to January, when the temperature decreases (Figure 3). Two phases of gonad evolution were distinguished. The first was a regular increase from June to October and from February to April. The second phase was a regular decrease from April to June and from October to February (Figure 4).

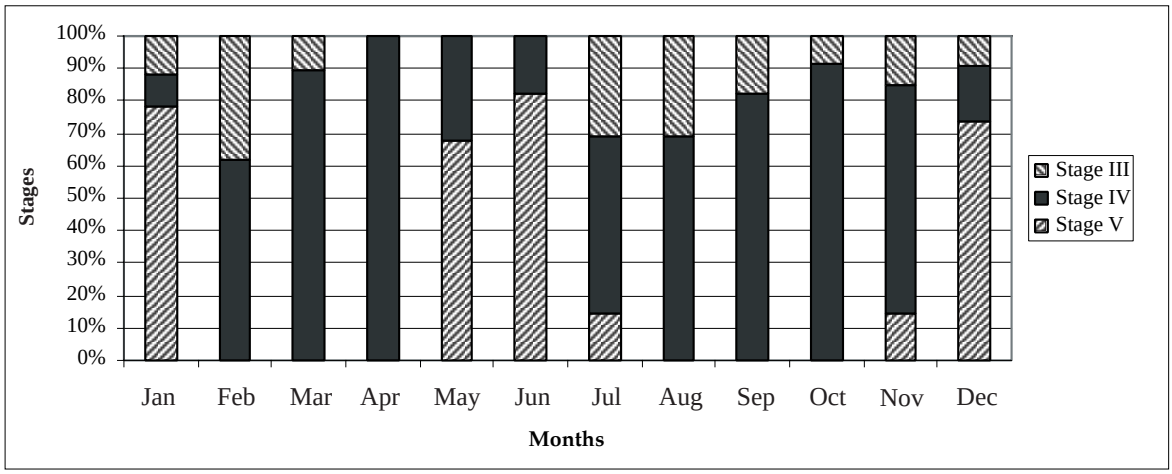

Figure 2
Monthly mean of the different stages of *Holothuria scabra*

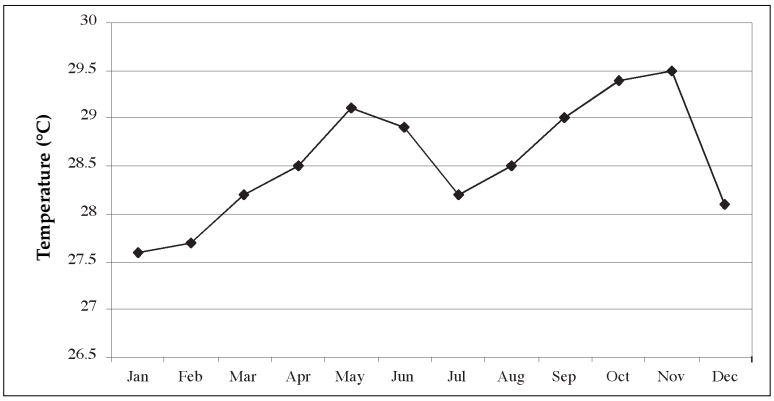

Figure 3
Monthly mean air temperature

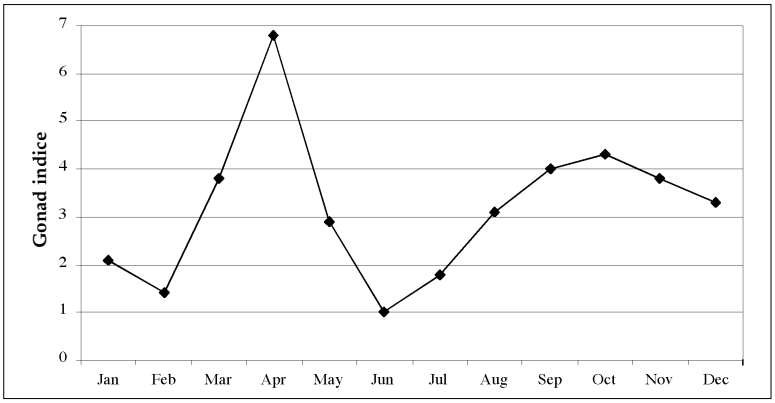

Figure 4
Monthly mean gonad index of *Holothuria scabra*

Holothuria scabra in Saugi Island had two spawning periods or a semi-annual reproductive cycle, as observed by Conand (1993) in the New Caledonia Lagoon.

In the maturation stage (stage III), an individual can have some mature tubules, so a small spawning concerning some mature tubules can occur at any time through the year, as observed by Ong Che and Gomez (1985) on Calatangan, Batangas, Philippines.

Conclusion

The *Holothuria scabra* population at Saugi Island has two spawning periods. Nevertheless some spawning from some mature tubules can be observed throughout the year.

Acknowledgement

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Asexual reproduction parameters and the influence of fission on a *Holothuria atra* sea cucumber population from a fringing reef on Reunion Island (Indian Ocean)

by S. Jaquemet, V. Rousset & C. Conand [1]

Introduction

Holothuria atra is one of the most common sea cucumbers of intertidal zones in the tropical Indian-Pacific region. Asexual reproduction through transverse fission is a biological phenomenon which has already been studied, most notably in the south of the island of Taiwan (Chao & Chang, 1989; Chao et al., 1994), on the reefs of New Caledonia (Conand, 1989) and on the Great Barrier Reef in Australia (Harriot, 1982; Uthicke, 1994; Uthicke, 1997).

On Reunion Island, *H. atra* can be found throughout the fringing reef of the St Gilles/La Saline reef system, where it varies in size from 10 to 30 cm and in weight from 10 to 220 g. It is usually located on substrata composed of sand and dead coral rubble. *H. atra* specimens divide into two parts (fission) at a point located about 45 per cent of the length of the body from the mouth (Conand & de Ridder, 1990; Conand 1996). Each part then regenerates, thereby giving rise to two new identical specimens. This phenomenon affects a significant percentage of the specimens of the population at the Planch'Alizés study site (between 11.4 and 35 per cent according to Boyer, Caillasson & Mairesse 1995; Conand 1996).

This study was conducted through biannual samplings in a 80 m^2 section marked out by permanent plot markers. The goal of the study was to monitor changes in the population over a period of four years (November 1993 to November 1997), for a variety of parameters (fission and regeneration rates, population density, specimen size), in order to determine the significance and effects of asexual reproduction through fission on this population.

There were two broad categories of specimens: normal specimens and those involved in asexual reproduction, which made it possible to classify specimens according to six different categories (Doty, 1977; Conand & de Ridder, 1990; Conand, 1996):

- 'N' (normal) specimens: showed no signs of asexual reproduction;
- 'F'(fission) specimens: showed signs of transverse division (i.e. constriction at a point 45% of the length of the body from anterior section);
- 'A' (anterior) specimens: had recently undergone fission and only had their anterior part;
- 'P' (posterior) specimens: had recently undergone fission and only had their posterior part;
- 'Ap' (Anterior–posterior) specimens: showed signs of regenerating their posterior part;
- 'Pa' (Posterior–anterior) specimens: showed signs of regenerating their anterior part;
- an 'S' category: included all specimens resulting from fission (F, A, P, Ap, Pa).

1. Marine Ecology Laboratory, University of La Réunion, 97715 Saint-Denis Cedex, La Réunion, France

In order to show the influence asexual reproduction had on this population we monitored:

- fission (S(%)=[(A+P)/2T]*100) and regeneration (R(%)=[(Ap+Pa)/2T]*100) rates, according to the work begun by Boyer et al., 1995 and Conand, 1996. (A+P) corresponded to specimens which had recently undergone fission, (Ap+Pa) corresponded to specimens in the process of regenerating and (T) to the total number of specimens sampled;

- the seasonal nature of asexual reproduction, by comparing samplings corresponding respectively to summer (November) and winter (June) for those specimens which had recently undergone asexual reproduction (A+P) and those in the process of regeneration (Ap+Pa);

- changes in population density, using a variance test to determine if there were any population fluctuations over time;

- changes in weight distribution over the four-year period for the normal specimen (N) category in order to observe the influence of fission on specimen size over the medium term. To do so, various modal weights were determined by graphic analysis of weight distributions according to the modal progression analysis method.

Results

Percentages of the various categories of specimens sampled as well as averages and standard deviations are been given in Table 1.

Fission rates, regeneration rates, seasonal nature of fission

The results on fission rates S (%) obtained from the data in Table 1 are given in Figure 1 (see page 14).

The average fission rate was 3.7 per cent and the standard deviation equalled 2.1. Fission rates calculated in this manner showed two distinct periods on the histogram (Figure 1). The first period was from November 1993 to June 1995, during which time the rate was high (>3.7%) and a second period extending from November 1995 to November 1997, during which time the rate was lower (< 3.7%). Although the June 1996 rate (1.3%) was the lowest of all those recorded, it can be seen that the average rate for the month of June (4.3%) was higher than the average rate for November (3.3%).

Moreover, it was observed that after a sharp decrease in June 1996, the rate again increased in the following reading. It can be surmised that something happened during this period which had an influence on fission.

Table 1: **General data on the number of specimens, various percentages, averages and standard deviations for normal specimens (N), those which had recently undergone fission (A+P), those in the process of regenerating (Ap+Pa), those in fission (F), total specimens (T) and all specimens involved in asexual reproduction (S).**

Dates	T	N	A+P	Ap+Pa	F	S
Nov-93	293	219	37	32	1	74
		74,7%	*12,6%*	*10,9%*	*0,3%*	*25,3%*
Jun-94	362	276	50	23	13	86
		76,2%	*13,8%*	*6,4%*	*3,6%*	*23,8%*
Nov-94	387	303	25	59	0	84
		78,3%	*6,5%*	*15,2%*	*0,0%*	*21,7%*
Jun-95	433	372	41	19	1	61
		85,9%	*9,5%*	*4,4%*	*0,2%*	*14,1%*
Nov-95	421	369	18	34	0	52
		87,6%	*4,3%*	*8,1%*	*0,0%*	*12,4%*
Jun-96	393	373	10	10	0	20
		94,9%	*2,5%*	*2,5%*	*0,0%*	*5,1%*
Nov-96	390	358	15	17	0	32
		91,8%	*3,8%*	*4,4%*	*0,0%*	*8,2%*
Nov-97	376	326	21	28	1	50
		86,7%	*5,6%*	*7,4%*	*0,3%*	*13,3%*
Total	3,055	2596	217	222	16	459
		85,0%	*7,1%*	*7,3%*	*0,5%*	*15,0%*
Mean	381,9	324,5	27,1	27,8	2,0	57,4
Standard deviation	42,6	55,6	14,0	14,9	4,5	23,7

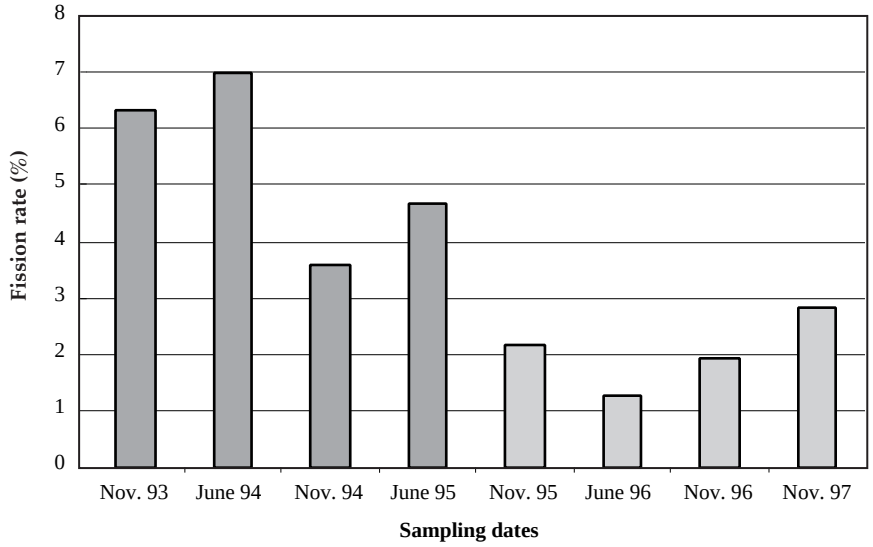

Figure 1: **Variations in the fission rate between November 1993 and November 1997**

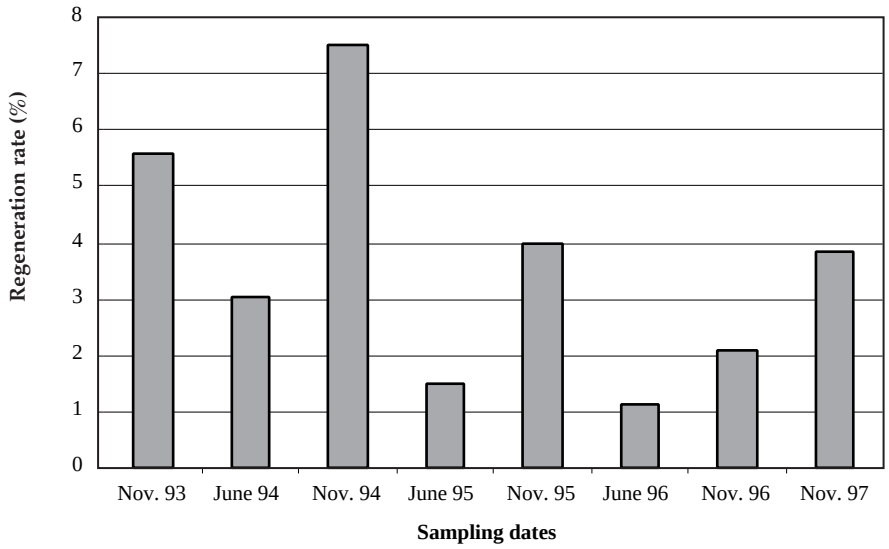

Figure 2: **Variations in the regeneration rate between November 1993 and November 1997**

Regeneration rates R (%), were calculated using the same formula as for fission rates, by simply replacing (A + P) specimens (in fission) by (Ap + Pa) specimens (those in regeneration), (Figure 2).

The average regeneration rate was 3.7 per cent. The average regeneration rate for the month of November (4.6%) was double the average rate for June (2.2%). These results were the opposite of those obtained for fission. As with fission rates, the June 1996 figure (1.2%)was the lowest of all.

Comparison of average fission and regeneration rates revealed equal values of 3.7 per cent for both, which led us to suppose that fission and regeneration periods were equal in length, and that the mortality rate was almost nil.

The dates selected for sampling (November – June) allowed us to study how significant asexual reproduction was in this population.

Readings for the warm (November) and cool (June) seasons did, in fact, alternate, except in 1993 (beginning of the study in November 93) and 1997 (no reading for June 1997).

Analysis of the changes in density for those specimens which had recently undergone fission and those in the process of regeneration (Figure 3) showed that the two curves (i.e. changes in the density of specimens which had recently undergone fission (A+P) and specimens in the process of regeneration (Ap + Pa)) alternated between high values and lower ones.

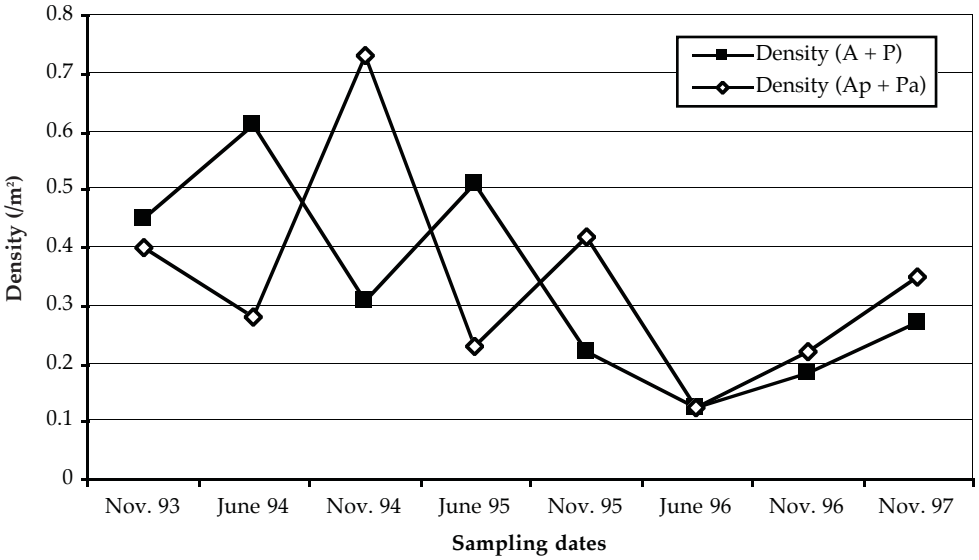

Figure 3: **Changes in density, between November 1993 and November 1997, for those specimens which had recently undergone fission and those in the process of regeneration**

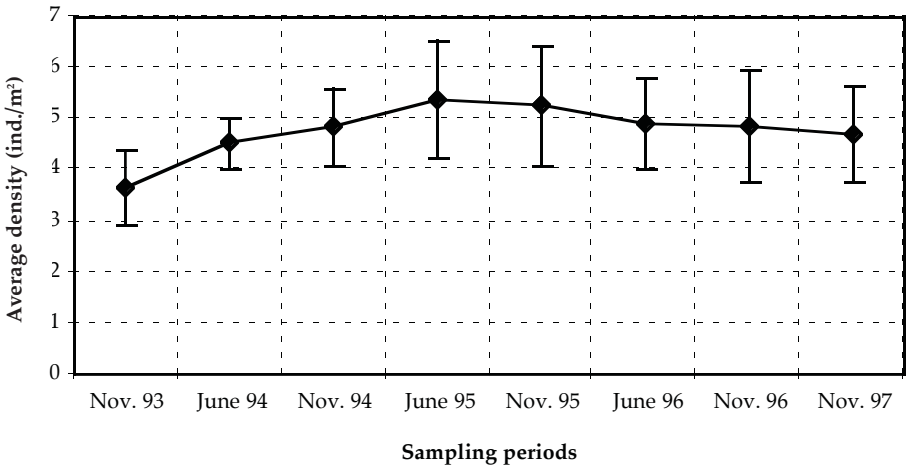

Figure 4: **Changes in the average number of specimens (± standard deviation) per sample (November 1993 – November 1997).**

Density among specimens in the process of fission (A+P) was lower in the month of November (in 1993: 0.45; in 1994: 0.30; in 1995: 0.20) than in June (in 1993: 0.65; in 1994: 0.50). Density among specimens in the process of regeneration showed an inverse tendency, i.e. lower values in the month of June (June 1994: 0.30; November 1994: 0.75; June 1995: 0.20; November 1995: 0.40).

This led us to suppose that the regeneration took about six months. This six-month period is shown on Figure 3 by the intervals between the successive peaks and troughs. For both curves, the figures obtained in readings in June 1996 were the lowest of all those taken (A+P:0.10; Ap+Pa: 0.10). Finally, analysis of the final three readings show a very large difference in relation to the overall shape of the first part of the curve, due to the large decrease in density among both categories of specimens studied in June 1996. Comparison of the averages from June and November for the number of specimens resulting from recent fission (A+P) confirmed that averages for June were significantly higher, by almost one per cent, than averages for November.

Changes in specimen density and weight

Figure 4 shows changes in the *H. atra* population over time for all eight quadrats (80 m²) sampled.

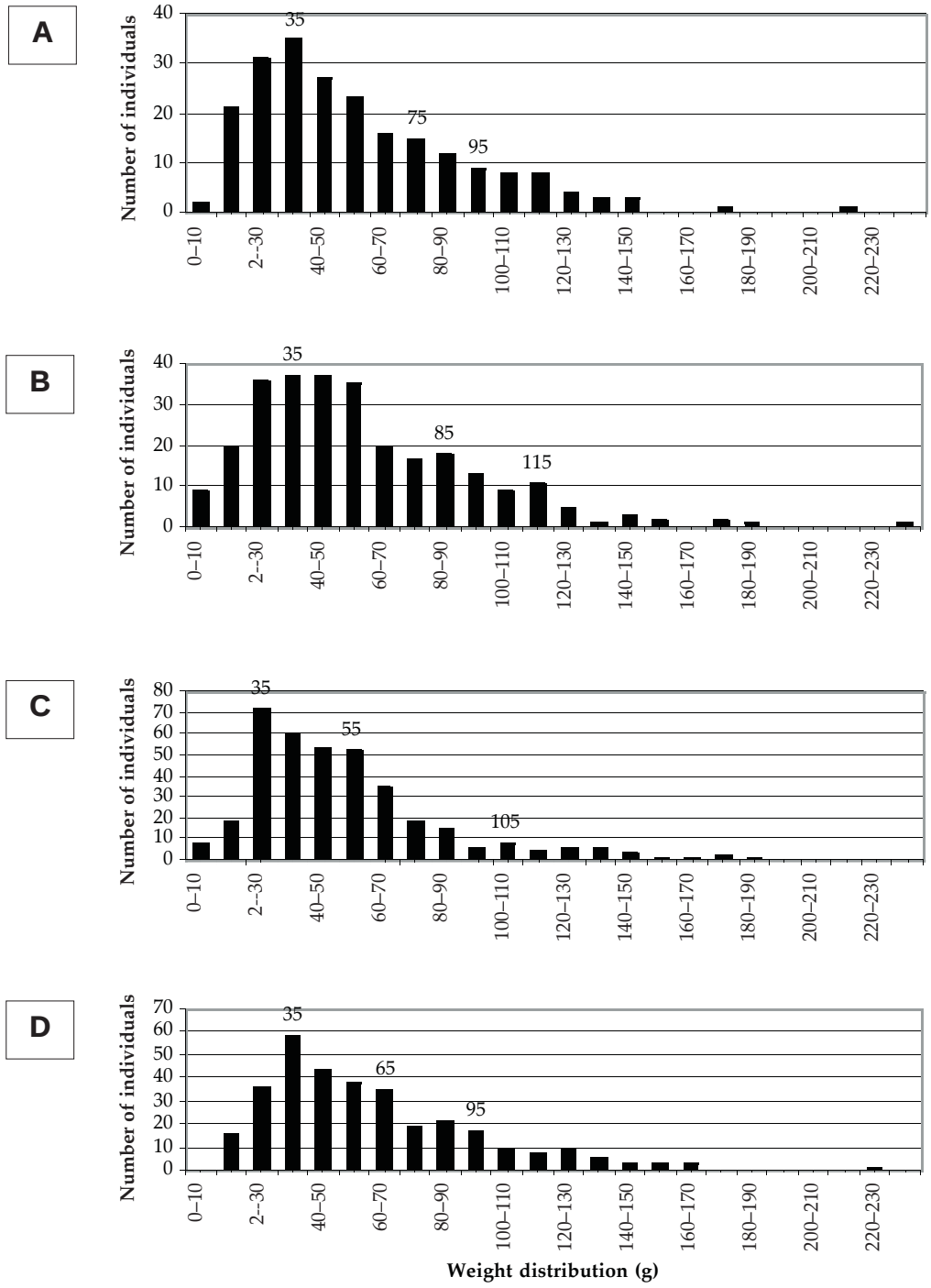

Figure 5 (A–D): **Changes in modal weight values in the weight distribution of normal specimens for samples taken in November 1993 (A) and 1997 (D) and June 1994 (B) and 95 (C).**

Overall, the curve remained relatively stable for the average number of specimens in this sea-cucumber population. However, two opposing trends were revealed: during the first part of the study (November 1993 – June 1995), the population increased in a slow but steady fashion; after June 1995, it decreased very slightly up to the month of November 1997.

The weight distribution for normal specimens (N) was plurimodal, but only the first three modal weights were taken into consideration, as the number of specimens in weight categories over 130 g was too low. These modal weights are shown in Figure 5, so that the changes in them over the four-year study period can be observed.

Weight distributions of normal specimens given in Figure 5 are based on sampling from November 1993 and 1997 and June 1994 and 1995. The first mode for all samplings combined (Nov. 93 to Nov. 97) varied from 15 to 35 g. The second mode calculated varied from 35 to 85 g and the third from 75 to 115 g. It can be observed that the values for the first mode were very similar in both November 1993 and November 1997 (35 g). The difference between the highest and lowest values of the first mode was 20 g, for the second 40 g and for the third 50 g. These differences indicate variations in specimen weights for certain years, but study of all samplings as a group did not show any changes in terms of either an increase or decrease in specimen weight for this population, since the figures at the beginning (Nov. 1993) and end (Nov. 1997) of the study were very similar, i.e. respectively, 35 g, 75 g, 95 g in November 1993 and 35 g, 65 g, 95 g in November 1997.

Discussion

Fission rates, regeneration rates and seasonal nature of fission

The fission rate S (%) during the study period (Nov. 1993 to Nov. 1997), calculated from those specimens that had recently undergone fission (A+P), was 3.7 per cent. It was lower than that calculated by Conand (1996), i.e. 4.5 per cent over the period of one year (1994), using monthly samplings. These differences can be explained in part by the extremely low fission rate observed in June 1996 (1.3%). The regeneration rate R (%) for *H. atra* during this study was 3.7 per cent. It would seem, then, that *H. atra* had a mortality rate of almost zero (S(%)=R(%)) for specimens in the process of regeneration. If there was almost no mortality in specimens that had undergone fission, the percentage of clones in the population should be increasing, since specimens resulting from fission can in turn give rise to two identical individuals. Over the long term this could lead to a drop in genetic diversity, which could have serious consequences for the conservation of this species.

The seasonal nature of the alternating high and low values for this rate, both in specimens that have recently undergone fission (A+P) and in those in the process of regeneration (Ap+Pa), was demonstrated. The density of (A+P) specimens was higher (test of comparison of mean significant at 1%) in June (cool season) than in November (warm season). Similar results were observed for this species over shorter study periods in New Caledonia (Conand & de Ridder, 1990), Taiwan (Chao et al., 1994) and on Great Palm Island, GBR (Uthicke, 1997). Boham and Held (1963) suggested that fission in *H. atra* may be caused by variations in water temperature and Conand (1989) thought that emersion time in New Caledonia may play an important role in fission.

Given both the fact that the area studied was located on the back reef and Reunion Island's tide characteristics, it can be deduced that there is never any emersion there. Moreover, the water temperature curve at the station for the period around June 1996 did not indicate anything abnormal in relation to average temperatures for that season. The low June 1996 rate seemed, then, to have been caused by other factors. Water salinity during these periods was also studied, but the readings did not show any anomalies. Uthicke (1997) theorised that the higher oxygen rate of the water during the cool season could facilitate sea cucumbers' regeneration after the total loss of the respiratory tree in *H. atra*. If eutrophisation of the environment occurred in June 1996, this could explain the sharp drop in the fission rate observed in Figure 3. The theory of eutrophisation of the environment was also raised by Conand et al., 1997 for a *H. leucospilota* population located on the back reef of La Saline, which, like our study site, is an area subject to significant human activity.

Specimen density and weight trends over time

Average densities in the quadrats were between 3.1 and 6.35 specimens per m^2. The overall average in this sector was 4.8 specimens per m^2 over a period of four years, which is relatively close to the figure calculated by Conand (1996) for the same population during the period 1993–1994. This average density figure is about 40 times greater than that observed for the same species on Rib Reef and about 10 times greater than the density of *H. atra* on Fantome Island (Uthicke, 1997). In contrast to Uthicke's results (1997), which noted higher density levels in populations that had a high fission rate (Rib Reef : S(%) = 9%, density: 10 specimens per 100 m^2; Fantome Island: S(%) = 76 per cent, density: 42 specimens per 100 m^2), at Planch'Alizés, despite very high density (4.8 specimens per m^2), the fission rate was only 3.7 per cent. The population seemed to have achieved optimum density in relation to the biotic and abiotic conditions of the environment (i.e. small back reef where only limited amounts of food are available). This would explain the low fission rate, which only allowed the species to maintain optimum density (Harriott, 1982; Conand & de Ridder, 1990; Chao et al.; 1993a; Chao et al., 1994; Uthicke, 1997). This theory could explain the low fission rate in 1996, which, perhaps, was not an 'accident' but rather the result of the high densities observed in June and November 1995. These may have been higher than the opti-

mum density (Chao et al., 1994) in these environmental conditions for this species (density< 5 specimens per m^2). Overall, over the period of four years, asexual reproduction did not bring about any increase in population density.

As for weight trends over time, while there were significant differences in modal weight values over the course of a single year, in relation to the overall study they remained relatively stable. Since weights were constant and so were average sizes, asexual reproduction did not bring about any decrease in the overall size and weight of normal *H. atra* specimens. It is difficult to find any correlation between the size and age of specimens, as there is no clear correlation between the various modal weights. In fact, determining possible age-groups was not simple, due to the influence of asexual reproduction. After regeneration, the weight of normal specimens can be low and so directly influence modal values, since during regeneration specimens stop eating but increase the amount of energy they spend and this has a negative influence on their growth rate (Chao et al., 1994). Futhermore, variations in modal weight within the weight distribution of two successive samplings can be explained by the availability of food and the influence of other factors modifying environmental conditions (Chao et al., 1994).

In conclusion, asexual reproduction in *H. atra* on Reunion Island was seasonal in nature, with a higher fission rate during the cool season. Regeneration took about five to six months. Population density and average specimen weight remained relatively stable throughout the study (four years), which could confirm the theory that asexual reproduction allows a 'threshold-density' regulated by environmental conditions and the availability of food to be maintained.

A more detailed study of environmental factors would allow a better understanding of the extrinsic causes of fission, as endocrinal mechanisms could also exist.

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Distribution and abundance of *Thelenota rubralineata* in the western Pacific: Some conservation issues

by David J.W. Lane[1]

Introduction

Thelenota rubralineata Massin & Lane 1991 (Fig. 1), is a spectacular recent addition to the known tropical echinofauna of the archipelagic western Pacific and was first described from specimens taken in the late 1980s from reefs off northern Papua New Guinea (PNG) and Flores in Indonesia. However it had certainly been observed in Papua New Guinea waters prior to that, albeit rarely, in the early 1980s (Horseshoe reef, off Motopore Is. near Port Moresby, 1980: Marsh, pers. comm.; near Madang, 1981: Conand, pers. comm.) and had been photographed underwater even earlier (Halstead, 1977).

T. rubralineata is stated to be not uncommon at some Papua New Guinea locations (Halstead pers. comm.) and at New Britain (Massin, pers. comm.) but, more usually, sightings are of single individuals. At Laing island (PNG), near the type locality, the species has been reported only once during 1,200 dives (Claereboudt, pers. comm., in Massin & Lane, 1991). The virtual absence of this species from the beche-de-mer trade, both currently and historically, may in itself attest to low population numbers and densities, at least at depths normally harvested by fishermen in the western Pacific.

Geographic distribution—update

Other and more recent collections and sightings have extended the known geographic range for *T. rubralineata* (see Figure 2 on next page). It has been collected at Guam, Micronesia, in 1992 (single specimen at about 60 m: Kerr pers. comm. & article in *Pacific Daily News*, 4 August 1992); at the Banda Islands (single specimen in Smithsonian museum, collected at 6–18 m by Hendler—Pawson, pers. comm.) and observed near the Loyalty Islands, New Caledonia (Conand, pers. comm.); in the Philippines at Bohol (Lobban, pers. comm.) and Mindoro (Watkins, pers. comm.); at Gizo Island, Solomon Islands (Gosliner et al., 1996; photo Watkins); and in Indonesia, at Manado (Lane, in press) and Komodo Island (Watkins, pers. comm.). In the South China Sea it has been recorded in 1994 at Taiping Island (single specimen at 40 m); in the Spratly (Nansha) Islands (Jeng, 1998); and at Layang Layang (single 43 cm individual at 23 m) off the west coast of Sabah in May 1998 (unpublished observation of the author). The author has also received uncorroborated reports of its presence in Fiji and Palau. Figure 2 maps the known distribution for *Thelenota rubralineata*, together with the latitudinal and longitudinal limits for the two congenerics, *T. ananas* and *T. anax*, in the Indo-Pacific. There are no reports of *T. rubralineata* in the Indian Ocean.

Population at north Sulawesi

At the site near Manado (Bunaken-Manado Tua National Marine Reserve) in Sulawesi, a small population of *T. rubralineata* was located in 1977 and documented (Lane, in press). This sea cucumber was locally abundant at a Bunaken island site. A reef-face survey plot of area 3750 m^2 (depth range 14–30 m), characterised by alternating slopes and coral rock spurs, harboured 17 individuals, an

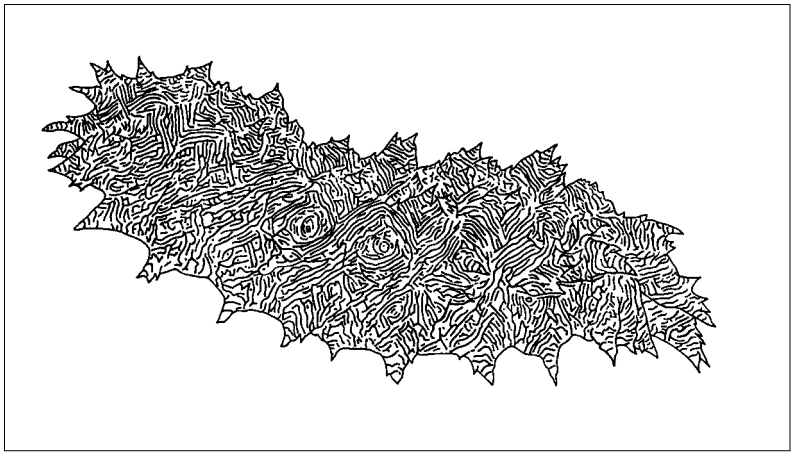

Figure 1: ***Thelenota rubralineata*** **(from photograph taken at P. Bunaken)**

1. Department of Biological Sciences, National University of Singapore, Lower Kent Ridge Road, Singapore 119260

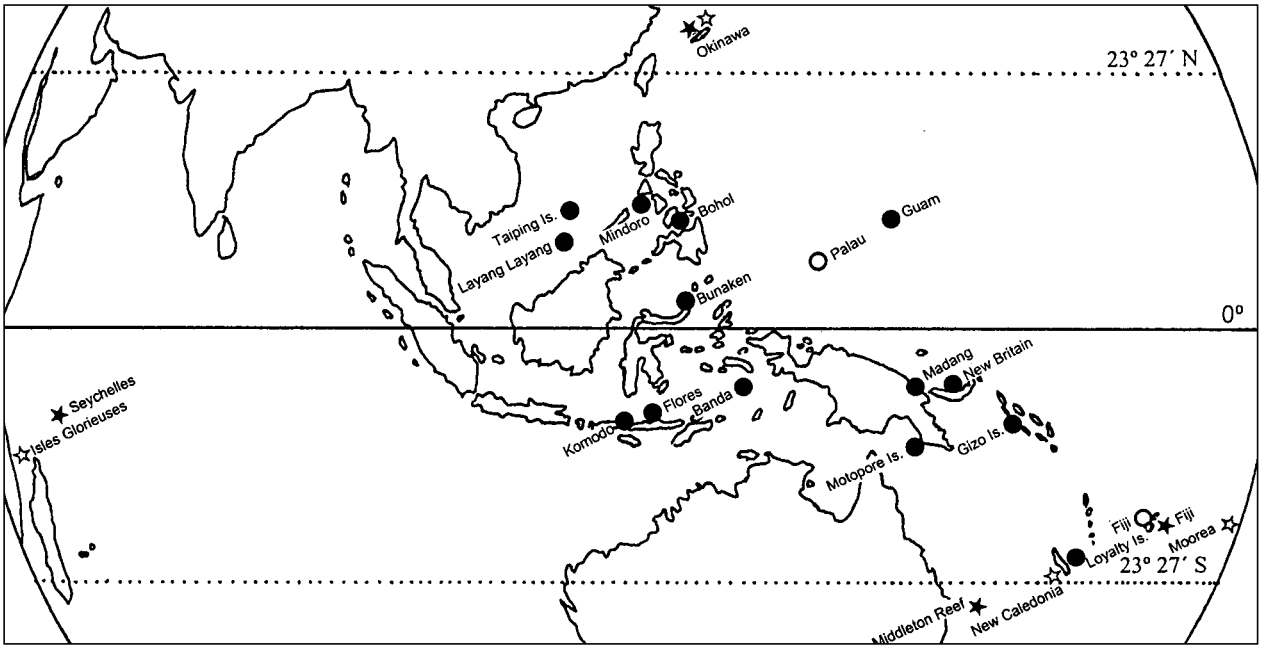

Figure 2: **Known distribution of *Thelenota rubralineata*. Solid circles (●) represent published or otherwise reliable reports; open circles (○) represent uncorroborated reports. The latitudinal and longitudinal distribution limits of *Thelenota ananas* (☆) and *Thelenota anax* (★) are also indicated.**

average density of 1 per 220 m^2 at this locality. A frequency histogram (Fig. 3) showing weight-class data for 31 individuals (collected then returned) suggests that all animals are at or near maturity. Juveniles were not recorded, the smallest individual found being 35 cm long and weighing in at 1150 g wet weight. There is a suggestion of a bimodal size distribution which, if real, might indicate repeated recruitment episodes, but the data are too limited to be certain.

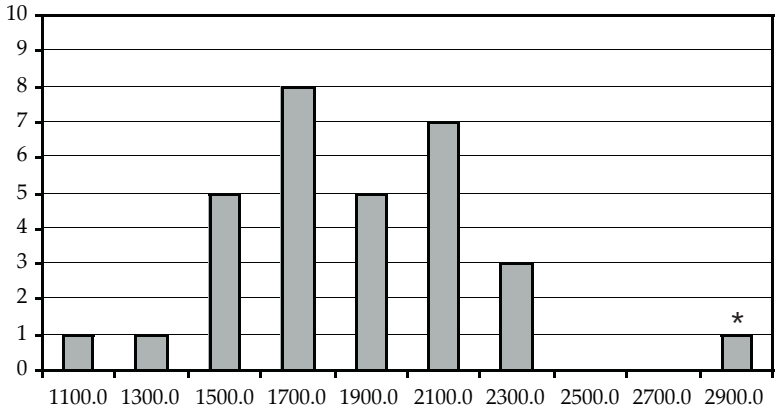

Figure 3: ***Thelenota rubralineata*** **size (wt.) frequency at Bunaken 3–5.9.97. One larger individual (*) recorded on 21.5.97**

Of interest is the recent appearance of *T. rubralineata* at the Bunaken marine reserve. This large and spectacular species has apparently not been sighted by local dive guides prior to 1997 despite the fact that the Bunaken area has been a major international SCUBA diving location for more than 20 years.

Other large stichopodid and holothurid sea cucumbers, including high-value commercial species such as *Thelenota ananas, Holothuria nobili* and *H. fuscogilva* are rare in the Bunaken area (unpublished observations of author), apparently due to intensive harvesting in earlier decades (Herlambang, pers. comm.). It is possible that *T. rubralineata* recruits are exploiting an unoccupied niche at this locality in Sulawesi.

The species may be increasing in numbers and/or geographic range in the western Pacific or, alternatively, individuals, in the Bunaken area at least, may be migrating vertically from adjacent deeper waters. The latter possibility at this northern Sulawesi location is suggested by the 'sudden' appearance of mature populations on shallow reef slopes (juveniles were seemingly absent) and supported by observations of the relatively rapid ambulatory behaviour of this species; moving individuals exhibited pronounced caterpillar-like undulations of the body. One animal, possibly due to handling stress, performed vigorous swimming flexures. An indication that coiling behaviour (Massin & Lane, 1991) may play a part in migration, at least horizontally, comes from an observa-

tion by B. Watkins (pers. comm.) of a tightly coiled individual rolling along the sea bed in a current near Komodo Island.

Conservation issues

Thelenota rubralineata is a spectacular animal and perhaps one of the most beautiful macro-invertebrates in the tropical Pacific. If population numbers are increasing in the western Pacific, it could become targeted and ultimately overexploited by the beche-de-mer industry, as has happened for several high-value sea-cucumber species throughout the Indo-Pacific. Not one commercially traded echinoderm species, threatened sea cucumbers included, is currently listed under the CITES convention and only one echinoderm, an echinoid (*Echinus esculentus*), is on the IUCN Red List. There may be a good case for Appendix III listing of threatened beche-de-mer species (such as *Holothuria nobilis* and *H. fuscogilva*) and, perhaps, pre-emptive listing for *Thelenota rubralineata* in view of its rarity and vulnerability. At country level, *T. rubralineata* is deserving of at least localised protection, as at Bunaken, on the basis that its ecotourism value to the recreational diving industry, particularly as an attraction for underwater photographers, probably exceeds its value dried at market.

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Recent developments in the commercialisation of the northern sea cucumber *Cucumaria frondosa*

by Jean-François Hamel & Annie Mercier[1]

After 12 years spent as the subject of scientific research, market surveys, technological transfer and public-awareness campaigns, the sea cucumber, *Cucumaria frondosa,* distributed along the coasts of Quebec, eastern Canada, will officially begin a commercial career in Spring 1999.

Tonnes of *Cucumaria frondosa* are accidentally dredged daily by dozens of fisherman during the scallop harvest season along the St Lawrence Gulf and Estuary. At present, the sea cucumbers are returned to the sea, where a high proportion of them finds only death. Aside from a serious ecological disturbance, this situation represents a considerable economic loss for the fisheries industry, which is always searching for new ways to strengthen its activities in eastern Canada. Considering the decreasing availability of other sea products, this promising resource could give a new life to dwindling seafood factories and unemployed fishermen.

Despite the great abundance of *Cucumaria frondosa* along the coasts of Quebec, the people involved in the commercialisation of the species are very keen to avoid a second Galapagos crisis. The extensive knowledge gathered on the general ecology, reproductive biology, spatial distribution and migration behaviour of *C. frondosa* in the past decade should be very helpful in developing an exemplary fisheries programme.

Considering the very slow growth rate of this species, which can take 10 years to reach the commercial size, great care must be taken to protect the resource and avoid rapid stock depletion. Luckily, many conditions favour a sustainable harvest in the St Lawrence Gulf and Estuary. Sea cucumbers are

1. Society for the exploration and valuing of the environment (SEVE), 655 rue de la Rivière, Katevale (Québec), Canada J0B 1W0 Tel. & Fax: +819 843 3466, E-mail: seve@sympatico.ca

mainly distributed on rocky habitats within 10-15 km of the coast. Although most of the distribution area is accessible to fisherman, a good proportion of the habitat, comprised of steep cliffs and rough terrain, remains inaccessible to fishing apparatus. These protected zones will ensure that a good part of the sea-cucumber population remains untouched and fully reproductive. Furthermore, as an outcome of a size-dependent migration, large individuals of the commercial size are found deeper than juveniles, which remain in the shallow waters above 20 m, where dredging activities are unlikely to occur. The depth at which the adults concentrate, usually below 40 m, prohibits harvest by scuba divers. Commercial harvest will thus begin by using the by-catch of scallop and other fishermen before a specialised fishery is developed.

Starting the commercialisation of sea cucumbers in Quebec has not been an easy thing. The first reports published early in the 1980s were not very favourable to *Cucumaria frondosa*. Nonetheless, Mme Monette Dion from Les Entreprises Ondines Inc., located in Saint-Anne-des-Monts on the Gaspesian Peninsula, was never discouraged. Convinced that the previous feasibility studies were not solid and that the accidental catches of sea cucumbers could be used instead of wasted, she started anew with the product, preparing samples and promoting *Cucumaria frondosa* on the North American, European and Asian markets. All the while she was trying to attract the attention of the government. Her perseverance finally gained her the support of the local population as well as the authorities. Today, the sea cucumber *Cucumaria frondosa* is considered to be one of the most interesting unexploited species in eastern Canada. Mme Dion has already received financial assistance to develop her project, seek technological transfer and deal with potential clients.

The comments that Les Entreprises Ondine Inc. received after sending samples to Asian importers were very encouraging. Although *Cucumaria frondosa* is smaller than most tropical species such as *Holothuria scabra* or *Holothuria fuscogilva*, its dark body wall, pinkish muscle bands and abundant protuberances seem appealing, whereas its phytoplanktonic diet apparently gives it a special taste appreciated by specialists around the world. Les Entreprises Ondine Inc. will soon undertake the pilot phase in the commercialisation of beche-de-mer and other by-products, with the collaboration of the government and local industries. The future looks promising. Last October, an international event brought some of the greatest chefs in the world together in Quebec City and the Canadian team entered the competition with a new local product... sea cucumber '*à la Québécoise*'!

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Diving accidents related to sea-cucumber fishing at Nosy Be, Madagascar[1]

by Dr C. Maillaud

Summary

On the north-east coast of Madagascar, certain varieties of sea cucumber (dingha-dingha in Malagasy) are collected by scuba-diving or skin-diving and then marketed as trepang in Asian countries. Diving accidents are frequent even though no statistics are available locally. We describe decompression accidents, cases of drowning of skin-divers and shark attacks, and highlight the circumstances surrounding these types of accident. With regard to decompression accidents, no safety rules were followed by divers, whose equipment was generally poorly maintained. The amount of money they could earn from their work seemed to be their only concern. No specialised treatment was available locally. Efforts should be made to provide those concerned with information about safety rules, but would be hindered by their complete lack of interest in the subject.

Introduction

Our study covered accidents which affected divers specialising in the collection of certain edible varieties of sea cucumber (also known as holothurians, or beche-de-mer) in the Nosy Be region of Madagascar. Our main focus was on decompression accidents, but we also included skin-diving accidents and shark attacks.

Material and methods

The data we used were collected from sea-cucumber fishermen from Ambatoloka and Dar-Es-Salam at Nosy Be with the assistance of an interpreter, who was also a fisherman. However, our work did not always offer the scientific precision that we would have liked it to have. This was because we could not always meet accident victims personally, due to logistical difficulties inherent in local communication methods, and because it was not possible to cross-check the information collected from local medical facilities. More specifically, we were unable to find any hospital records of the accidents described.

For all these reasons, our methods did not allow us to collect information that could be used statistically, as no record of diving accidents was kept, an apparently impossible task in any event. In addition to this, a large number of unexplained disappearances at sea also complicated the data collection. Consequently, we concentrated mainly on describing in detail the exact nature of the accidents brought to our attention and the circumstances surrounding them.

Background

Madagascar is characterised by one of the lowest per capita incomes in the region. The two principal industries in coastal regions are tourism and artisanal fisheries.

Certain local varieties of sea cucumber, known as dingha-dingha, are marketed in Asia under the name of trepang. This mainly involves the following species: *Thelenota ananas* (in Malagasy: Zanga borozy) and *Holothuria nobilis* (in Malagasy: benono). They are eaten dried, mainly in soups.

Sea cucumbers are first boiled over open fires in large pots set up on beaches near the place where they are collected. They are then buried in the sand for one night, before being put on racks to dry in the sun.

Each dingha-dingha can earn a fisherman between FMG 20,000 and FMG 25,0000 (about US$ 3.5–5.0). Given the fact that one fisherman can collect up to 50 dingha-dingha a week, his monthly income could be as much as FMG 500,000. By comparison, the average monthly income for a salaried employee in Madagascar is between FMG 180,000 and FMG 250,000. However, these large sums of money are rarely converted into capital, as they are usually spent locally during the fishing expedition. Marketing sea cucumber requires divemasters (who provide the equipment but do not dive) and collectors. A kilogram of dried sea cucumber, i.e. two to four dingha-dingha depending on the size of the specimens, is then sold locally for as much as FMG 120,000 (about US$ 23.00), with, of course, the added value being pocketed by the middlemen.

Divers, diving circumstances and factors in accidents

Divers are young (between 18 and 35 years old), usually illiterate and do not receive any kind of preparatory training. Only a small minority has had any previous experience, usually empirical, with scuba-diving. Infrequent attempts to provide

1. Communication presented at the Indian Ocean Round Table Diving Medicine Meeting, Mauritius, 12–13 September 1998

training seem to have encountered difficulties in understanding and met a complete lack of motivation on the part of the concerned parties.

Nosy Be has 80 to 100 such divers, a good number of whom are currently fishing in the Mahajanga region, or even in Les Glorieuses due to the increasing scarcity of the resource in their region.

Dives are commonly carried out in a state of intoxication, or under the best circumstances, the day after immoderate alcohol use, since most of the money earned from fishing is immediately converted into alcohol, which is consumed in the company of lady friends in a festive atmosphere.

The depth of dives carried out with scuba equipment varies: i.e. 15 to 40 m as a general rule, and less frequently, 50 m or even more.

The length of dives does not follow any rules. It is limited only by the amount of air in the tanks and is based on the need to fill a sack with sea cucumbers. The switch-over to the reserve tank is normally the signal to ascend. Divers then re-surface as quickly as possible, with no intermediate stages. The small portion of divers equipped with buoyancy control devices (5 to 10%) may use them to ascend to the surface more quickly. The amount of effort needed to re-surface is often increased by the need to heave up a sack containing sea cucumbers.

Divers do not use diving tables, watches, or depth gauges, as these are not included in their equipment. Depth is estimated by using a rope hanging from the boat. The equipment is not maintained, diving tanks are never serviced and regulators are often defective. When equipment fails, divers make panic ascents. Each diver does at least two dives a day, and sometimes three or even four. Diving in pairs is unknown.

Skin-diving is carried out at maximum depths of between 17 and 20 m, under the same physical conditions as scuba diving and without any mutual surveillance.

We should note that the shark attacks reported only involved skin-divers working on banks in the open ocean. Known factors that favour shark attacks, such as time of day, water clarity or the feeding instinct, did not appear to be determining factors in these accidents.

Types of accident

We found three categories of accident:

- Diving accidents in the strictest sense, i.e. Type 2 decompression accidents, mainly with neurological symptoms and at least one embolism. Fatalities did not seem to be unusual with this type of accident.

- Drowning during skin diving, probably following a black-out.

- Shark attacks.

The total number of accidents is difficult to determine: between 10 to 20 according to estimates whose reliability, however, is subject to caution.

Another factor which should be noted is frequent disappearances at sea (4 to 5 a year), probably due to one of the categories of accidents identified.

Reported cases

We decided to present four cases, illustrating two of the three categories identified:

- *Case no. 1:* Subject: 22 years old. 18 m dive at Mahjanga, on an empty stomach after a night of intoxication. Became ill after ascending to the boat, with difficulty in breathing and coughing blood. Died after 24 hours in hospital. Probable embolism.

- *Case no.2:* Subject: 31 years old. 40 m (?) dive on the 5 m bank at Nosy Sakatia (not far from Nosy Be). Paraplegia appeared shortly after ascension. Patient currently bedridden with severe complications (bedsores).

- *Case no.3:* Subject: 24 years old. 40 m dive (location not indicated). Hemiplaegia and aphasia after return to boat. Re-immersed by diving companions to 25 m, slow re-ascension: complete recovery.

- *Case no.4:* Subject: 19 years old. 14 m skin-dive off Nosy Be (exact location not indicated). Poor visibility between surface and 10 m, but very acceptable on sea floor. The diver accidentally bumped into a sawfish lying in the sand. The animal reacted in defence and injured the fisherman with its bill: deep cuts on the right thigh and left arm. Favourable outcome.

Treatment of accidents

Treatment is purely symptomatic (except for surgical treatment of shark-related accidents). No means of therapeutic recompression are currently available locally.

Acquisition of a de-compression chamber does not appear to be a public health priority in Madagascar.

Conclusion

After the data had been collected, our modest efforts involved arranging an information session, at the request of some of the concerned parties, on:

- ENT physiology of diving;
- preventing black-outs during skin diving;
- the usefulness and principles of diving tables. A set of tables was given to the president of the Fokontany (village assembly), who was supposed to give copies to those concerned.

We do not, however, have any illusions about the impact, even short-term, of our work.

Acknowledgements to: C. Conand, Marine Ecology Laboratory, University of La Reunion and Mr J. Kamisy, Fisherman at Nosy Be.

About the Latin name of the Japanese sea cucumber

by Pr.V.S.Levin

Eight genera are specified in the family Stichopodidae: *Stichopus* Brandt, 1835; *Thelenota* Brandt, 1835; *Astichopus* Clark, 1922; *Parastichopus* Clark, 1922; *Neostichopus* Deichmann, 1958; *Eostichopus* Deichmann, 1958; *Isostichopus* Deichmann, 1958; *Apostichopus* Liao, 1980.

Identification of the taxonomic status of a very common and commercially important species—the Japanese sea cucumber *Stichopus japonicus*—has been one of the obscure questions in the family's taxonomy. Liao (1980) included this species in the newly established genus *Apostichopus*. However, he provided only a comparison between *S. japonicus* and the type species of genera *S. chloronotus* without considering the status of other 'problematic' representatives of the family, primarily *Parastichopus californicus* and *P. parvimensis* that inhabit the Pacific coast of the USA. Deichmann (1937) had attributed those species to the genus *Parastichopus* established by H. Clark in 1922 for *S. tremulus* (north Atlantic) and *S. nigripunctatus* (Japan).

Established by us, a very pronounced morphological and chemical similarity between *S. japonicus* and *P. californicus* (Levin et al., 1985, 1986; Kalinin et al., 1994), and their wide difference from the type species, explain the need of separating these species from the genus *Stichopus*. Therefore, despite the limited data used by Liao in establishing the genus *Apostichopus* I consider it valid to place *Stichopus japonicus* within the monotypic genus *Apostichopus*.

Thus, the correct Latin name of the Japanese sea cucumber is *Apostichopus japonicus* (Selenka).

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Potential culture of sea cucumber in Mexico

by Alexandra Gutiérrez-García[1]

Attempts to raise and produce sea cucumber from an aquaculture system in Mexico have been scarce, almost nil. Despite the increasing interest of this sea product in the world markets, the only approach has been an unregulated extracting fishery, which has led only to a serious depletion of natural populations of species *Isostichopus fuscus* in the sea of Cortez (Gulf of California), Mexico (Figure 1). To understand the scenario more thoroughly, we can review some main aspects.

Introduction to the species

The sea cucumber *Isostichopus fuscus* (Figure 2) belongs to the Phylum Echinodermata, Class Holothuroidea, Order Aspidochirota and Family Stichopodidae. It presents an elongated body, with soft texture, very vigorous, with thick borders. The body shape is convex at the dorsal surface and flat on the ventral side. The coloration of *I. fuscus* is dark brown, spotted with orange papillae, while ambulacral extensions are arranged in bands. It has a thick, spikeless dermis, which makes it a highly edible and valuable species. The market was open for dry and cooked product.

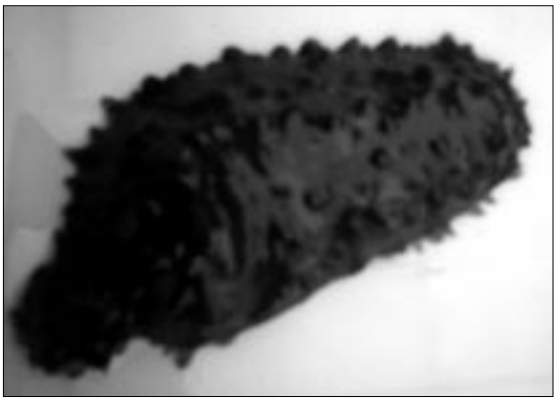

Figure 2: ***Isostichopus fuscus*, 'rock sea cucumber', native species from the Sea of Cortez, Mexico**

Sea cucumber fishery situation to date

The fishery started in 1988 on the eastern shorelines of the Peninsula of Baja California, where catch records reached 646 t in 1989, and a maximum of 1,230 t in 1991, but decreased to only 467 t in 1994 (Ministry of Fisheries, 1995, see Figure 3). However, these statistics must be interpreted with caution, since the last records may refer to dry product only.

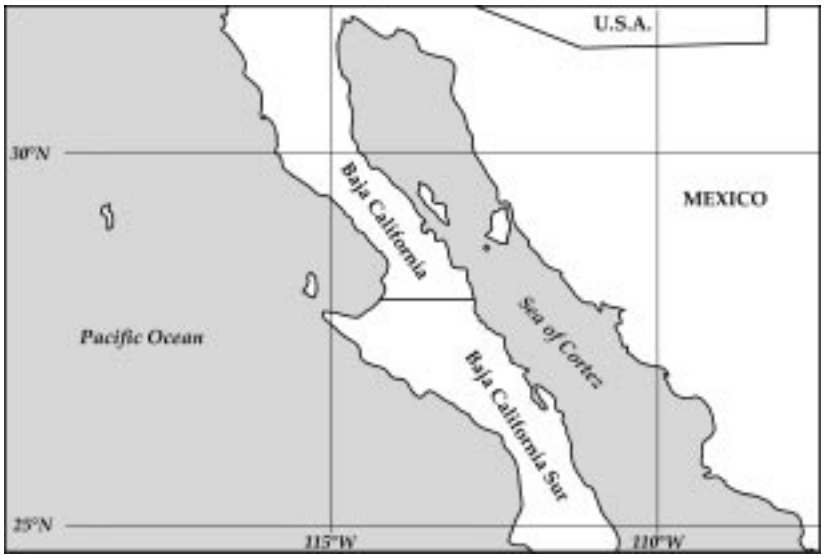

Figure 1: The Sea of Cortez (Gulf of California), Mexico, natural habitat of the species *Isostichopus fuscus*

The same trend in world landing records is reported by other analysts (SPC *Beche-de-Mer Information Bulletin* #6). Nevertheless, based on the figures alone and without any further consensus with the scientific community assessing the resource, Mexican authorities assumed a severe depletion of natural populations in the area due to overexploitation and, in 1994, established an indefinite ban on the fishery for the species, labelling its condition as *endangered.*

The National Fisheries Institute has observed that official catch records are different from those reported by its researchers. This highlights the need for the fishery sector to participate in the costs of protecting the resource and in the experimental design to assess natural stocks. To estimate the growth potential of this species, the National

1. National Fisheries Institute, Mexico. E-mail: alexinp@servidor.unam.mx

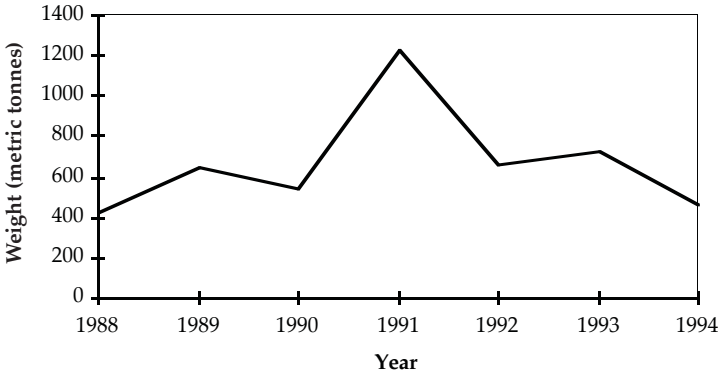

Figure 3: Annual production, 1988–1994, of sea cucumber *Isostichopus fuscus* on the eastern coast of Baja California, Mexico (Ministry of Fisheries, 1995)

Fisheries Institute proposes to place the species under a *special protection* condition, allowing a controlled fishery (Ministry of Environment, Natural Resources and Fisheries, 1998).

Consideration of aquaculture of the sea cucumber *Isostichopus fuscus*

All these conditions have led to much interest among the private sector in developing alternative methods of producing beche-de-mer. The development of an aquaculture system would provide a solution, making it possible both to enhance wild populations and to provide product to satisfy the increasing market demand for the species (Gutierrez-Garcia, 1995). The following considerations should be borne in mind in relation to the culture of this holothurian in Mexico.

Natural behaviour of the species

The Mexican sea cucumber *I. fuscus* occurs naturally along the coast of Baja California, Mexico. It is a native species from the Sea of Cortez and is distributed along the Mexican Pacific coast, reaching the Galapagos and Ecuador (Kerstitch, 1989). The natural habitat of this species can be a variety of substrates, including reefs, rocks, coralline algae, coral, sand and mud. It has been found in shallow waters at 20 m and as deep as 200 ft (61 m) (Kerstitch, op. cit; Salgado-Castro, 1993). Due to oceanographic dynamics in the area, there is a seasonal upwelling from January to June. *I. fuscus* then migrates to surface waters to feed on the rich nutrient medium. It is after this period, during July and August, that it reaches its seasonal maturity (Salgado-Castro, op. cit.; Herrero-Pérezrul, 1994; Fajardo-Leó, et al., 1995). The cucumbers consequently spawn during September and October (Ministry of Fisheries, 1995).

Juveniles (60–160 mm) are found within rocks and underneath them, whereas the biggest specimens (>170 mm) are distributed over rocks and stones (Fajardo-Leon et al., op. cit.). Gonadic development is in five stages: undifferentiated, gametogenesis, maturity, spawning and post-spawning (Herrero-Pérezrul, 1994). Gonadic development and the gonadosomatic index are related to temperature changes. This factor plays a significant role in synchronising the reproductive cycle, but it does not cause spawning (Fajardo-León & Vélez-Barajas, 1996).

Aquaculture alternatives for sea cucumber

It is necessary to promote the interest in aquaculture of the research media, as well as fishery authorities, not forgetting the participation of fishermen and investors. The culture of sea cucumber could be feasible if following elements were in place:

Review of and consensus on the regulation of the fishery: Fishery activity should be reactivated by means of reviewing up-to-date information on the species *I. fuscus* and assessing whether the permanent ban and classing it as an endangered species have been positive instruments for the natural stock since their establishment in 1994.

The evaluation can be carried out with different methods, such as visual observation of catching areas and density assessments with transects and quadrants (Conand, 1990). If results indicate no significant improvement, discussion between authorities, fishermen, entrepreneurs and researchers should be encouraged to identify feasible measures and actions for a suitable and participatory co-management of sea cucumber in the Sea of Cortez .

A biological research background that can provide the basis to establish an experimental culture. Regarding this point, previous studies on reproduction and development (Herrero-Pérezrul, 1994; Fajardo-León et al., 1995), and fishery parameters (Salgado, 1992, 1993) must be considered as supporting background for further studies.

In particular, the study should focus on broodstock management, controlled spawning, life-cycle description and larval development. We need to know optimum conditions for growth and survival, such as salinity, temperature, dissolved oxygen, food ratio and larval density.

Experimental systems must be designed to grow-out juvenile stages up to commercial size, probably with the use of partially-controlled natural areas or by integrated culture systems in shrimp ponds (Gutiérrez-García, 1995).

A stock enhancement programme should be designed by fishermen and authorities working together, in order to allocate harvest restrictions and recovery benefits fairly and equitably among all sectors of the fishing community.

The programme could use either harvest areas or artificial reefs; these have proved suitable as controlled systems to shelter and recover natural stocks in other areas of Mexico (Ministry of Fisheries, 1993), such as coastal areas of Manzanillo, in Colima State. The programme should be monitored and enforced with stock assessments in subsequent years to rebuild measures and regimes. These actions are recommended in a Strategic Plan for Fisheries (NOAA, 1997) to eliminate over-fishing and rebuilding of overfished stocks.

Results produced by these elements will provide information for the implementation of steps in the aquaculture process of the sea cucumber, beginning with an experimental system, upgraded to a pilot study and then leading finally to the commercial production of sea cucumber.

The time needed to achieve these goals is long, but the efforts made by many people so far must be spread to help to maintain the interest of authorities, researchers and fishermen in working together for the sustainable benefit of the sea cucumbers of Mexico.

The author wishes to express her interest in contacting expertise and financial organisations devoted to sea-cucumber culture and conservation, to explore the possibility of initiating a co-operative programme which could support a research project on sea-cucumber culture. Any feedback will be most welcome.

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Observations on fission and spawning

Communicated by Ram Mohan, Tuticorin RC CMFRI, Tamil Nadu. India 628 001.

1. Spawning observations

1. Date: 24.03.1998
Time: 09:45
Species: *Holothuria atra*
Moon phase: NM-3
Remarks: Two male specimens spawned one after the other in laboratory holding tanks at 30°C, for about 15–20 minutes. No peculiar spawning behaviour was noticed.

2. Date: 22.07.1998
Time: 08:30
Species: *Holothuria atra*
Moon phase: NM-1
Remarks: One male specimen spawned during transit in the container by slightly lifting its anterior end, for 12 minutes. The water temperature recorded was 27.5°C.

3. Date: 27.08.1998
Time: 11:45
Species: *Holothuria atra*
Moon phase: 1/4-3
Remarks: Four male specimens spawned in holding tanks by lifting their anterior end, but showed no swaying action. The spawning duration was 15–40 minutes. Later, two more male specimens spawned, but for a shorter duration. A single female specimen spawned in the same tank intermittently for about 4 hrs. No peculiar behaviour was observed. The water temperature recorded was 29.5–31°C.

4. Date: 15.09.1998
Time: 17:50
Species: *Holothuria atra*
Moon phase: 3/4+2
Remarks: One male specimen spawned for 30 minutes during transportation at 28°C water temperature. It erected its anterior end and showed swaying movements.

5. Date: 24.09.1998
Time: 09:30
Species: *Holothuria atra*
Moon phase: NM+3
Remarks: Two male specimens spawned in containers for 30 minutes to 1 hr. at 28°C by lifting their anterior end. One specimen had two gonopores; spawning time of 1 hour.

6. Date: 21.10.1998
Time: 14:10
Species: *Holothuria atra*
Moon phase: NM+1
Remarks: Three male specimens spawned in holding tanks, at about 29.0° to 29.5°C water temperature. The spawning duration extended from 45 minutes to 2 hrs. 15 min. One specimen had 3 gonopores. This particular animal lifted and swayed its anterior end.

2. Fission and regeneration observation

Species: *Holothuria atra*
Site: South Brezk Water, New Harbour, Tuticorin, Tamil Nadu, India.
Habit: Calm, loamy bay with beds of seagrass such as *Cymodicea* sp., and *Halophila* sp., along with some sea weeds and dead coral stones.
Date: November 1997 – October 1998.
State: Fissioned and regenerating anterior as well as posterior parts were observed. A maximum percentage of such specimens was noted during October, 1998 and minimum during April, 1998. The fission rate was higher at a temperature range of 25–27° C, at a steady salinity level of 34–45 ppt.
Behaviour variations: Not observed.

aquaculture
beche-de-mer

Aquaculture section prepared by Stephen Battaglene

News from ICLARM Coastal Aquaculture Centre

by Stephen Battaglene

Collection and spawning induction

During 1998, there was a ban on the harvesting of sandfish, *Holothuria scabra*, in Solomon Islands. However, villagers continued to harvest them and it was difficult to obtain broodstock and specimens for biological samples. To overcome this problem we put more effort into holding broodstock in captivity and securing new field sites. In 1997, we found spawning could be induced for sandfish, white teatfish *H. fuscogilva* and surf red fish, *Actinopyga mauritiana*, by elevating seawater temperature by 3° to 5°C. This year we evaluated the use of powdered algae as a spawning stimulant and found it to be more effective than thermal stimulation alone.

During the life of the programme we have now obtained fertilised sandfish eggs in all months of the year, except December, a month in which we have not attempted spawning. Overall in 1998, 16 per cent of the sandfish spawned, up from 12 per cent in 1997. To date we have produced over 8.5 million fertilised eggs in 1998.

To assess the use of captive broodstock, we stocked 12 x 4000 l fibreglass tanks with six sandfish each. The experiment will be run from July to December. We have covered half the tanks in 70 per cent shade cloth and feed half of the covered tanks, and half the uncovered ones, with prawn pellets.

After three months the sandfish in tanks receiving pellets weighed more than those which did not receive pellets, and those in uncovered tanks weighed more than those in covered tanks. Isolated sandfish spawned during the first three months, but towards the end of October, 33 per cent spawned, two days after the new moon.

Study of spatial distribution and movement in surf redfish

The decline in harvests of high-value species saw medium-value species, such as surf redfish, come under increasing pressure in 1998. Stocks of surf redfish, once plentiful on inshore reefs near the Coastal Aquaculture Centre (CAC), are now almost completely wiped out.

With the help of an Australian volunteer, Ms Jane Harris, who is undertaking a MSc degree from the Macquarie University in Sydney, we investigated the spatial distribution, movement and exposure of surf red fish within the CAC reserve and another site, Tuki in the Western province.

We found unharvested populations on reef flats to have clumped distributions in association with coralline rock substrates. Densities within clumps ranged from 5 to 10 /100 m^2. Daily movement is generally short, less than 2 m, and there is no homing behaviour. Surf redfish within the CAC reserve displayed distinct movement patterns in relation to tidal cycles: feeding and moving at low tide and sheltering and not feeding at high tide.

In contrast, those at Tuki exhibited a circadian rhythm: feeding and moving at night and not feeding and sheltering during the day. Field observations and tank experiments suggest surf redfish have an endogenous circadian rhythm modified by tidal cycles and wave action.

Determination of spatial distribution and movement patterns will assist in the collection of broodstock and in deciding when is an appropriate time and location for release of hatchery-produced juveniles.

Larval rearing trials

In the second year of hatchery operation, from September 1997 to September 1998, three batches of sandfish, totalling over 50,000 individuals, were produced at the CAC. We conducted three experiments in replicated 500 ml glass flasks to determine the best algae to feed sandfish larvae. The experiments complemented two conducted in 1997, and used a new improved water bath and continuous stirrer. Larvae survived and grew best on single diets of *Rhodomonas salina* (a red alga with a large cell size, 8–12 μm) and *Chaetoceros muelleri* (gracilis) (diatom, 5–8 μm). They grew poorly on diets of *Isochrysis galbana*,and *Tetraselmis chuii* and to a lesser extent *Chaetoceros calcitrans*. The proportion of competent larvae reared on *R. salina*, defined as auricularia with lipid spheres or doliolaria, was higher at algal cell densities of 10 000 cells/ ml, than in those reared at 3000 and 7000 cells/ml. Feeding equal parts *R. salina* and *C. muelleri* was more effective than feeding *R. salina* alone.

Juvenile grow-out

We are now confident that newly-settled *H. scabra* can be reared in tanks using simple technology, and little or no added feed, at low cost. Absolute growth rates of 0.5 mm Day-1 and 0.2 g Day-1 are possible for juveniles reared initially on hard substrates and then on sand at final stocking densities of < 200 g/m^2. We believe there should be no major impediment to the production of juveniles for stock enhancement programmes, provided that juveniles can be released successfully into the wild at sizes of <60 mm and 20 g. The three months it takes to produce juvenile *H. scabra* of this size, and the ease of culturing them, compares favourably with other tropical marine invertebrate species under active consideration for stock enhancement.

However, the large number of juveniles that will be required for stock enhancement, and the possibility that they may need to be larger than 60 mm at release, has prompted us to investigate the possibility of on-growing sandfish in prawn-farming ponds. We have conducted experiments in 50 l and 4000 l tanks which indicated that *Penaeus monodon* stocked into tanks with sandfish juveniles can cohabit, although there were some indications that sandfish may be detrimental to prawns. We were encouraged by the results and sought the co-operation of a local prawn farmer, who allowed us to stock two of his 30 000 l concrete nursery ponds with juvenile sandfish. Early indications suggest that sandfish grow faster in these tanks than in the smaller concrete tanks at the CAC and that there is no negative effect on prawn survival. We have subsequently stocked a larger prawn pond with 1000 juvenile sandfish.

News from the Pacific Islands

Beche-de-mer stocks continue to come under increasing pressure around the region. A ten-year ban has been placed on the taking of sea cucumbers in Tonga, and at a regional SPC meeting I spoke with representatives from many Island countries and territories who are concerned about the future of beche-de-mer stocks. There is also increasing interest in the potential of stock enhancement as a method for restoring depleted stocks.

In Kiribati the Japanese-funded Kiribati/OFCF Fisheries Cooperation Project has made a breakthrough in the production of white teatfish juveniles. The Japanese scientist in charge of the project, Mr Yoshio Sato, has told me he has been able to spawn white teatfish on at least 6 occasions and rear over 40 000 juveniles. Some juveniles have been held for up to 8 months. They have adapted the techniques used in Japan to produce *Stichopus japonicus*; however, the growth rate of juvenile white teatfish appears to be rather slow.

For anyone interested in the culture of *Stichopus japonicus*, I recommend a chapter by Yanagisawa, T., 1998, Aspects of the biology and culture of the sea cucumber, **In**: S. De Silva S. (Ed.), Tropical mariculture, Academic Press, London.. pp. 291-308.

News from Australia

While visiting the Queensland Department of Primary Industry Aquaculture Research station at Bribie Island in September, I spoke with some industry representatives, who indicated that the current harvest of beche-de-mer in Queensland is about 500 tonnes dry weight. Most of the catch is now white teatfish, black teatfish, and sandfish, with some interest in greenfish coming from Japan. Quotas are given to individual divers and area restrictions apply.

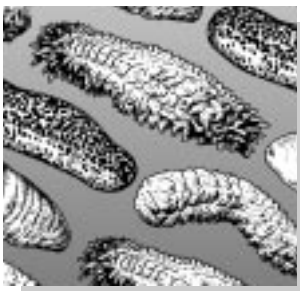
The most productive area for sandfish appears to be Harvey Bay. Moreton Bay is closed to fishing but has good populations of sandfish.

While at Bribie I spoke to Andrew Morgan who is currently writing up his M Sc thesis on the collection, induced spawning, egg incubation and larva rearing of sandfish. His results showed broodstock held for some months in tanks all lost weight but continued to spawn. There is considerable interest in sea-cucumber stock enhancement in Queensland and two industry representatives are currently applying for permission to build sea-cucumber hatcheries.

Presentation

Can hatcheries produce juvenile tropical sea cucumbers for restoration and enhancement of wild stocks? by Stephen C. Battaglene, presented at the Australian Society for Fish Biology Annual Conference in Hobart, September 1998.

In recent years, high demand for beche-de-mer has led to a dramatic decline in wild stocks of sea cucumbers. As it can take over 50 years for isolated and heavily harvested stocks to recover, poor management of sea cucumbers deprives developing countries of much needed export earnings. Release of juvenile sea cucumbers reared in hatcheries is a potential way of restoring wild stocks, and then increasing yield through stock enhancement. However, these measures are contingent on being able to produce juveniles cost-effectively. A number of attempts have been made to rear tropical sea cucumbers without success and only sandfish, *Holothuria scabra*, has been cultured *en masse*. Fortunately, sandfish is considered the best candidate for restoration and stock enhancement because it is of high value, widely distributed, relatively easy to culture, and grows rapidly at high densities on simple, low-cost diets. The current bottlenecks to mass production of juvenile sandfish are reliable spawning induction, and mortality of larvae at settlement. ICLARM has demonstrated that both bottlenecks can be overcome and we are now in a position to produce the 100 000 specimens that will be required to experimentally test the survival and growth of juveniles in the wild.



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

1. 8th International Congress on Invertebrate reproduction and development, Amsterdam, August 98

Asexual reproduction in populations of *Stichopus chloronotus* (Holothuroidea): a comparison between Pacific and Indian Ocean populations

C. Conand & S. Uthicke

Stichopus chloronotus is a widespread holothurian species, in the Indo-Pacific which often occurs in high population densities. Its asexual reproduction by fission was monitored in several populations from the Great Barrier Reef (GBR, Australia, Pacific Ocean) (Uthicke, 1997) and from La Reunion fringing reefs (France, Indian Ocean) (Conand *et al.*, 1998). The results obtained at these locations are compared, to investigate similarities in the fission pattern between the two geographic regions. Fission rates showed distinct seasonality, with maxima occurring during the cold season (May to July), both in La Reunion and the GBR. The processes of external and internal regenerations have been described in view to understand the resumption of the nutrition and the sexual reproduction after fission. Annual fission rates and population densities are positively correlated in all populations studied. In contrast, annual fission rates and modal sizes in the populations are negatively correlated. The consequences of fission in terms of density and size of the individuals are discussed. Several abiotic factors, which may differ between species, have been hypothesised to trigger fission in holothurians. For *S. chloronotus* we suggest that food availability and population densities may be involved in the regulation of asexual reproduction. However, the comparison of more stations remains necessary to substantiate this hypothesis.

2. 5th European conference on Echinoderms, Milan, September 1998

Asexual reproduction by fission in Indo-Pacific tropical holothurian populations (Echinodermata: Holothuroidea): characteristics of the phenomenon and consequences on populations

C. Conand

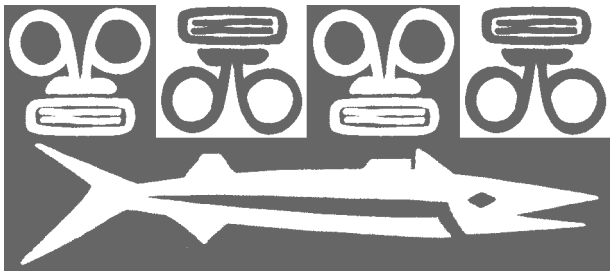
Although only a small portion (1%) of the existing holothurian species show asexual reproduction by fission, as well as sexual reproduction, this process has an important adaptative significance. Several recent studies have concentrated on tropical Indo-Pacific holothurians species (Conand C., 1996; Conand C. *et al.*, 1997 ; Uticke S., 1997; Conand C. *et al.*, 1998; Conand & Uticke, 1998). These studies have monitored several populations from La Reunion fringing reefs and from the Great Barrier Reef, of different species, mainly *Holothuria atra*, *H. leucospilota* (first evidence of this phenomenon) and *Stichopus chloronotus*. A synthesis on the following populations parameters are given for each population studied : 1) rates of fission and regeneration, 2) situation of the splitting site on the individuals, 3) size distributions of normal and regenerating individuals, 4) seasonality of fission and sexual reproduction, 5) density. Geographical variations of these parameters are also presented. New data on the long-term evolution (5 years) of an *H. atra* population from La Reunion allow to discuss the consequences of fission in terms of density and size of the individuals, in a population where fission is important. Triggers for asexual reproduction mainly remain hypothetical and have to be experimentally verified, as they are presently still derived from field observations. Environmental exogenous factors (from the habitat, as temperature or emersion and anthropogenic perturbations, and from the population itself, as density or body size) are discussed; they probably regulate endogenous chemical or nervous factors, as in other related phenomena (arm autotomy of sea stars and holothurian evisceration).

Holothurian neuropeptide Ngiwy-Amide: localization and effects on muscles

M. Inoue[1], R. Birenheide[1], T. Motokawa[1], O. Loizumi[2] and Y. Muneoka[3]

1. Tokyo Institute of Technology, Fac. Bioscience & Biotechnology, Basic Biology, Meguro, Tokyo, Japan
2. (Fukuoka Woman's Univ. Fac. Human Environmental Science, Fukuoka, Japan
3. Hiroshima Univ., Fac. Integrated Arts and Sciences, Higashi-Hiroshima, Japan)

NGIWY-amide is a peptide recently isolated from the sea cucumber *Apostichopus japonicus*. It stiffens the dermis of the holothurian body wall. We investigated the effects on muscle activities of the sea cucumber. It induced contraction in the longitudinal body-wall muscles and tentacles, and inhibited spontaneous activities of intestine. The antiserum raised against NGIWY-amide stained the hyponeural and ectoneural parts of radial nerves, the tube feet nerves, the tentacle nerves and the nerve plexus of intestine. These results suggest that NGIWY-amide is a neuropeptide controlling contraction of muscles and stiffness changes of connective tissues in the sea cucumber.



Ecological monitoring of *Holothuria tubulosa* and *H. polii* (Echinodermata: Holothuroidea) in nearshore waters of Elba, Italy

S. Scheiblauer & T. Reinthaler

University of Vienna, Institute of Zoology, Dept. of Marine Biology, Althanstr. 14, A-1090 Vienna, Austria.

The distribution and abundance of *Holothuria tubulosa* and *H. polii* on algal meadows were investigated at 4 stations with different depths at Fetovaia and Sant'Andrea at the island Elba, Italy. The study were conducted from May to October 1997. At Station 1 (6–7 m depth) *H. polii* was most abundant in September with 1.16 ind. m^{-2} and least abundant in October (0.4 ind. m^{-2}). The mean total wet weight (twwt) was 118.6 g and 120.7 g respectively. *H. tubulosa* was most abundant in June at Station 3 (23–24 m) with 0.4 ind. m^{-2} and a mean twwt of 337.1 g while *H. polii* reached only 0.16 ind. m^{-2} and a mean twwt of 154.7 g. At Station 2 (12–13 m) both species were least abundant because of the higher water movement. They were found next to each other at Station 2 and Station 3 but with higher abundances of *H. tubulosa*. *H. polii* only was found at Station 1. Faeces of *H. polii* were more fined-grained compared with those of *H. tubulosa* indicating possible resource partitioning through selective feeding. Investigation of surrounding and gut sediment and faeces showed an increase of chlorophyll-a and organic carbon content from the surrounding sediment to faeces in both species. Further biometrical data is presented.

Some thoughts about the 'supergenus' *Thyone* Jaeger (Echinodermata: Holothuroidea)

Ahmed S. Thandar & Vish Rajpal

Department of Zoology, University of Durban-Westville, South Africa

Pawson and Miller (1981) pointed out that Panning's (1949) transference of *Havelockia* and its type species, to the Scerodactylinae and the remaining species to *Thyone,* resulted in the latter genus becoming a 'supergenus' with thre groups of species: those with only tables in the introvert, those with only rosettes in the introvert, and those with both tables and rosettes in the introvert. The inclusion of one species with only plates in the introvert results in four groups of some 59 species. Thandar (1989) suggested a restriction of the family Sclerodactylidae to form with compact calcareous rings, as opposed to subdivided rings in the Thyoninae. He further erected the Sclerothyoninae to include those sclerodactylids with non-tubular rings, thereby apparent that several species, currently classified in *Thyone*, can be referred to the Sclerodactylidae. With this and the complexity of the genus in mind, the calcareous rings and tentacle and/or introvert spicules of 34 well-described nominal species of *Thyone* were examined. Of these, eight can be referred either to the Sclerodactylinae (sensu Thandar 1989) or to the Sclerothyoninae. The remaining 26 species share three types of rings: those in which the dorasl radial plates extend beyond the level of the interrradials before bifurcating (8 spp.), those in which the dorsal interradial plates extend beyond the point of bifurcation of the radials (6 spp.), and those in which the dorsal radials bifurcate at the level of the posterios margins of the interradials (12 spp.). There is no correlation between the type of calcareous ring and the tentacle and/or introvert spicules. Because of this, the fact that the interradial plates are known to lengthen with age, and that the calcareous ring has this far been used to separate only higher taxa, it is suggested that more attention be given to body wall and/or introvert spicules to subdivide *Thyone* into smaller, more manageable groups.

3 - 1998 North American Echinoderms Meeting

Communicated by Thomas Scott Klinger, Ph.D. Professor and Vice President for Academic Affairs, Marine Science Consortium, Department of Biology, Bloomsburg University, 400 East Second Street, Bloomsburg, PA 17815-1301, USA. Phone: +1 717 389 4118; fax: +1 717 389 3028; e-mail: tklinger@bloomu.edu

The sea urchin *Tripneustes depressus*, the sea cucumber *Selenkothuria theeli*, and the starfish *Phataria unifasialis* (Echinodermata) at Punta Los Frailes and Punta Carnero (Ecuador)

John M. Lawrence & Jorge Sonnenholzner

Tripneustes depressus and *Phataria unifasialis* were found together on rubble in a protected embayment on the west side of Punta Los Frailes (PLF) while *Selenkothuria theeli* was found in crevices on a rock bottom

at the east tip of the point and in tide pools of the rocky intertidal at Punta Carnero (PC). 80% of the *T. depressus* had a test diameter of 91–110 mm with a 1% cohort of 66–70 mm. 60% of the *P. unifasialis* had an arm radius of 61–70 mm with cohorts of 10% at 76–80 mm and 2% at 91–95 mm. *S. theeli* at PC had body lengths ranging from 45 to 135 mm, with 92% > 70 mm while those at PLF had body lengths ranging from 50 to 100 mm, with 85% > 70 mm. The incidence of arm loss in *P. unifascialis* and of body regeneration in *S. theeli* were < 5%.

What is 'local degeneration' in holothurian body wall?

Robert B. Hill

Department of Biological Sciences, University of Rhode Island, Kingston, RI, 02881 USA

What is 'local degeneration' in holothurian body wall? Is liquefaction different from the widely studied relaxation or softening? Crozier (1916) first used the term 'local degeneration' to describe the softening induced by mechanical pressure in the body wall of *Isostichopus badionotus* the 'sea pudding' (SP). Since then, rapid local degeneration (LD) has been familiar to anyone who has handled living sea cucumbers of that species at the Bermuda Biological Station (BBS). In the course of minutes, the major part of the initially firm body wall flows out in a sticky mass. This appears to be physiologically triggered rapid tissue self-destruction, which is quite different from the phenomenon of echinoderm tissues plasticised and stiffened under calcium control. Work at the BBS, communicated by W.R. Ellington, showed that collagenase is present in SP body wall tissue and that collagen breakdown increased during LD. Specimens of the SP, collected at the BBS, were kept in the URI Research Aquarium for experiments on LD. Samples of ooze were analysed by F. Rahemtulla at UAB. The amino-acid composition of the ooze produced in LD resembled that of proteoglycans from mammalian tissue, being rich in aspartic acid, glutamic acid, glycine, serine, alanine and leucine. Immunodetection, gel electrophoresis and gelation zymography confirm the release of proteoglycans in LD of SP body wall. The proteoglycans absorb water and form the mucinous ooze which is characteristic of LD. Specimens of the SP were taken to the BioCurrents Research Center at the MBL in Woods Hole. In a preliminary experiment with the self-referencing calcium probe, mechanical stimulation led to an immediate large inward calcium current at the epithelial surface of a segment of body wall. With time, LD set in and the inward calcium current gave way to an outward calcium current, which may be due to loss of tissue integrity. We hypothesise that pressure induces a massive cellular influx of calcium, which leads to activation of latent collagenases, releasing proteoglycans. Tests with manual mechanical pressure, carried out at the BBS, have established that 4 antioxidants are effective in blocking LD in cubes cut from SP body wall: ethyl gallate, propylene phenoxetol, BHA and propyl gallate. They are hypothesised to block a step in which reactive oxygen species mobilise a cascade of intracellular reactions.

The tagmatized echinoderm

Richard L. Turner

Tagmosis is a derived condition of metamerism in annelids, arthropods, and chordates in which groups of adjacent segments are modified to perform specific functions. Examples are the clitellum of earthworms, the carapace of lobsters, and the sacrum of tetrapods, to mention a few of many. Examples of tagmosis are not hard to find among echinoderms, a fourth major phylum of metamerized animals; but the degree of tagmosis is weak in most cases. The first few elements of the axial skeleton are often fused as special structures (jaws and other parts of the oral frame, lantern supports) in asteroids, echinoids, and ophiuroids. Crinoid pinnules occur in groups along the arms as genital pinnules and oral pinnules. Porcellanasterid seastars have cribriform organs along the marginal plates for generation of respiratory currents. Well-developed podial pores and podia are restricted to basal segments of the ophiuroid genus Ophiomusium. Ambulacral plates of most post-Palaeozoic echinoids occur in clusters that result in arcs of pore-pairs and in the compound formation of spine tubercles, giving rise to several non-cidaroid tagmatized patterns. The strongest degree of tagmosis occurs in the bilaterally symmetrical echinoids, with petals, phyllodes, plastrons, and frontal ambulacra; and tagmosis differs among the axes. Tagmosis is poorest in holothuroids, bodies of which are almost entirely composed of extra-axial elements.

How do echinoderms maintain fluid balance?

John C. Ferguson

Echinoderms have an obvious need to maintain fluid in their usually spacious body cavities. Most other animals maintain fluid balance primarily by osmotic uptake of water through the gut or directly through the integument, and adjust ion or water levels with excretory structures. Echinoderms, however, are usually thought to lack such requisites, although they do possess a hydropore or madreporite which questionably could provide an unusual route for fluid uptake. A series of studies on different types now provides insight into this puzzle. They indicate that a variety of mechanisms contribute to water balance, with often several being important in any given species. Indeed, a major explanation for the diversity of echinoderm body forms may be found in the balance of strategies that are emphasised by different groups. It has been found that all these animals are really slightly hyperosmotic and thus can take up some water directly, that the madreporite system pumps water into the body for the benefit of all regions (not just the water vascular system), and that physical (hydrostatic) uptake of water through the mouth, anus, or other parts can play an important role in diverse species. Most notably, the flexible fluid-filled bodies of asteroids are made possible by the supplement of relatively large volumes of water filtering through the Tiedemann's bodies from the madreporite and stone canal. Ophiuroids have reduced coelomic spaces and positive pressures in their genital bursa, and thus only have a minimal hydropore system which provides small additional amounts of fluid primarily to the water vascular channels. Echinoids rely on a rigid test, which not only fixes fluid volume, but also allows a negative net hydrostatic pressure to develop in the body cavity by action of the lantern, which draws in water reducing the need for madreporitic influx. Holothuroids undoubtedly gain water through hydrostatic pumping of their rectum, and thus use their internal madreporite to distribute fluid to their water vascular system and to maintain an internal circulation and filtration that is probably common to all echinoderms. No data are yet available on crinoids.

Distribution of the holothurian fauna in the Mexican Pacific: a general view

Ana Claudia Nepote

The main purpose of this work was to compile and actualise all the dispersed information about the holothurian distribution into the Mexican Pacific. For this purpose, published taxonomic and distribution information about Mexican Pacific holothurian fauna were reviewed, including the Gulf of California. The catalogue of some important collections were reviewed in order to get information on the distribution of species (Coleccion Nacional de Equinodermos 'Dra. Maria Elena Caso', Instituto de Ciencias del Mar y Limnologia, U.N.A.M. Mexico; Smithsonian Institution, Washington, D.C., U.S.A.; Allan Hancock Foundation, actually held at the County Museum of Los Angeles, CA., U.S.A.; Museum of Comparative Zoology at Harvard University, U.S.A.). The Mexican Pacific (including the Gulf of California) has a total of 104 species reported, included in 16 families and 55 genera. 88% of the families, 83% of the genera and 69% of the species reported for the Central Eastern Pacific are present in the area. Because of the great collecting effort made since a long time ago, the best known area in the Mexican Pacific is the Gulf of California. Nevertheless there are still a lot of gaps in the knowledge of the Mexican Pacific holothurian fauna, especially in some coastal states such as Jalisco, Michoacan, Oaxaca and Chiapas.

4. Procedings of the 8th International Coral Reef Symposium, Panama

H. Lessios I.G. Macintyre, 1997 - Smithsonian Tropical Research Institute, Panama, 2 volumes.

5. International Echinoderm Conference, San Francisco 1997

The communications are published in the book : R. Mooi and M. Telford (eds.) (1998). Echinoderms: San Francisco. A.A. Balkema, Rotterdam, 923 pages. Abstracts cited in the SPC *Beche-de-Mer Information Bulletin* #9 are published in this book.

BRADBURY, A., W. PALSSON & R. PACUNSKI. (1998). Stock assessment of the commercial sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington State, USA

CONAND, C. (1998). Overexploitation in the present world sea cucumber fisheries and perspectives in mariculture. 449-454.

MARTINEZ, P.C., M.V. TORAL, & R.H. BUSTAMANTE (1998). Population and reproductive biology of the sea cucumber *Isostichopus fuscus* in the Galapagos Islands

MLADENOV, P.V. & A. CAMPBELL (1998). Resource evaluation of the sea *cucumber (Stichopus mollis*) in an environmentally sensitive region of New Zealand

POMORY, C.M., T.W. FORET, S. HILL & J.M. LAWRENCE (1998). Characteristics of a population of *Holothuria floridana* (Echinodermata: Holothuroidea) in the Florida Keys.

RODRIGUEZ, E. & S. MARQUES PAULS (1998). Sea cucumber fisheries in Venezuela

6. - Other abstracts and publications

Diet and feeding behaviour of the sea cucumber *Cucumaria frondosa* in the St. Lawrence Estuary, eastern Canada

Jean-François Hamel and Annie Mercier
Société d'exploration et de valorisation de l'environnement (SEVE), 90 Notre-Dame Est, Rimouski (Québec), Canada G5L 1Z6 and Département d'Océanographie, Université du Québec à Rimouski, 310 allée des Ursulines, Rimouski (Québec), Canada G5L 3A1 Author to whom all correspondence should be addressed (e-mail: seve@sympatico.ca)

Combined laboratory and field experiments showed that sea cucumbers (*Cucumaria frondosa*) from the St. Lawrence Estuary in eastern Canada have well-defined feeding cycles with marked seasonal and tidal variations. Typical feeding behaviour involved extension of the tentacles, which were then successively introduced into the oral cavity. Field observations and analysis of intestinal contents and indices demonstrated that *C. frondosa* fed mainly during spring and summer. Their diet comprised an abundance of phytoplanktonic cells (*Coscinodiscus centralis, Chaetoceros debilis*, *Skeletonema costatum* and *Thalassiosira gravida*), with occasional ingestion of small crustaceans and variety of eggs and larvae. Food types found in the digestive tract were closely related to the periodic abundance of plankton species in the water. Fewer individuals were observed feeding during fall and winter; they mostly ingested nonliving particles and the intestinal indices were low. In field populations, feeding rates were highest during ebb and rising tides, whereas under laboratory conditions without tidal variation, individuals showed no distinct feeding periods. However, individuals maintained under laboratory conditions and periodically provided with phytoplanktonic cells demonstrated a strong ability to detect the food in the water and react accordinly by extending their tentacles and beginning to feed. The results of the study suggest that food availability, rather than physical parameters such as temperature or current, best explains the cyclic feeding behaviour of *C. frondosa* at seasonal and tidal scales.

Source: *Can. J. Zool*. 76 (1998)

Evidence of chemical communication during the gametogenesis of holothuroids

Jean-François Hamel & Annie Mercier

This research provides evidence for chemical mediation in the initiation of gametogenesis and interindividual fine-tuning among populations of the holothurian *Cucumaria frondosa*. Initiated in the laboratory by increased day length, the gametogenesis of *C. frondosa* developed normally when individuals were transferred to an environment in which temperature and photoperiod were held constant and food was withheld. Gonad development and spawning of these sea cucumbers occurred simultaneously with animals that were fed. Individuals collected from the deep aphotic zone showed gonadal indices and histological development of gametes synchronous with populations found in the shallower photic zone. These data strongly suggest that day length and temperature were not the sole factors controlling the onset and development of gametogenesis, but rather that they act synergistically with other mechanisms. Laboratory experiments showed that gametogenic synchrony was less for individuals separately maintained under natural environmental conditions than it was for similarly treated individuals kept in groups. Finally,

gametogenesis was initiated by exposure to more developed individuals, even without the photoperiod cue. This induction, effective only between animals of the same sex, became more evident with increasing maturity of the more developed individuals.

Source: *Ecology*, 77(5), 1996, 1600–1616, 1996 by the Ecological Society of America

Sea cucumbers: current fishery and prospects for aquaculture

Jean-François Hamel & Annie Mercier

Source: *Aquaculture Magazine*, January/February 1997, 42–53

Regulation of cell-dependent viscosity in the dermis of the sea cucumber *Actinopyga agassizi*

John A. Trotter and Kazumi Chino
Department of Anatomy, University of New Mexico, School of Medecine, Albuquerque, NM 87131, USA.

The effects of various treatments on the viscosity of the deep dermis of the aspidochirote sea cucumber *Actinopyga agassizi* were investigated to elucidate the physiological mechanisms of viscosity regulation. Dermal specimens showed a significantly reduced viscosity in the presence of the Ca^{2+} chelator EGTA, the Ca^{2+} antagonists verapamil and TMB-8, isobutylmethyl xanthine, propranalol, phentolamine, caffeine and 1.9 dideoxyforskolin. With the exception of the Ca^{2+} chelator, these drugs were used in the presence of normal extracellular Ca^{2+} concentrations. The viscosity of the dermis was significantly increased by 100 mM K^{+} and by phorbol myristate acetate. These compounds were ineffective in the presence of EGTA. Inconsistent effects were seen with cyclic AMP, 8-bromo-cyclic AMP, ATP, sodium orthovanadate, staurosporine, forskolin, trifluoperazine, atropine, isoproterenol and acetylcholine. No effects were seen with okadaic acid, genistein, H-7, hypericin and epinephrine. Lysis of cellular membranes, caused either by freezing and thawing the tissue or by exposing it to the non-ionic detergent Triton X-100 (1%) or to deionized water, significantly increased viscosity, even in the continuous presence of EGTA. Extracts of frozen and thawed dermis contained one or more non-dialyzable, heat labile factors that stiffened of the dermis in the presence of EGTA. The results are consistent with the notion that stiffening of the dermis is the result of a Ca^{2+} dependent secretory event that releases a soluble organic stiffening factor into the dermis.

Source: COMP BIOCHEM PHYSIOL 118A; 3: 805–811, 1997. Copyright Elsevier Science Inc.

End-Plate spicules in *Bohadschia marmorata* (Jaeger) (Holothuroidea: Holothuriidae)

R. M. Clouse,
Ponape Agriculture & Trade School, P.O. Box 39, Pohnpei, FM 96941, Federated States of Micronesia

End-plate spicules from the tube feet of the sea cucumber *Bohadschia marmorata* are described. These spicules may be confused with large plate-like spicules in the body wall, which are not supposed to be in the genus. End-plate spicules are generally considered of non taxonomic value, but they are conspicuously missing from specimens originally described as *Holothuria bivittata* and currently placed in synonomy with *B. marmorata*. Considering the taxonomic problems with *Bohadschia*, and the type species, *B. marmorata*, it may be useful to use end-plate spicules in future Holothurian taxonomic work.

Source: *Micronesica* 30(1): 187–192, 1997

7. Forthcoming Conferences

9th International Coral Reef Symposium : Bali, October 2000

Secretariat : c/o Coremap jl Raden Saleh 43, Jakarta 10330 Indonesia. coremap@indosat.net.id

International Echinoderm Conference : New Zealand, February 2000

Conference organiser : Mike Barker, Department Marine Science, Portobello, POB 8, Portobello, Dunedin New Zealand. mike.barker@stonebow.otago.ac.nz

correspondence
beche-de-mer

Research conducted by the Pacific Sea Cucumber Harvesters Association

by Sophie Campagna, PSCHA biologist, 364 Vancouver Avenue, Nanaimo, BC, V9S 4G2 Canada. E-mail: CampagnaS@pac.dfo-mpo.gc.ca

The Pacific Sea Cucumber Harvesters Association of British Columbia (PSCHA) includes all commercial fishing-licence holders. The *Parastichopus californicus* dive fishery is opened 3 weeks a year. The current quota of 275.7 t (split weight) is divided equally among the 85 licences and only be taken from 25 per cent of the coast. The Department of Fisheries and Oceans (DFO) develops survey and research protocols that are implemented by PSCHA in collaboration with First Nations groups. Expansion of this fishery beyond the 25 per cent of the coast (based on the shoreline length) is limited until information from surveys and experiments can be used to establish sustainable quotas. Dive transect surveys to estimate density began in 1996 and these have found densities higher than the conservative estimate of 2.5 sea cucumbers per metre of shoreline used to estimate quotas. Long-term experimental fishery projects have just been initiated to test various exploitation rates. A survey conducted by PSCHA and the Heiltsuk Fisheries Program in the open area resulted in a quota increase for the surveyed areas for the 1998 fishery. The future of this fishery is promising.

About possible environmental impacts of beche-de-mer ranching on an atoll environment

by wallison@dhivehinet.net.mv

There is a sea cucumber ranching operation proposed for an atoll in the Maldives (as noted in the abstract by Battaglene and Bell in Bulletin 10, p. 37).

(a) The holothurian to be farmed is *Holothuria scabra*, which has not previously been found here. The closest endemic species seems to be *Holothuria versicolor*. It is claimed that these are both subspecies of *H. scabra*, i.e., *H. scabra scabra* and *H. scabra versicolor*. Is this information accurate?

(b) Are there reasons for not wanting such an introduction?

(c) Possible environmental impacts of the sea cucumbers *per se* are hard to imagine—can you suggest anything to look out for?

(d) Holothurians are here regarded as secreting a toxin that kills baitfish. The reason seems to be that baitfish died when put into the hold of a fishing boat recently holding holothurians; mortality of fishes in embayments has been, by default, attributed to dumping of water from the holds of boats recently holding holothurians.

There is therefore concern that a ranching operation could kill off the fishes in an atoll popular as a source of baitfish. Any comments?

The Editorial Committee of *Fauna Sinica, Academia Sinica*

Phylum Echinodermata Class Holothuroidea, *FAUNA SINICA*, Phylum Echinodermata, Class Holothuroidea (Chinese edition with English abstracts). This volume is edited by Liao Yulin. 1997/334 pages. 187x260 mm. ISBN: 7-03-005435-0. US$58 sea mail

This book is a volume of *Fauna Sinica* which deals with a class Holothurioidea of the Phylum Echinodermata occurring in Chinese waters. The number of species included is 134, belonging to 57 genera in 15 families of 6 orders.

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Peter Brayshaw
P.O. Box 2861, Southport 4215, Qld, Australia

Sian Damschke
Natural Resource Management Officer
Qld Fisheries Management Authority
P.O. Box 344, Fortitude Valley
Queensland 4006, Australia
E-mail: damschs@qfish.cbd.dpi.qld.gov.au

Russell Kelley
Producer/Science Communicator
Coral Sea Imagery, P.O. Box 2186
Townsville, Queensland 4810, Australia
E-mail: russell@coral-sea.com.au

Jim T. Luong-Van
Faculty of Science, School of Biological and
Environmental Sciences
Casuarina Campus, Building 40
Darwin 0909, Northern Territory, Australia
E-mail: jluongva@darwin.ntu.edu.au

Dan Machin
Fisheries WA Midwest, P.O. Box 1171
Geraldton, Western Australia 6531, Australia
E-mail: dmachin@fish.wa.gov.au

Adam Maskew
Hatchery Manager, Oceanwest Fisheries
Giralia Bay, Exmouth WA, Australia
E-mail: oceanwest@nwc.net.au

Lyn McKillop
P.O. Box 60, Karumba,
QLD 4891, Australia

Richard Torelli
Tasmanian Seafoods P/L
17 Red Gum Drive, Dandenong South
Victoria 3175, Australia

Sven Uthicke
Australian Institute of Marine Science
PMB 3, Townsville MC, QLD 4810, Australia
E-mail: S.Uticke@aims.gov.au

Elvira Diaz-Guardamino
Union Européenne
Bibliothèque DG VIII, G-12 00/43
200, rue de la Loi, 1049 Bruxelles, Belgium
E-mail: Elvira.Diaz-Guardamino@dg8.cec.be

Claudia Hand
Pacific Biological Station
Shellfish Stock Assessment
Fisheries and Oceans, Nanaimo
B.C., Canada V9R 5K6
E-mail: HandC@pac.dfo-mpo.gc.ca

Sophie Campagna
364 Vancouver Avenue, Nanaimo
BC Canada V9S 4G2
E-mail: CampagnaS@pac.dfo-mpo.gc.ca

Mike Hasurmai
Marine Research Specialist
Marine Resources Management Division
Dept. of Resources & Development
P.O. Box 251, Colonia, Yap, FSM 96943

Johnson Seeto
Marine Studies Programme
USP, P.O. Box 1168, Suva, Fiji
E-mail: Seeto_j@usp.ac.fj

Walt Smith
P.O. Box 4466, Lautoka, Fiji

P.S. Asha
Scientist, CMFRI, Tuticorin Research Centre
South Beach Road Extension
Tuticorin 628001, Tamil Nadu, India

M.S. Shaleesha A.
M.S. Swaminathan Research Foundation
Third Cross Street, Institutional Area
Taharamani, Madras 600 113, India

Dessi Wulandhari
Environment & Natural Resources
Management Program, Biology Department
Bandung Institute of Technology
JI. Ganesha No.10, Bandung, Indonesia
E-mail: dessi206@ciberlib.itb.ac.id

Akamine Jun
National Museum of Ethnology
10-1 Senri Expo Park, Suita
Osaka, 656-8511, Japan
E-mail: akamine@idc.minpaku.ac.jp

Laila Abubakar
K.M.F.R.I, P.O. Box 81651, Mombasa, Kenya

Fredrick Guya
K.M.F.R.I, P.O. Box 81651, Mombasa, Kenya

Nyawira Muthiga
Kenya Wildlife Service
P.O. Box 81244, Mombasa, Kenya
E-mail: nmuthiga@africaonline.co.ke

Benjamin M. Mwashote
P.O. Box 40874, Mombasa, Kenya

Jacob Ochiewo
K.M.F.R.I., P.O. Box 81651
Mombasa, Kenya

Ezekiel Okemwa
K.M.F.R.I, P.O. Box 81651
Mombasa, Kenya

A.C. Yobe
K.M.F.R.I, P.O. Box 81651,
Mombasa, Kenya

Arsenio Fernandez R.
IMPEX S.A. de C.V.
Carr. Picacho Ajusco No. 238. 60. Piso
Jardines de la Montana
14210 Mexico, D.F., Mexico
E-mail: 104164.3456@compuserve.com

Alexandra Gutiérrez
P.O. Box 102-108
Mexico 08931 D.F, Mexico
E-mail: alexinp@servidor.unam.mx

Thomas Gloerfelt-Tarp
Pacific Island Programme Officer
Asian Development Bank
P.O. Box 789, Manila 0980, Philippines

Arjan Heinen
PIPULI Foundation Inc.
P.O Box 1088, Ozamiz City, Philippines
E-mail: snvphil@misa.irf.ph.net

Gilles Hosch
Marine Resources Information Officer
FAO Sub-regional Office
FAO Private Mail Bag, Apia, Samoa
E-mail: gilles.hosch@field.fao.org

Monica Moodley
Librarian, SEAWORLD
P.O. Box 10712, Marine Parade
Durban 4056, South Africa

Simon Milledge
Programme Officer,
TRAFFIC East/Southeast Africa-Tanzania
P.O. Box 63117, Dar es Salaam, Tanzania

Simong M. Ndaro
Dept. of Zoology and Marine Biology
University of Dar Es Salaam
P.O. Box 35064, Dar Es Salaam, Tanzania

Hansa Chansang
Head of Marine Ecology Subdivision
Phuket Marine Biological Center
P.O. Box 60, Phuket 83000, Thailand
E-mail: pmbcnet@phuket.ksc.co.th

Patricia Lee
P.O. Box 37877, Honolulu, Hawaii 96837, USA
E-mail: rcinternational@ibm.net

Maui Pacific Center
590 Lipoa Parkway
Kihei, HI 96753, Hawaii, USA

Susan McBride
University of California Sea Grant Extension
Program, 2 Commercial Street, Suite 4
Eureka, CA 95501, USA
E-mail: scmcbride@ucdavis.edu

Catherine Cheung
UNDP, PO Box 551, Sana'a, Yemen
cpscheung@y.net.ye

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